Analysis of the Causes and Consequences of Flash Flood and Design for Flood Resilient Neighborhood in Kebelle 02 of Bishoftu Town

Thesis submitted to School of Graduate Studies of Addis Ababa University in the partial fulfillment of the requirements for the degree of Master of Science in Environmental Planning and Landscape Design.

By: Biruk Tilahun

Advisor: Prof. Hailu Worku

Ethiopian Institute of Architecture, Building Construction and City Development, Addis Ababa University.

October, 2018

Addis Ababa

Ethiopian Institute of Architecture, Building Construction, and City Development Addis Ababa University

Chair of Environmental Planning and Landscape Design

Analysis of the Causes and Consequences of Flash Flood and Design for Flood Resilient Neighborhood in Kebelle 02 of Bishoftu Town

A thesis is submitted to the Ethiopian Institute of Architecture, Building Construction and City Development (EiABC) and to School of Graduate Studies of Addis Ababa University for partial fulfillment of all requirements of Master of Science in Environmental Planning and Landscape Design.

By

Biruk Tilahun

Advisor

Hailu Worku (Ph.D.)

(Professor)

Ethiopian Institute of Architecture, Building Construction, and City Development Addis Ababa University

Chair of Environmental Planning and Landscape Design

Thesis Title: Analysis of the Causes and Consequences of Flash Flood and Design for Flood Resilient Neighborhood in Kebelle 02 of Bishoftu Town

Author: **BIRUK TILAHUN**

Date: October 2018

Name and Signature of members of the Examining Board

Prof. Hailu Worku (PhD)	___________________	_______________
Advisor	Signature	Date
Dr. Dagnachew Adugna (PHD)	___________________	_______________
Internal Examiner	Signature	Date
Dr. Kumelachew Yeshitela (PHD)	___________________	_______________
External Examiner	Signature	Date
Dr. Fisseha Wegayehu (PHD)	___________________	_______________
Chair Person	Signature	Date

Declaration

I **Biruk Tilahun**, declare that this study is my original work towards the Executive **Master of Science in Environmental Planning and Landscape Design** and has not been submitted for any Degree or Diploma in any University. To the best of my knowledge, all source of materials used for the study has been duly acknowledged. I have undertaken the study independently with the guidance and support of the research advisor.

Students Name: Biruk Tilahun

Signature ……………………………………..

Confirmation

The thesis can be submitted for examination with my approval as an Institute`s advisor.

Advisor`s Name: **Prof. Hailu Worku (PHD)**

Signature: ______________________________

Acknowledgment

First and foremost, praises and thanks to the God, the Almighty, for His showers of blessings throughout my research work to complete the research successfully.

I would like to express my special gratitude to my advisor Prof. Hailu Worku for his strong commitment in giving me valuable comments, and constructive suggestions during the entire period of the study.

I am indebted to the respondents (Kebelle 02 Residents) for providing me valuable information. Without their kind cooperation, my fieldwork would not have been successful.

I am indeed grateful to all my friends especially Ms. Rahel Abebe, who had a contribution in this study in one or the other way.

Finally, I would like to thank my family for their encouragement and prayers throughout the study period. My Special thanks goes to my friend and brother in law Mr. Daniel Tesfaw for the keen interest shown to complete this thesis successfully.

Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviation

CRED	Centre for Research on the Epidemiology of Disasters
CSA	Central Statistics Agency
DEM	Digital Elevation Model
FGD	Focus Group Discussion
GIS	Geographic Information System
KII	Key Informant Interview
NA	Not Available
NMA	National Metrological Agency
OUPI	Oromia Urban Planning Institute
SUDS	Sustainable Drainage System
SSWM	Sustainable Solid Waste Management
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISDR	United Nations International Strategy for Disaster Reduction
WHO	World Health Organization
WMO	World Metrological Agency

Abstract

Natural hazards are the most known catastrophes on the planet earth. They cause devastation on property and loss of human life. Flood is one of the major natural hazards. According to the Intergovernmental Panel on Climate Change prediction, in the coming years the frequency and intensity of floods will increase at an alarming rate. The impact of flooding is very severe in developing countries. As a developing country, Ethiopia is one of the victim of natural hazards, of which flood is the prominent one. The country experiences two types of floods: river floods and flash floods. This research focused on flash floods that occur seasonally in Kebele 02 of Bishoftu town. The study has set objectives to identify major driving causes and effects of flash flooding, to generate maps of urban flood barrage by using data from peak runoff events, explore the coping strategy used by local residents and to propose an appropriate strategy for flood resilience in the study area. In order to meet the intended objectives, the present research followed descriptive and explanatory research methodology. The research employed field observation, survey, interview, document review and case study. The data obtained through questionnaire, interview guides and checklists were analyzed using simple descriptive statistical methods such as percentages, charts, and graphs. The qualitative analysis was presented through direct quotes followed by explanation using different spatial mapping. The study identified that: encroachment of fragile ecosystem (quarry at upper catchment), new developments, prevalence of impervious surface materials, poor solid waste management, lack of vegetation on the mountains and plain areas are the major driving factors of the flash flood in the study area. These driving factors have infrastructure and household equipment damage, health related effects due to contamination of edible items and water pollution and flood induced economic crises on the residents of the case site. Finally the study recommends appropriate strategies to bring flood resilience in the case site such as: sustainable drainage system, storm water detaining tanks, bio-retention basin, rehabilitation of the quarry and enhancing the local coping strategy of the residents.

***Keyword**: Ethiopia, Bishoftu, flashflood, coping strategies, Resilience, sustainable drainage system*

Chapter One: Introduction

1.1 Background of the Study

Globally, floods are the most frequently occurring destructive natural events, affecting both rural and urban settlements (K , Bloch , and Lamond, 2012). According to Centre for Research on the Epidemiology of Disasters (CRED) database, flooding caused the majority of disasters between 1994 and 2013, accounting for 43% of all recorded events and affecting nearly 2.5 billion people (CRED, 2014). Flooding is one of a major contributors to loss of life and economy from disasters. Furthermore, the Intergovernmental Panel on Climate Change expects that the frequency and intensity of floods will increase in the future (Vink, 2014).

> *"Today, more than half of the global population resides in urban areas. By 2025, roughly two-thirds of the world's inhabitants and the vast majority of wealth will be concentrated in urban centers. Many of the world's mega-cities, characterized as those with populations exceeding 10 million, are already situated in locations already prone to major earthquakes and severe droughts, and along flood-prone coastlines, where the impacts of more extreme climatic events and sea level rise pose a greater risk to disasters"* (UNISDR, 2012, p. 8).

Cities are directly threatened by physical events caused by climate change (Barkham, et al., 2014). One of the manifestations of climate change is urban flood which causes widespread devastation, economic damages and loss of human lives (Jha, et. al., 2012). In rapidly expanding towns and cities of developing countries flooding poses a serious challenge to development and the lives of people (Jha, et. al., 2012).

As a least developed and rapidly urbanized country, Ethiopia has substantial flood risk (WBG and GFDRR, 2017). The rapid urban growth, together with the cities' exposure to floods risks exacerbating existing urban challenges. Without proper planning and measures to manage the impacts of flooding, from a changing climate, Ethiopia could miss the opportunity to capitalize on the positive impacts of urbanization (WBG and GFDRR, 2017). In most cases, floods occur in Ethiopia as a result of prolonged heavy rainfall causing rivers to overflow and inundate areas along the river banks in lowland plains. The study conducted by WB (2017) indicates that all major cities of Ethiopia face increasing flooding events (WBG and GFDRR, 2017).

The country experiences two types of floods: flash floods and river floods. In Ethiopia, Flood hazard is still not well understood due to a limited number of hydrology and stream gauging stations. In Ethiopia, river flooding hazard usually affects locations close to river banks of cities and towns. However, there is a difficulty to measure and mapping all types of flood hazard in Ethiopia, due to a limited number of hydrology and stream gauging stations (WBG and GFDRR, 2017).

Most of the researches conducted by researchers addressed the issues of flood disasters occurring along the riverbanks and the mitigation strategies. However, it is seldom to find a research, which addresses the flash flooding. There are few researches conducted by Yonas Tadesse Alemu (2014), entitled 'Flash Flood Hazard in Dire Dawa, Ethiopia', which mainly focused on identifying flood causative factors and the resulting socio-economic impacts on Dire Dawa by Paolo et al. (2013) entitled 'The increased frequency of flash floods in Ethiopia: climate change or human impact?' with the aim of the root causes of flash floods in Ethiopia by taking Dire Dawa and Kobo-Alamata as case study areas. The other research conducted by Melsew Zenebe Danssie (2014) also aimed at the socioeconomic impacts of the 2006 seasonal flooding and coping strategies along flood-prone areas, taking Dire Dawa as a case study. All these researches are focused on the case of Dire Dawa and they give special attention on the socioeconomic impact and mitigation strategies from the social science perspectives. Due to these, there is scarcity of scientific research in the area of causes and mitigation strategies of flash floods in Ethiopia from the Environmental planners' perspective.

Therefore, it is essential to plan for Neighborhood Resiliency: the ability of a neighborhood to adapt to both internal and external social, economic, and environmental pressures to emerge stronger and more resourceful (Gromulat and Acevedo, 2016). In flood-prone areas Implementing flood resilience approaches could help the management of flood water and speed up the recovery of people and places (Gravin, 2014).

1.2 Problem Statement

Ethiopia is one of the less urbanized countries in the world and even in Sub-Sahara African countries. Based on the 2014/15 CSA projection, the urban population of Ethiopia reached nearly 20 percent (NPC, 2016), which is by far less than the global, middle-income countries, and Sub-Saharan African countries averages 52, 50, and 37 percent, respectively (WBG and CA, 2015). However, Ethiopia faces a unique rapid growth of urban population in the world-projected to nearly triple from 15 million in 2012 to 42 million in 2014, with an average 5.4 percent growth rate per annum (WBG and GFDRR, 2017).

Studies indicate that, rapid urbanization will lead to greater agglomeration of people, assets, and infrastructure; if such kind of scenario is not properly regulated and managed, it will result in increasing challenges and exposure to shocks and stresses (WBG and GFDRR, 2017). As a rapidly urbanizing state, Ethiopian cities are already struggling with access to jobs, infrastructure, services, and housing as well as an increased exposure to disaster and climate change impacts (WBG and CA, 2015).

Disasters that occurred due to the impact of climate change can intensify the socio-economic and political conditions that persisted before the disaster, perpetuating a cycle of poverty and vulnerability (World Bank, 2014). In other words, countries like Ethiopia where population size is increasing and urbanization is expected to grow at 5% percent a year, people are highly vulnerable for natural disasters like floods; especially the poor are the one who resides along natural risk-prone areas. Even if natural hazards occur everywhere, their impacts are more pronounced in developing countries due to their level of poverty (Eleni, 2011).

Flash floods are among the natural hazards formed due to excess rainfall on upstream watersheds and gush downstream with massive concentration, speed, and force. Often, they are sudden and appear unnoticed. Thus, such floods often result in a considerable toll; and the damage becomes especially pronounced and devastating when they pass across or along human settlements and infrastructure concentration (Kebede, 2012). Such types of flood usually occur in Ethiopian cities and towns like Dire Dawa 2006 which displaced 9,956 people and killed 256 and Bishoftu (*Sink Sefer*) has encountered such disaster as well. In Ethiopia Flood hazard is still not well understood, this is due to a less than a satisfactory number of hydrology and stream gaging stations (WBG and GFDRR, 2017).

This research gives special emphasis on flash floods by taking the town of Bishoftu (Debre Zeiet) as a case study. The pattern of natural terrain of Bishoftu is mostly the result of volcanic eruption. Some of the present lakes are the results of these geological formations. There are many hills and mountains such as Sofa, Baru, Bubissa, Dhibaayu, and Wulabbo mountains located on the southern side of the town forming chain-like structure are main sources of flood water that result damage in the central and peripheral parts of the town. Most mountains in the town are barren and exposed for natural hazard (OUPI, 2009).

There are thirteen Kebeles in the town of Bishoftu. Kebele 02 is one of the largest Kebele in the city with 17% of the total population of the town resides in this area, which has low lying topography that is surrounded by mountains. The mountain near Kebelle 02 is currently used as quarry site for red ash which is a great factor to promote flash flooding from the upper catchment.

In addition to Kebelle 02 has the largest population, the topographic feature laying within 0%- 2%, most of the neighborhood area is characterized as swampy and vulnerable to flooding. Regarding the flow accumulation and watershed map analysis of the case site made, the site has water flow accumulated on different parts of the specific site which is currently affecting the residents. Especially, during the rainy season, flash floods come from the upper catchment to the neighborhood at the low lying areas and destroy physical infrastructures, houses, and other properties.

Therefore, it is important to ensure the resilience of urban neighborhood that can be applied to any community and any type of disturbance: natural, man-made, or a combination of the two. Disaster resilience can be seen as a public good that builds an appropriate amount of redundancy into urban systems and encourages communities to plan how to deal with disruptions (K , Bloch and Lamond, 2012). Likewise, this research aims to find major driving causes and effects of the flash flood, explore the local coping strategy mechanisms and generate maps of urban flood barrage by using data from peak runoff events to design for flood resilient neighborhood in Kebelle 02 by taking specific flood vulnerable case sites within the Kebelle.

1.3 Objective of the Study

1.3.1 General Objective

The general objective of this study is to investigate the major flood aggravating factors and recommend appropriate strategy for flood resilience in Kebele 02 of Bishoftu town.

1.3.2 Specific Objectives

This research has the following specific objectives:

- To identify major driving cause and effect of flash flooding in the case site;
- Generate maps of urban flood barrage by using data from peak runoff events;
- To explore the coping strategy used by local residents;
- To propose appropriate strategy for flood resilience in the study area.

1.4 Research Question

In line with the above objectives; the following questions are designed to answer them:

1. What are the causes and effects of seasonal flooding in the case site?
2. Which specific areas are highly affected by the flash flood within the case site?
3. What are the coping strategies or local remedies used by local residents to prevent the seasonal flooding?
4. Which are appropriate strategies to promote flood resilience in the case area?

1.5 Significance of the Study

Ethiopia is highly vulnerable to natural hazards in particular to hydro-metrological hazards. The National reports from Ethiopian Disaster Prevention and Preparedness Agency indicate that the frequency and intensity of hydro-metrological hazards are increasing at alarming rate. Scholars systematically categorized hydro-metrological hazards in different categories. Of these flash food is one of the prominent hazards. The problem is visible in developing countries in general and in Ethiopia in particular. The effect of such kinds of hazards becomes harsh in urban areas. This research has significance, in exploring the contemporary theoretical perspectives to fill the knowledge gap. The research also scrutinized the existing problems of flash-flood hazard as well as identifying the prevailing causes and effects in the study area. Based on the findings the research provides a way forwards to bring resilience in the study area. Furthermore, the research will have its own contribution to the concerned government bodies and other stakes by taking the study area as a case for other areas which has similar scenarios.

1.6 Scope of the study

The study is geographically delimited to Bishoftu town and confined to Kebele 02 area. The case site covers an area of 237.8 ha. It is spatially bounded by four Kebelles, Kebelle 05 on the North, Kebelle 01on the West, Kebelle 03on the East and Kajima on the South.

Regarding the thematic scope of the subject matter; the study and analysis will focus on the neighborhood that is affected by flash flooding. It also encompasses the major driving causes and effects of the flood and understands the coping strategies or local remedies used by local residents to prevent the seasonal flooding. In addition, the study generates urban barrage maps by using different inputs like DEM file and spatial data.

1.7 Limitation of the Research

The researcher faced three major constraints; these are lack of interest on the respondents' side, political instability and time constraints. When the researcher conducted the household survey, the target groups were not willing to fill questionnaires, by presuming that the result of this research does not have impact for the area. After convincing those on the significance of the research in flagging the problems and suggesting possible solutions to bring resilience in the study area, they become willing to fill it. During the time of data collection there was turmoil in the study area. This has an adverse effect in collecting the filed data on the planed time.

1.8 Organization of the Paper

The thesis is divided into five chapters. The first chapter presents the background of the study, statement of the problem, the objective of the study, and significance of the study, the scope of the study, limitation of the study and organization of the paper. The second chapter deals with the review of relevant materials related to this study and empirical findings. The third chapter presents description of the study area, research methods and methodologies used in the study area. The fourth chapter depicts results, discussions and proposal of the study area, which consisted of the background of the respondents, major driving causes and effects of the flash flood, analysis of different maps as per regard to the flooding, the coping strategies employed by the residents of the area and proposal of appropriate flood resilience strategies. Chapter Five gives conclusions and recommendations based on the findings of the study.

Chapter Two: Literature Review

2.1. Flood Hazard

Flooding is debatably the weather-related hazard that is most widespread around the globe. It is a natural phenomenon and can happen at any time in a wide variety of locations. According to Doswell III (2003) flood is defined as water overflowing onto land that usually is dry. Floods may happen gradually and also may take hours or even happen suddenly without any warning due to breach in the embankment, spill over, heavy rains. Even though flooding usually results from a combination of meteorological and hydrological extremes, such as extreme precipitation and flows, it can also occur as a result of human activities: flooding of property and land can be a result of unplanned growth and development in flood-plains or from the breach of a dam or the overtopping of an embankment that fails to protect planned developments (Dey and Singh, 2006).

Globally, floods are the most frequently occurring destructive natural events, affecting both rural and urban settlements. Urbanization has become the defining feature of the world's demographic growth, with the populations of cities, towns, and villages swelling, particularly in developing countries. As a result, floods are affecting and destroying more urban areas, where unplanned development in flood plains, aging drainage infrastructures, increased paving and other impermeable surfaces, deforestation and lack of flood risk reduction activities all contribute to the impacts experienced. These problems are compounded by the effects of a changing climate (Bloch , Jha, and Lamond, 2011).

According to NWS, (2005) flooding severity is characterized by minor flooding, moderate flooding and major flooding. Minor flooding is with minimal or no property damage, but possibly some public threat or inconvenience. Moderate flooding is with the inundation of structures and roads near streams. This causes some evacuations of people and/or transfer of property to higher elevations. Major flooding is with the extensive inundation of structures and roads, which results significant evacuations of people and/or transfer of property to higher elevations.

Therefore, it is fundamental to understand flood hazards during flood emergencies, as well as before an event actually takes place, in order to allow for mitigation, preparation and damage reduction activities. However, understanding flood hazards requires knowledge of the different types of flooding, their probabilities of occurrence, how they can be modeled and mapped, what are the required data are for producing hazard maps and the possible data sources for these. A detailed understanding of the flood hazard relevant to different localities is also vital in implementing appropriate flood risk reduction measures such as development planning, forecasting, and early warning systems (Sene, 2013).

2.1.1 Types of flooding

Different types of flood can also have different effects in terms of their impact, damage and cost, both financially and to the people who experience them. Descriptions and categorizations of floods vary and are based on a combination of sources, causes and impacts. Based on such combinations, floods can be generally characterized into river (or fluvial) floods, pluvial (or overland) floods, coastal floods, groundwater floods or the failure of artificial water systems. Based on the speed of onset of flooding, floods are often described as flash floods, urban floods, semi-permanent floods, and slow rise floods (Bloch , Jha, and Lamond, 2011).

This particular study focus on flash floods, which are one of the most devastating natural hazards. They are often characterized by deep, fast flowing water which is combined with the short time available to respond where it increases the risk to people and property (Sene, 2013). Flash flooding can occur in almost any area where there are steep slope, but is most common in mountain districts subject to frequent severe thunderstorms. It can also occur within small catchments, where the response time of the drainage basin is short. Many hydrological factors have relevance to the occurrence of a flash flood: terrain gradients, soil type, vegetative cover, human habitation, antecedent rainfall, and so on. In steep, rocky terrain or within heavily urbanized regions, even a relatively small amount of rainfall can trigger flash flooding. These hydrological factors determine the response of the catchment to the precipitation event. Thus, a flash flood is clearly the result of both meteorological and hydrological circumstances (Doswell III, 2003).

Urban areas are notably susceptible to flash floods because a high percentage of their surfaces are composed of impervious streets, roofs, and car parking areas where runoff occurs very rapidly. Flash floods can be particularly dangerous because they occur suddenly and are difficult, if not impossible, to forecast. Such types of floods usually affect a more localized area compared to other types of floods, but can still cause serious damage depending on the intensity of the water (Bloch , Jha, and Lamond, 2011).

2.1.2 Causes of Flooding

Generally, the major causes of flooding are categorized as metrological, hydrological and anthropogenic. However, different types of flooding present different forms and degrees of danger to people, property and the environment, due to varying depth, velocity, duration, rate of onset and other hazards associated with flooding. With climate change the frequency, pattern and severity of flooding are expected to change, becoming more uncertain and more damaging (OPW, 2009). Hence, various factors, processes, and their combinations can induce floods.

Likewise, flash floods are induced by metrological, hydrological and anthropogenic factors. Such type of flooding has a possibility to be triggered naturally by river, pluvial or coastal systems convective thunderstorms, high rainfall intensity and duration, topography and slope of the receiving river catchment. While there are human induced factors such as catastrophic failure of water retaining structures, inadequate drainage infrastructure, surface conditions (Impervious pavement), poor or no drainage system, unplanned human settlement and encroachment of fragile ecosystem (Bloch , Jha, & Lamond, 2011).

2.1.3 Effects of Flooding

According to Rabalao , (2010) on his research papper entitled '*the social, psychological and economic impact of flooding in ga-motla and ga-moeka communities of moretele district in north west province, south africa'* explained that effects of flooding can be divided into primary, secondary and tertiary or long-term effects. The primary effects can be in the form of physical damage to any type of structure like buildings, bridges, roads, cars and sewer systems. The other form is of casualties where people and livestock die because of drowning. Secondary effects are water supplies which can be contaminated, water-borne diseases, crops and food supplies shortage and other species of trees which are non-tolerant can die from suffocation. Tertiary or long-term effects are of an economic nature – there could be decline in tourism, rebuilding costs, food shortage which normally leads to price increases, etc.

Many types of research related to flood studies emphasize the negative impacts of flooding. The flood losses can be categorized as direct and indirect. In particular, attention is given to direct losses, which occur immediately after the event as a result of the physical contact of the flood waters with human and the damageable property. However, indirect losses, which are less obvious but often operate on a long timescale, may be equally or even more important. Depending upon whether or not these losses are capable of assessment in monetary values, they are termed as tangible or intangible (Smith et al, 1998, cited in Gautam and van der Hoek , 2003). Tangible and intangible losses can also be divided into primary and secondary categories. Primary loss result from the event itself while secondary losses are at least one casual step removed from the flood (See Fig.1.).

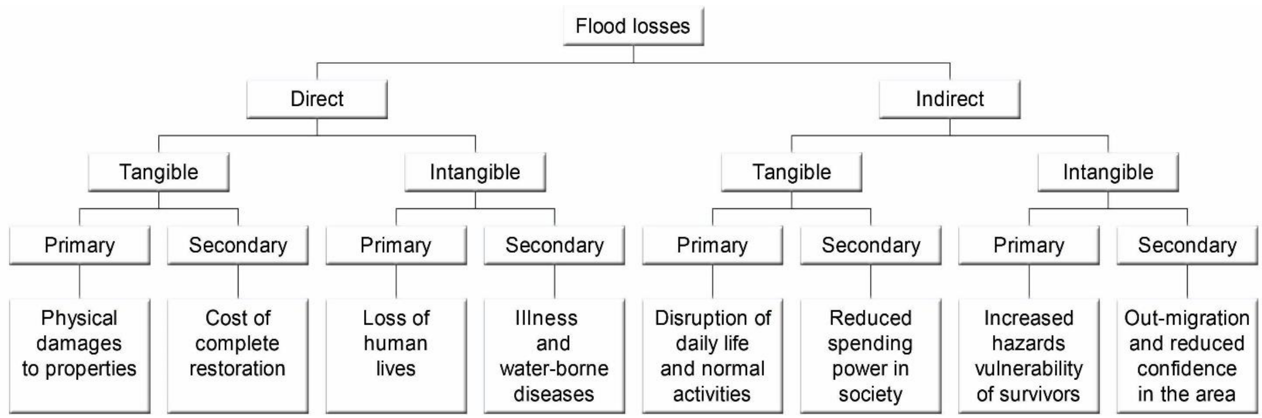

Figure 1: Flood loss classification

(Source: Smith et al, 1998, cited in Gautam and van der Hoek , 2003)

2.2 Coping Mechanism

In relation to flooding hazard, coping is defined as the manner in which people and organization act, using existing resources within a range of expectations of the situation to achieve various ends (Blaike, et al. 1994 cited in Dewi , 2007). According to Douglas, 1985 cited in Dewi , 2007, when people know an event may occur in the future because it has happened in the past, they often set up ways of coping with it. Such coping strategies depend on the assumption that the event itself will follow a familiar pattern, and that people's earlier actions will be a reasonable guide for similar events. The assumptions on which people make their decisions, therefore, rest in the knowledge that, sooner or later, a particular risk will occur of which people have some experience of how to cope (Blaikie, et al, 1994 cited in Dewi , 2007). He also emphasized that all coping strategies for adverse events which are perceived to have precedent consist of actions before, during and after the event.

According to Twigg, (2004, cited in Dewi, 2007) coping mechanisms pertainning to natural hazards is diveided into four catagries:

- **Economic/material;** (economic diversification, such as having more than one source of income, even having large family can be Seen as part of economic coping strategy because it gives household additional labor; saving and credit schemes are often an important component of economic coping strategies)
- **Technological;** Modifications to the physical and built environment: this may include modifications within the house or to the house structure which include building houses on stilts so that flood water can pass underneath and building houses on plinths or platforms of mud or concrete so that they remain above flood levels. Also, improvements outside the house or at the neighborhood scale, such as retaining walls, drainage facilities or sandbags are also technological coping mechanisms.
- **Social/organizational;** (the family is a fundamental social mechanism for reducing risk. Extended kin relations are networks for exchange, mutual assistance and social contact).
- **Cultural** (include risk perception and religious views, which are frequently connected).

Therefore, coping mechanisms employed by the people can be applied in different phases of hazard management: mitigation, response, and recovery. Based on the hazard management phases (Wisner, et al., 2003, cited in Eleni, 2011). There are two types of coping mechanisms: “preventative” and “impact minimizing” strategies.

Preventative strategies can be employed at the individual and community level, which implies that people making choices so that they will not be affected by an event, such as avoiding dangerous places at certain times or choosing safe residential locations. By contrast, impact-minimizing strategies are those strategies adopted to minimize loss and to facilitate recovery in the event of a loss.

2.3 Flood Resilience

The term resilience is defined as define resilience as: ‘bouncing back from a terrible event’ or ‘having the strength to cope’ or ‘being determined to See things through the end’. Form these definitions we can realize that people being mentally strong, sufficiently strong to maintain a sense of wellbeing whilst facing challenges (Mowbray, 2011). According to the European Commission, (2012, cited in Bertilsson and Wiklund , 2015, p. 7,) defines resilience as *“the ability of an individual, a household, a community, a country or a region to withstand, to adapt, and to quickly* *recover from stresses and shocks"*. Hence, it's significant to achieve the concept resilience in any scenario especially, areas that are prone to different kinds of hazards.

Floods cause more damage worldwide to human life and property than any other type of natural disaster. This trend shows no sign of reduction. Many of the efforts to address flooding so far have been focused on recovery. Though, to reduce flood losses and help communities in both developed and developing countries improving flood resilience, is very crucial that it should be more focused mitigating risks and prepare for floods, rather than simply dealing with the consequences after a flood occurs (Zurich Insurance Group, 2014). Hence, relying on traditional flood control measures is recognized as inadequate, since the damage can be catastrophic if flood controls fail. The idea of a flood resilience is the one which can withstand or adapt to a flood event without being harmed in its functionality (Restemeyer, et al., 2015).

Resilience strategies can be characterized in general as strategies that allow floods, but aim at minimizing flood impacts, maximizing recovery rates, for all possible flooding types. They aim at increasing the capability of a system to recover from flood impacts. The measures used in a resilience strategy may change the flood probabilities or the impacts for specific locations within the system. They comprise both structural and non-structural measures. The flood probability can be changed by, for example, decreasing the protection of natural areas, or increasing that of cities, while flood impacts may be reduced by e.g. raising flood risk awareness and changing land use. Both types of measures may increase the resilience of the system as a whole since expected damages are lowered, recovery is enhanced and the reaction to flood waves may become more gradual (Karin , 2005).

Flood resilience can be enhanced through different ways that are stated below:

- Through better assessments of flood hazards and communicating the risk to residents.
- Taking measures to lessen the severity of floods and mitigate their impact, including first-aid and health training, community planning, and setting up emergency shelters.
- Gaining a better understanding of how decisions are made in the face of risks and uncertainty to make the most effective solutions easier to find.
- Improving warning systems and helping communities adopt emergency protocols.
- Supporting efforts to rebuild 'better' – to safer standards – after floods.
- Ensuring people have opportunities to secure an income during floods.

- Developing ways to safeguard assets exposed to flood risk at an individual or community level.
- Working with local officials and other policymakers and the private sector to help make communities more flood resilient.

2.3.1 Flood Resilience in the Context of Risk Management

In this thesis, flood risk management is defined as all activities that aim at maintaining or improving the capability of an area that is affected by flash flooding. According to Andjelkovic, (2001 cited in Dewi , 2007,) '*Floods cannot be prevented but planning the emergency measures through flood management can often reduce their disastrous consequences'*. He emphasized that only a comprehensive approach which covers all aspects of disaster management cycle, including an appropriate balance of prevention, mitigation, preparedness, response, recovery and disaster-related development, can be effective.

Flood risk management implies two main types of measures that are distinguished by their aim: structural and non-structural measures (Karin, 2005). Traditionally the focus has been on reducing the probability of flooding through extensive structural defense systems or pure engineering such as those found in the Rotterdam in the Netherlands, New Orleans in the United States and around the Huai River, China. Increasingly, there is the recognition that nonstructural actions often aimed at reducing the vulnerability of people and communities, such as flood warning, effective flood emergency response, or resilience measures offer a vital contribution to risk management. Many, however, nonstructural options exist, including actions to, first, reduce the exposure of people, the economy and ecosystems to flooding (through, for example, effective planning control in flood-prone areas, as in the city of Cape Town, South Africa); and second, reduce the vulnerability of those exposed to flooding (through, for example, the use of safe havens, better warning and evacuation planning, modern flash flood forecasts, flood-specific building codes and insurance arrangements) (Sayers, et al., 2013).

Flood risk management therefore, embeds a continuous process of adaptation that is distinct from the 'implement and maintain' philosophy of a traditional flood defense approach since the approach of non-structural measures not only minimize the negative impacts of flooding but also promotes how an individual or a community to withstand, to adapt, and to quickly recover from flooding incidences. There are multiple goals relating to multiple time and space scales (See

Fig.2.). Achieving these relies on the development and implementation of appropriate collections of measure (where the advantages of one compensate for the disadvantages of another), a process that is complicated by the changing nature of the flooding system (through climate, geomorphologic and socio-economic influences)

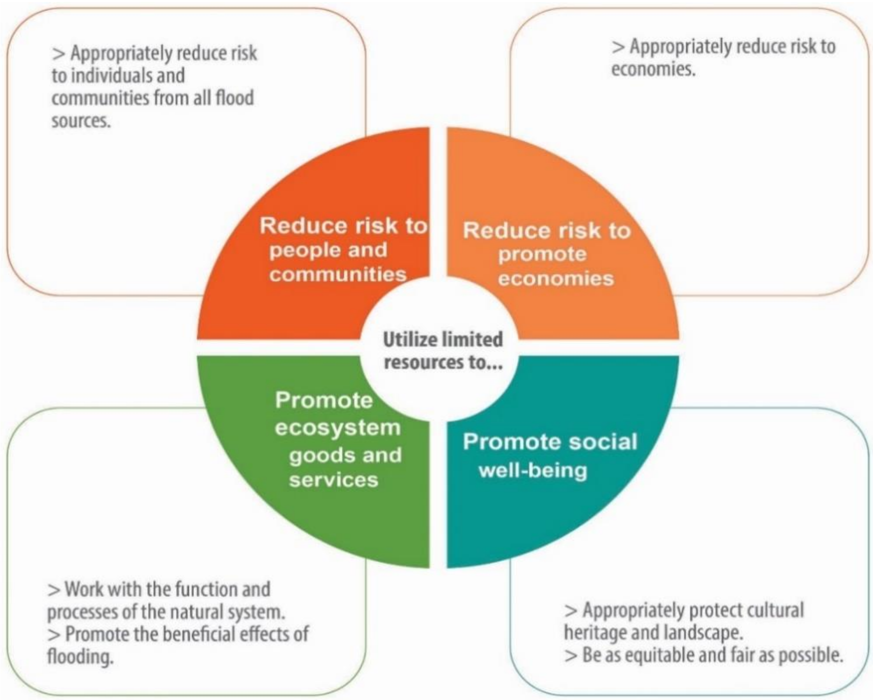

Figure 2: The primary goals of strategic flood risk management;
(Source: Sayers, et al., 2013)

2.3.2 Flood hazard and risk mapping

Development and provision of flood hazard and flood risk maps has a vital role as per prevailing hazards and risks (Prinos , 2008). Such maps generated will immensely help understanding flood risk for the following listed below:

- **Awareness Creation: -** Flood maps can increase public awareness of the areas at risk from flooding. To be effective, the public must believe the maps to be accurate, have a clear understanding of their content and have ready access to them (Sayers, et al., 2013).
- **Spatial planning: -** Flood maps can differentiate the spatial distribution of risk within the floodplain to support spatial planning decisions. To be effective, the evidence present in the flood maps (present day and future) must go hand-in-hand with spatial planning processes.

- **Asset Management: -** Flood maps help in prioritizing, justifying and targeting investments, in order to manage and reduce risk to people, property and the environment (Prinos, 2008).
- **Emergency and Evacuation Planning**:- Sayers, (et al., 2013,) stated that flood hazard and risk mapping has a great role in emergency and evacuation planning with regards to:
  - Informing the local risk assessment process.
  - Encouraging professional emergency responders (police, army, fire and ambulance) to focus on vulnerable sites and assets in the floodplain, and determine whether specific mitigation actions are needed to reduce the potential impacts should a flood occur.
  - Improving the planning and prioritization of effort (location of emergency shelters and equipment) to better mitigate the potential impacts during times flood
  - Supporting realistic training exercises.

2.4 Summary of Literature

Globally, the number of damaging flood events has increased throughout the last century (White, 2010, cited in, Restemeyer, et al., 2015). The results of climate change such as rising sea levels, prolonged periods of precipitation and more intense rainfall will likely add to future flood risk. Cities accommodating a multitude of people, businesses and ecosystems are, particularly at risk. However, floods are affecting and destroying both rural and urban areas, urban areas are more vulnerable due to the unplanned development in flood plains, aging drainage infrastructures increased paving and other impermeable surfaces, deforestation and lack of flood risk reduction activities all contribute to the impacts experienced. These problems are compounded by the effects of a changing climate (Bloch, et al., 2011).

Different types of flood can also have different effects in terms of their impact, damage and cost, both financially and to the people who experience them. Floods can be generally characterized into the river (or fluvial) floods, pluvial (or overland) floods, coastal floods, groundwater floods or the failure of artificial water systems. Based on the speed of onset of flooding, floods are often described as flash floods, urban floods, semi-permanent floods, and slow rise floods, where this particular research focuses on flash floods.

Floods can be induced by different natural and manmade factors, such as Continuous heavy rain, bad drainage facilities, blocking of river channels by landslides, narrowness of the river change in the course of river, inefficient engineering design in the construction of embankments, dams and canals, destruction of mangroves and trees which do not grow back, rapid urbanization with no proper drainage facility, storm surge, tsunami and etc…

As floods are caused by different factors as stated in the above, they have their own immense effect on the inhabitants and the natural environment where the degree of the effect varies depending on the location, coping mechanisms, flood risk management and other related factors. Effects of flooding can be divided into primary, secondary and tertiary of long-term effects. The primary effects can be in the form of physical damage to any type of structure like buildings, bridges, roads, cars and sewer systems. The other form is of casualties where people and livestock die because of drowning. Secondary effects are water supplies which can be contaminated, water-borne diseases, crops and food supplies shortage and other species of trees which are non-tolerant can die from suffocation. Tertiary or long-term effects are of an economic nature – there could be a decline in tourism, rebuilding costs, food shortage which normally leads to price increases, etc. (Rabalao , 2010).

However, floods more damage worldwide to human life and property than any other type of natural disaster, many of the energies spent globally is to recover from the disaster rather than minimizing flood occurrence from happening. This research mainly focuses on enhancing flood resilience into flood-prone areas by integrating the local knowledge of coping strategies, assessing major cause and effects of flooding and bringing the concept of resilience.

Chapter Three: Description of the Study Area, Research Materials and Methods

3.1 Descriptions of the Study Area

3.1.1 Introduction

This sub-section of the paper explored and discussed regarding the history and naming of the town where the study area is located. In addition, the absolute and relative location of the Bishoftu town and the specific study area Kebelle 02 site is described in order to give good insight about the study area and its surrounding Kebelle's within the town. The town and specific study area's topographic; hydrology and geological maps were generated accordingly to give better information towards the seasonal flash flooding in the specific case site.

3.1.2 History and Naming

The town took the name Bishoftu right from its foundation. There are divergent views about the name Bishoftu. According to one of these views it is called Bushoftu to mean it is unpleasant or of minimum value, due to the bad odor of the water of Bishoftu and bad-looking of the topography of the area. The other and popularly accepted view is that the name Bishoftu, to mean watery (Temesegen, 2009). According to this view, the name is derived from the abundant water resource of the area and even the term Bushoftu is a synonymous of Bishoftu, nothing to do with ugliness or unpleasantness. This name was officially used until its name was changed to a biblical name Debre Zeit (place of Olives) in 1955 (1948 E.C.). The change is said to have been made by Emperor Haile Sellassie probability due to the similarity of landscape between Bishuftu and Debre Zeit of the Middle East. However, it was of the Haile Sellassie Government's policy to change local names to either Amharic or biblical. Nevertheless, since the late 1990s, Debre ziet town was renamed as Bishoftu to its original naming (Kebede H. , 2009).

Bishoftu is one of the towns that were established along the Ehtio-Djibouti Railway line. It is difficult to get evidence on when exactly the railway construction reached each site where towns emerged. This is due to the international fact that the work was interrupted many times as the result of the political atmosphere of the period and the financial difficulties that the company had faced. However, the construction of this line which began at Djibouti in 1896 reached Akaki in

1915. From this, it can be said that it had passed through Bishoftu in 1913/4 (Hagos and Chuta, 2009).

3.1.3 Location

3.1.4.1 Absolute/Astronomical Location

Bishoftu town is located in the south eastern direction of Addis Ababa along the Ethio-Djibouti railway line. Astronomically, the town is located between 8°45′ 0″ North latitude and 38° 59′ 0″ East longitude.

3.1.3.2 Relative Location

Bishoftu town is bordered in the north Dire, in the east by Dhankaka, in the south by Godino rural Kebelles of Ada’a District and Dukem Town in the west. The town is one of the 1st ranked urban centers of Oromia Region of Ethiopia, located 47.9 km southeast of Addis Ababa. Currently, Bishoftu is served as the capital town of Ada’a District, which is the largest District in East Shewa Zone. (See Fig.3)

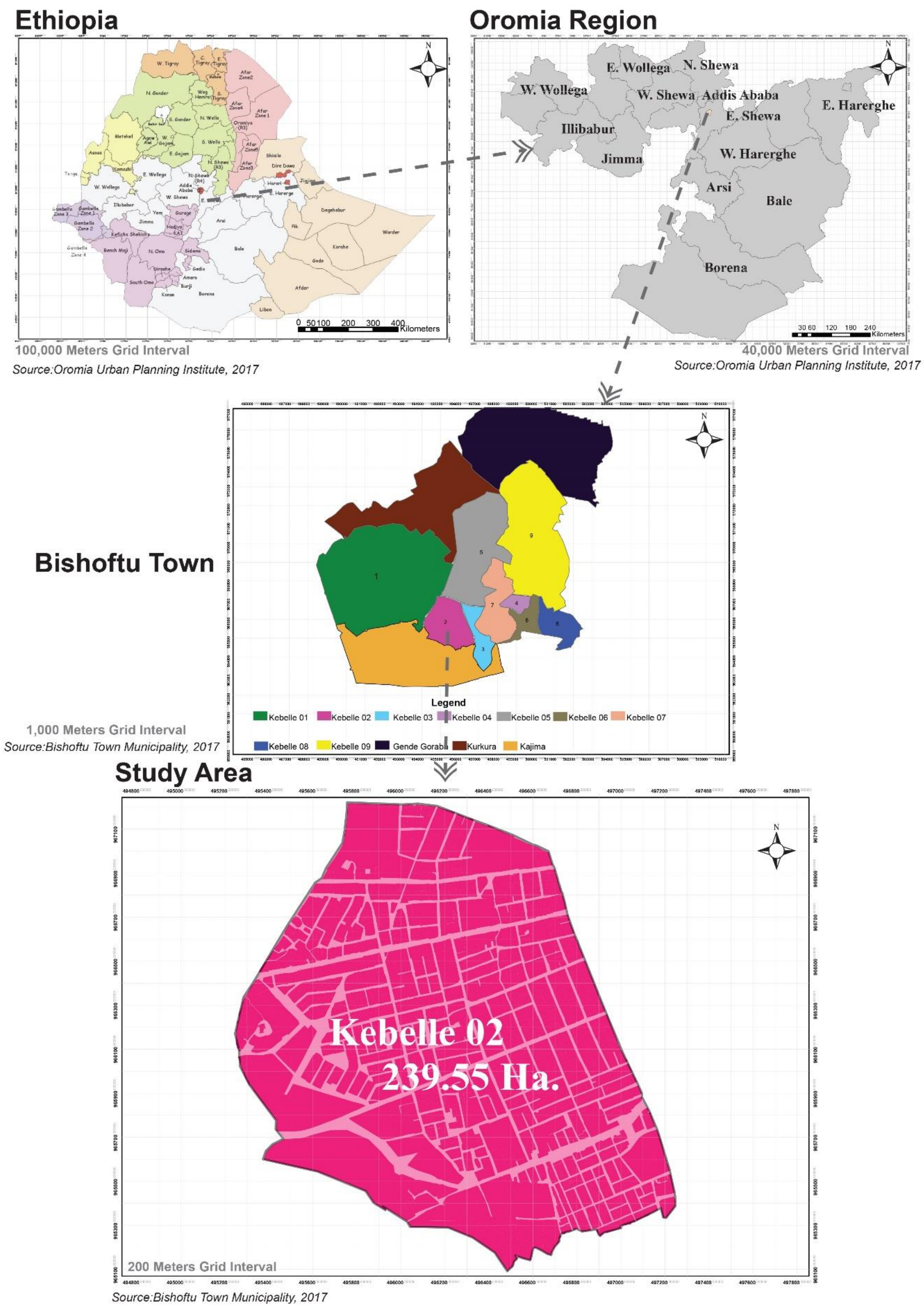

Figure 3 Location Map

3.1.4. Demography of Bishoftu and the Study area

Bishoftu Town it is a Wereda administrative center, however, the town is the fourth largest urban center in Oromia Region in population size, next to Adama, Jimma, and Sashemene and indeed one of few towns in the country with a threshold population of over 100,000. According to the May 2007 National Population and Housing Census, the total enumerated population of the Town was 100,114 and is estimated to reach 106,840 as of July 2009 (Hagos and Chuta, 2009).

Bishoftu is becoming one of largest urban center in Oromia region is due to the presence of many lakes, vast military camps, many research and educational institutions, industrial establishments and developed urban agriculture within the Town, its area is believed to be much larger than implied by its population size. According to Hagos and Chuta, 2009, the study area (Kebelle 02) is one of largest population size with 16.7% of the total population of the town followed by Kebelle 07, with more than 15.1%. Accordingly, the 2018 prediction indicates that Kebelle 02 with urban growth rate of 4.6 has 27,665.16 population size (See Table1).

Table 1: The population size of Bishoftu Town by Sex and Kebelle Residence
.

Kebelle	Male	Female	Total (2007 Census)	Percent	Sex Ratio	Prediction (2018)	Percent
Kebelle 01	6967	7813	14780	14.8	89.2	24514.74	14.8
Kebelle 02	**7939**	**8824**	16763	16.7	90.0	27803.83	16.7
Kebelle 03	3421	3537	6958	6.9	96.7	11540.84	7.0
Kebelle 04	3302	3585	6887	6.9	92.1	11423.07	6.9
Kebelle 05	5181	5443	10624	10.6	95.2	17621.42	10.6
Kebelle 06	4397	4889	9286	9.3	89.9	15402.16	9.28
Kebelle 07	7249	7876	15125	15.1	92.0	25086.97	15.11
Kebelle 08	3635	3961	7596	7.6	91.8	12599.05	7.59
Kebelle 09	5847	6248	12095	12.1	93.6	20061.28	12.08
Bishoftu Town	47,938	52,176	100,114	100.0	91.9	166053.4	100.0
Remark	The population growth rate is 4.6 using the formula of Percent (Straight-line) Growth Rates and Prediction was computed using the formula: $Nt= P e^{r*t}$ Where: 'Nt' represents the number of people at a future time; 'P' is the population at the beginning time; 'e' is the base of the natural logarithms (2.71828); 'r' is the rate of increase (natural increase divided by 100) and 't' represents the time period involved						

Source: Computed by the researcher based on a from CSA, 2007.

3.1.5 Physical Feature of the Town

3.1.5.1 Topography

According to 30m DEM file of Ethiopia, the altitude of Bishoftu town is as low as 1835m and as high as 2359m above sea level. Therefore, the town is situated at an average elevation of 2097m above sea level. A typical description of the topography of landform of Bishoftu town and its environ comprises vast plain areas, swampy and water bodies, soft, rounded hips and hilly mountains, steep and rounded hills and associated undulating dissected areas. (See Fig.4)

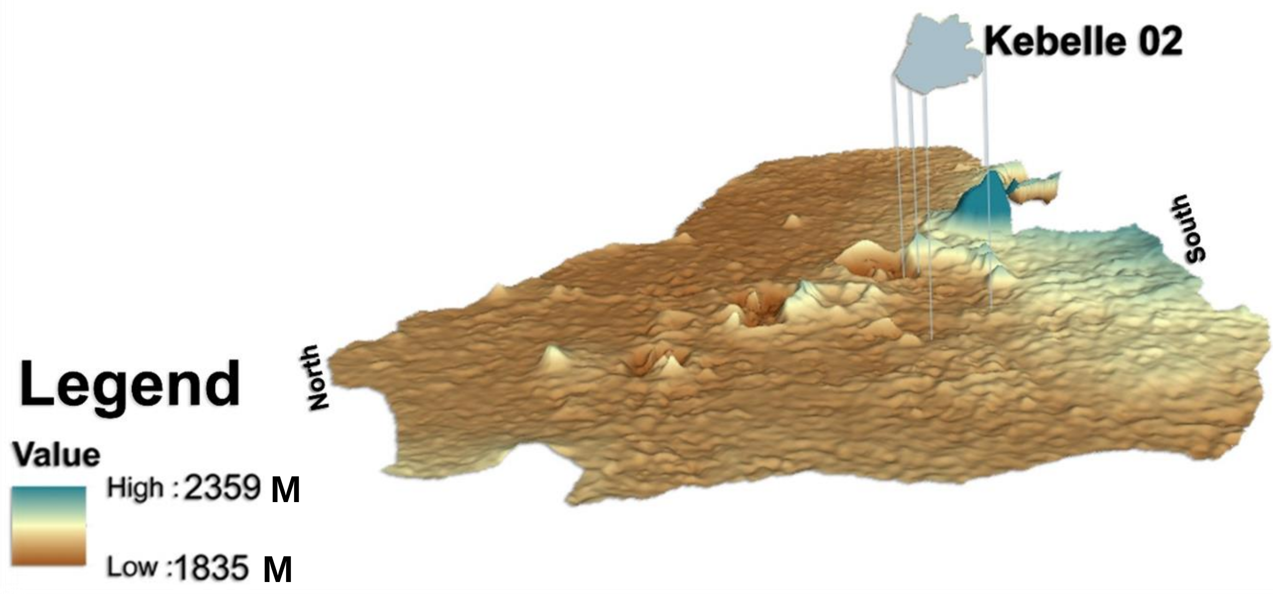

Figure 4: Topographic 3D view of Bishoftu Town

The southern part of the town is largely associated and characterized by undulating and rugged terrains whereas the eastern is to a large extent plain area. On the other hand, flat areas constituted the largest proportion in terms of area coverage. Such areas are found in the eastern, northern and northwestern expansion directions. The soft rounded hips found at the center of the town observed accessible with both non-motorized and motorized transport modes (Gezahegn, 2009).

According to Deitsch, 2013, the slope is an important component in flash flooding potential, due to the potential for rapid runoff. Experience suggests that any slope exceeding 30 percent leads to extremely quick runoff and a rapid response in local creeks and streams. Whereas slope ranging from 0-2% areas usually faces drainage problem, in addition, such areas are highly vulnerable for the flood. The relief map is classified into seven slope categories as appeared in the Fig.5 below.

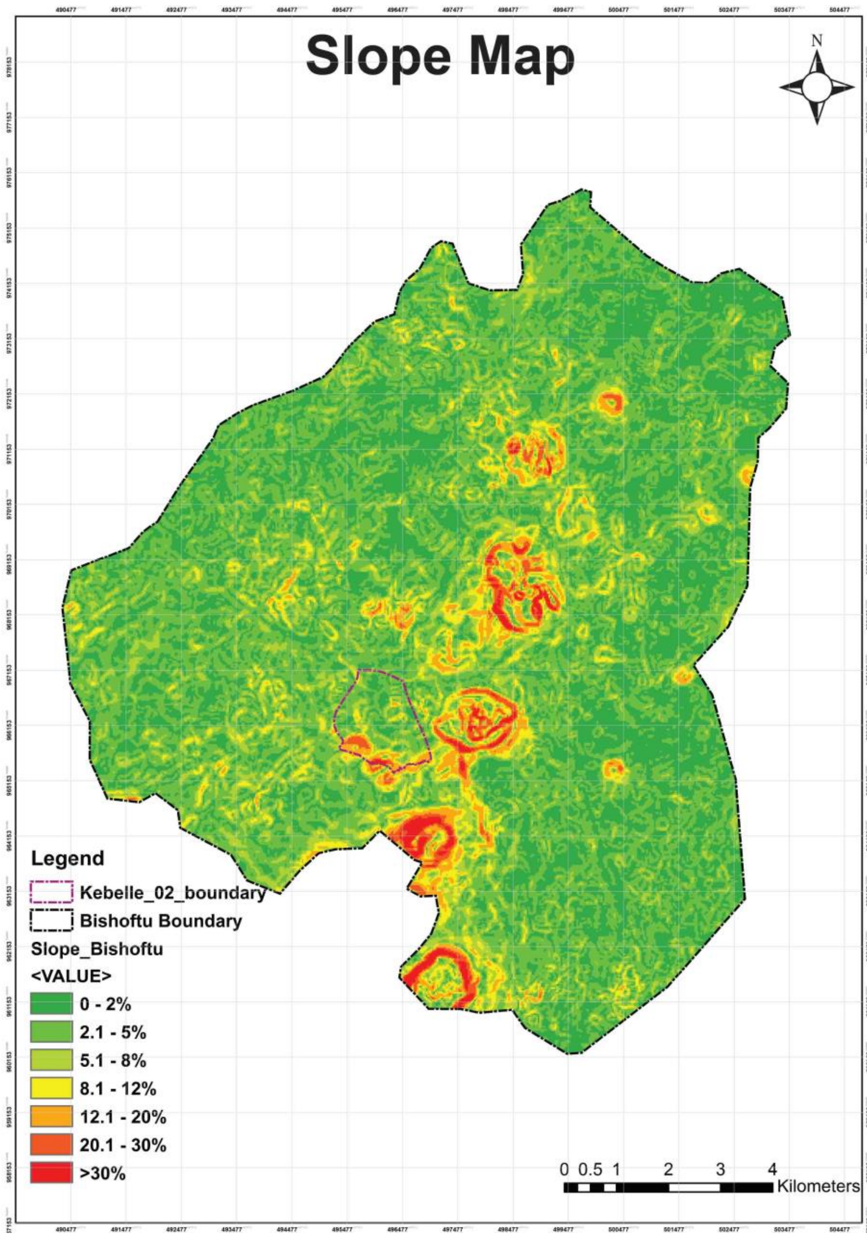

Figure 5.Classification of Relief Map of Bishoftu into Slope Categories

Table 2: Slope Classification of Bishoftu Town

Slope Class	Area(Ha)	Percentage(%)	Remark
0-2%	4364.51	30.61%	Prone to flooding and drainage problems in site development.
2.1-5%	6576.86	46.12%	For major roads and different kinds of large-scale development
5.1-8%	1903.31	13.35%	Housing development
8.1-12%	707.46	4.96%	Housing development
12.1-20%	416.88	2.92%	Undulating to steep slope
20.1-30%	182.03	1.28%	Steep slope
>30.1%	108.01	0.76%	Prone to quick runoff.
Total	14,259.06	100%	

(Source: Computed by the researcher based on 30m DEM, 2017)

The topography and landform of Bishoftu town is also undulating that comprises several ups and downs, rivers and streams (both perennial and permanent), swampy and crater lakes of Hora Harsedi, Babo Gaya, Kuriftu, Cheleleka and Bishoftu and associated mountain hills such as Gara Beru, Kidanemihret and Sofa Mountain are hilly undulated areas (Gezahegn, 2009).

The town's slope classification (Table 2) shows that most of the areas found are flat areas which are considered as major problems for drainage, swampy and prone to flooding areas. On the other hand slope classifications ranging greater than 20% in the town promotes major flash flood to the lower slopes in the down catchment. The specific study area (Kebelle 02) slope lies mostly on 0-2% and on the south side of the site around Sofa Mountain has percentage greater than 30%. This implies that the study area is highly prone to flash flood that comes from steep flood and settles on the flat terrains.

3.1.5.2 Geology

According to Abebe et al., 1998 the geology of Main Ethiopian Rift (MER), of which the study area is part, is dominated by Quaternary Volcanic strata underlain by Tertiary and Late Tertiary volcanic rocks and in some places underlain by Sedimentary rocks. The volcanic rocks are predominantly fissural basaltic lava flows and central type volcanoes confined to the upper part of the succession. The eruptions occurred from Miocene to Pleistocene and formed successive strata that have near similar composition. Bishoftu area represents a transition zone between the Ethiopian Plateau and the Main Ethiopian Rift (MER). In this area, the rift escarpment is not well defined, and the MER intersects the important E-W structure (the Yerer-Tullu Wellel Volcano Tectonic Lineament).

In addition to the different volcanic hills and crater cones, the strata of the Bishoftu area are rarely exposed. In the plain regions, there are hardly outcrops of the depositions of the lacustrine sediments. The lacustrine beds are mostly redeposited volcanic sands, tuff with calcareous material and diatomite. The region is mainly covered by volcanic rocks and the sedimentary rocks consist of an alluvial cover and lacustrine sequences. Volcanic activity in the area has given rise to central composite volcanoes as well as to monogenic strata as domes, spatter cones and maars (Feyissa, 2009).

3.1.5.3 Soil

As mentioned above, the topography of Bishoftu area varies from nearly flat to rolling, with some hills and old volcanic cones. Soil characteristics may be dependent upon the topographic setting of an area and type of parent material from which the soil originated and some other factors.

Therefore, the soil in Bishoftu area can be the weathered product of the volcanic rock that formed the area and that alluvial type which may be washed down from the surrounding hills and settled at the lower flat surface. The soil around Bishoftu is primarily gray to very dark gray, or black clays or clay loams. In addition, some areas there are also brown to reddish brown clay soils. On the other hand, the slope of the hills are often reddish brown and in the lower areas, the soils are dark colored.

In general Bishoftu's soil type is characterized as dark clay and very dark gray clay with high organic content where this type of soil character is a good potential for agricultural production. Nevertheless, such type of soil has high swelling and shrinkage properties which is not comfortable for construction and development, therefore it is essential to put much consideration before any type of development. Such types of soil characters usually has low infiltration rate during intense rainfall and promotes rapid runoff (Hill, Verjee, & Barrett, 2010).

3.1.5.3 Hydrology

A. Surface Hydrology

There is a river called Wadeecha River which flows perennially from north to south that has tributaries of almost all seasonal streams coming from the steep flanks of Mt. Sokoru and Mt. Yerer. According to Tamiru Alemayehu, 1992 cited in Feyissa, 2009, runoff that comes to Bishooftuu from the surrounding higher ridges, almost entirely do not leave the area. The water infiltrates into the porous surface and some part evaporates to the atmosphere. The part of runoff that leaves the area is through Wadeecha river flow system and according to the study result of the runoff amount is calculated as 25.568million m3 /year water. The estimated amount of water available to actually recharge the groundwater circulation within Wadeecha catchment was 54.391 m3/year.

Seasonal lake like Chalalaka, near the study area, also receives runoff water from the mountains such as Sofa, Gara Baru, Bubissa, Dhibaayu, and Wulabbo located on the southern side of the town forming a chain-like structure. The lake surface is good agricultural potential area when the water dries out. Moreover, the area has good recharge zones to groundwater in the surrounding.

B. Groundwater Hydrology

The groundwater movement is generally in the same direction as the drainage. Therefore, the flow direction of groundwater around Bishoftu is towards north and northwest of the town following the flow direction of streams.

In particular, groundwater potential is identified along slightly inclined flat surface located on the north and northwest of the town known as Dambi and Qurqura along the extensive flat surface Chalalaka. At this particular area, there exist low gradient of the water table and hence the low velocity of the groundwater movement, high recharge to groundwater from rainfall and runoff; and surface materials of high permeability that infiltration to subsurface takes easy access to enrich the groundwater potential. Shumbura Meda and Garbi where the existing wells are located at present are also good potential areas (Feyissa, 2009).

3.1.5.4 Climatic condition

According to the Ethiopian Traditional climatic zone classification, areas which lies on an altitude ranging from 1500 – 2300 meters is considered as Weiyna Dega (Midlands) (Deressa, 2010). Bishoftu town's climatic zone can be considered as Weyna Dega agro-climatic zone since the altitude of Bishoftu also lies between 1835 – 2359 meters. On the other hand, the average annual rainfall and temperature data of the town is 860mm and 19.32 ^{0}C respectively.

3.2 Research Materials and Methods

3.2.1 Study Design

The present study used both descriptive and explanatory research methodology. As the study requires, the descriptive research seeks to provide an accurate description of observations of phenomena and explanatory studies look for explanations of the nature of certain relationships. The researcher's methodology is designed in the form of field observation, survey, key informant interview, and document review.

Using all these research methodologies helped the researcher to overcome the pitfall of one method by the other. This is technically known as methodological triangulation. In addition, methodological triangulation can be used to enhance the analysis and the interpretation of findings. As data are drawn from multiple sources, it broadens the researcher's insight into the different issues underlying the phenomena being studied. (Bekhet AK, 2017)

3.2.2 Sampling Techniques

The purposive sample is a type of non-probability sampling which means selecting a sample by the judgment of researcher rather than using mathematical probability for selecting a sample. In purposive sampling researcher targets, a group form of the general population under consideration based on research. (School of MBA, 2017) In reference to the above statement the research used a purposive sampling technique to select the town, Kebelle and the Neighborhood by identifying the most vulnerable areas for the flash flood. In order to avoid subjective ways of sample selection, the researcher set objective criteria. These are:

- Since there is lack of research pertaining to flash flood occurrence in the study area from an environmental planning perspective.
- Since the Neighborhood affected by the seasonal flash flood.
- A neighborhood where there is a concentration of residential housing.
- Kebelle 02 is one of the Kebelle's in the town where population size is greater.
- The study area has a slope percentage ranging from 0%-> 30% that are prone to drainage problem and susceptible to high runoff accordingly (See Map 5).
- Since the case site has overexploitation of natural resources like the Red ash quarry site where the some of the flash-flood originates from.

3.2.3 Sample Size

The researcher used a purposive sampling technique to select flood vulnerable districts within the Kebelle. According to the Kebelle 02 administration, there are around 27 districts ('*Gotte')* within the Kebelle 02. Bisoftu town is divided into Kebelles and within the each Kebelle it is divided into districts *('Gotte')*. Out of these districts, the Kebelle administration helped the researcher to purposively select the Districts that are frequently affected by the flash flood and those selected districts were also categorized as high, medium and low exposure. There are seven Districts named District 03, District 06, District 07, District 08, District 09, District 19 and 23 areas, where each District has a minimum of 100 households. The total number of households considered affected is around 700, the researcher used 12 % of the total affected as a representative for the house to house questionnaire survey. The sample size for this study was determined by employing a formula to calculate sample size from a finite population (Kothari, 2004). It is given by:

$$n = \frac{z^2 p.q.N}{e^2 (N-1) + z^2.p.q}$$

Where: n= size of the sample;

p= reasonable estimate for the key proportion to be studied (12%);

q= 1-p;

N= Sample frame; (700)

z= standard variation at an acceptable confidence level; (1.96) and

e= acceptable error (0.05%).

$$n = \frac{1.96^2 \times 0.12 \times (1-0.12) \times 700}{0.05^2(700-1) + 1.96^2 \times 0.12 \times (1-0.12)}$$

n=<u>132</u>

Out of the 132 sampled households, from each purposefully selected districts the researcher used quota sampling technique from districts that are highly exposed are district 06, 07, 08 and 09 were 24 household sample each, from districts that are medium exposed are district 19 and 23 were 14 household sample each and from district that is low exposed is district 03 were 8 household sample. (See Fig.6)

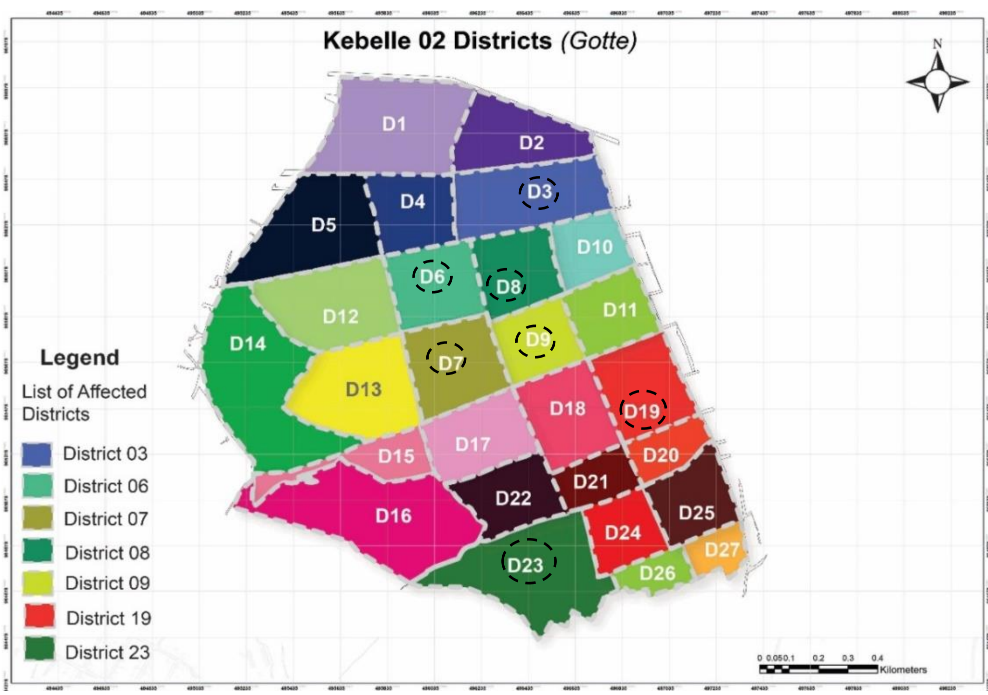

Figure 6.Flood Affected Districts within Kebelle 02;

(Source: Bishoftu town, Kebelle 02 administration office, 2017.)

In addition, the researcher used simple random sampling to select the residential housings during house to house survey after the districts were selected.

3.2.4 Methods of Data Collection

Primary and secondary data were used in this study. Secondary data were obtained from relevant literature both published and unpublished, government report, policy documents and other related articles.

Primary data were gathered from different stakeholders such as households affected by floods or subjected to flood, service providers such as Kebelle 02 administration, Bishoftu town municipality and metrological Agency at different spatial levels. Primary data was gathered through interview question guides (FGD and KII), questionnaire and check-list, which was used for key informants, household survey and filed observation respectively.

3.2.5 Data collection Instrument Development

In order to gather adequate and reliable data, the study used three basic instruments. These are field observation, questionnaires and interview guide questions.

A. Field observation

This method was applied to observe the existing situation of the area under study such as the physical infrastructure of the neighborhood (street pavement, drainage lines and etc...), solid waste management system, housing condition, existing soft landscape condition, topographic feature of the case site and adjacent neighborhood on the southern upper catchment. Thus information that was gathered through site survey and observation was included in the research finding and pictures taken during observation time were also incorporated in the paper to show the current status of the flash flood-prone neighborhood.

B. Questionnaire

This was specifically prepared for sampled Households affected by seasonal flash flooding in Kebelle 02 residents. The questionnaire has both closed and open-ended questions. It was prepared in an understandable manner in order to make the questions as clear as possible for both the interviewer and the interviewees. Thus to achieve this there was one pilot survey to identify the gap between the informants and the Questionnaires. Then the Questionnaires were designed in a convenient manner and translated into Amharic language. Finally, the questionnaire was deployed at the household level that different data were collected.

C. Interview Guide

The interview was employed to gather different information pertaining to flash flood occurrence in Bishoftu town, projects that are designed to defeat the flash flood, opinions of the main causes and effect of the flood from different stakeholders. Two types of interview guides were systematically prepared for FGD and KII, to obtain relevant information from the community and relevant government officials; such as Bishoftu town government bodies (Kebelle 02 administration officers and environmental protection bureau of Bishoftu town municipality). Kebelle 02 administration are interviewed to get reliable data as they are close enough to work with the residents on their day to day lives.

- *Focus Group Discussion*

Focus group discussion was conducted with the local communities of the affected area. As mentioned in Sample size sub-topic in the above Kebelle 02 area residents are classified into different groups called '*District*'. For the FGD different flood affected Districts were selected by snowball sampling technique. Each flood affected District's community leaders were part of the focus group discussion and discussed the objectives of the research. The FGD clearly gave a good understanding of the location of flood-prone areas (by using community mapping), local coping strategy knowledge, the driving cause and effects of the flash flood were discussed thoroughly and other points were raised regarding how they can be resilient to such disasters.

- *Key Informant Interview*

The interview was used as data collection to get ample information on personal thought, experience, and attitude of the case site residents. Hence, the researcher, in this study chose five respondents who have been tenants for more than ten years by the help of the district's leaders. Out of the five respondents, two were women and the rest were men. The KII participated women respondents due to reason that women are vulnerable to such kind of disaster events and have a great role in identifying the causes and consequences of the flash flooding.

3.2.6 Data analysis

This research used two analytical approaches; namely quantitative and qualitative analysis. This unit of analysis is a quantitative and qualitative discussion of the data which obtained from both primary (using questionnaires, interviews, sight visit etc.) and secondary sources. This section is supported by SPSS, MS Excel and GIS soft-wares and demonstrated using Maps, Diagrams, Graphs, Tables, and Charts.

3.2.1 Summary of the Research Methodology

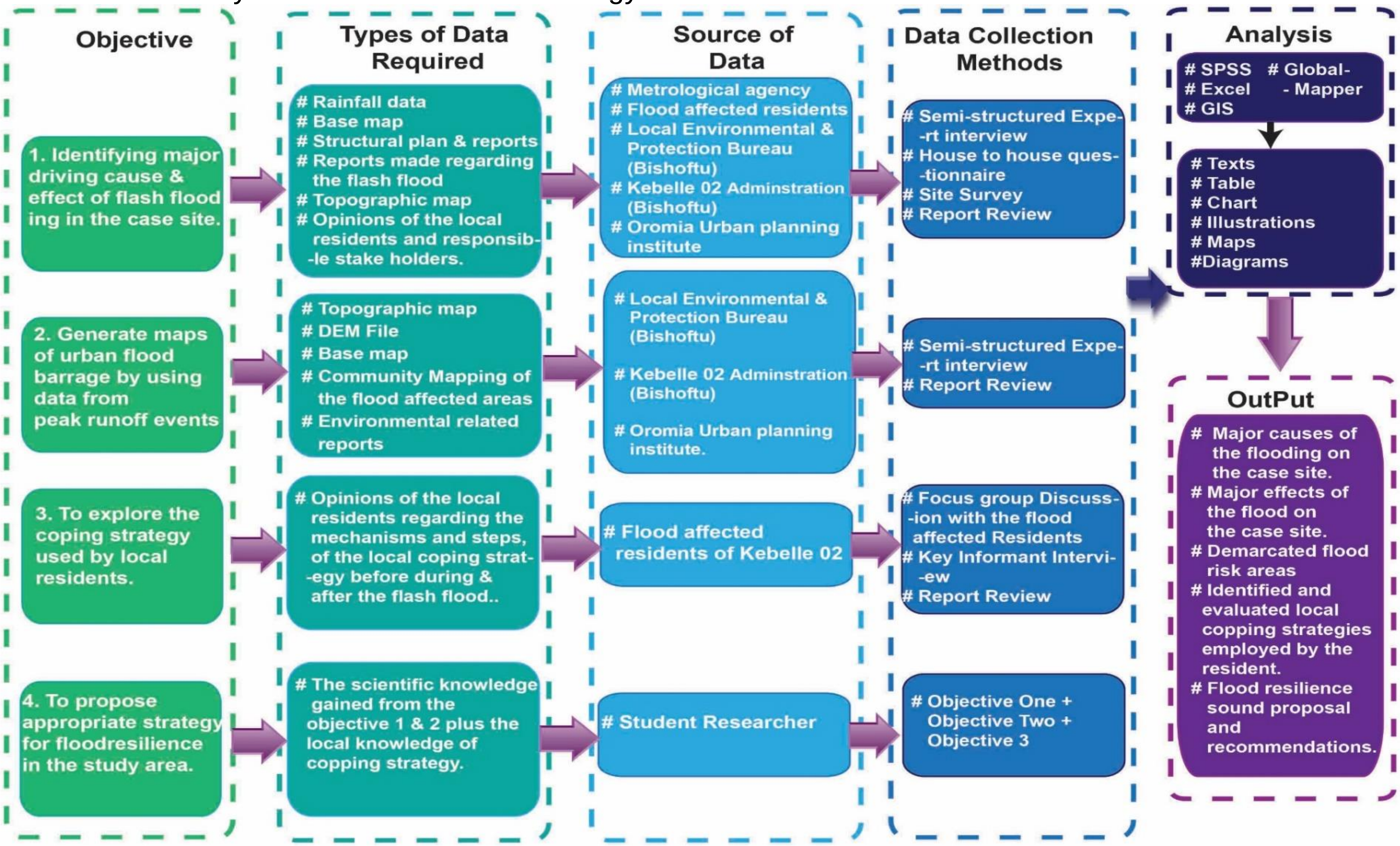

Figure 7. Summary of Research Methodology

Chapter Four: Results, Discussion and Proposal

4.1 Introduction

This part of the study presents the data gathered through field survey, questionnaire, KII and FGD from seven purposely selected study districts (‘*District’)* in *District 03, District 06, District 07, District 08, District 09, District 19*, *District 23* areas, and Bishoftu town government bodies (Kebelle 02 administration officers and environmental protection bureau of Bishoftu town municipality). In addition, all the research findings were thoroughly discussed and appropriate design proposal to bring flood resilience in the study area were set.

4.2 Results

4.2.1 Background of the Respondents

As the data revealed on the Figure 9, with regards to distribution of sex of the respondents Household head shows that male household headed are 59.10% and female household headed are 40.90%. Around 56.90% the average household size of the respondents lies between five to eight people per household. Which implies that the above-indicated family size on average usually are affected because of the flash flood occurrence in the study area. (See Fig 8.)

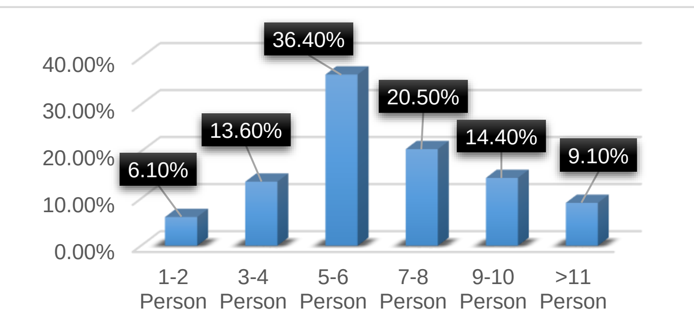

Figure 8. House Size of the respondents
(Source: Household Survey, 2017.)

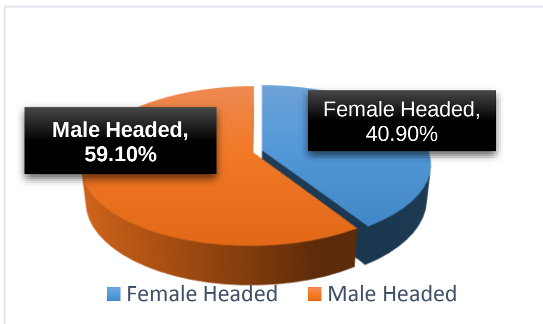

Figure 9. Sex Distribution of the Respondents
(Source: Household Survey, 2017.)

As per the educational background of the respondents shown in figure 10, Out of the total sampled households, most of the respondents are below enrolment 29.50% followed by basic reading and writing 26.20%, elementary 17.40%, high school 16.20%, TVET 4.90% and university or college 5.80%. Even though the total sum of the literate sampled household is greater than the below enrolment ones. This shows that the number of respondents with basic reading and writing and a higher level of educational qualification is significant for the specific study.

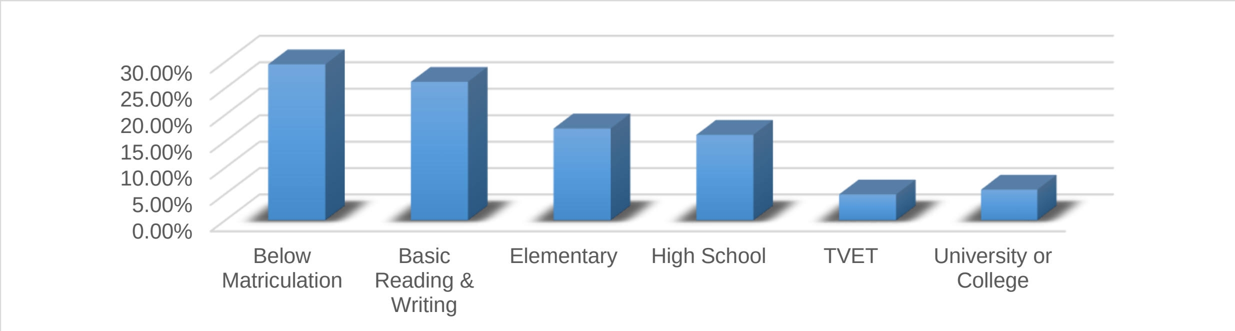

Figure 10 Educational Background of the Household Head
. (Source: Household Survey, 2017.)

In terms of occupation (See Fig 11), most of the respondents of this study were found to be public sector employees 29.50%, private sector employees 25%, and retired 22.00%. Only 9.10%, 7.60%and 6.80% of the respondents are others (daily laborer), own business (traders) and unemployed (Housewife) respectively. From this one can conclude that the highest proportion of respondents earn their means of living from public sectors and private sectors. During the survey, most of the respondents who were engaged in work far away from of their residential area, have complained that whenever the flash flood occurs during the daytime, they were not able to prevent their property from damage unless otherwise there are people in the house.

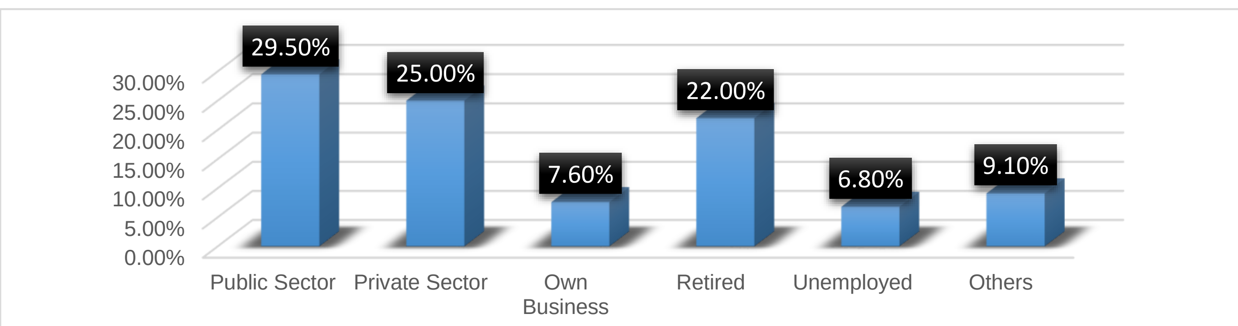

Figure 11.Occupation of the Household Head
(Source: Household Survey, 2017.)

According to the tenancy of the respondents (See Fig.12.) in the study area shows that most of the household lived in the area more than 20 years. Whereas an insignificant number of respondents lived in the area for less than one year. The greater number of the sampled survey buildings are residential buildings 70.30% and Mixed-use buildings (Residence plus Shop)

20.50%. The other different types of building use found on the study area survived were pure commerce (shop, restaurants) 6.8%, industry (Alema farm) 0.8%, School (Biruh Tesfa Elementary School) 0.8%, and Service (Debreziet Berhane Wongel Baptist Church) 0.8%. (See Fig. 13.)

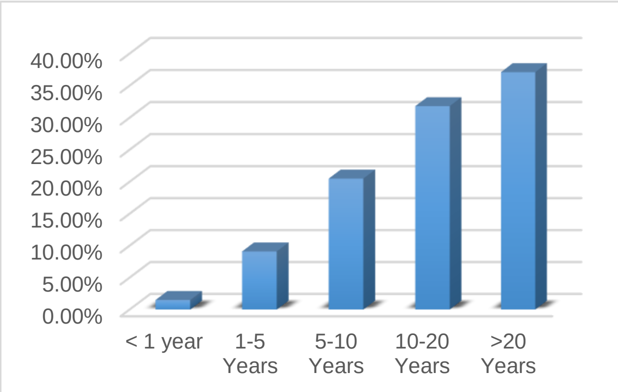

Figure 12 Tenancy of the Respondents
(Source: Household Survey, 2017.)

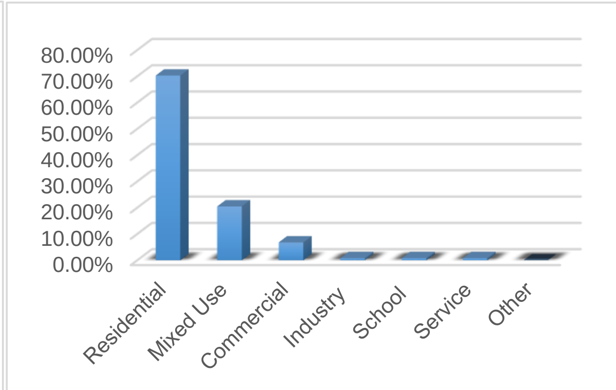

Figure 13 Building Use of the Respondents
(Source: Household Survey, 2017.)

4.2.2 Major Driving Cause and Effect of Flash Flooding in the Case Site

Flash floods are induced due to different factors as some of them can be through catastrophic failure of water retaining structures, inadequate drainage infrastructure, surface conditions (Impervious pavement), poor or no drainage system and unplanned human settlement. Encroachment of fragile ecosystem (*Bloch , et al., 2011*). As flood occurs there are different kinds of effects, starting from loss of lives, property and infrastructure damages, health-related problems and in the long run, there will be economic damages (Rabalao, 2010). In the study area both major driving causes and effects of the flash flood in the neighborhood are discussed below:

A. Major Driving Causes of the Flash Flood

The data collected from the household survey shows that majority of the informants stated that lack of drainage line (50%) are the major causing factor. While the rest believe that around 41.66% poor drainage line or stuffed with garbage, topographic location of their houses (27.27%), the quarry site (18.93%), other causes (lack of attention by the local government (10.60%)), new development (9.84%), lack of vegetation (7.57%) and 15.90% of the respondents were not able to identify what causes the flash flood in their neighborhood. Note that, during the household survey each informant was able to select more than one causing factor if they believe that there is more from the choices of driving factors (See Fig. 14.).

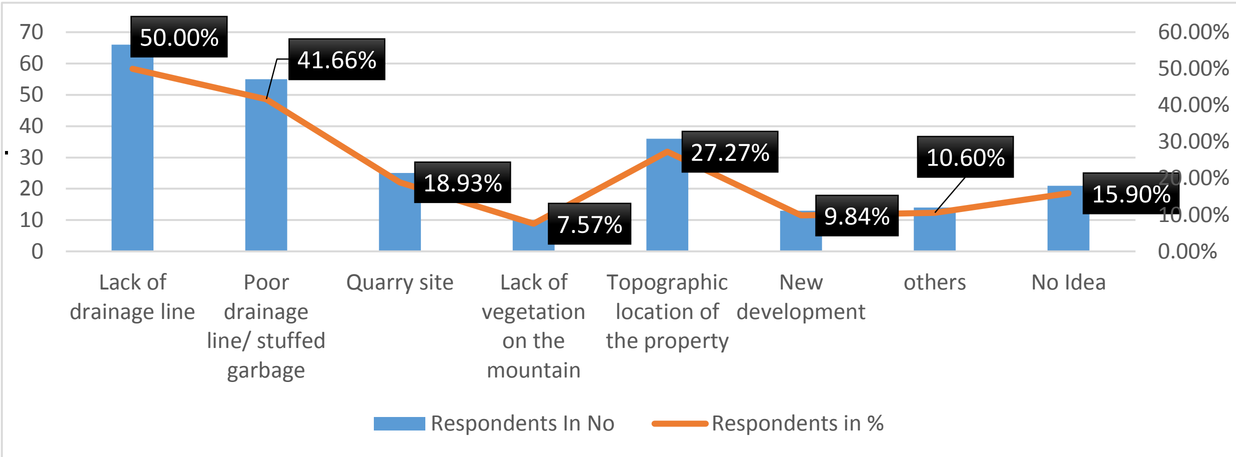

Figure 14 Major Driving Factors of the Flash Flood from Residents Perspective
(Source: Household Survey, 2017.)

Out of the total 132 respondents, the majority of the respondents around 50% believe that lack of drainage in-front of their houses causes the flood. The respondents claim that they tried to construct drainage line so that they minimize the flood during the rainy season but the Kebelle administration denied the construction since the construction of the drainage may divert the water to other areas of the neighborhood (See Fig. 15.).

Figure 15. Lack Drainage line on the Street
(Source: Field Photograph, 2017.)

On the other hand, areas that have drainage lines believe that the drainage line is poor for many reasons (41.66%). Some are stated below:

The drainage line width is not adequate to accomodate the runoff. In addition to the width of the drainage lines, some of the drainage lines wider in size are directly connected to the smaller size drainage lines, which makes high power runoff that comes through wider size drainage overflow on the streets and cause flooding (See Fig.16.).

Figure 16. Incompatible drainage line Connection

(Source: Field Photograph, 2017)

According to the KII, interviewee replied that *" As I lived in the neighborhood for more than twenty years, no one from the government side cared to maintain or reconstruct the few drainage lines found in my Kebelle. However, most of the flooding that occurred in my house is the flood that overflows from the drainage line adjacent to my compound."*

As it was investigated during the site survey some of the drainage lines found on the northern part constructed are against the topography. Hence the runoff cannot pass through this drainage lines. In addition, there are drainage lines that become a dead end where the water bursts out (See Fig.17.).

Figure 17. Dead end Drainage Lines

(*Source: Field Photograph, 2017)*

During the site survey, it was observed that the existing drainage lines are deteriorating and the KII interviewees also explained that the drainage lines were constructed not a while ago. The informants believe that the construction material of the drainage lines is very poor. As a result, some particular parts of drainage lines are currently destroyed (See Fig.18.).

Figure 18. Poorly Constructed Drainage Lines
(Source: Field Photograph, 2017)

The solid waste management in the area is poor due to this most of the garbage are washed by the runoff from different parts of the area and clogged the drainage line. Plastic bottles and plastic bags are the major types of waste that basically restrains water to pass rather it makes water to overflow. In addition to the garbage stuffed in the drainage, the runoff usually causes sedimentation of soil in the drainage line that comes from upper catchment (See Fig.19.and.20.).

As the key informant interviewee explained, *"most of the plastic bottles dumped in the drainage comes from the bus terminal since many travelers pass through our neighborhood and they threw this used bottles into the drainage that resides with the compound of the terminal."*

Figure 20. Clogged Drainage with Garbage

Figure 19. Sedimentation of Soil in the Drainage

(Source: Field Photograph, 2017)

Some of the respondents (18.93%) replied that the presence of the quarry site near their premises has a contribution to the flooding. Since the quarry site is being excavated until the current time, the natural waterway is being disrupted and the runoff from the mountain becomes more powerful to the inhabitants adjacent to quarry and down catchment areas (See Fig.21.) With regards to the quarry the interviewee replied that *“it was 10 years ago after the quarry was started the waterway started to divert into my neighborhood, since then I started suffering because every time there is flood, the floodwater enters in my house where it reaches up to 50-60cm below the ground and I have children usually sleeping on the mattress that is found on the ground.”*

Figure 21. Quarry Site (Sofa Mountain)
(Source: Field Photograph, 2017)

Only 7.57% of the respondents believe that lack of vegetation on the two mountains *(Gara Biruu and Sofa Mountain)* found adjacent to the study area could induce the flash flooding since both mountains are deserted and the greatest amount of the runoff originates from this areas. In addition, as it was revealed during the field survey, it was witnessed that there is gully like structures formed on the mountains because of the runoff coming from the upper area. On the other hand, an insignificant number of informants believes it is lack of vegetation can also trigger the flash flooding in the neighborhood.

Respondents also stated that the topographic location of their neighborhood (27.27%) is highly at risk of flooding due to there is steep slope at the southern part of the neighborhood whereas the settlement mostly resides on the flat slope area, which promotes runoff from the sloppy areas to the down catchments where water mostly inundate on the settlement area.

The study area settlement pattern has changed through years. There are particular respondents who have replied that the existence of new development (9.84%) especially the real state that has been built near the mountain area has blocked the natural waterway and since then the frequency and power of the runoff have increased. Few other illegal constructions like expanding individual fences, building unauthorized houses also blocks waterway in the study area.

The rest 10.60% has responded their own opinion about the different cause other than the stated ones. The respondents stated that the issue of the flood was not given proper attention by the local government. Therefore the flooding in the study area is becoming worse and worse since different help comes to the area after it occurred but no prevention techniques were used before flooding occurs.

All the above driving causes stated in the above was also confirmed by the district leaders during the FGD as the major causes of the flood. The representatives of the districts narrated as follows:

- *“Lack of drainage lines in our area causes the flooding. Because the runoff is pressure is very powerful, it comes directly through the street surfaces and enter into our compounds and housing units”. (Representative of District 06.)*
- *“The existing drainage lines found in our areas some are clogged with solid waste and sedimentation of soil washed from the quarry area, while the others has drainage line connection problem. The drainage line connections are incompatible to each other since the line that collects the water from the upper catchment is wider while the inlet at our area is very narrow the runoff burst into the streets and compounds. In addition, the solid waste management in our area is very poor, some residents not all in our area usually dumps wastes either on streets, open space and other vacant areas which is usually washed to the drainage lines whenever there is a rain and creates blockage of waterway”. (Representative of District 03.)*
- *“In my opinion, I think the local government is also responsible for the overflow water from the drainage lines because clearing out sedimentation and solid waste dumped inside the drainage lines is employed by the government employees only on the beginning of the rainy season. Which makes it difficult to clean everything since the waste and soil in those drainage lines has been accumulated for more than half a year”. (Representative of District 08.)*
- *“Some new developments in our area such as new fences that blocks the waterway and divert the runoff into our residential units. We have complained to the Kebelle 02 but no reply was found. Now we are asking those for the neighborhood elderly to mediate as*

with those individuals to open their fences in a way water can pass through freely". (Representative of District 23.)

- *"Our area is found in the flat area, as the water runoff approaches our areas from the upper catchment and it inundate in our compounds to the stage we cannot do anything about the water". (District 07.)*

As thirty years rainfall data was gathered from the National Metrological Agency revealed that, the average rainfall occurred 854.38 mm within the past thirty years from year 1987-2016 G.C. the chart below shows that the maximum rainfall recorded annually is 1089.30mm occurred in the year 2003 G.C. while the minimum rainfall recorded annually is 587.20 mm occurred in the year 1995 G.C.. The thirty years monthly rainfall data records shows that the rainfall becomes high during the months of June, July, August, and September. This months of the year are months that rainy season starts. During the house to house survey, the informants replied that most of the flash flood occurrence are in the above stated months of the year. (See Fig.22.)

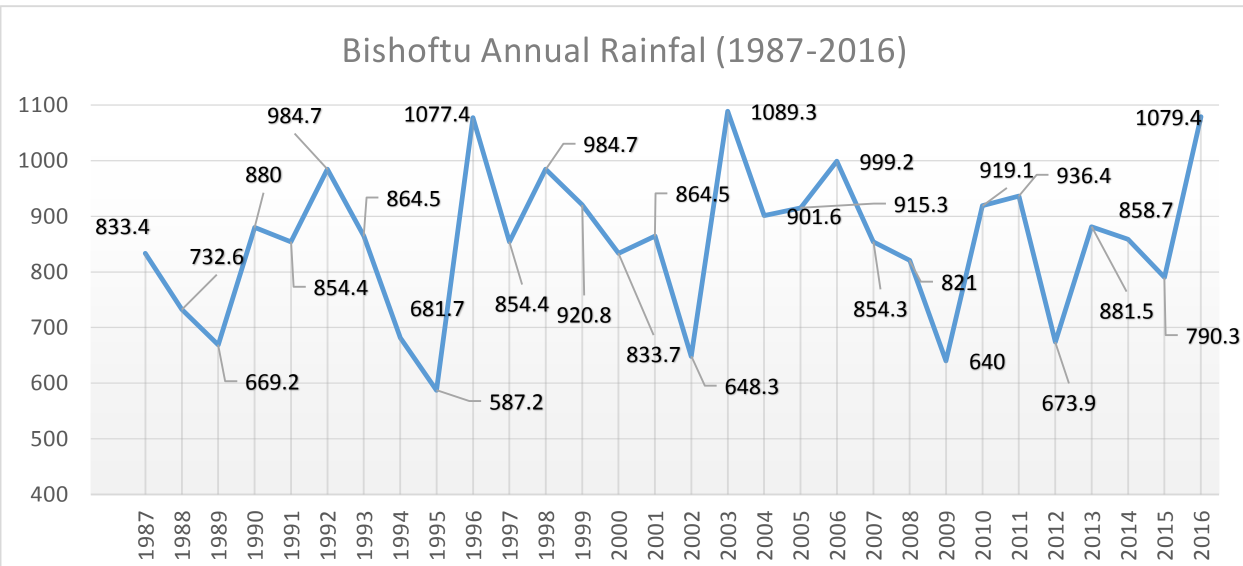

Figure 22 Bishoftu Town Thirty years Annual Rainfall
Source: Computed by the researcher based on NMA thirty years rainfall data, 2017

The flooding history of the flood events in the neighborhood was revealed (Table.3.) by the help of informants to relate it with rainfall data that was recorded the past thirty years. As shown in the above rainfall chart on the year of high rainfall data was recorded likewise the historical flood events depicts the same information. Such as in the year 1992 G.C. (984.7mm), 1996 G.C.

(1077.4mm), 2003 G.C. (1089.3mm), 2004 G.C. (901.6mm), 2011 G.C. (936.4), 2013 G.C. (881.5mm), and 2016 G.C. (1079.4mm) annually was recorded.

Table 3. Most Recalled Historical Events of Flooding in Kebele 02 As Per Respondents Opinion

No	Flood Incident		Flood Location						Rain Intensity				Property Loss					Loss of Life
	M	Year	Inside the house	Compound of the property	The street	Playground/open space	Drainage line	Others	Heavy rain	Medium rain	Small rain	No rain	High	Medium	Low	Non		
1	Aug	1992	√	√	√			√	√				√					none
2	Na	1996		√	√				√				√					none
3	Aug	2003	√		√				√					√				none
4	Na	2004		√	√	√				√						√		none
5	Na	2005			√					√				√				none
6	Sep	2011		√	√		√		√					√				none
7	Jul	2013			√		√			√					√			none
8	Aug	2016	√	√	√		√		√				√					none

According to the data gathered regarding awareness of the respondents, where the flooding comes from and flooded their premises (See Fig.23.) shows that most of the respondents (73.48%) states that the runoff from the mountains nearby directly comes to their living area. Also, runoff from the street (51.51%) is the second largest contributor to the flooding inside the premises of the residents especially streets that lacks drainage line. Even though some respondents have described there is also an overflow of the drainage line since most of the drainage lines are constructed below the standard (37.12%). An insignificant number of respondents replied that most of the flooding in their residences occurs from the runoff from neighbors gutter comes directly to their residential compounds and buildings (2.27%). Around two respondents (1.51%) believe that most of the flooding comes to their area from other neighborhood called Kajima, which is located in the southern part of the study area.

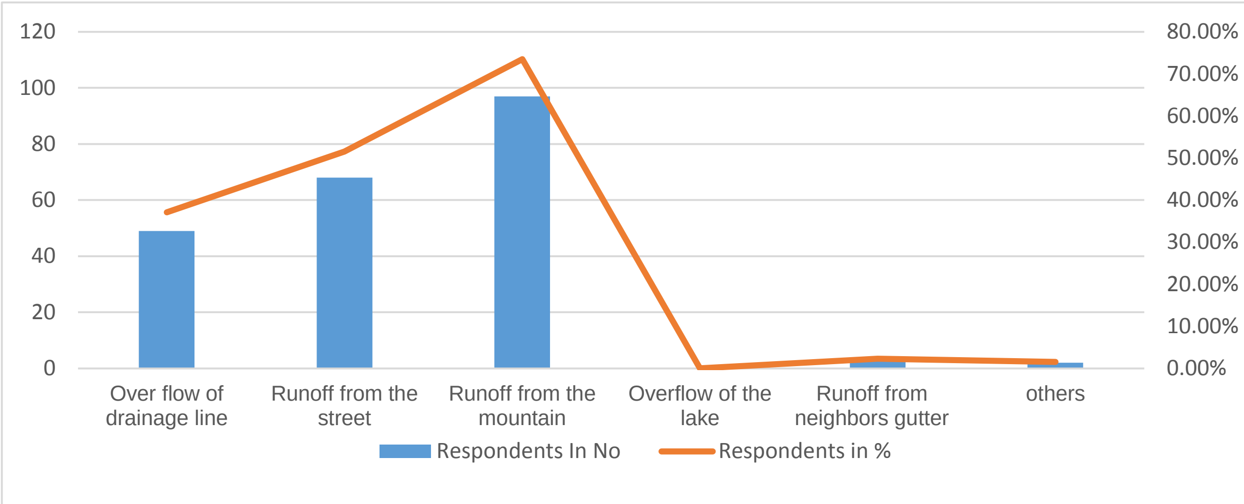

Figure 23 Resident's perception of where the Flash Flood Comes from
(Source: Household Survey, 2017.)

B. Effects of the Flash Flood

The effects of flooding is divided into primary effects, secondary effects and tertiary effects of long-term effects. The informant's responded that, most of the respondents choose more than one effects stated on the house to house questionnaire. The flood has cost them physical infrastructure loss(25.75%), destroyed their houses (19.69%), household equipment loss (44.69%), different kinds of health effects related to the flooding (20.45%), agricultural or garden areas were destroyed (7.75%), pet animal life were lost (3.03%) and other effects (relocate to other area until the rainy season ends, septic tanks were filled with runoff water, residents were not able to go out or in to their houses and the destroyed valuable commercial items for sale (8.33%)) were described as major effects cause by the flash flood in the study area. However, Out of the total respondents of this survey, only 5.30% of the informants happen to have no effects towards to them that is induced by the flood. (See Fig.24.).

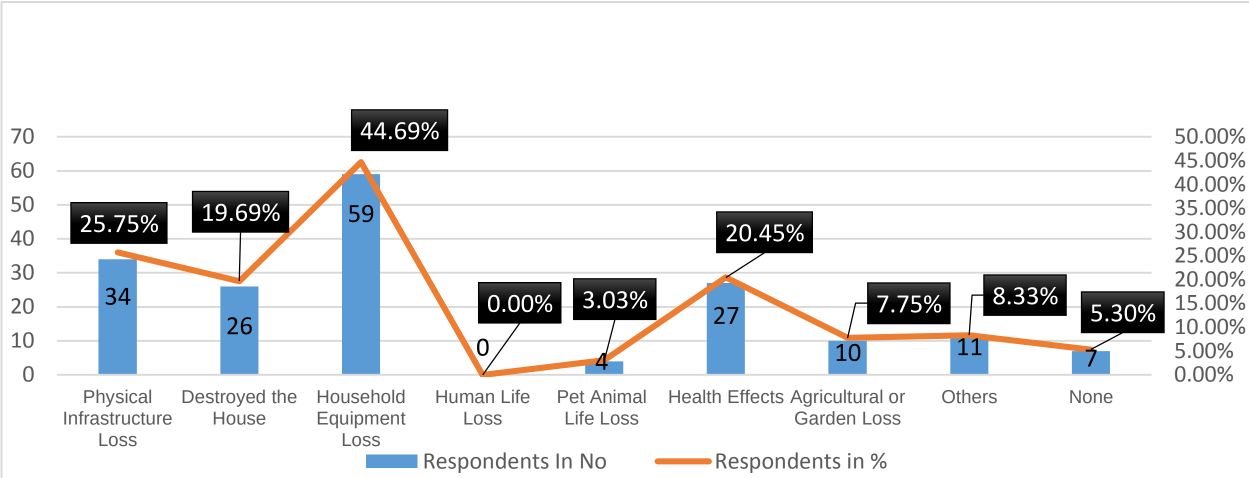

Figure 24 Effect of the Flash Flood

(Source: Household Survey, 2017.)

I. Primary Effects

As primary effects on the study area, around 25.75% of the respondents responded that physical infrastructure gets damaged in their area whenever there is flooding. Since the storm water runoff from the upper catchment is very powerful it washes off the pavement of the street. In addition sedimentation of the soil in the few drainage lines found in the study area also decreases the quality of the drainage and the residents residing around the edges of the drainage line are forced to clean the sediment soil whenever there is a rain. (See Fig.25.)

Figure 25. Deterioration of physical infrastructure

Source: Field Photograph, 2017

The utmost number of informants (44.69%) believe that the flood in their area has destroyed their household equipment such as refrigerator, television, tape, wooden furniture and paper documents. In addition, the flood also damages food items like *Teff* wheat, *Berebere*, *Shiro* and other edible things found within the informant's houses.

Some informants replied that over thousand chicken (3.03%) died because of the flood. One of the respondent named Alema Farms industry mentioned that in 2005 G.C. the company has lost over ten thousand chicken along with expensive machinery as result of the flash flood occurred at that time of the year and other two individual informants also said they had lost chickens at different times due to the heavy rain and flooding.

Moreover, the FGD result shows that district representatives narrated the primary effects of the flash flooding as follows:

- "*In my district (District 09) housing units are sometimes swamped by the flooding, therefore it is very dangerous especially for children women and elderly. In addition, the water destroys very important documents, food, electronics and crack down the wall and floor of the buildings".*
- *"Electric power loss during heavy rains in the night time is another factor which makes it difficult for us to save important household items from the flood". (Representative of District 19)*
- *"Individual septic tank of toilets gets filled with the flooding in our area to the maximum and sometimes burst into our compound, housing units, and street". (Representative of District 23)*

II. Secondary Effect

During the house to house survey, it was investigated that around 20.45% of the respondents are exposed to health problems that are caused by the flooding. Most of the respondents who claims there is health-related problems replied that "*after the flood is gone our buildings and other parts of our compound does not dry fast, hence the moisture from the water creates a pungent smell through time and not only the bad smell but it's putting us at risk for respiratory-related diseases like common cold and Asthma".* (See Fig.26.) In addition to this, the flood that comes to their area is very contaminated water that also gets in contact with their food and utensils, the informants claim that the flood poisons their food items and water lines.

Figure 26. Housing Unit Floors Moistened from the Flooding
(Source: Field Photograph, 2017)

As per the effects on the agricultural or garden areas, 7.75% of the informants who were engaged in the business of plant nursery complains that since their property is found on a very flat slope area the water that comes to their premises usually brings waste from other areas and inundate within the garden area. Therefore the vegetation is highly exposed to different kinds of pollutants that come along with the flash flood which makes some of the vegetation susceptible to suffocation and dies afterward.

III. Tertiary or Long-term Effects

As the informants stated that there are other effects (8.33%) around five informants evacuate from their house during the rainy season and rent other places or go to their own relative houses nearby until the summer is gone. While others have a problem regarding their septic tank usually gets full because the runoff directly comes through, which basically expose them for unwanted cost for discharging the flood water and there are also some residents who were not able to go out or into their house because of the inundation of the flood. (See Fig.27.) All the above-stated effects have their own effect economically since most of the informants are forced to rebuild their building, to fix or buy their household furniture's and food items, to go to health centers to maintain their health status and other related additional costs.

Figure 27. Blocked House Entrances Because of the Flood

Source: Field Photograph, 2017

The FGD results of the district leaders narrated as follows:

- *"Since the flood is very powerful in our area, we are always worried where ever we are. Whenever rain rains we are in rush to save our children, elderly people found within our houses and household equipment. This thing is affecting our day to day routines such as work and other socio-economic activities". (Representative of District 06)*
- *"The flooding also affects harmonious social relationships between neighbors. Due to the reason behind that each household has a responsibility to collect the rainwater and transfer to the neighbor adjacent to minimize the impact or the pressure at individual houses. However, some individuals literally block waterways since they are not affected as the other houses at the upper part, because of that residents gets into conflicts which affects the social bond". (Representative of District 09)*

4.2.3 Spatial Distributions of the Study Area

A. Existing Land Use

According to the field survey, the total land coverage of the study area is 239.55 ha of land. Out of this residential takes majority of the land use coverage by covering 46.26% of the total land use. Existing street pattern (18.39%) of the site is the second largest land use category, mixed use (8.65%), service (6.98%), bare land (Sofa and Gara Birru Mountains (6.72%)), industry (Alema Farms and Blue Nile Factory (2.55%)), commercial (2.47%), open space (2.40%), quarry

(1.91%), manmade unpaved drainage line (1.60%), urban agriculture/ plant nursery (1.36%), bus terminal (0.43%), and Keblle 02 administration (0.28%) respectively. (See Fig.28.).

Hence, as stated in the above land use distribution of open space coverage is only 2.40%, whereas literature support that lack of previous surfaces is one of the major contributors for flooding (Bloch, et al., 2011). As identified in the field survey, Gara Birru Mountain lack vegetation, it is currently used as a quarry which can be Seen as an encroachment of the fragile ecosystem and in addition to other factors degradation of the natural terrain of the mountain diverts the natural waterway.

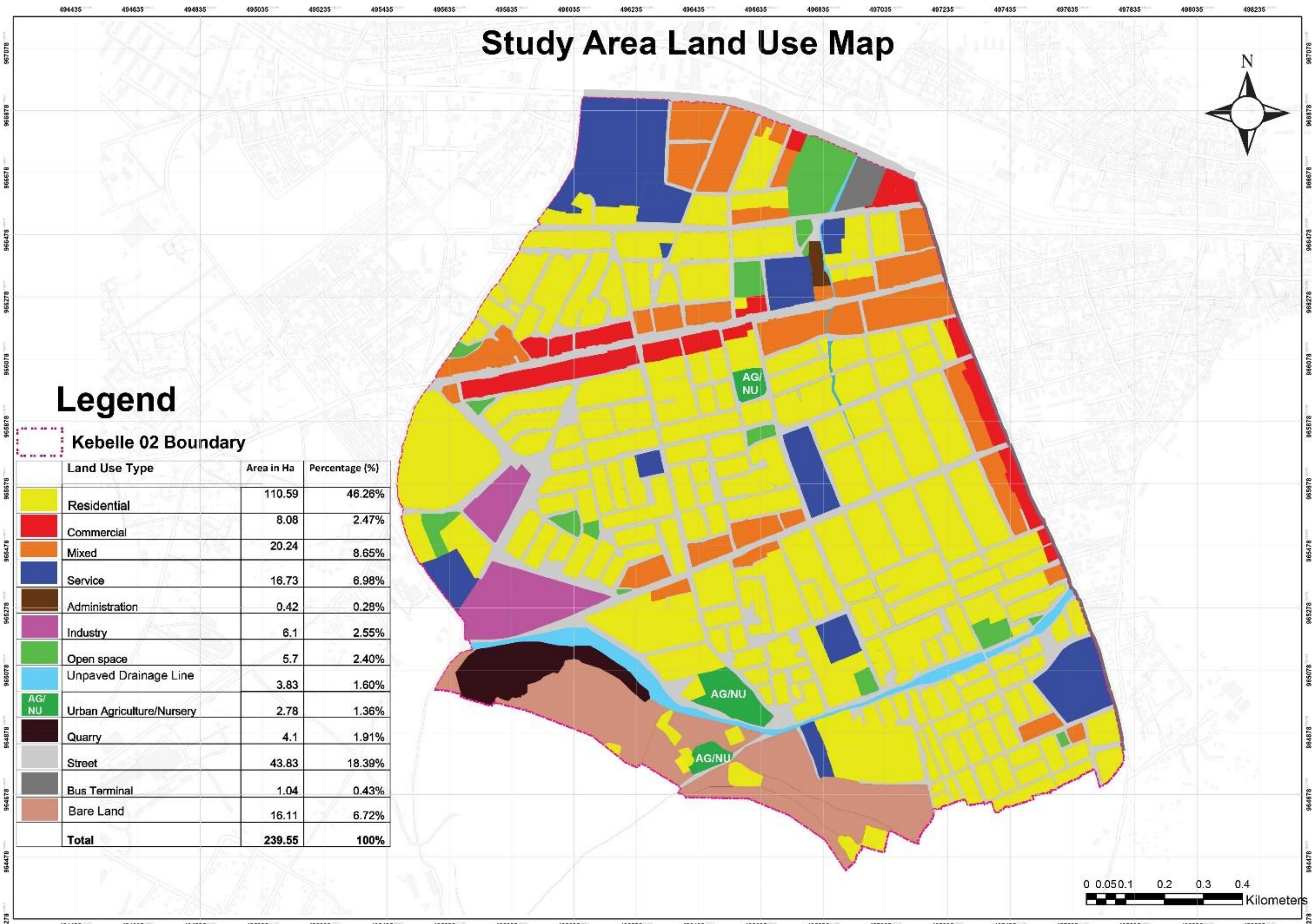

Figure 28 Existing Land Use Classification of the Study Area

(Source: Field survey and Keblle 02 Adminstration of Bishoftu Town, 2017)

B. Topography of the Study Area

The topographic nature of the case site is analyzed by calculating the slope and classifying it into seven categories. Out of the total area of the case site, the majority of the area coverage (38.45%) ranges with slope percentage of 2.1-5%. About 22.12% of area coverage lies between 0-2% slope percent, which implies that areas ranging in the specific slope classification are considered as swampy areas. As discovered during the field survey, during rainy seasons most of the case site areas such as, '*Sink Meda'*, some streets, drainage lines and individual compounds that range within 0-2% becomes inundated for longer hours or sometimes the water lasts until the rainy season is over.

Figure 29. Swampy Area within the Bus Terminal
(Source: Field Photograph, 2017.)

Whereas, the southern mountainous part of the case site has a slope percentage >20.1% where most of the flash flood originates (5.13%). (See Fig.30.)

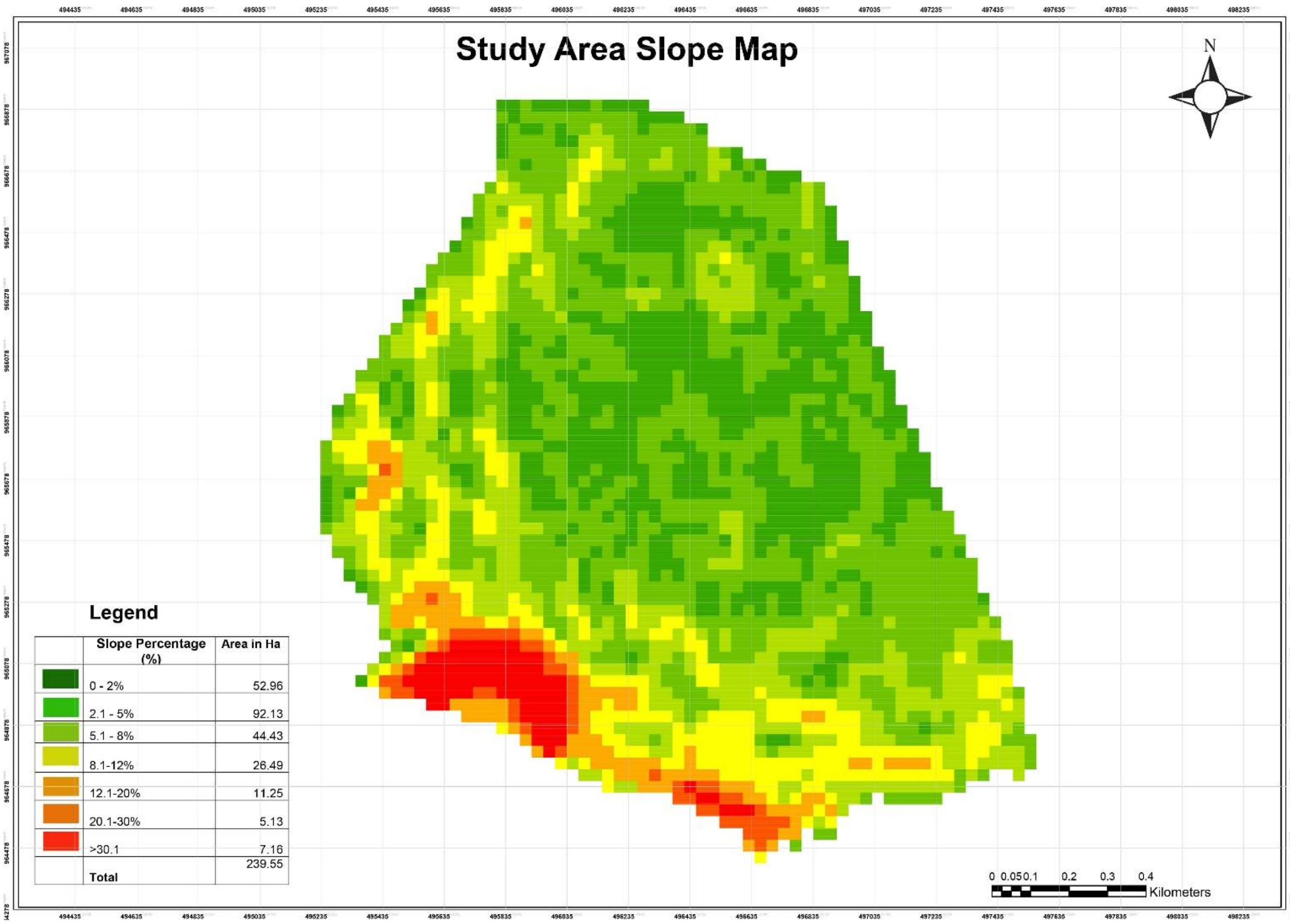

Figure 30 Classification of Relief Map of Study Area into Slope Categories

C. Watershed of Bishoftu town and the Specific Case Site

The watershed map of Bishoftu was extracted from DEM using Arch Hydro plugin software on GIS. The watershed map Bishoftu town has 74 watershed sub-catchments that are contributors of water to the town. As shown in the below the maximum watershed catchment covers around 683.10 ha and the minimum watershed catchment covers 3.10 ha. (See Fig.31.)

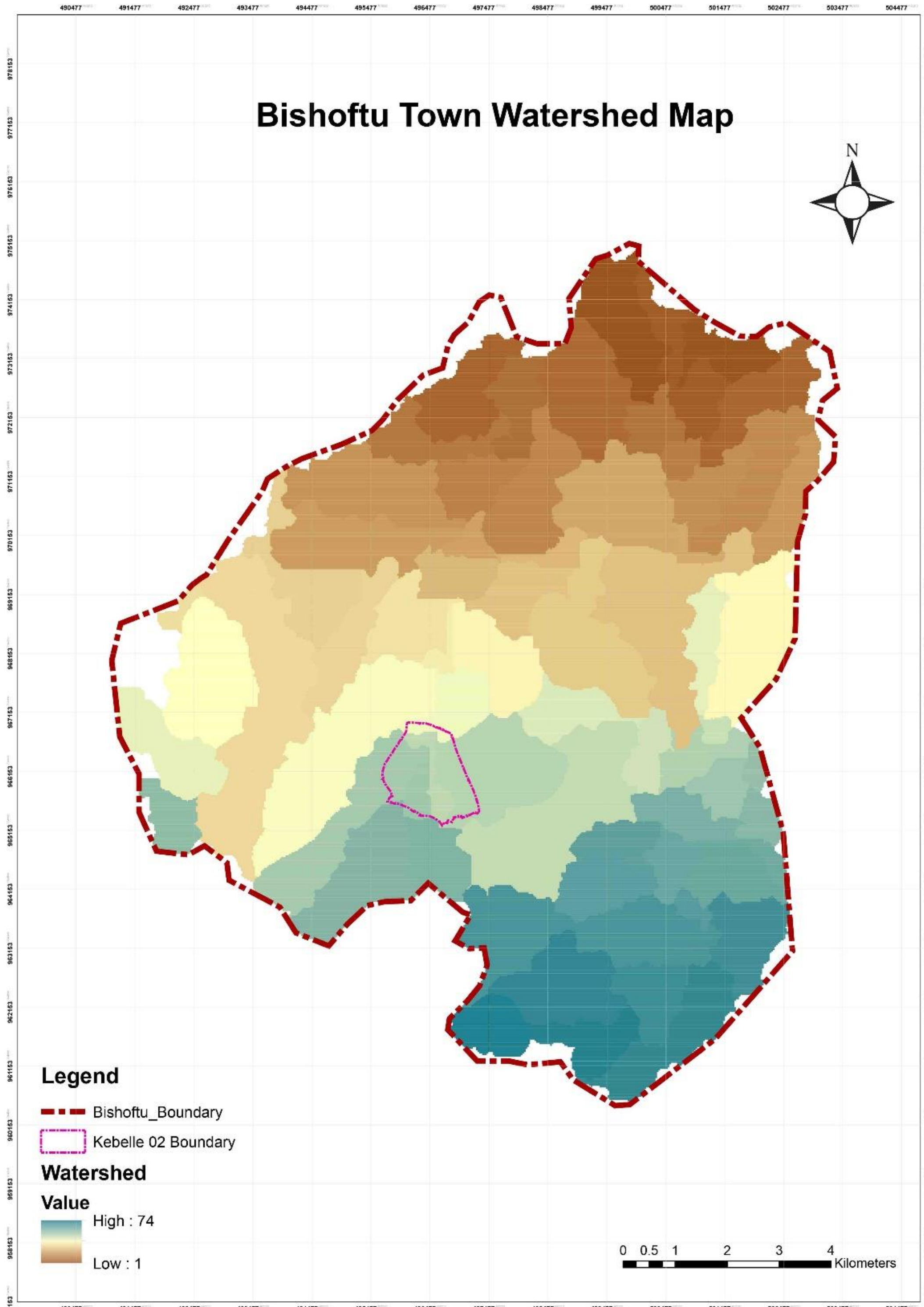

Figure 31 Bishoftu Town Watershed Map

Kebelle 02 has 6 watershed catchment areas where the map shows that from southern west part of the study area has the highest watershed catchment where it contributes to the other parts of the case site. Out of the six watershed sub-catchments in the study area, the maximum area coverage of the watershed is 373.46 ha. while the minimum area coverage is 45.56 ha.. (See Fig 32.)

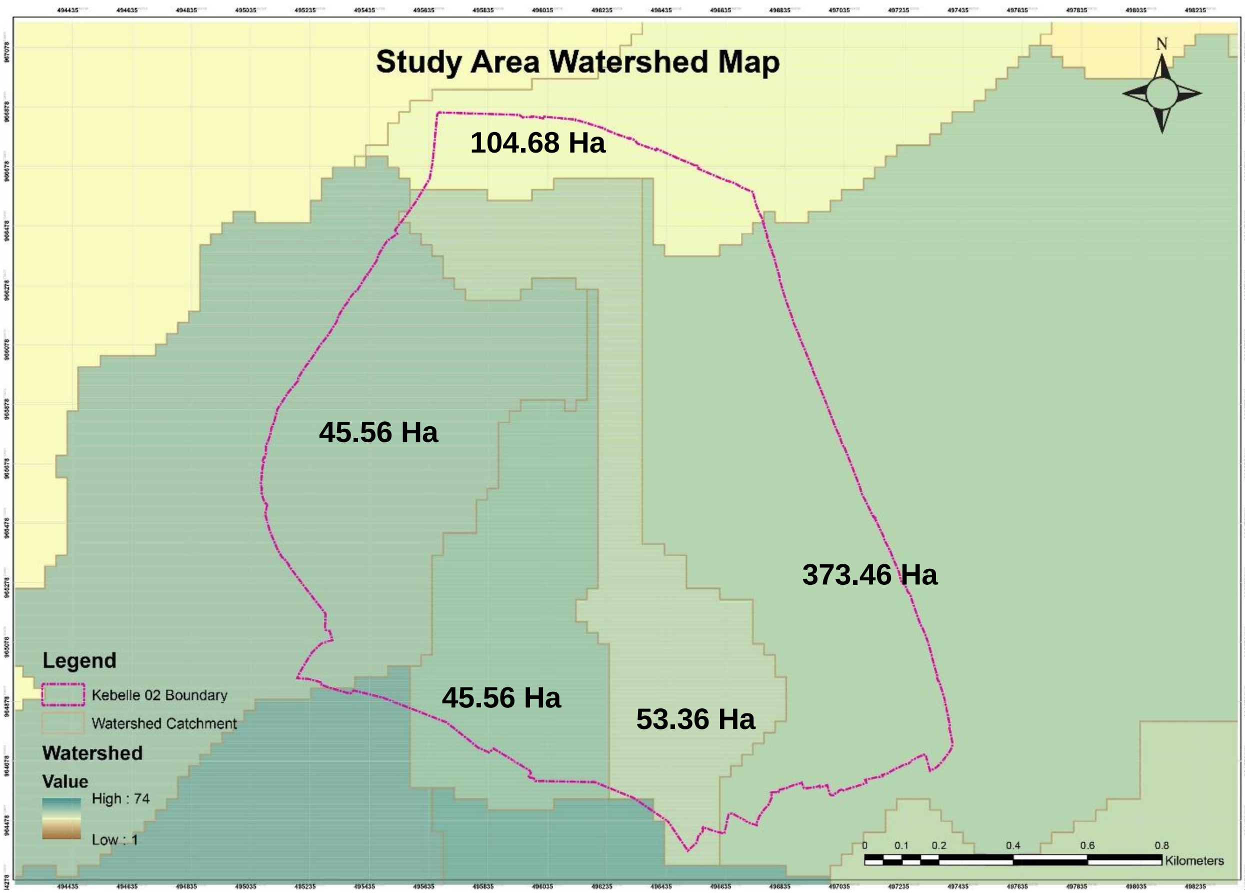

Figure 32 Study Area Watershed with Their Respective Area coverage

Bishoftu town flow accumulation map was also extracted for the purpose of understanding the level of accumulation in the study area. The maximum and minimum flow accumulated value is 106384 and 0 cell units respectively. (See Fig.33.)

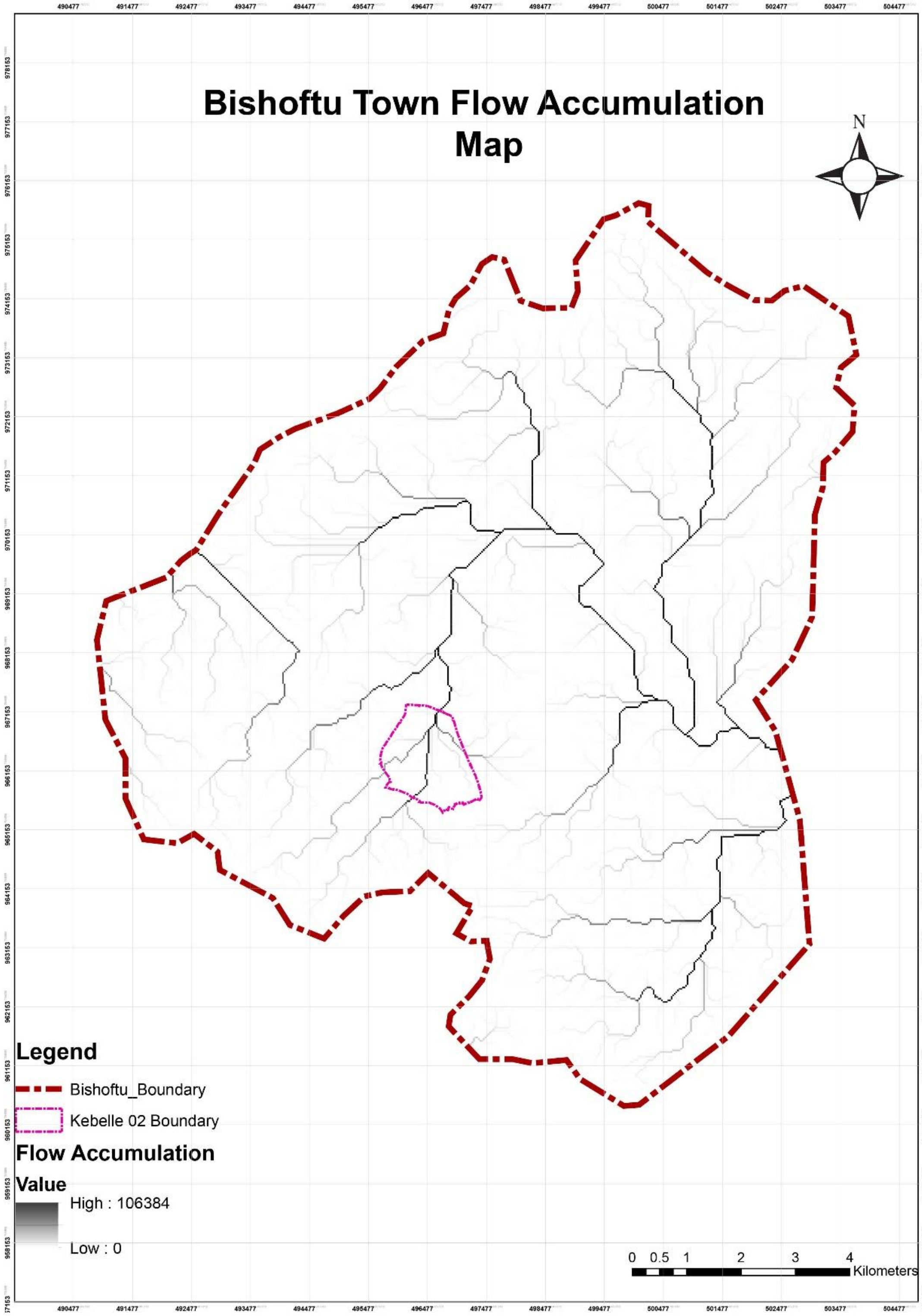

Figure 33 Bishoftu Town Watershed & Flow Accumulation Map

During the field survey, it was recognized that areas found from upper catchment centrally down to the northern part of the study area, amount of accumulation is relatively greater than the other parts of the site. As result of this, the areas found in such accumulation are considered as one of the flood-prone areas. (See Fig.34.)

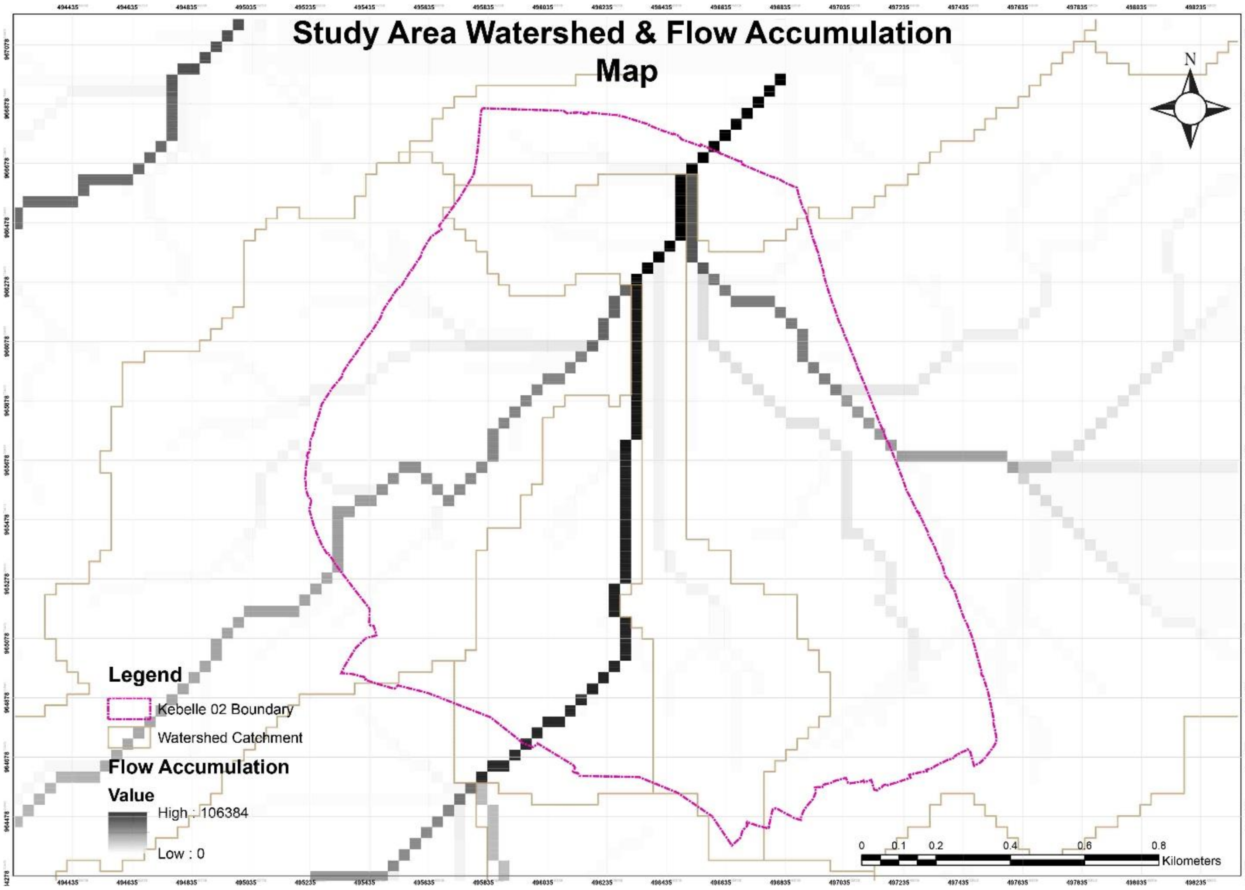

Figure 34 Study Area Watershed & Flow Accumulation Map

Out of the flow accumulation map, natural drainage map of the study area was extracted. This map helps the researcher to understand and observe the natural waterway and current physical developments such as drainage line, buildings and other developments are compatible with each other. (See Fig.35.)

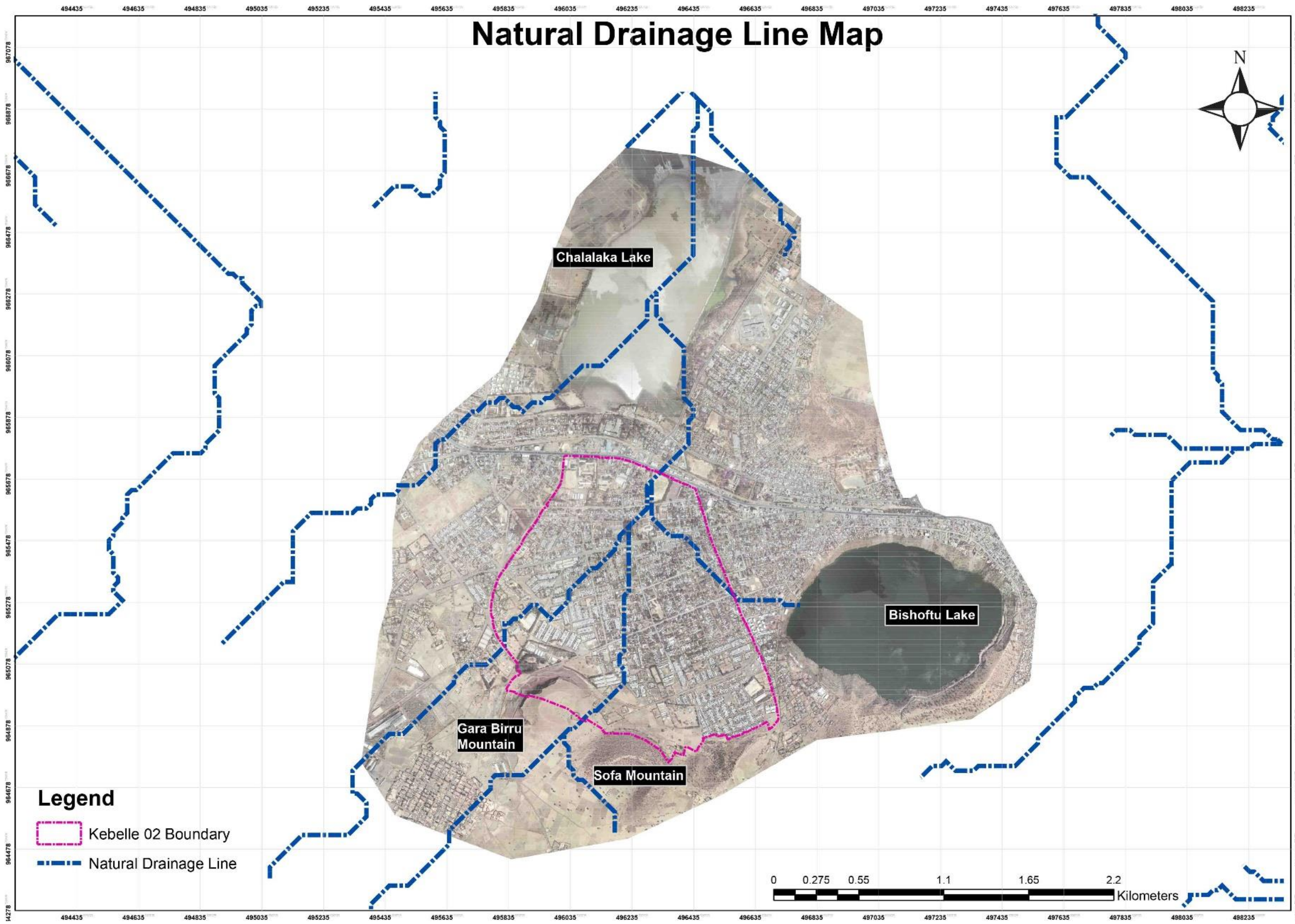

Figure 35 Study Area Natural Drainage Map Projected on Google Earth Image

D. Street Pavement Material of the Study Area

The total area coverage of the street pattern is 43.84 ha. As per the field visit, there are four types of street paving materials such as asphalt, coble Stone, earthen (non-paved) and red ash paved materials are found. Coble stone paved streets takes the largest street area coverage (23.1 ha. (52.69%)) in the study area. Earthen (non-paved) streets take the second largest area (13.16ha. (30.02%) followed by red ash paved areas (4.65ha (10.61%)) and asphalt (2.93ha (6.685%)) accordingly. (See Fig.36.)

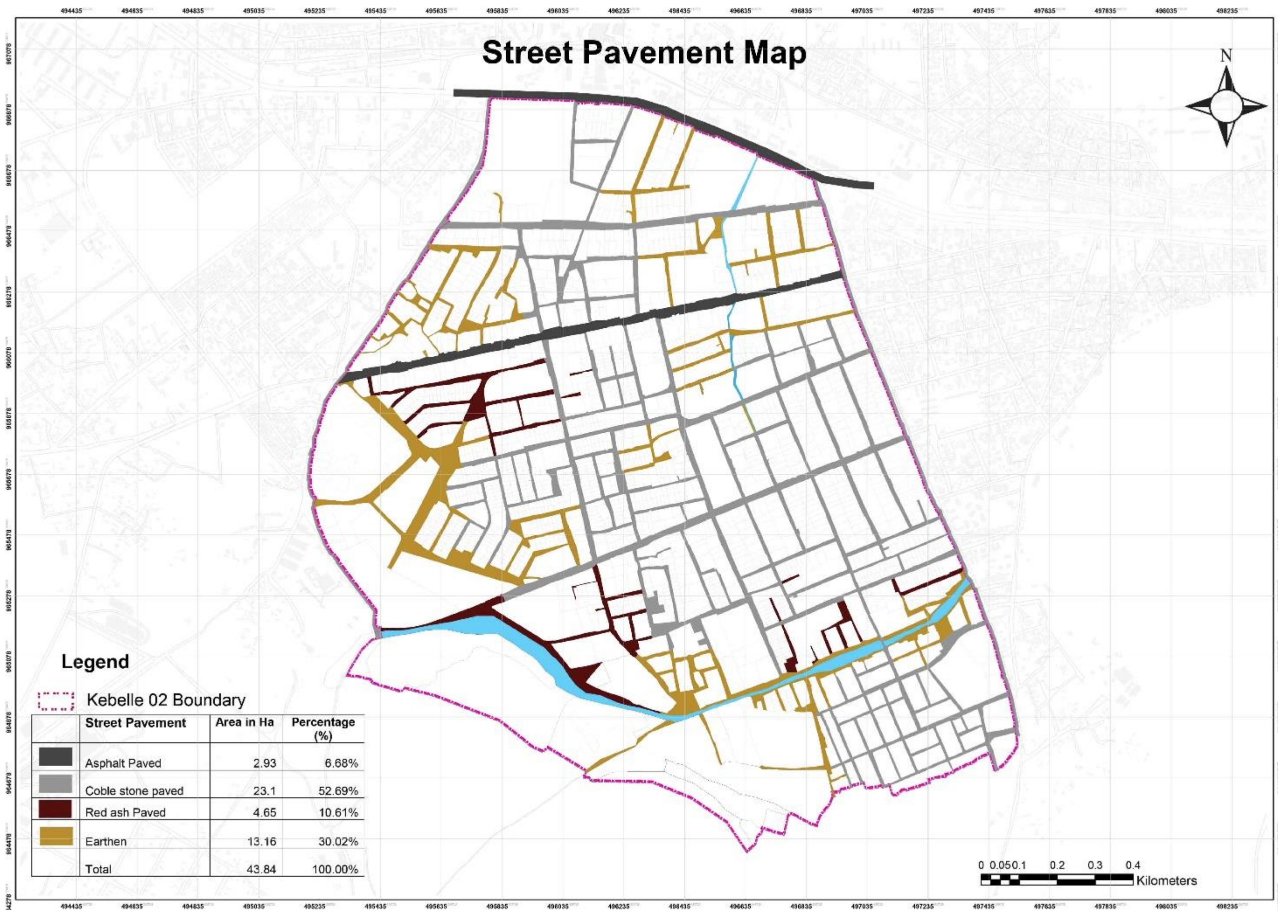

Figure 36 Street Pavement Material of the Study Area

However, coble stone-paved streets are constructed to ease percolation of water, in the study area it was observed that these streets are one means of the flash flood in the neighborhood. As per the field survey, the cobble stone paved street is poorly constructed and most of the street networks in the area lacks drainage line.

Figure 37. Poorly Constructed Cobble stone Paved Streets Promoting Inundation of Rain Water.
(Source: Field Photograph, 2017)

E. Drainage Network of the Study Area

The existing drainage lines in the study area are presented in the Figure 40 below. During the field observation, it was revealed that the existing drainage lines are found on the arterial and collector street networks. The drainage lines construction material are with stone except the non-paved one found on the southern part of the site that is not paved with stone. This drainage line was constructed to divert the flash flood from the mountains directly to Bishoftu Lake hence the drainage line is used only during the rainy seasons but can be used as walkway during the dry seasons. (See Fig.38.and.39.) This drainage line was constructed with the help of the Kebelle 02 Administration and the residents.

Figure 39.Non-Paved Drainage line serving as Waterway during Rainy Season

Figure 38. Non-Paved Drainage line serving as Walkway during Dry Season

(Source: Field Photograph, 2017)

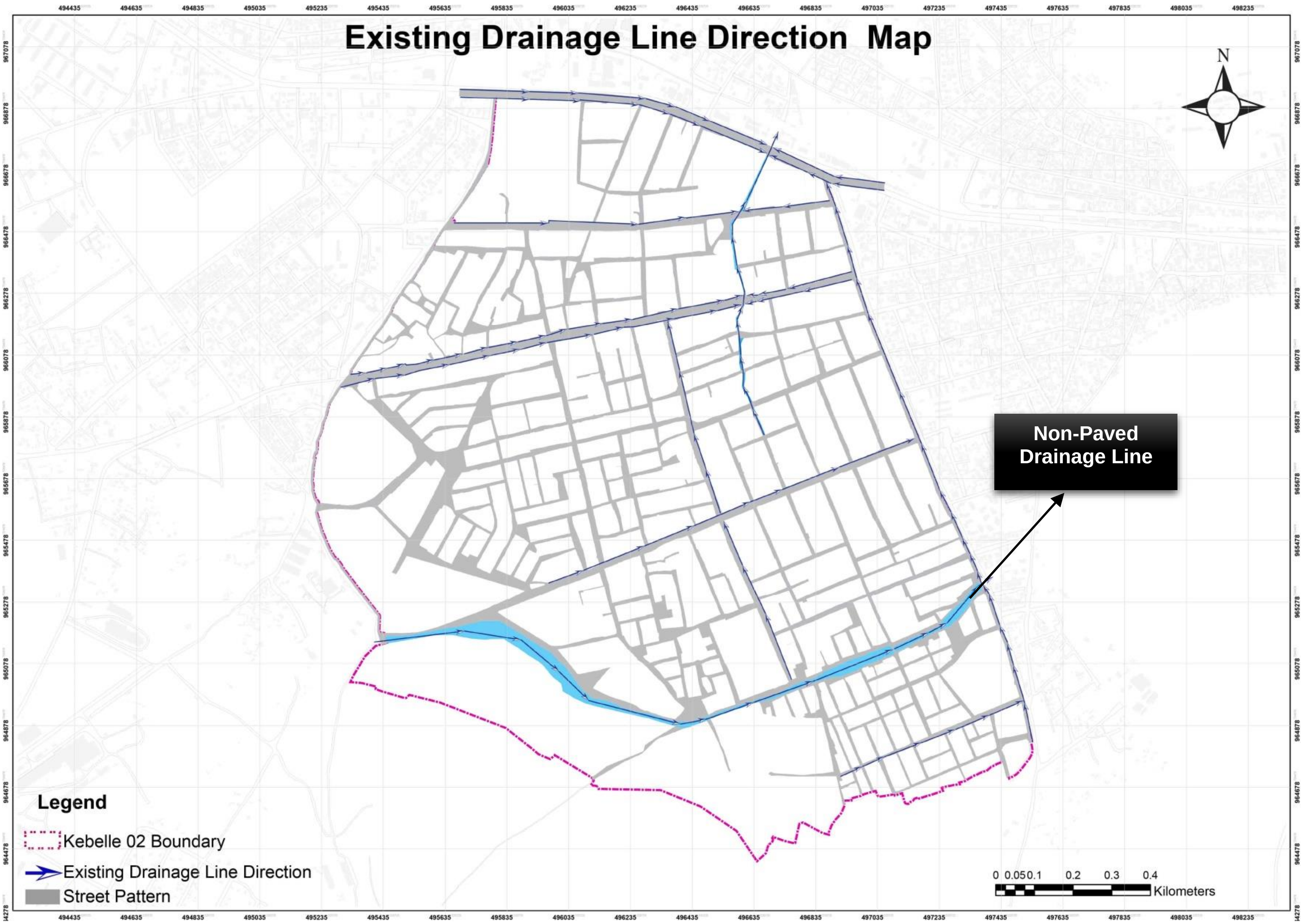

Figure 40 Existing Drainage Line of the Study Area

However, the drainage lines found in the study area has different characteristics with regard to their construction technique, incompatibility of connection, drainage lines that constructed against the topography and their exposure to solid waste and sedimentation. These problems are discussed thoroughly below;

I. Construction Technique of the Drainage Line

The drainage lines found are currently deteriorating due to the poor construction technique. Since the bus terminal and other industries are found within the case site heavy vehicles pass through the street which makes the drainage lines more susceptible to cracking. As a result of these reasons some drainage lines currently don't let water pass and aggravating flash flood in the neighborhood. (See Fig.41.)

Figure 41. Deteriorating Drainage Lines
(Source: Field Photograph, 2017)

II. Drainage Lines Incompatibility of Connection

As per to the drainage line width, there are some drainage lines wider that comes from the upper catchment but becomes narrower when it comes to the down catchment. Such types of bottleneck connection usually cause an overflow of the storm water. In addition, as it was observed during the site survey, there are dead-end drainage lines found on the site which bursts water to streets and other properties found in the case site.

III. Drainage Lines Constructed Against the Topography

For this particular section, the researcher used the drainage map versus the slope map to identify existing drainage lines that were built against the slope. The below-circled areas on the map show that the drainage lines were built on the slope percentage of 0-2%, which implies that such flat topographic slope forces water to inundate on that particular area rather than draining. (See Figure 42.)

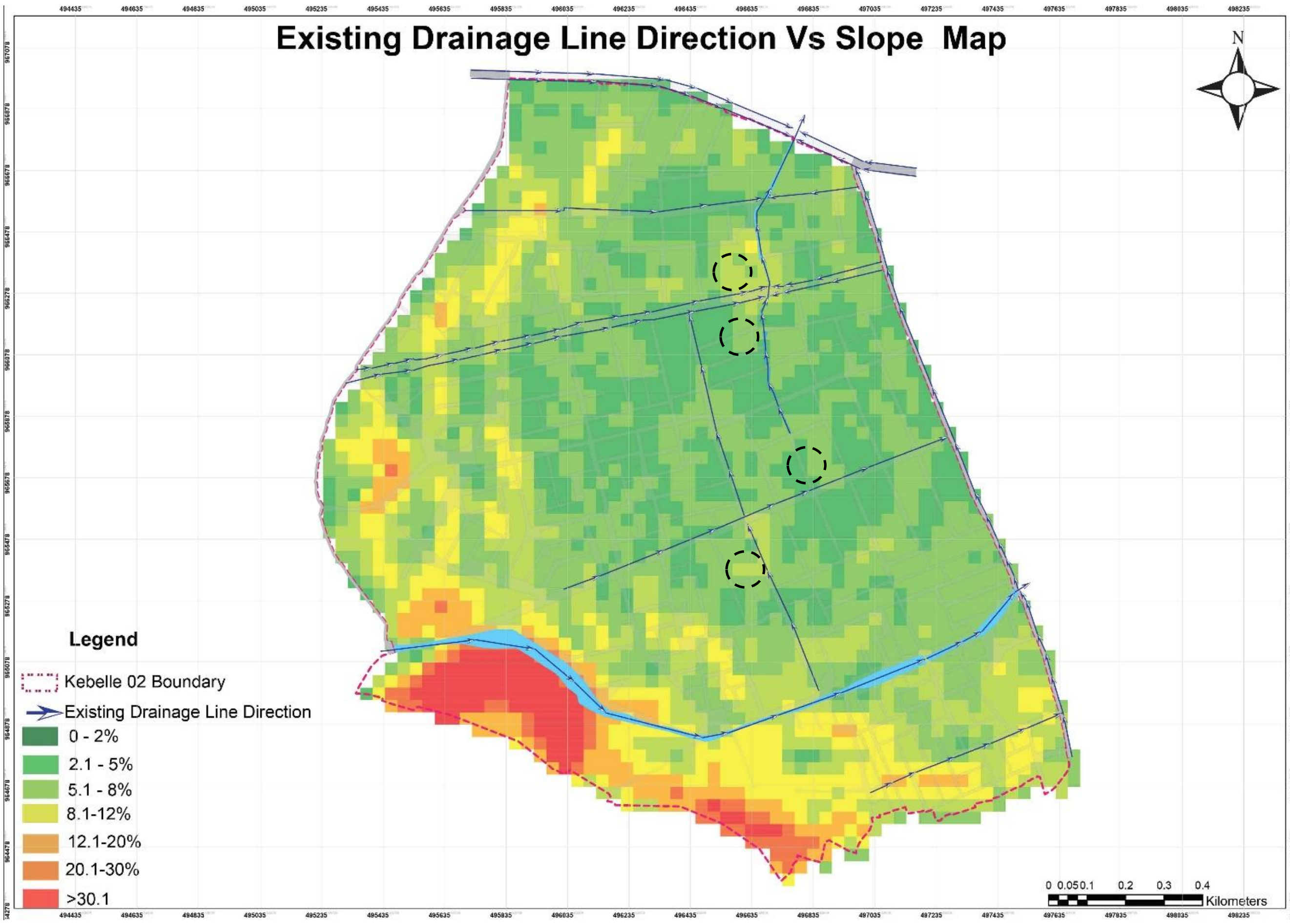

Figure 42 Existing Drainage line versus slope map of the study Area

IV. Solid Waste Management versus the Drainage Line

Most of the drainage lines found on the site are usually clogged by non-degradable solid wastes such as plastic bags, plastic bottles and other kinds of waste materials. As a result of this the clogged drainage lines overflow water to the streets and in some area, the pressure of the water also brings wastes out to the streets and individual housings.

F. Existing Buildings of the Case site

According to the figure-ground analysis of the case site, the total built-up area percentage of the site is only 26.37%. The reason behind the total built-up area is less than the non-built-up is because of the existence of the street network, open spaces and mainly the existence of the two mountains in the case site. (See Fig.43.).

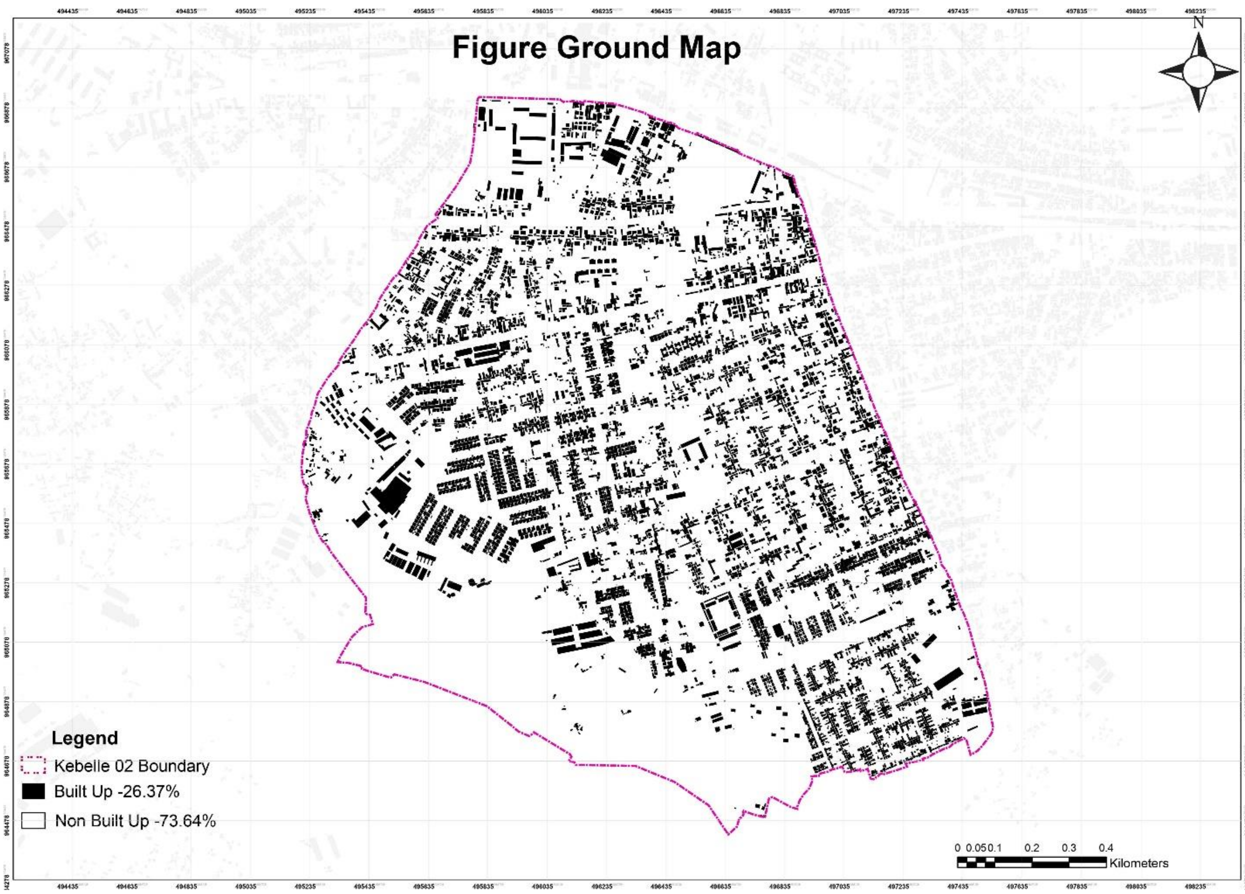

Figure 43 Figure Ground of the Study Area Map

Therefore the researcher used the existing building structures versus flow accumulation map to analyze the flood-vulnerable built up buildings along the high flow accumulation areas. (See Figure 44.).

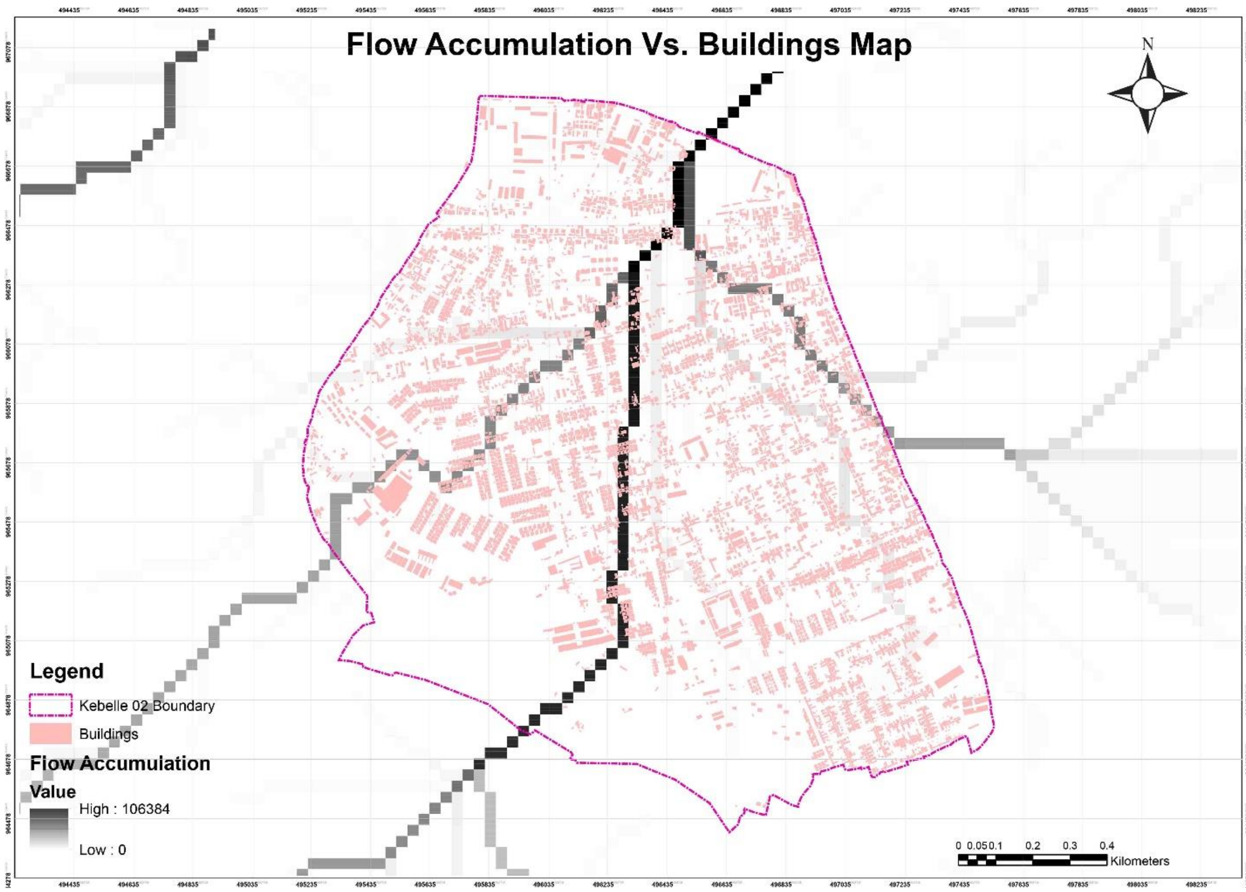

Figure 44 Flow Accumulation map versus Buildings

In addition, the natural drainage line map was used to compare it with both plot of buildings and building structures. This helps the researcher to identify both parcels and building that are constructed against the natural waterway. (See Fig.45.).

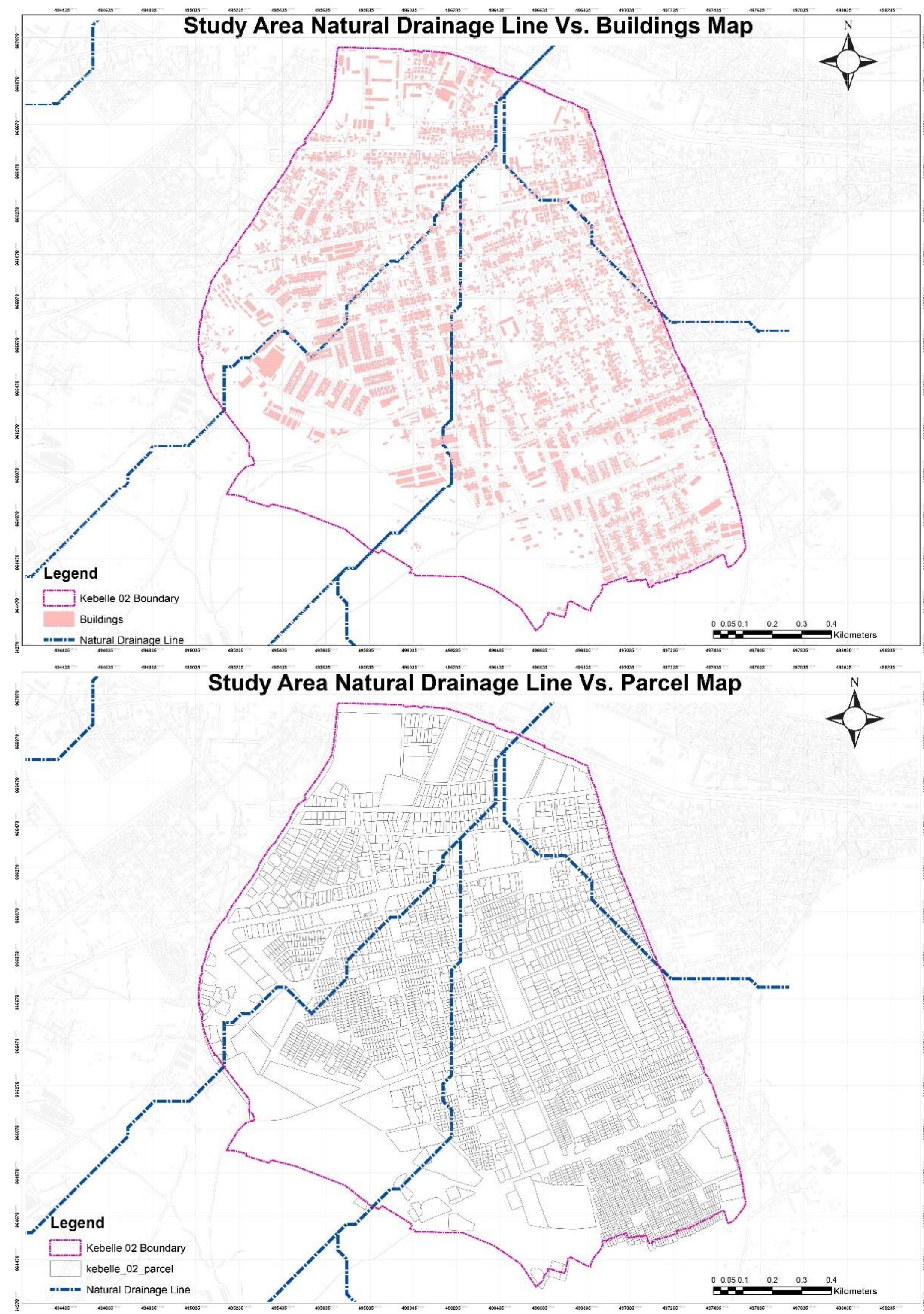

Figure 45 Study Area Parcel and Buildings versus the Natural Drainage

G. Community Mapping of the Flood Prone Areas

During the FGD the researcher has prepared base map of the study area to get the perception of the flooding from the representatives of the seven sampled districts tried to map the flash flood direction and the intensity or tried to rank the level of the flooding by hatching on the provided map stating very high, high, medium and low flooding. During the mapping of the flood direction, the representatives were facilitated by the researcher and were given a brief introduction to reading the base map of the case site provided (Fig.46.).

Figure 46. Introduction on reading the Base map for The District Leaders
Source: Field Photograph, 2017

As the representatives indicated on the map most of the flooding coming from the southern upper catchment where there is quarry area and some of them who are found in the northern part also indicated flooding coming also from western part of the town. Each and every representative were able to sketch the direction of the flood, where it comes from and how it reaches their districts. (See Fig.48.)

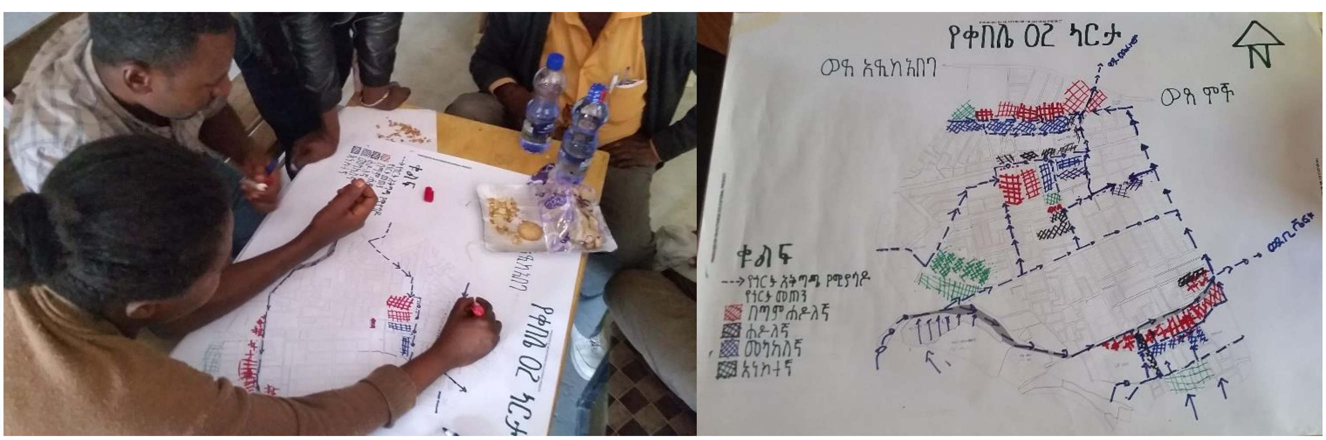

Figure 47. Community Mapping on Flood Direction and Intensity of the Study Area
Source: Field Photograph, 2017

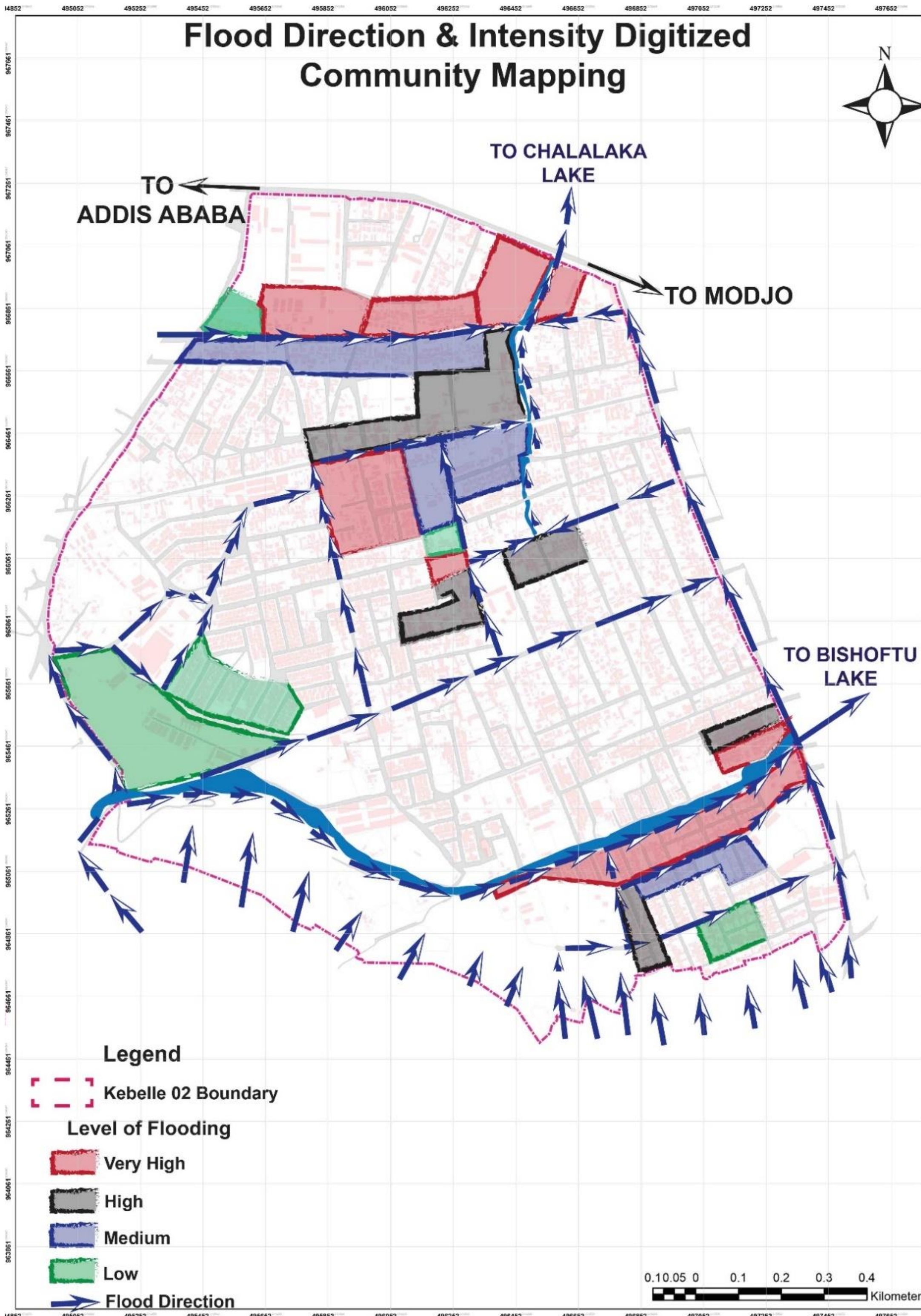

Figure 48 Flood Direction & Intensity Digitized Community Mapping

4.2.4 Coping Strategies of the Residents

As the data revealed, the greatest number of informants (82.60%) use a local coping mechanism to prevent the flash flood before different kinds of damage. (See Figure 50.). However, as per the informants' evaluation of their coping technique, around 79.50% believe that it is not as effective. (See Figure 49.). Those who replied that their coping technique is not effective claims that due to financial and other constraints they cannot develop sustainable coping strategy that lasts, rather they are forced to develop the same types of strategies every rainy season that is most likely to be demolished as the rainy season is over.

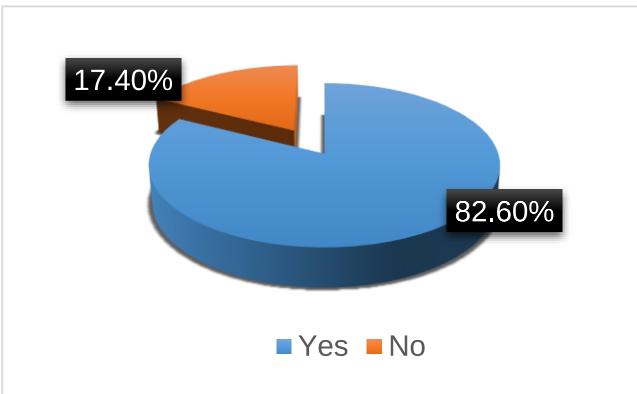

Figure 50 Whether the Household Head has Coping Strategy

(Source: Household Survey, 2017.)

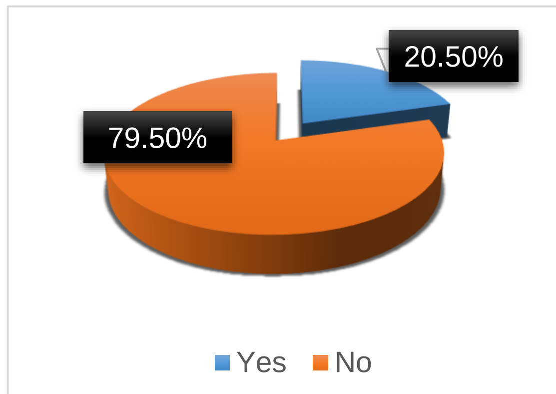

Figure 49 Efficacy of coping strategy of the residents

(Source: Household Survey, 2017.)

In addition, as it was investigated from the house to house questionnaire, the majority of the informants had a way of knowing when the flood is about to occur traditionally. Each informant chose more than one way of knowing when the flood is about to occur such as, by listening of the rainfall power (rainfall intensity (25.00%)), the sound of runoff from the upper catchment (20.45%), neighbors calling and shouting regarding the flooding coming (31.06%) and others (whenever there is a rain there is likely to be flooded (3.03%)). The study area has no siren that can warn the flood-prone area residents and no delegated person that can warn the residents by using loudspeakers or other technologies. On the other hand, there are around twenty-eight informants (21.21%), who do not have any precaution about the flood, hence most of the flood incidents affect the informants without them knowing the flood is approaching their neighborhood. (See Figure 51.)

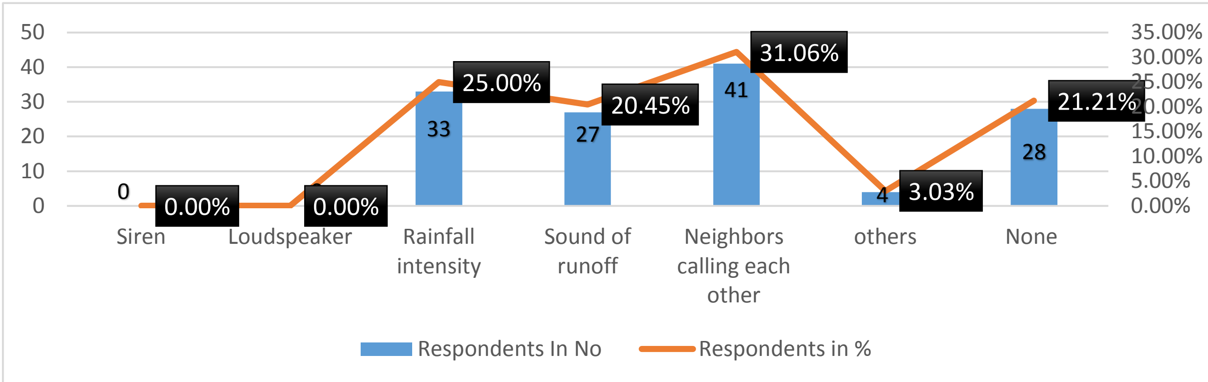

Figure 51 Aware of the Flood Before It Occurs

(Source: Household Survey, 2017.)

4.2.4.1 Types of Local Coping Strategies Used by the Residents

There two types of coping strategies used on the study area classified as prevetative and impact minimizing strategies. Out of the total respondents, 19.69% of the residents don't use any type of coping strategy since the flood didn't cause any serious damage to their wellbeing and their property until now. Local strategies in the study area used are moving to higher ground or standing on elevated furniture's or structures (4.54%), making sandbags (38.63%), evacuating from their homes (10.60%), diverging the water (25.00%), and other coping strategies (building temporary retaining wall like structures made of hollow blocks, compacting soil and clearing out soil and solid waste from the drainage lines (12.87%)).

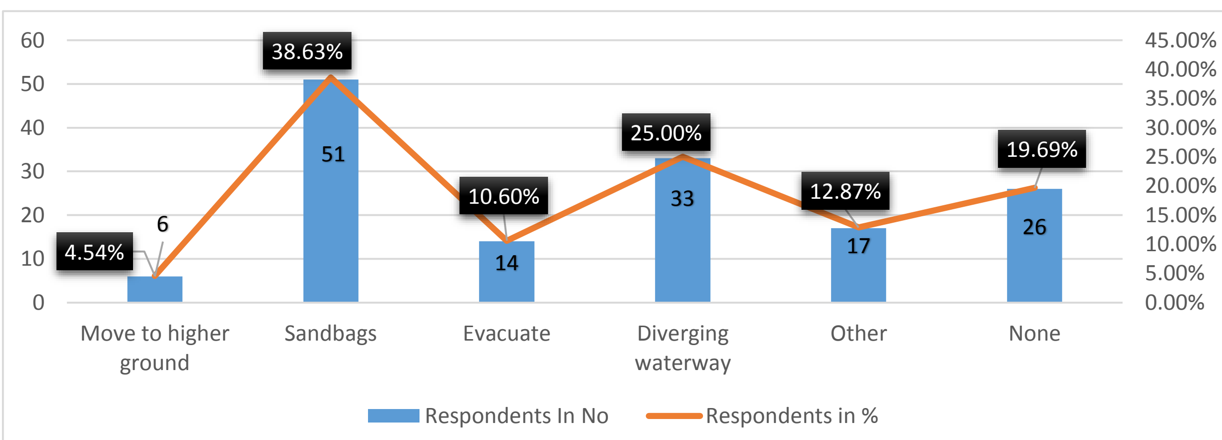

Figure 52 Local Coping Strategies of the Residents

(Source: Household Survey, 2017.)

A. Preventative Strategies

As figure 52 shows there are preventative strategies used such as evacuating from their house until the rainy season is over. Around fourteen respondents replied that they are always forced to rent a house or reside with their relatives during the rainy season. Some residents' moves to elevated areas or objects until the flood passes their premises or areas. However, such kinds of strategies usually affect the respondents socially and economically due to the distance from their social activity, insecurity of individuals about their houses and exposure to additional cost.

B. Impact Minimizing Strategies

The respondents replied that the commute different strategies to minimize the impact of the flood in their area. Here are the strategies:

Making sandbags around the streets, compound entrances and buildings. These sandbags block the water from entering and used as a bridge to pass swampy areas, however, the bags won't last more than one rainy season due to their poor visual quality, their inconvenience for walking and blocking entrances of compound gate and buildings. (See Fig.53. and .54.)

Figure 53. Sand Bags used as Walkway in swampy areas

Figure 54. Sand Bags used as Blockage to Minimize the Water from Entering

(Source: Field Photograph, 2017)

Diverging the waterway in the neighborhood is also employed by 25.00% of the residents. As they responded that even though the Kebelle 02 administration restricts them not to divert the water due to diverging the water may affect other neighborhoods. However, the informants stated that every rainy season they happened to divert the water for the sake of relief from the flooding that enters into their premises. (See Fig.55.)

Figure 55. Diverging Waterway Strategy
(Source: Field Photograph, 2017)

Other types of impact minimizing strategies employed in the study area are building a retaining wall-like structure with a hollow block, compacting their houses and or compound entrances either with selected materials or soil, rebuilding houses with elevated structures, clearing out garbage and sedimentation from the drainage lines before the rainy season starts. The retaining wall making strategy can be considered somehow effective since it blocks the water from entering. However such structures are not convenient for human access since the riser of the structure reaches up to 60 cm. (See Fig.56.)

Figure 56. Hollow Block Structure
(Source: Field Photograph, 2017)

Compaction of soil on the edges of the compound and building entrance is one of the other coping strategies used in the case site. Nevertheless, such type's compaction usually gets eroded through time because of the rain and the runoff on the streets. Therefore the residents who use such strategy are forced to maintain the compaction minimum every year. (See Fig.57.)

Figure 57. Soil Compacted Entrances

(*Source: Field Photograph, 2017)*

Informants also use clearing out the sedimentation of soil as coping strategy since most of the soil eroded from the quarry area. In addition cleaning the solid waste disposed in the drainage line clearly minimizes the flood in the area. On the other hand, some informants whom are financially well replied that they tried to rebuild their houses with elevated foundations built with stones so that the runoff does not affect the wall structures and enter into the housing units.

Figure 58. Housing Unit Foundations up to 1 M.
(Source: Field Photograph, 2017)

According to the response of the district leaders regarding the coping strategies employed by residents is described as follows:

- *"We usually dig the land every year to provide waterway whenever there is a rain. However, the cleared out drainage line always last a few days since there is sedimentation and waste approach the waterways. So we are forced to do it now and then to minimize the damage". (Representative of District 23)*
- *"Clearing out clogged drainage lines with different solid wastes and soils". (Representative of District 03)*
- *"Compacting soil and red ash around the edges of compound fences". (Representative of District 07)*
- *"Making sandbags and putting it on the edges of our compounds with the support from rich people in our Kebelle like Alema farms and other individuals. Other affected household with good financial status construct retaining wall made of hollow block with cement which usually demolished once the rainy season is over". (Representative of District 09)*
- *"Households in our area with good financial stands build tank (hole) minimum of 2m by 3m with 3m up to 3-4m depth covered and one inlet (See Fig.59). Such tool is built within the compound to trap the flooding water into the hole and percolates into the ground through time. This technique is very effective because it calms the flood approaching our house and we have times until the hole is full and inundates our compound". (Representative of District 06)*

Figure 59. 2m by 3m Width with 4m Depth Hole for Flood Water Trapping
(Source: Field Photograph, 2017)

An interview was conducted with two officials of Bishoftu town, they replied that currently there is drainage project that is going to be constructed soon. They believe that the current flooding problem is going to be solved by the project. As per their response regarding the help from their side to the neighborhood, both interviewee replied that *“we gather people from the different districts of Kebelle 02 to help the victims of the flood to move their property to another places, try to drain the water that has entered individual houses, help them construct sandbags on the edges of their entrances and if the flooding is worse we apply to the red cross and other non-governmental partners to provide some materials such as blankets and mattress for those whose property was severely damaged.”*

4.3 Discussion and Proposal

It is irrational to believe that floods or any natural disasters can be avoided or fully predicted rather it is essential to learn how to live with floods, minimize damage and rapidly recover from disruptions. The study tried to understand the main factors that triggers the flash flood in the study area and identified the consequence it has brought to the residents. The present research linked the traditional (local) with scientific coping strategies to bring flood resilience to the neighborhood.

4.3.1 What are the Causes and Effects of Seasonal Flooding in the Case Site?

According to Doswell III, 2003, many hydrological factors have relevance to the occurrence of a flash flood: terrain gradients, soil type, vegetative cover, human habitation, antecedent rainfall, and so on. In steep, rocky terrain or within heavily urbanized regions, even a relatively small amount of rainfall can trigger flash flooding.

Likewise, as it was witnessed from the field survey, house to house questionnaire, interview guide, KII and FGD the flash flooding in the case site is induced by different natural and man-made factors. The natural factors that causes the flooding in the area is the topographic feature where most of the area in the slope range lies between 0%-5%, which explains that the area is characterized as swampy and the Sothern upper catchment of the study area is characterized as a hilly and deserted mountainous area where the flash flood comes from. Other natural factor studied was the precipitation of Bishoftu town. It was recorded that whenever there is annual rainfall greater than 881.5mm during the past thirty years there was a record of the possible flooding in the study area. In addition, the soil character of the study area is characterized as dark clay and very dark gray clay which has very low infiltration rate that can trigger runoff (Hill, et al., 2010).

The man-made factors investigated on the case site were mainly the case site lacks provision of drainage lines. Whereas the existing drainage lines that are expected to calm the runoff are not properly designed with regard to drainage width compatibility issues, poor construction materials that are currently deteriorating, sedimentation of soil that is eroded from *Gara Birru* and *Sofa* Mountain and poor solid waste management practice in the area clogs the existing drainage lines.

The other factor investigated is the encroachment of the *Sofa* Mountain for the purpose of red ash mining. The quarry practice in the area diverted the natural waterway towards the settlement in the case site. In addition, the two mountains in the case site lack vegetation cover that can prevent the erosion that leads to sedimentation in the existing drainage lines. However, during the house to house questionnaire, the few respondents believe that lack of vegetation cover induces flooding. Therefore, its essential to create awareness among the residents of the case site regarding planting trees on the mountainous areas has a probability to minimize the runoff.

Some new settlement in the case site are also considered as one of the flood driving factors due to the settlements blocks the waterway and divert it into other parts of the case site. Hence it is important for those settlements to provide flood passageway so that it can minimize the negative impact on the other settlers. On the other hand lack of proper attention given by local government regarding preparedness for the flashing flooding before occurrence was also considered as a factor to aggravate the flooding impact on the case site.

The damages caused by flash floods can be more severe than other types of floods because of the speed with which flooding occurs (possibly hindering evacuation or protection of property), the high velocity of water, and the debris load (Alhassan, 2015). As a result, the effects of the flooding on the case site witnessed were, most residents have lost household equipment. While some lost their houses or else were forced to rent new house until the rainy season ends. In addition residents of the case site are exposed to different health-related problems. Such kinds of effects cause social frustration and economic loses (Twigger, 2005).

4.3.2 Which Specific Areas are Highly Affected by the Flash Flood within the Case Site?

Flood risk mapping has a vital role with regards to increasing public awareness of the areas at risk from flooding, reducing risk to people, property and the environment, supporting spatial planning decisions, and encouraging professional emergency responders (police men, local government officials and other non-governmental institutions whom are volunteers) (Sayers, et al., 2013).

After producing different flood related maps using DEM file, base map of Bishoftu, and field survey data the researcher combined different layers such as the slope, flow accumulation, natural drainage line, man-made drainage line, flood direction and flood intensity maps to identify flash-flood prone areas. The flood risk map of the case area shows that the flash flood mostly originates from the two mountains found on the southern part of the study area. The flood that is originated from the mountains pass through the street networks and on some particular areas through man-made drainage lines. However, due to different natural and man-made factors stated in the above sub-section the case site is flooded, especially the residents that resides adjacent to the street networks and near the mountainous areas (See Fig.60.).

Those areas designated by the blue shades on the below figure 60 provided shows areas that are found in flood risk areas and it was observed that some residents lack information about floods. To create awareness about flooding problematic and a better knowledge of the flood risk and its management by the local populations can improve reaction in case of flood and also adequate anticipation. To achieve this, the concerned communities like district leaders of the case site must be provided with a relevant material as the designated flood prone maps and be taught how to use them. It is always more effective to present visually based information. From which members of the neighborhood can understand what are the potential hazards possibly happening in their area and to learn the measures possible to apply before, during and after flood event (Pavlova , 2016). Hence, easy illustrations of flash flood prone areas will be visually accessible for all kinds of users with different kinds of educational background.

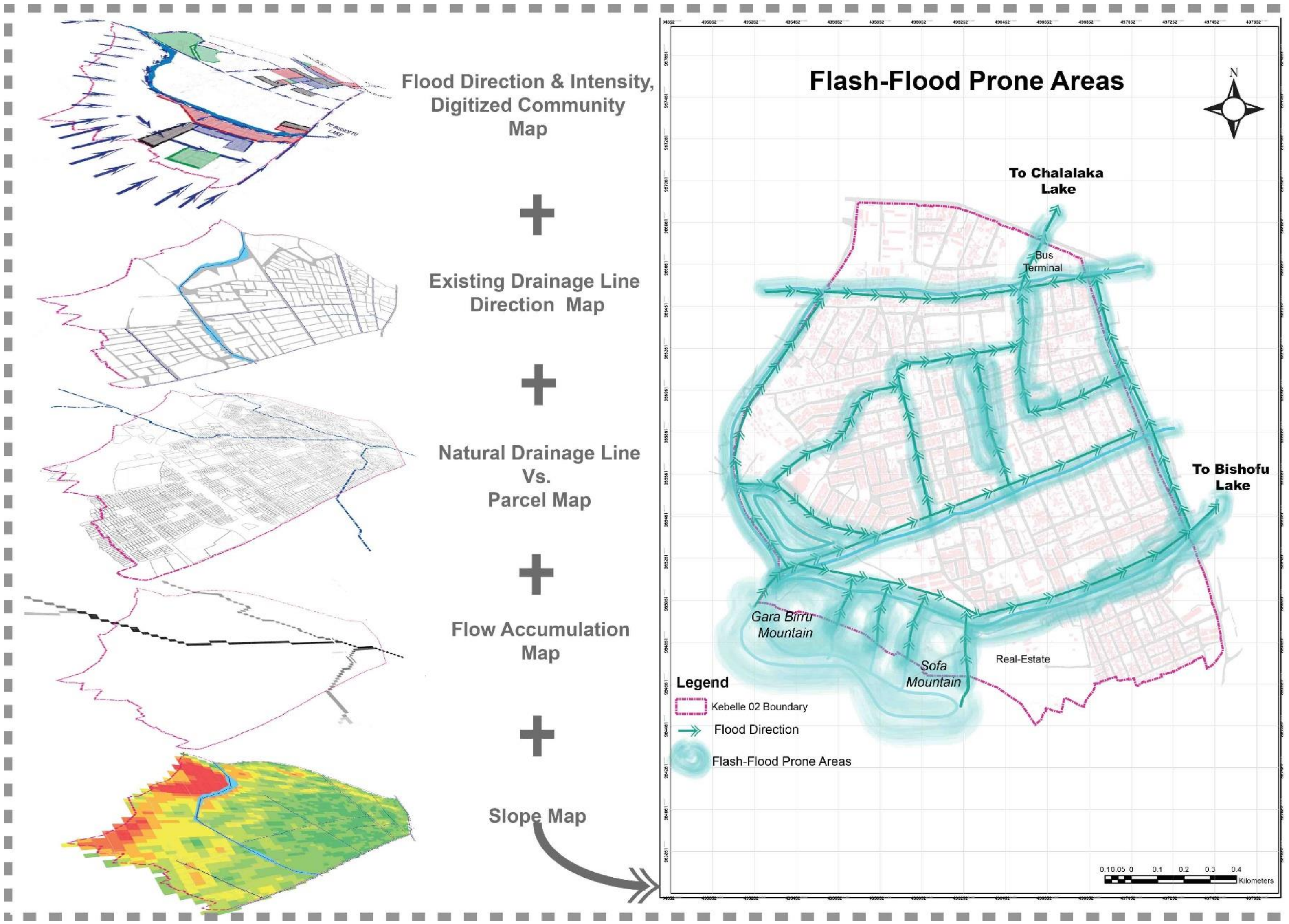

Figure 60 Flash-Prone Areas within the Case Site

.

4.3.3 What are the coping strategies or local remedies used by local residents to prevent the seasonal flooding?

There are various coping strategies which people apply in order to handle or to adapt to flood situations as forms of local knowledge which can directly contribute to designing for flood resilience if the full potential of the indigenous knowledge supported with scientific flood prevention and mitigation strategies (Ehlert, 2007). As per the coping strategies of the residents, most of the respondents believe that their coping strategy is not efficient to protect them. During the field survey and collected data from house to house questionnaire it was investigated that the coping strategies employed by the local residents were making sandbags, constructing retaining wall, elevating the foundation of housing units, diverging the flood direction, digging hole to trap the water, clearing out sediment of soil and garbage and finally move to higher ground or evacuate from their house until the rainy season ends.

Construction of sandbags mechanism in the study area is employed by most of the flood-affected residents. However, the sandbags are elevated higher than the entrance to their compound and or to their house which makes it difficult for the dwellers to enter in to their premises comfortably. The filling and placing of the sand-bags as a barrier for the flooding is not properly done. As a result, most dwellers who use such mechanisms can minimize the flooding to some extent and are forced to remove the sandbags whenever the rainy season is over and reconstruct when the rainy season returns.

Sand-bags must be filled and placed properly to give the best protection. Any available material can be used to fill sandbags, but sand is easiest to handle. Silt and clay will form a good dike but are more difficult to work with (Moen, 2009). Hence, it is important to adapt easy way of filling sand-bag with available local materials and properly placing them in order to minimize the damage of flooding in the case site (See Fig.61).

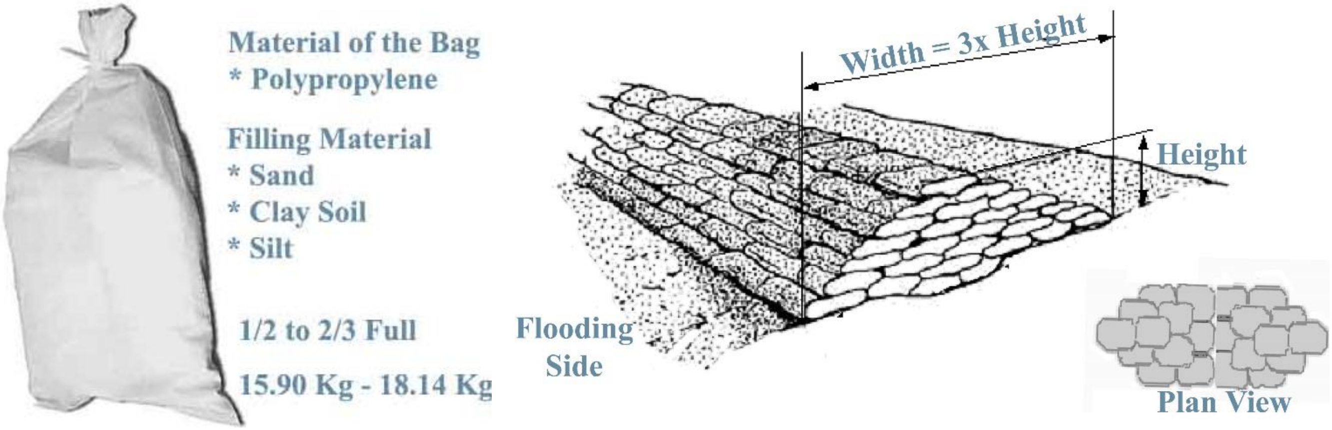

Figure 61. Preparation and proportional Placement of Sand-bags.

(Source: Adapted from US Army Corps of Engineers: Support to Domestic Incidents under the Stafford Act, 2009.)

Construction of retaining wall made of hollow block as a coping mechanism is employed by those residents who are able to afford since such technique is costly and for the same reason explained for the sandbag technique, this technique is usually reconstructed every year. Floodwalls are usually constructed of concrete or steel and take up far less room. They are more suitable for use in congested areas like the study area (Groot, et al., 2002). However such techniques in the area are more of constructed on the entrance gateways of residents housing unit and compounds. Therefore permanent retaining wall structures made of concretes or steel is not affordable since the gateways cannot be blocked throughout the year rather it gets demolished once the rainy season is over due to inconvenience for the residents.

Some specific residents on the case site constructs flood detention tanks within their compounds. Nevertheless, the detention tank only gives temporary relief for the residents from the flood entering their compound, but the water trapped in the tank has no further use since different debris enters along with runoff. It is important for those residents who uses water detention tank as coping strategies should enhance their technique in away the water detained becomes use full for some period of time during the dry season. Therefore it is important to design for pretreatment techniques before the water enters the detention tank such as sort of iron mesh, leaf screenings and grass filters as first step. Secondly, the tank should have overflow out let that can release the water to adjacent drainage line units. Finally, the detention tanks should be covered from the top to minimize risks of mosquito breeding, children and elderly falling in, and other related risks. (See Fig.62.)

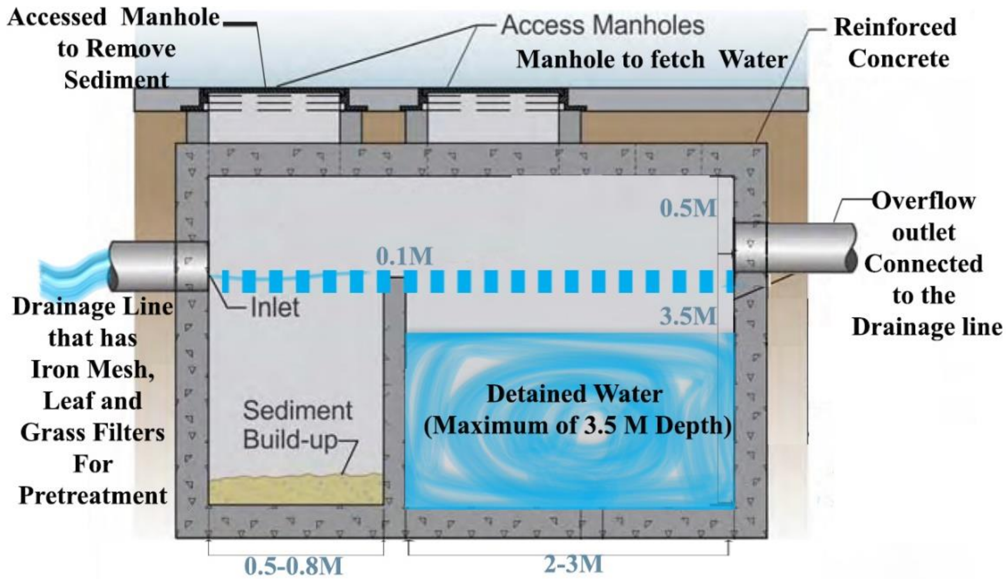

Figure 62. Flood Water Detaining Tank

(Source: Adapted from On-site storm-water management as an alternative to conventional sewer systems: a new concept spreading in Germany, 1998.)

As observed during the field survey and gathered data from the dwellers, diverging the water-way is done with a group of people during the flooding because most of the time the flood direction might be diverted from other particular areas where the flooding originates from. Such mechanisms happen to cause conflicts between neighbors because of complaints that diverging the waterway may increase the flooding on other parts of the areas even though it gives relief for those who diverge. The other mechanism which is employed in the group is clearing out sediment of soil and garbage from the drainage line. Clearing out is usually done once a year by some labor force hired by the local Kebelle 02 Administration and group of willing residents of the neighborhood. Such technique enhances social interaction between the residents of the neighborhood since they are working for their own benefit.

In general residents of the study area have limited way of early warning system like neighbors shouting when the flood is about to approach their area and by looking at the behavior of the rainfall. However, flash-flood are quick response flood events causing sudden flooding that follows within 6 hours or less after the heavy rain event (Grabs, 2010). Therefore it is essential to use different scientific techniques that can be supported by governmental and non-governmental organizations, such as, improving regional and local level ground observation stations quality, forecasting technique (what time the flash flood flow happen), allocating sensor to receive frequency and alarm system can enhance the preparedness of the local residents and government (Jinxing, et al., 2004).

4.3.4 Which are appropriate strategies to promote flood resilience in the case area?

The following design strategies of this study are based on the research findings that needs immediate intervention in order to promote flood resilience in the study area that can make people and their properties less vulnerable to the physical and mental impacts of flooding. As per the community mapping, the district leaders helped the researcher to identify the flood direction and the intensity of the flooding. In addition, the flow accumulation and natural drainage map analysis also showed where the flow is accumulated and the possible blocked natural waterways respectively. Depending on the above statement the researcher identified three intervention areas such as, the existing street network that passes from the northern part of the study area to the southern and a street network that pass from eastern part to the western part as an Intervention I. The second intervention area is the non-paved drainage line that comes from Sofa and Gara Birru Mountain directly to Bishoftu Lake. The third intervention area is Quarry area (Sofa Mountain) and Gara Birru Mountain. (See Fig.63.)

Figure 63 Possible Flood Prevention Intervention areas

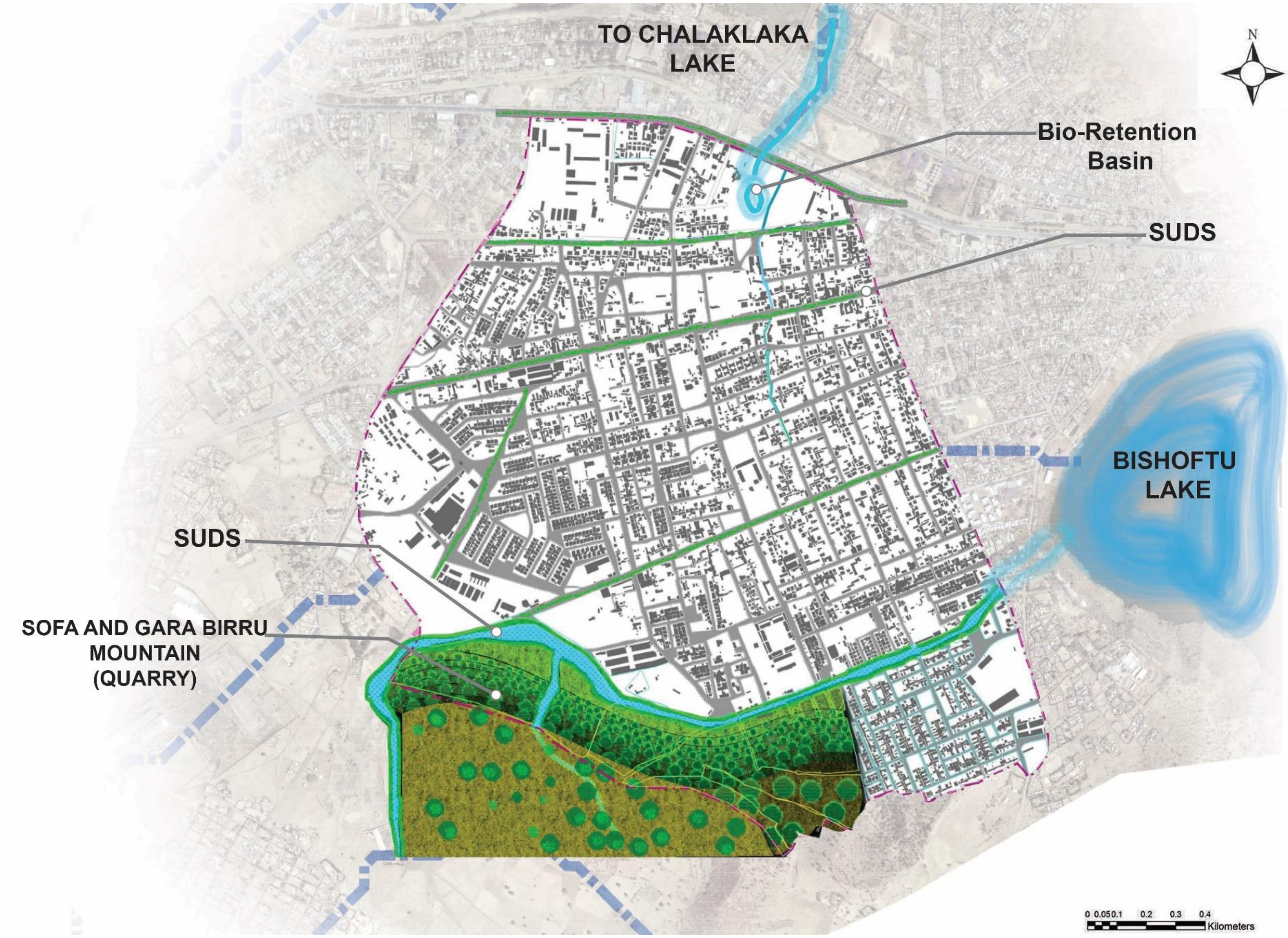

Figure 64 Intervened Areas

A. Intervention Area I

This particular intervention area receives water from the mountainous areas in southern part and western part (From Kebelle 01). However, the water received from both sides will flood the bus terminal and open space found adjacent to the terminal eventually enters into Cheleklaka Lake. Therefore, it is important to design for a sustainable drainage system in order to minimize the flash flood impact. Here are key considerations when designing sustainable drainage system:

- Design drainage networks along with the coble stone paved street that enhances water percolation.
- Drainage inlet-outlet should be compatible with each other.
- The drainage lines could be made of grass channels (Swales) which can slow down high runoff and has a tendency to purify polluted water. (See Fig.65.)
- Design for retention basins that can provide short-term storage for excess rainwater. During very heavy rainfall the water level will slowly rise. Afterwards, the water level drops slowly as the water flows out of the basin into the nearby Cheleklaka Lake. The Designed basin is in the open space is multifunctional which can increase the biodiversity and also can be used as a recreational area.

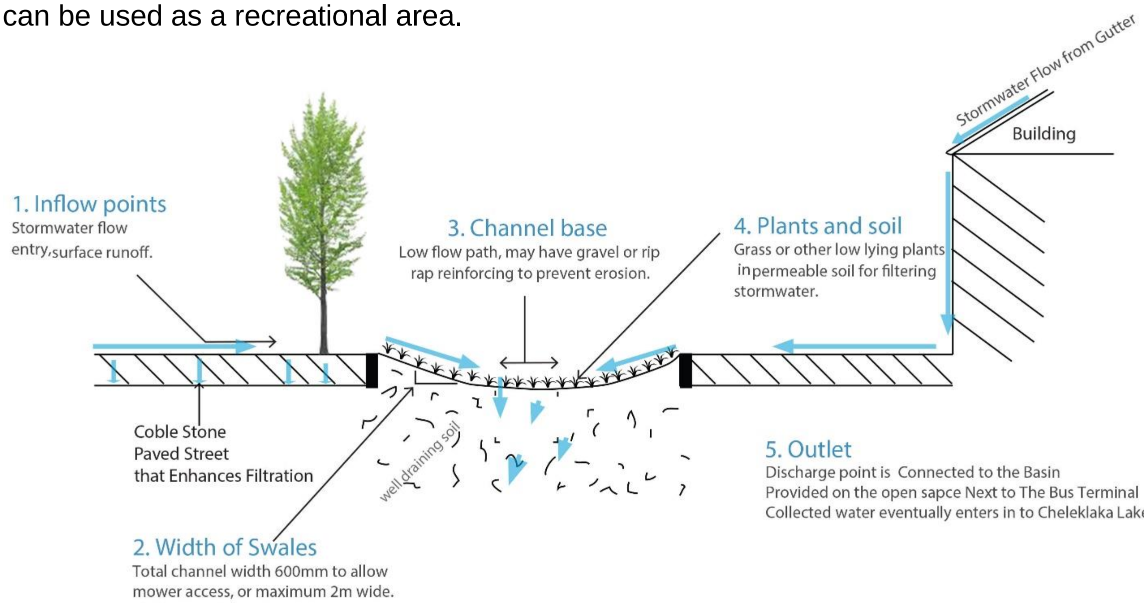

Figure 65. Drainage Design Intervention for the Case Site

(Source: Adapted from Swales and Filter Strips Construction Guide, Auckland Council, 2017.)

B. Intervention Area II

This particular intervention area collects storm water from Sofa Mountain (the Quarry area) and Gara Birru Mountain. The waterway channel that collects the water from upper catchment is non-paved drainage line which ends at Bishoftu Lake. Nevertheless, as it was revealed in the study this specific channel also has a contribution towards flooding adjacent houses due to the run of power is very high which erodes channel and burst outside. Therefore, it is possible to adopt a design for swale channel in order to minimize the flash flood impact. Here are key considerations when constructing the swale:

A. Excavate

- ➢ Remove material to form a channel.
- ➢ Form to levels on construction plans with excavator and blade. Side slopes not to exceed 3:1 horizontal to vertical slope. Base of channel usually minimum 600mm to allow mower access or maximum 2m wide.
- ➢ Do not compact ground at base of channel, as it acts as filter for flows.

B. Connect

- ➢ Construct flow collection inlets made of concrete or other stone materials in order to avoid erosion from the initial point.
- ➢ Construct outlets (may be concrete or rock sill, catchpit or vertical riser pipe with grate or scruffy dome) and connect to Bishoftu Lake.
- ➢ Make buffer zone minimum 2- 3 m from both sides in order to avoid flooding in case of the water level rises than expected.

C. Sow and Plant

- ➢ Place 100mm minimum topsoil across swale length and channel width.
- ➢ Topsoil must be free of clay to allow free draining.
- ➢ Sow grass densely (and plant native plants, if specified). Sow to cover entire swale length and width. The landscaping has a potential to delay flood water.
- ➢ Fence off until grass established, and water regularly early on to establish dense grass growth.

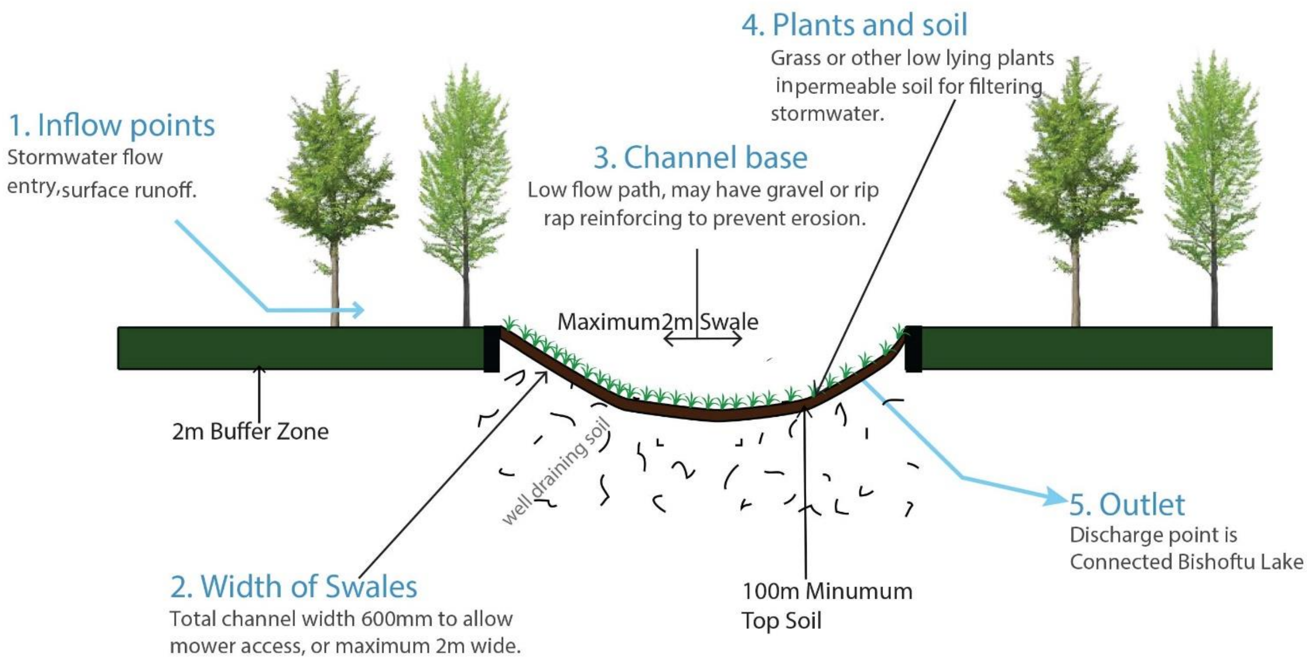

Figure 66. Non- Paved Drainage Line Design Intervention for the Case Site

(Source: Adapted from Swales and Filter Strips Construction Guide, Auckland Council, 2017.)

C. Intervention Area III

According to Pavlova (2016, p.22.), *'Flooding is a natural hazard and for the most part might be mitigated by nature itself'.* However, the situation the case site in term of environment is problematic. Conditions of existing natural resources are deteriorating due to encroachment of the mountain for mining red-ash, new developments on the natural drainage which causes blockage of natural drainages, deforestation and so on. Thus, such activities promotes the flash flooding unless otherwise the natural environment is restored.

This specific intervention area III located on the mountainous area was revealed as one of intervention points during the site survey and other information gathered. The southern part of the study area it is one of the major causes of the flash flooding in the case site. Sofa mountain area is used as red-ash mining area which is interrupts the natural water way. On the other hand, the Gara Biruu Mountain adjacent to the Sofa Mountain was also claimed as means of runoff since the area lacks vegetation cover. Therefore, it is essential to rehabilitate the encroached fragile ecosystems by taking intensive afforestation and/or reforestation technique into consideration.

Since vegetated land cover can reduce surface water runoff and risk of flash flooding (Bosher and Dainty, 2011).

The other specific intervention area III is located at the northern part of the study area. The specific site is currently operating as an open space which is found adjacent to the regional bus terminal of Bishoftu Town. As per the flow accumulation map analysis, topographic feature and Household Survey shows that the open space is one of the major areas where the runoff accumulate and lasts for some certain period of time due to the topographic character is flat slope that lies between 0-5%. Therefore, it is essential to design for bio-retention basins in the open space in order to use the flood water for different purposes rather than the flood harming both residents of the area and the environment in general. Bio-retention basins can be incorporated or integrated into any site to help improve water quality and contain increased quantities of runoff (Prince George's County, 2002).

There should be due considerations when designing and constructing bio-retention basins. The basic design parameters for a bio-retention basin is its storage volume, the thickness, character, and permeability rate of its planting soil bed, and the hydraulic capacity of its underdrain (Davis, et al., 2009). Details of these and other design parameters are presented below.

I. Storage Volume, Depth, and Duration

Bio-retention systems shall be designed to treat the runoff volume generated by the storm water. Hence, the minimum diameter of any outlet or overflow opening should be 6.5 Centimeters. The bottom of a bio-retention system, including any underdrain piping or gravel layer, must be a minimum of 30 centimeters above the seasonal high groundwater table. As the flow direction of groundwater Bishoftu is from the southern part towards north and northwest of the town following the flow direction of streams, there should be vital consideration regarding setting the bio-retention basin within the open space. Finally, the planting soil bed and the different kinds of layers system shall be designed to fully drain the storm water quality design storm runoff volume within 72 hours. (See Fig.67.)

II. Permeability Rates

As mentioned in the above, the design permeability rate through the planting soil bed must be sufficient to fully drain the storm water quality design storm runoff volume within 72 hours. The different layers of the bio-retention basin used as filtering of the flood water should be planted as per their percolation rate. However, the percolation rate of the different layers may decrease depending on the run-off accumulation of sediment that comes along with the runoff from the other parts of the study area. Therefore, pretreatment of the flood water that comes from the upper catchment should be taken using different screening methods before it reaches the destination. (See Fig.67.)

III. Planting Soil Bed

The planting soil bed material should consist of 10 to 15 percent clays, a minimum 65 percent sands, with the balance as silts. The material's pH should range from 5.5 to 6.5. The total depth or thickness of the planting soil bed should be a minimum of 100 centimeters. As noted above in chapter 3, sub-section 3.1.5.3, Bishoftu town's soil character is clay loams, which can be used in the planting of the soil bed.

IV. Vegetation

The vegetation in a bio-retention system removes some of the nutrients and other pollutants in the storm water inflow. The environment around the root systems breaks down some pollutants and converts others to less harmful compounds. The use of native plant material is recommended for bio-retention systems wherever possible. Therefore, recommended vegetation types are Ficus Sycomorus ('oda'), indigenous shrubs, and elephant grasses that can be planted on the bio-retention basin. The recommended vegetation types has a potential to improve soil and water quality.

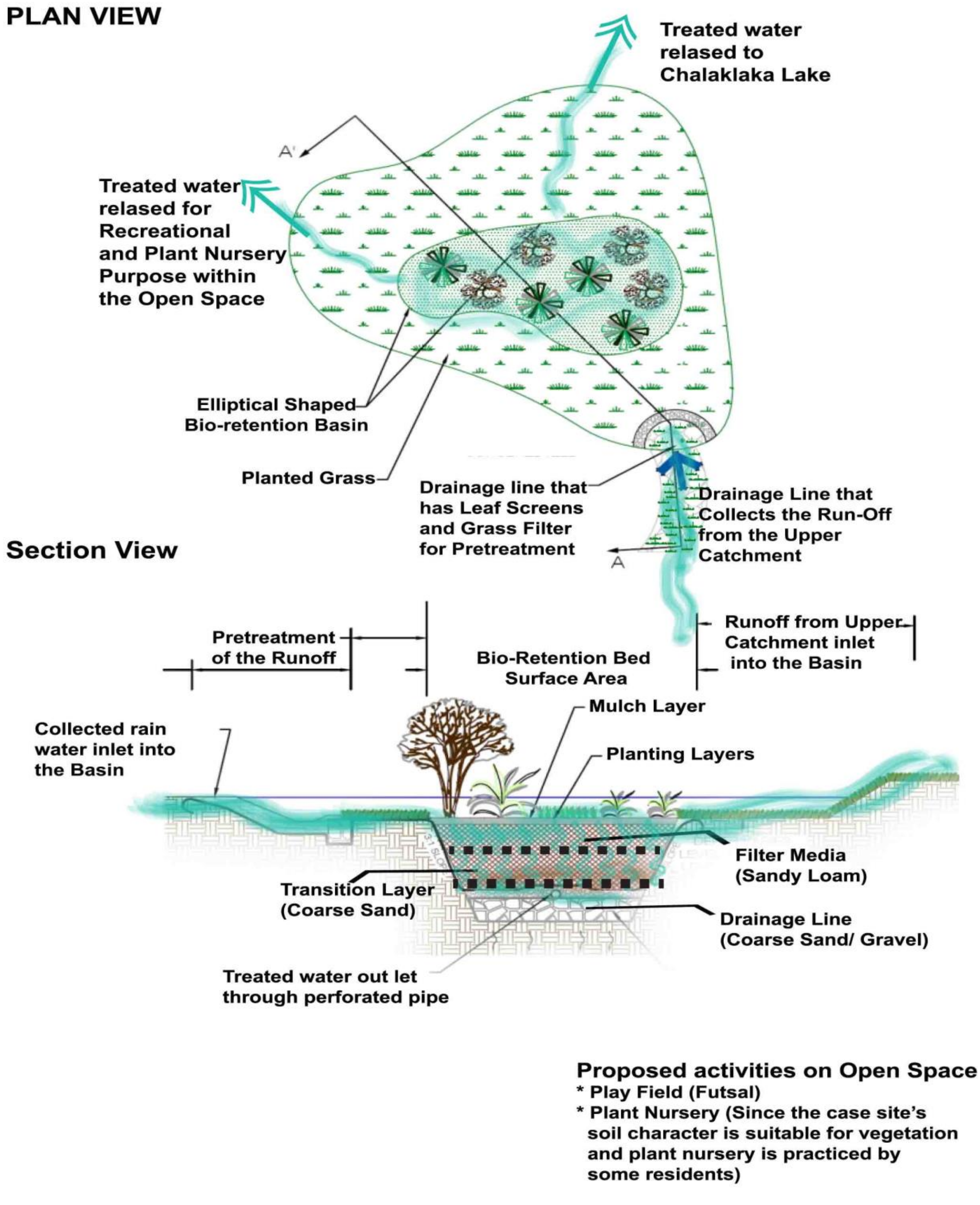

Figure 67. Proposed Bio-Retention Basin on the Open Space adjacent to Bishoftu Town Bus Terminal

(Source: Adapted from Review and research needs of bio-retention used for the treatment of urban storm water, 2014.)

4.4 Summary of Research Findings

Table 4. Summary of Research findings

No.	Causes of the Flash Flooding	Effects of the Flash Flooding
1.	Lack of drainage line on the local streets. ➢ Street networks that promote runoff.	Physical Infrastructure loss ➢ Washes of street pavements like cobble stone. ➢ Demolishes existing drainage lines. ➢ Loss of electric power.
2.	Poor construction of drainage lines. ➢ Dead end drainage networks. ➢ Incompatible connection of drainage lines. ➢ Drainage lines constructed against the slope. ➢ Impermeable drainage lines.	Destruction of housing units. ➢ Cracking down of walls. ➢ Cracking of housing unit floors.
3.	Clogged drainage lines ➢ Drainage lines stuffed with solid waste (Plastic bags, Plastic bottles, and other non-degradable wastes). ➢ Sedimentation of soil from the quarry area inside the drainage lines.	Household equipment loss. ➢ Destroyed valuable documents of household heads. ➢ Ruined food items. ➢ Destroyed household furniture like table, chair, and couch. ➢ Loss of electronics items such as refrigerator, television and some expensive machinery of Alema farm.
4.	Encroachment of fragile ecosystem.	Loss of Pet animals.

	➢ Presence of the operational red ash quarry. ➢ Deforestation on the mountainous areas. ➢ Developments on the natural waterways	➢ Alema Farm has lost over 10,000 chickens per one flash incidents in 2005 G.C.
5.	Topographic location of the site. ➢ 60.57% of the study area coverage lies between 0-5% slope percent. (Enhances water inundation). ➢ 9.83% of the study area coverage lies between >12.1% slope percent. (Promotes Runoff)	Health-related effects. ➢ Since floors of individuals do not dry up the moister creates a pungent smell that is making them vulnerable to different kinds of respiratory-related illnesses. ➢ The flashflood sometimes makes septic tanks burst into the streets and individual compounds. Hence, food items found in individual housing gets contaminated. As a result, people are exposed to different kinds of illness.
6.	Lack of proper attention by the local government. ➢ Clearing of the drainage lines is employed once a year before the rainy season starts. Which makes it difficult for the employees to clear out everything. ➢ Construction of cobblestone paved streets without provision of proper drainage line.	Socio-economic loss. ➢ Loss of money for recovery from the flooding. ➢ Effect on their day to day activities for instance if the flooding occurred during the morning times residents will face hard time passing through, which affects their work. ➢ Neighbors argument with each other regarding letting water pass through their compound or adjacent to their compound

	➢ No restrictions are taken regarding the quarry site.	
Local Coping Strategies Of The Study Area		
No.	**Preventive Strategies**	**Impact-minimizing Strategies**
1.	Evacuation from their houses whenever the rainy season begins. ➢ Renting houses outside of the study area for the time being. ➢ Residing along with relatives until the rainy season is over.	Making sandbags. ➢ Residents use polypropylene bags or fiber bags to fill sand or soil in order to block the flooding enter into their compounds and houses.
2.	Moving to higher ground. ➢ Some particular residents, when the flooding level starting to rise they usually move on elevated grounds like compacted sand, furniture, and any other objects height more than the water level.	Diverging Waterways ➢ Residents try to divert the water into other areas so that it does not affect their area. ➢ Diverge the runoff coming via the street networks into existing drainage line.
3.		Residents gathering together and clearing out clogged Drainage.
4.		Constructing retaining wall ➢ Residents with good income construct retaining wall made of hollow blocks with height up to 60 cm above the ground. Which

		demolished every year after the rainy season is over.
5.		Compaction of soil and other selected materials on the edges of entrances. ➢ Residents who were not able to afford construction of retaining wall, usually compact their entrance and fence areas with soil and other selected materials.
6.		Construction of hole to trap the flood water. ➢ Residents with good income construct hole with a size 2m by 3m with 3-5m depth that is covered and only has one inlet to trap the flood that enters their compound.
7.		The rebuilding of housing units with elevated foundations from the ground level.

Chapter Five: Conclusion and Recommendation

5.1 Conclusion

The main aim of this study was to design for flood resilient neighborhood for those who are affected by the flash flood. On this ground, the study intended to look at, in-depth regarding the major causing factors and effects of the flood in the neighborhood. Identifying and mapping flood-prone areas within the study area. In addition, understanding the local knowledge of coping strategies within the study area. To achieve the above-mentioned objectives data were gathered through the house to house questionnaire, key informant interview, interview guide and field observation. In this subsection, the main findings of this research as per the intended research objectives are summarized and concluding remarks are presented.

It was investigated from the analysis that major causes of the flashflood are poor construction of street pavements which promotes runoff, lack of drainage line on the local street of the case site, poor drainage line, drainage line stuffed with garbage/ soil sedimentation, topographic location of built houses (slope percentage between 0-2% and houses built on the natural waterway), new developments, the quarry site, and lack of vegetation.

As a result of the flash flood, the residents of the area are exposed to different effects. The study categorized the effects into three types of phases such as primary, secondary and tertiary or long-term effects. The primary effects of the flood in the case site are damage on the physical infrastructures, destroyed housing units, loss of household equipment's, loss of pets (chickens in Alma Farms) and loss of heavy machinery. The secondary effects in the area are residents especially the ones whom flood enters their housing units are exposed to different health-related problems due to the flood does not dry for some time and it creates pungent smell as explained by the residents even the flood water is very polluted before it reaches their premises. The long-term effect on site analyzed are, the residents are exposed to unexpected expenditure for maintenance of damaged properties.

The residents of the area use different kinds of coping strategies as it was classified in to preventive and impact minimizing strategies. As preventive strategies, some residents in the area usually evacuate from their houses before the rainy season starts while some move to elevated grounds or objects until the flood washes of from their vicinity. On the other hand most of the residents in the area use different kinds of impact minimizing strategies such as diverging waterway, making sandbags (flood inundated street sides, walls and entrance gates), constructing retaining wall along the entrances of the houses and main gates, rebuild housing units with elevated foundation and compacting entrance areas with soil or other selected materials. According to the majority of the residents believe that their coping strategies are not as effective as they expect them to be. In addition, each year on the rainy season the rebuild the above-mentioned strategies due to the materials used are not long-lasting.

Finally, the study identified that the existing poor drainage lines found in some parts of the case site, lack of drainage line, poor construction of street materials, the quarry site, waste management, deteriorating housing units and local coping strategies should be the intervention priorities in order to bring flood resilient neighborhood.

5.2 Recommendation

Based on the findings in the above chapters, the study has forwarded the following recommendations that need the involvement of various stakeholders from the residents of the case site, Kebelle 02 administration, municipality of Bishoftu town and other non-governmental organizations:

- Flood Disaster reduction policies and measures to be formulated at individual level, street level, neighborhood level. The Policy should strengthen societies and prevent any development that can increase vulnerability to the hazard.
- The municipality of the town should force to stop or restrict the quarry operation and engage the communities and other stakeholders to rehabilitate quarry.
- Green cover and vegetation density increasing especially on the bare lands found on the mountains need to be encouraged among the residents of the case site and outside the case site areas that should protect or minimize the flood impacts.
- The municipality and the specific study area Kebelle should provide appropriate waste collection strategies. In addition, it is very essential to create awareness to the community by introducing sustainable solid waste management (SSWM). However further studies should be made regarding solid waste management system of the town in general.
- During new housing construction, living spaces should be raised above flood level by concrete structure in order to avoid flood water entering the housing units.

- Encouraging the concept sustainable drainage systems (SUDS), which can control the quantity and rate of run-off from a development, improve the quality of the run-off, enhance the nature conservation, landscape and amenity value of the site and its surroundings, while enhancing the water way connection to the two existing lakes (Lake Bishoftu and Lake Chalaklaka). In addition, Maintenance and seasonal cleaning of these systems has a vital role due to the fact that drainage line blockages enhances flooding.
- Flood preparedness plan is essential due to the study has revealed that at least once a year the case site is affected by the flash flood. Hence, it is important that responsible government bodies and non-governmental bodies to raise public awareness regarding what to do before the flood occurs, during and after. Likewise, provide proper training and equipment for managing future floods in the study area will minimize the impact.
- Reintroducing permeable streets in order to minimize the runoff. Since permeable streets are constructed, sunken the road (Making a road lower than its surroundings increases its water capture and drainage capacity).
- Construction of dams should be considered to trap the excess storm water runoff coming from the upper catchment. Which can be used for urban agriculture and other types of recreational activities.
- Introducing retention and infiltration basins. They are open, usually flat, areas of grass that are normally dry. In heavy rainfall, they are used to store water for a short time and so they fill with water. They are often multiuse, for example, they can double as play areas. Likewise, in the case site, the open space found adjacent to the bus terminal where there is a high accumulation of water can be redone as retention and infiltration basins.
- The resident's local coping strategies should be supported by scientific strategies to build flood resilient neighborhood. In the long term, since flash flood is unpredictable, an early warning system for flash flood and flood forecasting system should be developed.

References

Ahsan , S. M. (2013) *Resilient Cities for the Poor or by the Poor? , A Case Study from Bangkok .* Berlin.

Alhassan, H. T. (2015) *The Impact of Flooding on Social Services in the Tamale Metropolis of Ghana.* Kumasi, Ghana: Kwame Nkrumah University of Science and Technology.

Ashley, R., Rijke, J., Gersonius, B., & Sakic, R. (2016) *Adaptation mainstreaming for achieving flood resilience in cities .* Melbourne: Cooperative Research Centre for Water Sensitive Cities Level 1, 8 Scenic Blvd, Clayton Campus Monash University Clayton, VIC 3800 .

Bekele , R. (2014) *Agrobiodiversity in the Homegardens of Bishoftu Town, Oromia National Regional State, Ethiopia .* Addis Ababa: Addis Ababa University.

Bertilsson , L., & Wiklund , K. (2015) *Urban Flood Resilience: A case study on how to integrate flood resilience in urban planning. .* Lund: Department of Building & Environmental Technology, Lund University .

Bloch , R., Jha, A. K., & Lamond, J. (2011) *Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century.* Washington DC: World Bank.

Bosher, L., & Dainty, A. (2011) *Disaster risk reduction and 'built-in'resilience: towards overarching principles for construction practice.*

CRED. (2014) *The Human Cost Of Natural Disasters.* Brussels, Belgium.

Davis, A. P., Hunt, W. F., Traver, R. G., & Clar, M. (2009) *Bioretention technology: Overview of current practice and future needs.*

Deressa, T. T. (2010) *Factors affecting the choices of coping strategies for climate extremes: the case of farmers in the Nile Basin of Ethiopia.* Pretoria: University of Pretoria .

Dewi , A. (2007) *Community-Based Analysis Of Coping With Urban Flooding : A Case Study In Semarang, Indonesia .* Netherland: International Institute For Geo-Information Science And Earth Observation Enschede, Netherlands .

Dey, B., & Singh, R. (2006) *Natural Hazards & Disaster Managment* (1st ed.). Delhi: The Secretary, Central Board of Secondary Education, 2, Community Centre, Preet Vihar, Delhi-110092.

Doswell III, C. A. (2003) Flooding. In *Severe Convective Storms* (pp. 769-776). Oklahoma: Elsevier Science Ltd.

Ehlert, J. (2007) *Local and Global Knowledge on Flood Management ; How Can Local Knowledge Contribute to Resilience in the Mekong Delta, Vietnam?* Bonn, Germany: Bonn International Graduate School for Development Research.

Eleni, H. G. (2011) *Coping Strategies of Displaced Flood Victms: The Case of Dire Dawa.* Addis Ababa: Addis Ababa University.

Feyissa, A. (2009) *Structure Plan of Bishoftu Town: Geology.* Addis Ababa: Oromia Urban Planning Institute.

Gautam , K. P., & van der Hoek , E. E. (2003) *Literature Study on Environmental Impact of Floods .* Keverling Buismanweg: Delft Cluster.

Gezahegn, A. (2009) *Structure Plan Of Bishoftu Town: Executive Summary Report.* Addis Ababa: Oromia National Regional Government In Colaboration With Federal Urban Planning Coordinating Bureau.

Grabs, W. E. (2010) *"Regional Flash Flood Guidance and Early Warning System." In WMO Training for Trainers, Workshop on Integrated Approach to Flash Flood and Flood Risk Management.* Nepal.

Gravin, S. (2014) *A Future Flood Resilient Built Environment.* England.

Gromulat , M., & Acevedo , S. (2016) *Resiliency Planning for Neighborhoods: Principles, Indicators, and Cases.* Chennai: Bravic Works Press.

Gromulat , Martin ; Acevedo, Shannon. (2016) *Resiliency Planning for Neighborhoods: Principles, Indicators, and Cases.*

Groot, D., Rudolf , R. S., Matthew, A., & Boumans, R. M. (2002) *A typology for the classification, description and valuation of ecosystem functions, goods and services.*

Gudina, T. (2009) *Structure Plan of Bishoftu Town: History of Bishoftu Town.* Addis Ababa: Oromia Urban Planning Institute.

Hagos, A., & Chuta, N. (2009) *Structure Plan of Bishoftu Town, Demographic Profile, Utilities and Social Services Final Report.* Addis Ababa: Oromia Urban Planning Institute.

Hill, C., Verjee, F., & Barrett, C. (2010) *Flash Flood Early Warning System Reference Guide .* USA: University Corporation for Atmospheric Research: Boulder.

Jinxing, Z., Yan, W., & Yijun, L. (2004) *A Review of an Early Warning Technique of Flash Flood and Debris Flow Disaster. In ISCO 13th International Soil Conservation Organization Conf.* Brisbane.

Jha, A.K., Bloch, R. and Lamond, J. (2012) *Cities and Flooding, A Guide to Integrated Urban Flood Risk Management for the 21st Century.* Whashington D.C: The World Bank.

Karin , B. (2005) *Resilience and Flood Risk Management: A Systems Approach Applied to Lowland Rivers.* Netherlands: Delft University Press.

Kebede , B. (2012) *Application of GIS and Remote Sensing Techniques for Flood Hazard and Risk Assessment: The Case of Dugeda Bora Woreda of Oromiya Regional State, Ethiopia.* Addis Ababa: Addis Ababa University.

Kebede, B. (2012) *Application of GIS and Remote Sensing Techniques for Flood Hazard and Risk Assessment: The Case of Dugeda Bora Woreda of Oromiya Regional State, Ethiopia.* Addis Ababa: Addis Ababa University .

Kebede, B. (2012) *Application of GIS and Remote Sensing Techniques for Flood Hazard and Risk Assessment: The Case of Dugeda Bora Woreda of Oromiya Regional State, Ethiopia.* addis ababa.

Kebede, H. (2009) *Structure Plan of Bishoftu Town.* Addis Ababa: OROMIA URBAN PLANNING INSTITUTE.

Kothari, C. (2004) *Research Methodology: Methods and Technigues* (2 ed.). New Delhi: New Age International Ltd Publishers.

Liu, J., D, J., Bell, C., & Guan, Y. (2014) *Review and research needs of bioretention used for the treatment of urban stormwater.*

Mandych , A. F. (2002) Natural Disasters – Vol.II. In *Classification of Floods* (pp. 63-88). Encyclopedia of Life Support Systems.

Moen, W. B. (2009) *Support to Domestic Incidents under the Stafford Act.* usa.

Mowbray, D. (2011) *Resilience and strengthening resilience in individuals.* UK.

OPW. (2009) *The Planning System and Flood Risk Management.* Ireland: The Office of Public Works.

OPW. (2009) *The Planning System and Flood Risk Management.* Ireland: The Office of Public Works.

OUPI. (2009) *Bishoftu Structure Plan.* Oromia Urban Planning Institute.

Pavlova , V. (2016) *Strategies For City Resilience To Riverine Floods. Case Of Mzimbazi River, Dar Es Salaam.* Milan: Politecnico Di Milano.

Prinos , P. (2008) *Review of Flood Hazard Mapping .* UK: HR Wallingford Pltd.

Rabalao , R. T. (2010) *The Social, Psychological and Economic Impact of Flooding in Ga-motla and Ga-moeka Communities of Moretele District in North West province, South Africa.* Bloemfontein: University of the Free State .

Restemeyer, B., Woltjer, J., & Brink, M. v. (2015) *A strategy-based framework for assessing the flood resilience of cities – a Hamburg case study.* Groningen: Department of Spatial Planning and Environment, University of Groningen.

Sayers, P., Yuanyuan, L., Penning-Rowsell, E., Fuxin, S., Kang, W., Yiwei , C., & Quesne, T. L. (2013) *Flood Risk Management: A Strategic Approch.* Asian Development Bank, GIWP, UNESCO, and WWF-UK.

School of MBA. (2017, April 10) *MBASKOOL.com*. Retrieved from http://www.mbaskool.com/business-concepts/statistics/16676-purposive-sample.html

Sene, K. (2013) *Flash Floods; Forecasting and Warning.* London: Springer Science+Business Media Dordrecht.

Twigger. (2005) *The impact of flooding on urban and rural communities.*

UNDP. (2004) *Reducing Disaster Risk: A Challenge For Development.* New York.

UNISDR. (2012) *Making Cities Resilient Report 2012 .*

Vink, K. (2014) *Vulnerable People and Flood Risk Management Policies.* Tokyo, Japan: Submitted in Partial Fulfillment of the Requirement For the Doctor of Philosophy Degree in Disaster Management.

WHO. (2006) *Risk reduction and emergency preparedness: WHO six-year strategy for the health sector and community capacity development.* Geneva: WHO Document Production Services, Geneva, Switzerland .

WMO. (2011) *Manual on Flood Forecasting and Warning.* Geneva: World Meteorological Organization.

World Bank. (2014) *Striving Toward Disaster Resilient Development in Sub-Saharan Africa.* Whashington D.C: World Bank Group.

Zogg, J., & Deitsch, K. (2013) *The Flash Flood Potential Index at WFO Des Moines, Iowa .* Iowa : National Oceanic & Atmospheric .

Zurich Insurance Group. (2014) *Enhancing community flood resilience: a way forward.* Zurich: Zurich Insurance Company Ltd.

Annex-1

House to house questionnaire

Dear respondents,

I am a post graduate student at EiABC, Addis Ababa University in the chair of Environmental Planning and Landscape Design. I am conducting research Design for Flood Resilient Neighborhood in Bishoftu Town: The case of Keblle 02 in partial fulfillment of the requirements for the completion of Master of Science Program. Thus, this questionnaire is designed to collect information on causes and effects of the flash flood and understanding the local coping strategies. Since the information you provided is highly valuable to the success of the study, you are kindly requested to give your genuine responses for the following questions. The information you give will not be used for any purpose other than the achievement of the objectives of this research.

Research Information

Research Title: Design for Flood Resilient Neighborhood in Bishoftu Town: The Case of Kebelle 02

University: Ethiopian institute of Architecture Building Construction and City Development /EiABC/, Addis Ababa University south campus.

Chair: Environmental Planning and Landscape Design.

Prepared By: Biruk Tilahun

Supervised By: Dr. Hailu Worku (Associate Professor)

Part I: General profile

Name ______________________________ House No_________________________

Position in the household head: ☐ Male house hold ☐ Female house hold

No of people living within your house_____________

Education level of household head

☐ Below matriculation ☐ Basic reading and Writing ☐ Elementary ☐ High school
☐ TVET ☐ Preparatory ☐ University, colleges

Occupation

☐ Public sector ☐ Private Sector ☐ Own business ☐ Retired ☐ Others ______________

Part II: Background of the Residents

1. How long have you lived at or occupied the property?

A. > 1 year B. 1- 5 years. C. 5- 10 years D. 10 – 20 years E. <20 years

2. Please indicate the type of property?

A. Residential house B. Mixed use (Residence + Commerce) C. Commercial D. School
E. Other__________________________

3. Have you witnessed or been affected by flooding?

A. Yes B. No

4. If yes which areas were affected by the flooding? (NB: you can choose more than one)

☐ Inside the residence/ other type of property
☐ Compound of the residence
☐ The street
☐ Playground/ open space
☐ Drainage line
☐ Other____________________________________

5. How often are you affected by the flood?

A. Every Month B. Every 6 Month C. Every 12 months D. Every other Year
E.Other____

6. Do you know where the flooding came from? (NB: you can choose more than one)

☐ Yes ☐ No

If yes?

- ☐ From the overflow of drainage line
- ☐ Runoff from the street
- ☐ Runoff from the mountain
- ☐ Over flow of the lake, if so which lake______________?
- ☐ Runoff from the neighbor's gutter during rain
- ☐ Others ____

7. If the flooding entered your premises, please indicate where it entered from.

A. Front Side B. Left Side C. Right Side D. Back Side

8. In your opinion, what are the major driving factors of the flood in your area? (NB: you can choose more than one)

A. Lack of drainage system

B. Poor drainage system/ drainage line stuffed with garbage

C. Because of the quarry site near my property

D. Lack of Vegetation on the mountain

E. Topographic Location of my property.

F. Development of housing and blockage of the natural drainage or water way

G. Others____

9. Just before the flood, how did you first become aware that flooding might reach your home? (NB: you can choose more than one)

☐ Siren

☐ Loud Speaker

☐ Rain fall intensity

☐ Sound of the runoff from the upper catchment

☐ Neighbors calling each other

☐ Others ________________

10. Did the flood in the past years has ever cost you someone's life?☐ Yes ☐ No

If yes, please specify when was it? ____________________________________ ______________________________

11. In your Opinion, how much worth of property was destroyed throughout your tenancy?

A. 500-1000 birr B. 1000-2000 birr C.2000-4000 birr D. 4000-1000 birr E. > 10,000 birr F. None G. Don't know how much worth

Please specify the properties Destroyed_________________________________ ____ ____

Part III: Coping Strategies of the Residents

12. Is there any sign or alarm before the flood comes to your neighborhood? ☐Yes ☐ No

If yes, Please specify____ ____

13. Is there any help that has been done from the government and/or non- governmental institution side to prevent the flood before happening, during and afte☐ Yes ☐ No

If yes, Please specify,

Before (Prepare and Prevent)

____ ____

During (Coping)

____ ____

After (Recover)

____ ____________________

14. Is there any type of strategy from your side that has been done to prevent the flood before happening, during and afte☐ Yes ☐ No

If yes, Please specify,

(Prepare and Prevent)

____
____

During (Coping)

____
____

After (Recover)

____
____

In your opinion, is your coping strategy effective? ☐ Yes ☐ No

Please specify the reason for the above question NO. 13? _______________________
____
____

15. Which coping method you usually use when flood occurs? (NB: you can choose more than one)

A. Moving to higher ground

B. Filling sand in bags and placing around the edges of our premises

C. Evacuate from the premises

D. Diverging the water way to other parts

E. Others_______________________

Part IV: Flood History, Causes and Effects of the Study area

16. Please indicate when and where flooding occurred and tick as appropriate. List all dates you can remember, if you can only recall the month and year leave the day blank.

No	Flood incident Date			Flood location						Rain intensity				Property Loss				Loss of life	Loss of life in No.
	DD	MM	YY	Inside the house	Compound of the property	The street	Playground/open space	Drainage line	Others	Heavy rain	Medium rain	Small rain	No rain	High	Medium	Low	Non		
1																			
2																			
3																			
4																			
5																			
6																			
7																			
8																			

17. In your opinion, what improvements should be done in your area to prevent the flood happening?

____

____

____

18. Can you Elaborate or mention the effects the flood has on you and others?

A. Physical Infrastructure Loss (Damage the Street, Drainage, Electric and Others)

B. Destroyed My House

C. Destroyed house hold Equipment's

D. Human Life Loss

E. Pet Animal Life Loss

F. Health Effects

G. Others_________________

H. None

Annex-2

Key Informant Interview

Name of the respondent ____________________

Age________________ SEX_____________ Occupation _____________

How long have you lived in the area? __________________

1. Have you been a victim of flooding?
2. If yes, in your opinion, what were the major causes of the flooding occurred in your area?
3. What are the effects that the flooding has in your neighborhood? The social effect? Economical? Environmental effects?
4. What are the coping strategies you use from your side to protect your selves from the flash flood?
5. Is there any help or measures taken from governmental and/or non-governmental institutions to prevent the flood before happing, during and after?
6. In your opinion, what improvements should be made to prevent flooding before affecting your living area?

Key Informant Interviewee Profile

Interviewee Id	Name	Gender	Age	Tenancy in years	Occupation
01	Ato. Aklilu Wondimu	M	43	15	Merchant
02	Ato. Yonas Haile	M	38	12	Driver
03	Wro. Shewaye Kotu	F	58	25	Government Office
04	Ato Birhanu Girma	M	64	23	Director Of Birhu Tesfa Elementary School
05	Wro. Senait Alemu	F	45	13	Teacher

Annex-3

Interview Guide (For concerned city authority)

Name of the Officer: ____________________________

Position: _____________________________

Name of the Institution: ____________________

1. Is flood considered as one of the main challenges of Bishoftu Town? Why?

   ____
   ____

2. Why Flood happens in Bishoftu Town, Kebelle 02?

   ____
   ____

3. What is the plan for responding to flood?

   ____
   ____

4. Who is responsible for managing Flood (which institution)?

   ____
   ____
   ____

5. Is there any help that has been done from the government side to prevent the flood before happening, during and after ☐ Yes ☐ No

   If yes Please specify,

   Before (Prepare and Prevent)

   ____
   ____
   ____

During (Coping)

____

After (Recover)

____

6. How are the Kebelle 02 dwellers supported either by your institution or others during flood?

____

7. What are the ongoing flood protection and drainage improvement projects?

____

8. If there are any Projects ongoing or considered, how the interests of Keblle 02 flood affected dwellers are considered in those projects?

____

9. How the Kebelle 02 dwellers are involved in project planning and implementation?

____

Interview Guide Interviewee Profile

Interviewee Id	Name	Gender	Designation
1.1	Ato. Shembel Debebe	M	Social Service officer of Kebelle 02
1.2	Ato Aschalew Hailu	M	Head Of Environmental Protection Bureau Of Bishoftu Town Municipality

Annex-4

Focus Group Discussion Guide

1) Have you been a victim of flooding?

____

2) If yes, in your opinion, what were the major causes of the flooding occurred in your area?

____

____

____

3) What are the effects that the flooding has in your neighborhood? The social effect? Economical? Environmental effects?

____

____

____

4) What are the coping strategies you use from your side to protect your selves from the flash flood?

____

____

____

5) Is there any help or measures taken from governmental and/or non-governmental institutions to prevent the flood before happing, during and after?

____

____

6) In your opinion, what improvements should be made to prevent flooding before affecting your living area?

____

____

7) Which areas of your neighborhood are affected by flash flood? Please try to sketch the ways of the flood coming from on the Kebelle 02 base map provided.
8) Please show the intensity of the flooding in your specific district by hatching.

A. Very High B. High C. Medium D. Low

Attendance Sheet of the FGD Participant

ተራ ቁጥር	ስም	የየትኛው ጎጥ ተጠሪ	ፊርማ	ስልክ ቁጥር
1	ማርማ፡ ሌገሠ	ጎጥ 07		0912235157
2	በለጡ፡ ጎንደር	ጎጥ 09		0910749804
3	ደሳለኝ፡ ዘለቀ	ጎጥ 07.		0933314749
4	ገብረስላሴ ዘውዴ	ጎጥ 8		0913120052
5	እጠገበት ማርቆስ	ጎጥ 19		0910279396
6	ጳንጼ ተፈሪ	ጎጥ 06		0912235106
7	በከጠ ገብሬ	ጎጥ 03		0910243475