JIMMA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
JIMMA INSTITUTE OF TECHNOLOGY
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
HYDROLOGY AND HYDRAULIC ENGINEERING

FLOOD HAZARD ASSESSMENT AND ITS IMPACTS ON PEOPLE LIVING DOWNSTREAM BY USING GIS (CASE OF BARO AKOBO RIVER, JEKOW DISTRICT, GAMBELLA, ETHIOPIA)

A Thesis Paper submitted to the School of Graduate Studies, Jimma University, Jimma Institute of Technology, Faculty of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree Masters of Science in Hydraulic Engineering.

by

Jiech Bol Zuor

January, 2021

Jimma, Ethiopia

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Co-Advisor: Mr.Tadele Shifarew (MSc)

Main Advisor: Dr. Dawud Temam (PhD)

January, 2021

Jimma, Ethiopia

DECLARATION

I hereby declared that, the research work entitled "*Flood Hazard Assessment and its Impacts on People living Downstream by using GIS* in Case of Baro-Akobo River, Jekow District, Gambella, Ethiopia" is my own work that I submitted for partial fulfillment of the degree of Master of Science in Hydraulic Engineering to Jimma University, School of Graduate Studies, Jimma Institute of Technology, Faculty of Civil and Environmental Engineering, and Hydrology and Hydraulic Engineering Chair.

Jiech Bol Zuor	_______________	____/____/______
(Candidate)	Signature	Date

As research Adviser, I hereby certify that I have read and evaluated this thesis paper prepared under my guidance, by Dr. Dawd Temam and Mr. Tadele Shifarew entitled "FLOOD HAZARD ASSESSMENT AND ITS IMPACTS ON PEOPLE LIVING DOWNSTREAM BY USING GIS IN CASE OF BARO-AKOBO RIVER, JEKOW DISTRICT, GAMBELLA, ETHIOPIA" and recommend and would be accepted as a fulfilling requirement for the Degree Master of Science in Hydraulic Engineering

Dr.Dawud Temam (PhD)	_____________	_____/_____/______
(Main Advisor)	Signature	Date
Mr. Tadele Shifarew (MSc)	______________	_____/_____/______
(Co-Advisor)	Signature	Date

APPROVAL PAGE

This is to certify that, the thesis paper prepared by Mr. Jiech Bol Zuor entitled **"FLOOD HAZARD ASSESSMENT AND ITS IMPACTS ON PEOPLE LIVING DOWNSTREAM BY USING GIS (CASE OF BARO AKOBO RIVER, JEKOW DISTRICT, GAMBELLA, ETHIOPIA)"** and submitted as Partial fulfillment for the award of the Degree of Master of Science in Hydraulic Engineering complies with the regulations of the University and meets the acceptance standards concerning originality, content, and quality.

Approved by Board of Examiners

External Examiner	Signature	Date
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ABSTRACT

Flood is one among major problems faced in the Jekow district as it has a devastating effects on households, crops damage, loss of livestock and destruction of other properties. Naturally, flood is a potentially damaging physical event, phenomenon or human properties, cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation. The recent flood impact has displaced many people in the district. The purpose of this study is to assess the flood hazard areas and its impacts on the people living downstream of the Baro river in Jekow district by using Geographic Information System (GIS) tool. From this study, GIS tools of this study used to determine the areas affected by floods due to the high water level in a river caused by the heavy rainfall in the Ethiopia highland. In addition to this, Meteorological data such as temperature data and rainfall data obtained from National Meteorological Service Agency and the digital elevation model (DEM) of the catchment area extracted from the country Digital Elevation Model. Furthermore, frequent field observation also used together with the Global Positioning System readings to generate primary information such as the Jekow river coordinates. Software that have been used in this study is the Arc Hydro 10 software that works as extension on ArcGIS 10.4.1. It has been used for the delineation of the watershed, flood factors generation such as elevation, slope, soil types, land use/cover, rainfall and drainage density maps for the development of the flood hazard map and Multi Criteria Decision Making (MCDM) called Analytical Hierarchy Process (AHP) has been also used for weighting coefficient calculation for the overlay of flood hazard map. Microsoft Excel used for some constructive tables. The study finding shows that, many parts of the district occupied by flood hazard but the areas which are the most suffering (very high) flood areas located in the south-west part of the district. The most suffering areas identified as, Mading, Banyrial and Kalkich kebeles. In addition to this, the study finding also found that, the main causes of the flood hazard in the district is the overflow of the Baro river that caused by the heavy rainfall from the Ethiopia's highland. Moreover, the most flood affected areas identified and its causes are known and the possible mitigation measures are not taken seriously for the control of the flood hazard. Overall, the lives of individuals living in flood-affected areas are at high risk due to a variety of causes, including the deterioration of the flood-prone area's food security status. The District Flood Task Force (Committee) should take their given responsibility seriously and actively.

Key Words: *Flood Hazard, Flood Mitigation, GIS, Impact, and Preparedness*

ACKNOWLEDGEMENT

First of all, I would like to give my special thanks to the Almighty God who cares, guides and leads me in all things I do and who made it possible since the beginning of this research work write-up to the successful completion of the research. Without his support and blessings, this piece of work could not be accomplished today and I know that everything is possible through him.

Secondly, I would like to express my deepest gratitude to my dear respected advisors Dr. Dawd Temam (PhD) and Mr. Tadele Shifarew (MSc) for their persistent, support, constructive ideas and guidance, and fruitful advices throughout the work. Without their constructive ideas and guidance, this piece of work could not be completed today.

Furthermore, I would also like to thank Jimma University staffs, particularly Jimma Institute of Technology for their support and contribution on my study. I warmly thank my best friend Mr Gatbel Chany who is always around me and giving encouraging words when I feel weak and exhausted but his inspirational words with his positive thoughts and experiences contributed a lot to my research work completion.

Last but not least, I would like to thank my wonderful family specially my brothers Duol Bol Zuor, Isaac Kak Yer and Pinygile Kun Tut, my sister Nyanhial Bol Zuor, my wife Nyakom Riek Bamuoch, and my two sons, Chieng Jiech Bol and Samuel Jiech Bol for their encouragement and unlimited support and giving valuable advices during my study and throughout my entire life.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

ABBREVIATIONS AND ACRONYMS

AHP:	Analytical Hierarchical Process
CI:	Consistency Index
CR:	Consistency Ratio
CRS:	Community Rating System
CSA:	Central Statistical Agency
CW:	Criteria Weight
DEM:	Digital Elevation Model
DMFSS:	Disaster Management and Flood Security Sector
DPPC:	Disaster Prevention and Preparedness Commission
DRM:	Disaster Risk Management
GIS:	Geographic Information System
GPRS:	Gambella People's Regional State
GPS:	Global Positioning System
HMA:	Hazard Mitigation Assistance
MCDM:	Multi Criteria Decision Making
MoWIE:	Ministry of Water, Irrigation and Electricity
NGO:	Non-Governmental Organization
NMA:	National Meteorological service Agency
NPDPM:	National Policy on Disaster Prevention and Preparedness Management
RI:	Random Index
RRC:	Relief and Rehabilitation Commission
WS:	Weighted Sum value

1. INTRODUCTION

1.1. Background of the Study

Natural disasters have claimed the lives of hundreds of thousands of people and caused billions of euros in damage and losses around the world in recent decades. Over two million people died as a result of natural disasters between 1974 and 2003 (Guha-Sapir *et al*., 2004). Floods are the leading source of mortality and property devastation around the world (CEOS, 2003).

Flood by definition is a potentially harmful physical event, phenomena, or human property that can result in the loss of life or injury, property destruction, social and economic disruption, or environmental degradation. The majority of natural streams and flush floods in Ethiopia begin in the highlands and travel until they reach the lowlands plain zones. Because of the steep slope and accompanying topographical configurations, enough energy is conveyed against flow resistance to shorten flood water concentration time. It floods a large region in a short period of time, resulting in significant loss of lives and property. Furthermore, the outbreak of pandemic aquatic infections has put the health of both urban and rural communities in danger. As a result of decreased of crop production it also causes physical damage, mental health difficulties, and starvation (Haile, 2013).

Floods generated by river overflows, flash floods in cities, and coastal floods in coastal areas are among the most severe natural dangers. Floods are one of the most hazardous natural risks to an area's growth. There are a variety of flood risk management techniques that can help to mitigate this devastation, and managing flood risks necessitates estimating flood threats and their potential consequences (Kourgialas, 2011).

Risk estimation is difficult and requires careful consideration of a number of factors, including watershed properties such as size, topography, and land use, storm types and characteristics that cause rainfall and flooding in the region, and the number, location, and types of buildings and other assets that may be damaged (Abaya *et al*., 2009).

Poorly conducted hazard and risk assessments can result in poor risk management decisions, ranging from inadequate protection to run through scarce resources on unnecessary protection. Flood hazard and risk assessments on the other hand, can give useful information for a variety of decisions, including land use master planning, infrastructure design, and emergency response planning (Gashaw, 2011).

Before doing a hazard assessment, it is crucial to determine which types of floods are the most prevalent or destructive in the area because the hazard and risk assessment methods used in most circumstances differ based on the type of flood. Injuries and deaths can result from failing to flee flooded areas or entering flood waters. Heavy rain, the most basic explanation for floods, overflowing rivers, broken dams, urban drainage basins, storm surges and tsunamis, lack of vegetation, and so on are some of the main causes of flooding. River flooding and flash flooding are the two most common types of flooding that are usually occurred. The Baro-Akobo basin, Awash river basin (lower, middle, and upper Awash sub-basins), Wabi Shebelle, Ribb, and Gumara area, and localized flooding risks such as Lake Awassa, Lake Besseka, and Dire dawa are among the areas commonly flooded annually. When a body of water exceeds its capacity, the river flooding has occurred and this type of flooding is one of the most prevalent types of inland flood (Gashaw, 2007)

Floods in rivers pose a major hazard to millions of people who live along the river's bank. Floods can be such severe natural calamities that they can harm anyone living downstream at nearly any time. Flood hazards can be divided into primary hazards that occur as a result of contact with water and secondary effects that occur as a result of flooding such as disruption of services, contamination of drinking water supplies, especially if sewerage treatment plants are flooded, health impacts such as famine and disease, and tertiary effects such as changes in the position of river channels have occurred. This problem is most commonly faced by people and livestock commonly settled on flood plains in Ethiopia's Awash and Baro river basins. Water is readily available and the resulting moist soil is rich enough to support agriculture in these places (ABAYA, 2008)

Thousands of lives and property have been lost as a result of flooding in these places in recent years. As a result of climate change, the intensity of flood impacts may worsen in the future. Climate change present itself in many locations not only as a gradual change in the average circumstances, but also as a change in the frequency and intensity of extreme occurrences (Haile, 2013).

In Ethiopia, the rainy season occurs primarily between June and September, when around 80% of the rain falls. In most parts of the country, torrential rainfalls are common. Because the country's landscape is rocky, with clearly defined watercourses, large-scale flooding is common, especially in low-lying locations where major rivers flow into neighboring countries (Daniel, 2007).

The Gambella People's Regional State (GPRS), which is located in the western part of Ethiopia is one of the Ethiopian regional states that has experienced severe flooding with the downstream area of the region being the most affected. Due to continued heavy rains in Ethiopia's central highlands, the Gilo, Baro, and Akobo rivers begin to overflow in June, posing a flood risk. Flooding has much effects on the areas along the Baro rivers, particularly in the districts of Itang, Jikow, Makuey, and Wanthoa (Mayual, 2018).

Floods have long been identified as having complicated and multiple consequences. Financial damage to property, loss of livestock, agricultural effects such as crop damage, disruption of communications, public infrastructure damage, and business losses have all been major issues in Jekow district in recent years (Mayual, 2018).

Makuey and Wanthoa districts which are located between the Baro and the Alwero rivers or Makuey river are both affected by flood hazard to varying degrees at different times during the flood, but when compared to the flood hazard in Jekow district which is located on the river bank, Jekow district is more affected than Makuey and Wanthoa districts. During the heavy rainy season, the Akobo and Gilo rivers/ Pibor rivers flooded to Gog, Jor, and Akobo districts (Mayual, 2016).

Thousands of people have been uprooted and their homes have been abandoned as a result of the torrential rain that has flooded the Baro river with water. The flood waters have driven snakes to leave their holes (homes) due to the water entering the hole and people have died as a result of snake bites when they fled their homes in search of a dry place already occupied by the snakes. When children who have never learned to swim attempted to cross the Jikawo river to play with their friends on the other side of the river during the flood, they drowned. Agricultural, property destruction, and economic effects are all the challenges caused by floods that occurred on an annual basis with little warning (Haile, 2013).

The Baro–Akobo river basin in southwestern Ethiopia has abundant freshwater resources, according to (Woube, 2005). The government began resettlement initiatives in the region in 1984, anticipating that the fertile soil and plentiful water resources would be used.

Field studies and hydrological observations conducted in 1986, 1988, 1991, 1994, and 1996 to explore the causes of post-resettlement floods and their consequences on natural resources, agricultural land, and human settlements. Agriculture, including cultivated and grazing land, as well as human settlements, have been reported to be impacted by unfavorable floods. Abnormal floods in the area caused by two natural factors: overflow of river banks beyond regularly inundated zones and rainfall storms, as well as human involvement within the catchment due to a lack of effective land use planning (Wakuma, 2009)

1.2. The Statement of the Problem

Flood began threating the lives of people in the world since people began dwelling on the river bank for the searching of food. The overflow of the river caused a lot of destruction on people lives, properties and others. As humans began to develop farms and communities in the floodplains of streams and rivers, floods became a threat (Fattorelli, 1999).

According to the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA), the floods of 2006 affected 357,000 people across Ethiopia, with 136,528 forced to flee their homes. By paving the earth and constructing stream channels, they not only exposed their lives and properties to the devastation of floods, but it is also a worsened flood. Continuing to decrease natural floodplains has resulted in significant annual losses of both wealth and human life.

Flood hazards account for a large proportion of the most severe natural disasters in the Gambella region, particularly in the downstream part of the region such as Jekow district in terms of losing soil by eroding large amounts of fast flowing water, ruining crops, destroying agricultural land and government infrastructures such as schools, hospitals, and health centers, drowning farm animals, and loss of lives and associated damages to people properties (Mayual, 2018)

Water from Ethiopian highlands causes river water to swell in Jekow district, allowing water from various sources to flood away into some portions of the district due to the area's long rainy season and heavy rainfall. The major perennial rivers as well as their numerous tributaries that compose the areas drainage systems have their highest discharges during the rainy season (June-

September). Many people have been forced from their homes as a result of the recent flood, which has caused agricultural damage, livestock loss, and other property harm (Haile, 2013).

Furthermore, the primary impacts of floods such as those who come into direct contact with flood waters or when water entering human built structures cause serious problems. Humans caught in high-velocity floodwaters are frequently drowned and lose their lives. Flood waters can transport rubbish, debris, and harmful chemical contaminants into drinking water supply systems and posing a secondary impact to human health.

As a result of all these problems identified, the researcher become so pity to conduct the research in this study area entitled flood hazard assessment and its impacts on the people living downstream of Baro-Akobo river because of all these lives threatens problems identified in this district.

1.3. The Objectives of the Study

1.3.1. The general objective

The general objective of this study is to assess the flood hazard and its impacts on people living downstream of the Baro river in Jekow district by using Geographic Information System (GIS) tool.

1.3.2. Specific objectives

The following specific objectives were met, based on the above mentioned general objective:

- To identify the areas which are most suffering from flood hazard in Jekow district.
- To explore the possible causes of flood hazard and provide possible mitigation measures.
- To assess the flood hazard impacts on socio-economic activities, resident, environmental, agriculture & government infrastructures in Jekow district.

1.4. Research Question

The following research questions addressed in order to obtain useful information about the Baro river flood impacts, flood hazard, and flood damages, as well as exposure damage:

- Which areas suffered most by flood hazards in Jekow district?
- What are the possible causes and the possible mitigation measures taken?

- What extends are the flood hazard impacts on socio-economic activities, resident, environment and agricultural factors and government infrastructures?

1.5. Significant of the Study

The importance of this study is the assessment of the flood affected areas and its impacts on downstream of the Baro river basin. As it is very known that floods are naturally occurring phenomena that are difficult to prevent but can be reduced to limit their social and economic impacts. As a result, understanding the chance of a flood of a certain intensity occurring over a long period of time is essential to assess the flood hazard and flood impacts on downstream. To develop community members' understanding and awareness of flood impacts, allowing neighboring communities in a flood-affected area to see factors that may affect them and promote collaboration, minimize the flood losses on existing structures or homes for people living downstream of the river basin.

To minimize flood hazard in the lower part of the area, the following factors put in to consideration such as government support, flood plan management, Hazard Mitigation Assistance (HMA) funds, and Community Rating System (CRS) activities. To highlight the most severely affected locations, improvement of emergency and community planning are also important of this study. Help people to understand the exposure and negative impact of flood hazard on human health, the environment, cultural heritage, and economic activity in flood-prone areas by assisting them in calling proper planning processes in flood-prone areas.

1.6. The Scope and Limitation of the Study

This study focused on the assessment of flood hazard and its impacts on lives of people in Jekow district, Nuer nation zone, Gambella regional state in order to reduce all the flood threats and their consequences on lives of people living downstream of the Baro river. In the study area, some drawbacks occurred such as areas which are displaced by the recent conflict between the sub clans. The researcher did not reach some of the flood affected areas to obtain the flood data on those conflicting areas because of fear and the insecurity/instability in those kebeles. The above mentioned drawbacks resulted as the limitation of the study. Therefore, to overcome these limitations of the study, further researches are needed to be conducted in this district.

2. LITERATURE REVIEW

2.1. Flooding and its Occurrence

“Floods were among the most common and destructive types of disaster, causing significant damage and disrupting livelihoods around the world,” according to the World Bank Group. Many river systems have a clear distinction between a well-defined river channel and adjacent flat land or the floodplain. Flooding occurs when the river's flow exceeds the capacity of the channel and water spills onto the floodplains.

Seasonal flooding was an annual occurrence in some areas and expected to continue. Seasonal flooding like this occurred every summer for thousands of years along Egypt's Nile river. The monsoon season river flooding happens when river waters overflow outside of the river channel or overflow the river banks. This was an unavoidable aspect of life by a river. When annual rains filled the river basins with too much water, too rapidly, some river flooding occurred. Vulnerability was the set of circumstances and processes that affected the chance of exposure and, the susceptibility of individuals and social systems resulted to the danger. The degree of susceptibility to damage from hazardous, water-related occurrences was known as flood vulnerability (Gallopin, 2006).

2.2. Flooding in Urban Areas and Causes

The perceived and actual causes of flood threats in cities across Sub-Saharan Africa had generated a lot of discussion. Flooding had been a major source of human vulnerability in Accra, Ghana's capital (Amoako, 2015). Flood vulnerability studies in the city had yielded a variety of explanations for their frequent occurrences. The reasons of flood threats in cities across Sub-Saharan Africa had been hotly debated. Flooding had been a significant source of human vulnerability in Accra, Ghana's capital (Amoako, 2015). Flood vulnerability studies in the city yielded a variety of explanations for the frequency with which they occurred.

2.3. Flood Vulnerability of People

Vulnerability, as defined by the 2007 flood, was the likelihood of a system or unit being harmed as a result of disturbances or stress. The term "vulnerability" was coined by researchers studying risks and hazards, climatic impacts, and resilience. The degree of flood disasters was determined by the vulnerability of the community at risk (APFM, 2004). Thus, exposure to floods, degree of protection from flood dangers, quality of available infrastructure, degree of access to resources, and ability to prevent, withstand, or recover from flood hazard were all elements that contributed to susceptibility. The population's vulnerability to floods increased by socioeconomic variables such as acute poverty, high population density, insufficient emergency preparation, and a lack of technical choices to deal with the crisis.

2.3.1. A Vulnerability Framework

According to Senbato (2018), vulnerability was defined as a mix of threshold capacity, coping capacity, recovery capacity, and adapting capacity based on a review of vulnerability studies. Capacity at the threshold: Threshold capacity referred to a society's ability to establish a barrier against variance in order to avoid damage. Building river dikes and raising flow capacity to set a threshold again were examples of flood risk management. The goal of developing threshold capacity to avoid injury. The temporal horizon was in the past, and the height of the threshold was determined by society's previous catastrophic experiences. Coping capacity referred to a society's ability to reduce damage in the event of a disturbance that exceeded the damage threshold. The presence of effective emergency and evacuation plans, the availability of damage-reduction measures, a communication plan to raise risk awareness among inhabitants, and a defined organizational structure and responsibilities for disaster management influence society's coping capability. The goal of coping capacity development was the reduction of stress. Because only the ‘here and now' matters in an emergency, the temporal orientation was instantaneous. The third component was the recovery capability, which referred to a society's ability to return to the same or similar state it was in prior to the catastrophe. It referred to a flooded area's ability to rebuild buildings, infrastructure, and dikes. The goal of creating and increasing recovery capacity was enabled to respond swiftly and effectively in the aftermath of a disaster. Adaptive capacity was referred to a country's, a community's, or even the entire world's ability to cope with and adjust to unexpected future developments and catastrophic events. Extreme floods, for example, were not a common occurrence.

2.4. Flooding and Its Consequences

Flooding was a widespread hazard that resulted in the loss of life and property, as well as significant economic consequences, particularly in developing countries. In fact, flooding can have social, economic, and environmental consequences, depending on the extent and severity of the flood. There were two types of flooding losses that were categorized direct and indirect losses. Direct losses emerged from direct contact with flood water, damage to buildings and infrastructure, while indirect losses resulted from the event but not from its direct impact, such as transportation interruption, unrecoverable business losses, and loss of family income, according to the Regional impact assessment document report. There were also two distinct types of losses in both categories; tangible losses and intangible losses. Tangible losses were the loss of items with a monetary (replacement) worth, such as buildings, livestock, and infrastructure. Intangible losses were those that cannot be bought or sold, such as lives, injuries, and historical artifacts. Flood damage and losses (tangible and intangible) were evaluated as an impact of seasonal floods in this research (Senbeto, 2018).

2.4.1 Flooding's impact on the economy

Any natural disaster caused both physical and intangible losses in terms of both economic and social consequences. Significant damages to public schools, public utility works, dwellings, and household assets were frequent when flooding occurred on the river's downstream bank. Economic implications induced by flooding included loss of earnings in industry and trade, loss of earnings to tiny shops and workers, loss of employment for daily earners, and loss of income due to road and transportation disruption (Haile, 2013).

2.4.2. Social consequences

Death was the most prominent and evident impact. Floods particularly flash floods, were deadly. Flood water traveled swiftly and weights a lot, making it easy for individuals to swept away by floods. Large chunks of debris and things, such as cars, were easily carried up by floodwater and could easily killed anyone who was impacted by the debris (FHIDP, 2011).

2.4.3. Environmental consequences

When sewage-contaminated flood water poured back into the river, it polluted rivers and land. Similarly, if the river spilled onto farmland, the water would have contaminated by pesticides and other chemicals put on the farmland, which, in turn, polluted the river when drained back into the river, it would poison the water and harm the river's living creatures (Bunn et al., 2002).

2.5. Coping Techniques

Coping techniques were frequently complex because they were based on the idea that an event followed a predictable pattern and that previous coping activities were fair guides for comparable events. They worked on a variety of scales, including individual household, community (neighborhood), and institutional levels (e.g. city-wide or beyond).

Preventive measures - at the individual and small group level, this referred to people making decisions to avoid being affected by an occurrence, such as avoiding risky places at certain times or avoiding certain foods selecting safe residential areas.

Impact-minimization techniques — These methods were used for reducing loss and facilitating recovery in the event of a disaster. In disaster literature, this was referred to as "mitigation," but in climate change literature, it was referred to as "adaptation." Looking to diversify sources of income: Families with multiple income earners, or even multiple income earners, might diversify their income sources. Savings organizations might be a source of income during difficult times if households had donated to them. The ability to call on the resources of others during difficult times was the development of social support networks. Networks could exist within a household, between extended family members, or with other organizations as well as larger groupings who had a common identity (religious, geographic, commercial, and others).

2.6. Flood control

Water systems' resiliency and adaptability in the face of expected climate change had been improved through planning and management actions. In order to moderate the phenomenon in its generation, a flood-prevention plan should begin in mountainous areas**.** The elevations of the river basin were divided into three management zones as low (200 m), intermediate (200-800 m) and high (>800 m) based on the European Floods Directive (CEC, 2007) and the Water Framework Directive (CEC, 2000).

As a result, in order to manage effectively by making accurate decision, a system was introduced in which temporal and spatial links were further explained and evaluated in order to comprehend the unique characteristics of flood mitigation. This was clarified both the feedback loops that caused vulnerability and those that promoted resilience (CEC, 2007)

2.6.1. Urban drainage management

A various study on urban flood management had been conducted and concluded that the existing management of urban runoff in underdeveloped countries was based on incorrect assumptions, causing irreparable damage to the inhabitants These negative effects had been primarily caused by two types of erroneous information. Drainage construction assumption in which urban drainage had been developed on the incorrect assumption that the best drainage system was one that carried excess water as quickly as possible away from its source and, evaluation and control in sections: on the assumption that, micro drainage designs increased flow and transfer all of their volume downstream. Urban drainage was typically controlled in macro drainage by canalizing critical sections. This type of solution was based on a specific perspective of a section of the watershed, with no regard for the implications on other sections or other aspects of urban settlement. Canalizing the crucial areas was merely moved flooding from one location in the watershed to another. It was essential to recognize the components of runoff transfer and damping without transporting impacts downstream, primarily with the necessary dedication from technical staff. The important thing was not to become overly attached to a preconceived notion, but to seek a collaborative solution focused on the fundamental principle that no project might transport its impact to another point in the watershed (Fernandez, 2010)

2.7. Global Flood Hazard, Impact, and Mitigation Measures

2.7.1 Flooding impact and mitigation measures in Scotland

According to Werritty et al., 2007, a survey study conducted in Scotland, rivers over-topping their banks were the most common cause of flooding, followed by surcharging sewers, overland flow, and coastal storms. As a result, in Scotland, people that lived near and/or around the river plain and were poor with inappropriate aged, and inadequate sewer systems and were the most susceptible members of the society to flood troubles.

Coping strategies- In Scotland, the most common immediate responses to a warning were to remove belongings from the ground floor, deploy sandbags or flood guards, move vehicles, and vacate the property. The majority of the emergency assistance were provided by neighbors and friends, who worked alongside local authorities and Fire service personnel.

2.7.2. Flooding impact and mitigation measures in Bangladesh

According to the case study conducted by Jabeen et al., 2009, the geomorphologic location was vulnerable to climate variability and change. In the last 55 years, the capital city of Dhaka had been hit by nine major floods, the worst of which occurred in 1988, 1998, and 2004 due to overflowing rivers. According to the findings of the case study, the facts of climate change were not obvious phenomena for the residents of Korail in Bangladesh, but they recognized climate variability. They were subjected to water clogging and flooding during the regular monsoon season, as well as unexpected rainfall. In addition to physical consequences, vulnerability grows was occurred as a result of unsecured livelihoods, prevalence of diseases, and limited economic activity.

2.7.2.1. Coping mechanisms

According to Senbeto (2018), in Korail, tangible coping mechanisms were chosen as a safe place to minimize flood hazard that was not an option for most slum dwellers. The option of constructing new houses was only possible through the expansion of water bank of vulnerable to flooding. As a recognized measure of coping strategy, most households take a few preventive measures prior to any disaster. Economic strategies savings were viewed as the primary coping strategy for the majority of households. 50 percent of households saved on a regular basis with savings groups or non-governmental organizations (NGOs) with the intention of borrowing from their savings during and after an emergency occurred.

2.7.3. Flood impact and preventive measures in India

According to a case study conducted by the India Bureau of meteorology in 2009, the most disastrous urban flood in India occurred in 2005 in Mumbai and the historic maximum rainfall of 944mm in 24 hours was occurred together with a high wave of 4.48m. Due to insufficient storm drainage capacity and heavy rainfall, urban floods had become an annual feature of Mumbai and interrupting road and railway traffic, flooding slums and low-lying areas, and collapsing older buildings effectively stopping all activities. Preventative measures were taken for maintenance of drainage system to prevent flooding and water logging. Mumbai Municipal Corporation had conducted structural measures to revamp the system by changing the design of the drainage system.

Flood warning systems were also another way of measuring in which all the Mumbai Municipal Corporation, India Meteorological Department, and National Emergency Management Agency collaborated to develop a warning system by installation of 35m rainfall gauging station

2.8. Ethiopia's Flood Disaster Profile

According to the Ethiopian early warning system agency 2007, flash floods and seasonal river floods became more common as a result of deforestation, land degradation, increased climate variability, and settlement patterns. Major floods in 1988, 1993, 1994, 1995, 1996, and 2006 had claimed many lives and destroyed property over the last two decades. Flooding on a large scale was limited to the country's lowlands; however, heavy rainfall in the highlands caused flooding of settlements in a number of river basins, particularly the Awash River Basin in the Rift Valley and the downstream part of the Baro river. Annual flooding in urban settlements, particularly in Addis Ababa, damaged property along streams descending from nearby hills. Flash floods were common in most parts of the country, especially when rains follow long periods of drought.

2.8.1 Disaster-related laws and organizational structures in Ethiopia

According to (DMFSS, 2009), in the last 30 years, Ethiopia's institutional framework for disaster risk management had undergone numerous changes in mandate, structure, and scope. The Relief and Rehabilitation Commission (RRC) was established in the aftermath of the devastating famines in Northern Ethiopia in 1973. Throughout its 20-year establishment, RRC concentrated on disaster response and distribution of relief supplies. The implementation of the National Policy on Disaster Prevention and Preparedness Management (NPDPM) in 1993 resulted in a paradigm shift based on a perceived requirement to more closely link the relief and development agendas. With all of that in mind, the government restructured RRC to create the Disaster Prevention and Preparedness Commission (DPPC), and charged it with focusing on the links between relief and development. Ethiopia Disaster Risk Management (DRM) Plan made mandatory for Disaster Management and Food Security Sector (DMFSS) to shift from ex-post emergency preparedness and rescue operations to the much wider ex-ante disaster prevention. The above organizational structures shown that the issue of flooding was concentrated at the national level, which was impeded work flow and efficiency in responding to and mitigating localized flooding emergencies unless the framework was networked and institutionalized even at the local government level.

In broad sense, Ethiopia had no special flood policy or proclamation, but flooding issues might be covered by other environmental policies such as water resource policies, DMFSS, and Disaster Prevention and Preparedness Agencies. These policies and proclamations were addressed at higher-level national emergencies such as the Dire Dawa and Omo flooding disasters, as well as local government emergencies.

2.9. The Importance of Geographic Information Systems (GIS) in Flood Hazard/Risk Assessment

Geographical Information System (GIS) was any manual or computer-based set of procedures for scoring and manipulating geographically referenced data (Aronoff ,1989). According to Khan G. and S. (2013), “the use of remote sensing and GIS software is an important information tool for flood hazard mapping and monitoring.” Because flooding was a spatial phenomenon, the use of GIS and remote sensing techniques was critical in the flood hazard/risk management process. Flood hazard map was useful tools for mitigating flood damage. Data synthesis and mapping of the relationships between natural hazard phenomena and the elements at risk necessitate the use of tools such as geographic information systems (GIS). Natural hazards were multidimensional phenomena with a spatial component; thus, the GIS was well suited for such applications (Zerger, 2002).

As a result, the protagonist of GIS and remote sensing technology to map flood areas that should be easy to plan essential measures that reduced flood damages and risks to be a great benefit to implement a flood management program that included flood forecasting, flood hazard, flood vulnerability, and flood risk mapping. Furthermore, geospatial technology such as GPS, GIS and Remote Sensing were widely used to gather information from various spatial data, aerial photographs, satellite images, and digital elevation models (DEM) for flood hazard assessment, analysis, and preparation of flood hazard mapping. Geographic information system covers a diverse range of tool for assessing flood-affected areas and forecasting areas that would be likely to flood due to a rise in river water level. The primary advantage of GIS used for flood management and planning generated visualization of flood-prone areas, which allowed for further analysis of the product to estimate probable flood damage (Alexander et al., 2011).

2.10. Flood Hazard and Risk Assessment Using Geographic Information Systems (GIS)

Flood hazard and risk maps were powerful tools for mitigating flood damage. The flood hazard and risk assessment of the Awash river in the wash was a critical factor in flood hazard studies using GIS. Flood dangers, which inflict serious economic damage and the loss of many lives, should be protected. The most common alternative should be flood protection by physical control of the river for a variety of reasons, but there was also a need for a broader and comprehensive program for managing flood hazard in the study area. Flood protection had been beneficial, and should be sustained alongside other preventive strategies such as smart city planning, the construction of a computerized GIS database for flood-prone areas, and precise flood risk mapping and zonation was to minimize the adverse consequences of flood hazard. Flood Hazard mapping was an essential component of flood-prone area land use planning. It generated simply readable, quick-access charts and maps that helped administrators and planners to identify risk regions and prioritize mitigation and response actions. They employed Analytical Hierarchical Process (AHP), a multi-criteria decision-making technique that provided a systematic approach for examining and integrating the influence of numerous factors at several levels of dependent and independent, qualitative and quantitative information. They provided a new method for calculating a flood danger composite index based on topographical, land cover, geomorphic, and population data. Finally, all of the data was combined in a GIS tool to create a final flood hazard map (Wondim, 2016).

2.10.1. Flood-related losses

2.10.1.1. Roads

The two major Irish crossings had been severely damaged, and as a result, a route that used to connect the Taiwan and Number One districts had been shut off. The loss was estimated to be about ETB 900,000.00. The path that connects the half cat and Vera Pasta regions had been partially destroyed and was only giving partial service as a result of flood damage (Senbeto, 2018).

2.10.1.2 Structures for flood prevention

The flood prevention structures built in various flood-prone areas of the city were also affected to some extent by the flood. The amount of damages that predicted was approximately around 950,000.00 ETB (Senbeto, 2018).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location

This research is carried out in the Jekow district of Gambella Regional State's Nuer Zone. 8°10'00" to 8°30'00" North Latitude and 33°29'30" to 33°51'30" East Longitude define the Jekow district in south-west Ethiopia.

The Oromiya Regional State borders with region on the north and east, the Southern Nations and Nationalities and People's Regional State on the south and southeast, and the Republic of South Sudan on the west.

Administratively, it is divided into three zones and thirteen districts or Woredas, one of which is a special Woreda. The Nuer Zone is one of Ethiopia's Gambella region's three zones. It is formed from Gambella's former administrative zone 3. Anuak zone on the east bordered South Sudan on the south, west, and north; the Pibor defines the border on the south and west, while the Baro defines the border on the north.

The Nuer zone is divided into five woredas: Akobo, Jekaw, Lare, Makuey, and Wanthoa, with towns like Tirgol, Kuachthiang, Kuergeng, Nyinenyang, and Matar respectively. The Nuer zone is located in Ethiopia's lowlands and is flat at an elevation of 400-430 meters above sea level. Grasslands, marshes, and swamps, as well as some trees, make up the zone.

Livestock is the mainstay of the economy. The zone was heavily flooded during the rainy season last year, forcing residents to flee to the highlands with their cattle until the water receded; as a result, growing livestock and agriculture are the principal sources of income in this zone.

The Nuer Zone consists of five districts (woredas) in which the population is impacted by floods on a yearly basis, with the majority of the population living in the flood plain zones of the Baro river basin.

The town of Kuachthiang, as well as the majority of neighboring settlements, are situated on the right and left banks of the river, which provides ecological value as well as a source of income for the locals. Flood-related recession the mainstays of the inhabitants in the district are cereal crops (sorghum and maize), vegetables, animal herding, and fishing. During high flood periods, overbank flow from the Baro river inundates a large amount of the rural settlements due to insufficient natural channel capacity. The figure shows below is the study area map of the district.

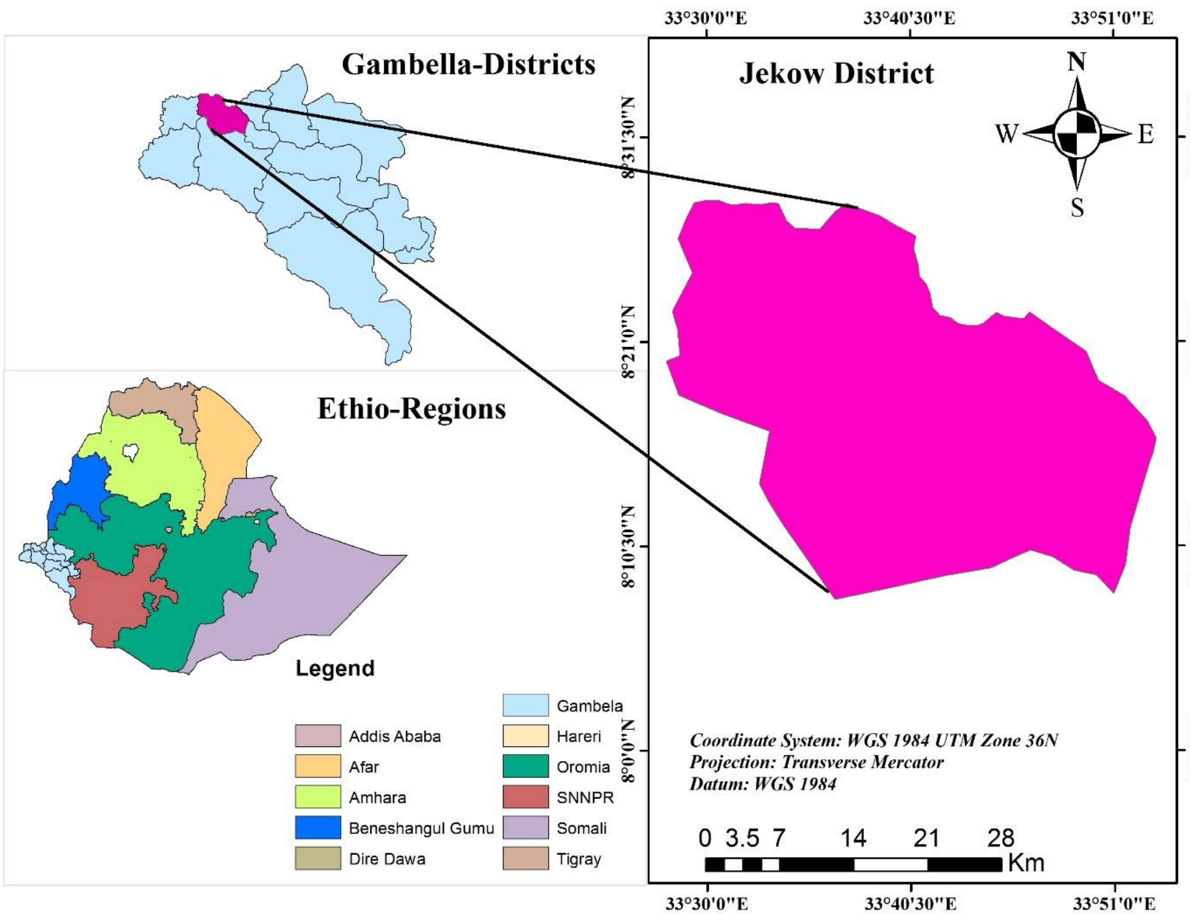

FIGURE 1: LOCATION MAP OF JEKOW DISTRICT

3.1.2. Demographics

According to the Central Statistical Agency of Ethiopia's (CSA) 2007 census, this district has a total population of 35,556, with 19,134 men and 16,422 women, and covers an area of 1110.16 square kilometers. Jekow has a population density of 32.89 people per square kilometer, with 2,261 people (6.36 percent) living in urban areas.

With an estimated population of 84.11 percent Protestants, traditional religion beliefs practiced by 9.08 percent of the population, Catholicism practiced by 4.48 percent, and Ethiopian Orthodox Christianity practiced by 1.71 percent of the population. Nuer are the most populous ethnic group in Jekow district, accounting for 97.96 percent of the total population, while other ethnic groups accounted for 2.04 percent. The Nuer language is spoken as mother tongue by 98.08 percent of the population, while other official working language are spoken by 1.88 percent and 0.04 percent of the population, respectively. Amharic is used as a working language in the area. The social activities in the study area are distinct from those of other Ethiopians. Women are always doing indoor duties such as cooking, stewing, gathering firewood, fetching water, and washing the family's clothes, among other things. Men also engage in outdoor activities such as farming, hunting, fishing, and raising cattle and other domesticated animals. The 18-year-old girls and boys can participate in marriage-related activities, either to marry or to be married (CSA, 2007).

3.1.3. Economic activities

The economy of the area based on mixed farming, which included food production and animal rearing. Crop production employed for crop planting during the rainy season. Maize and sorghum are the two most prevalent crops farmed by farmers for family consumption. During planting, maize and sorghum have a protracted cycle. Cattle, sheep, goats, donkeys, and chicks are among the livestock raised. Purchased livestock is replaced, as well as livestock from inside the herd. Boys between the ages of 15 and 18 are responsible for the care of animals. The major source of income is livestock. Agriculture, cattle, fishing, trade, and administrative services are the primary sources of income in rural villages and cities (Peter, 2010).

3.1.4. The Climate condition of the area

3.1.4.1. Rainfall

The agro climatic zones of the Jekow are classified as Moist Dega (2300-3200masl) and Weyna-Dega (1500-2300masl) based on the agro climatic classification technique (altitude and rainfall) with total annual rainfall ranging from roughly 1100 mm to 1530 mm/year. The rainfall distribution in the district revealed that some parts of the eastern and central parts received the most rain while some part of the northern and western parts received the least.

3.1.4.2. Temperature

The hottest month is March while the coldest month is the December with an annual precipitation of 7.5 mm. From the end of January to the middle of April and the hottest season last for three months with average daily high temperatures above 36°C. March has the highest average high temperature of 38°C and the lowest average low temperature of 26°C. From the end of May to the beginning of October, the cold season last for four months with an average daily high temperature of less than 30°C.

3.1.5. Soil and land use/cover

The area is covered in wet green forest and grass with a large amount of marginal land suitable for agriculture and other economic activities. Cultivated land, forest, woodland, bush land, grassland, and wetland are identified as existing land cover (vegetation) types in the Jekow district (marsh land). Fluvisols and Vertisols are the most common soil types in the research study area. The clay material is dominant in the Vertisols. When there is a wet condition, this clay mineral expanded, and when there is a dry condition, it shrank, generating surface fissures in the dry season (FAO, 2014)

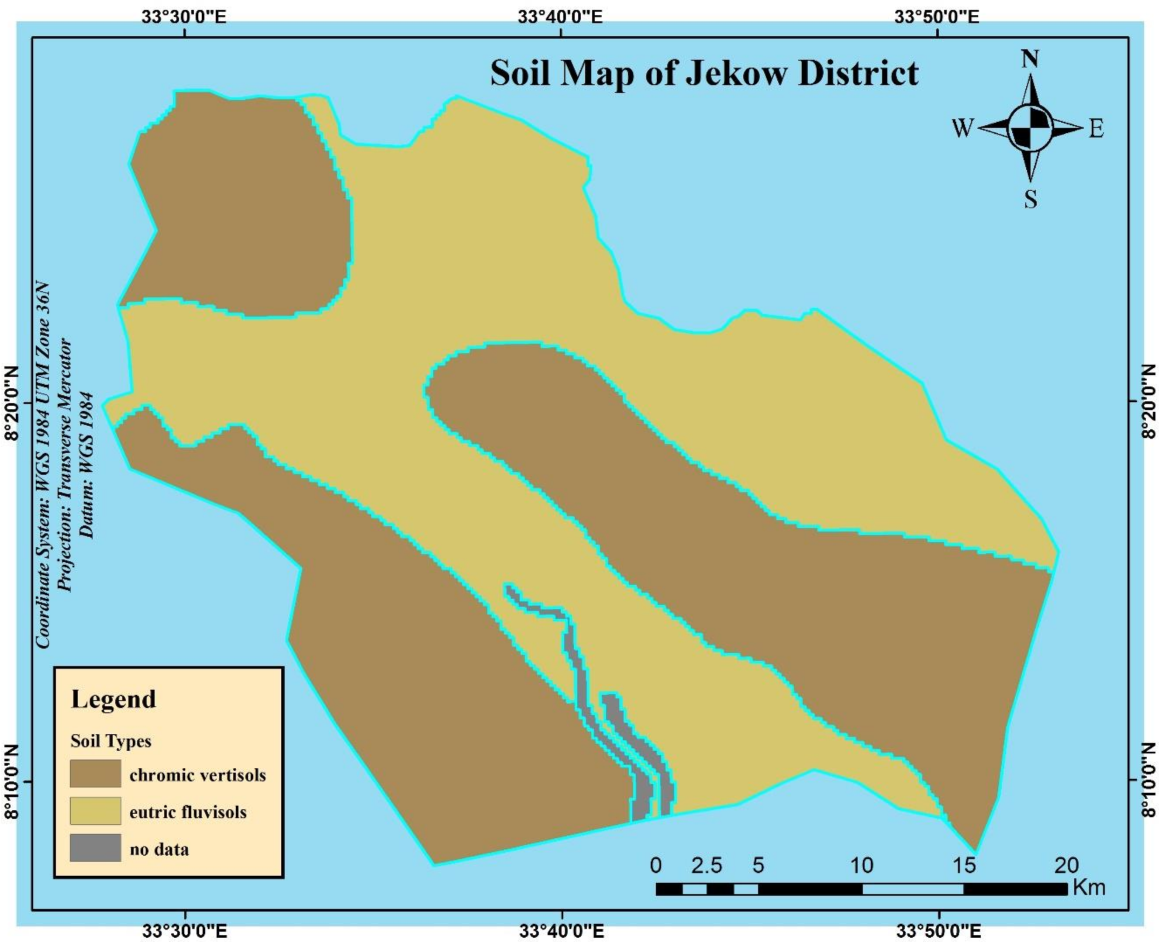

FIGURE 2: SOIL MAP OF THE JEKOW DISTRICT

3.1.6. Vegetation

The savannahs, riverine woods, and grasslands of the Jekow area are diverse. The district's overall topography is flat, but there are areas of higher ground that support deciduous forests and meadows. During the rainy season, large tracts of grasslands are submerged by water, generating useful seasonal wetlands. However, there are large tracts of permanently flooded wetlands, particularly around rivers. Grasses enjoy fast growth and some species can reach a height of 2-3 meters (Tesfaye et al., 2001)

3.1.7. Hydrology

The Baro, Makuey, and Jikawo rivers are the main rivers in the study area, however the Makuey and Jikawo rivers are sub basins of the main Baro river, which dry up in the spring and only fill up with water in the summer. The Baro and its tributaries drain a 41,400 square-kilometer watershed. At its mouth, the river's average annual discharge is 241 m3/s. The confluence of the Birbir and Gebba rivers east of Metu, in the Oromia region's Illubabor Zone, formed the Baro river. During the rainy season, rainfall from the highlands is the primary source of recharge for major portions of the groundwater system. The largest recharge took place in the eastern parts, where yearly rainfall is high from highland areas to the western lowlands along South Sudan's border when annual rainfall is quite low.

3.2. Research Strategy

The researcher employed both qualitative and quantitative research methods in the investigation. However, a mixed research technique in which study variables were measured in both qualitative and quantitative forms after interpretation and similarly beneficial for observing a wide range of factors.

3.3. Study Design

The researcher employed a descriptive research approach for this study which described the characteristics of flood hazard, flooding impacts, and coping strategies in the study area. As a result, the researcher employed a descriptive research approach to describe the seasonal flooding that occurred and its effects as well as the coping strategies used in reaction to the emergency in Jekow district. The research methodologies used in the assessment of flood hazard and its impacts in Jekow district are depicted in the diagram below.

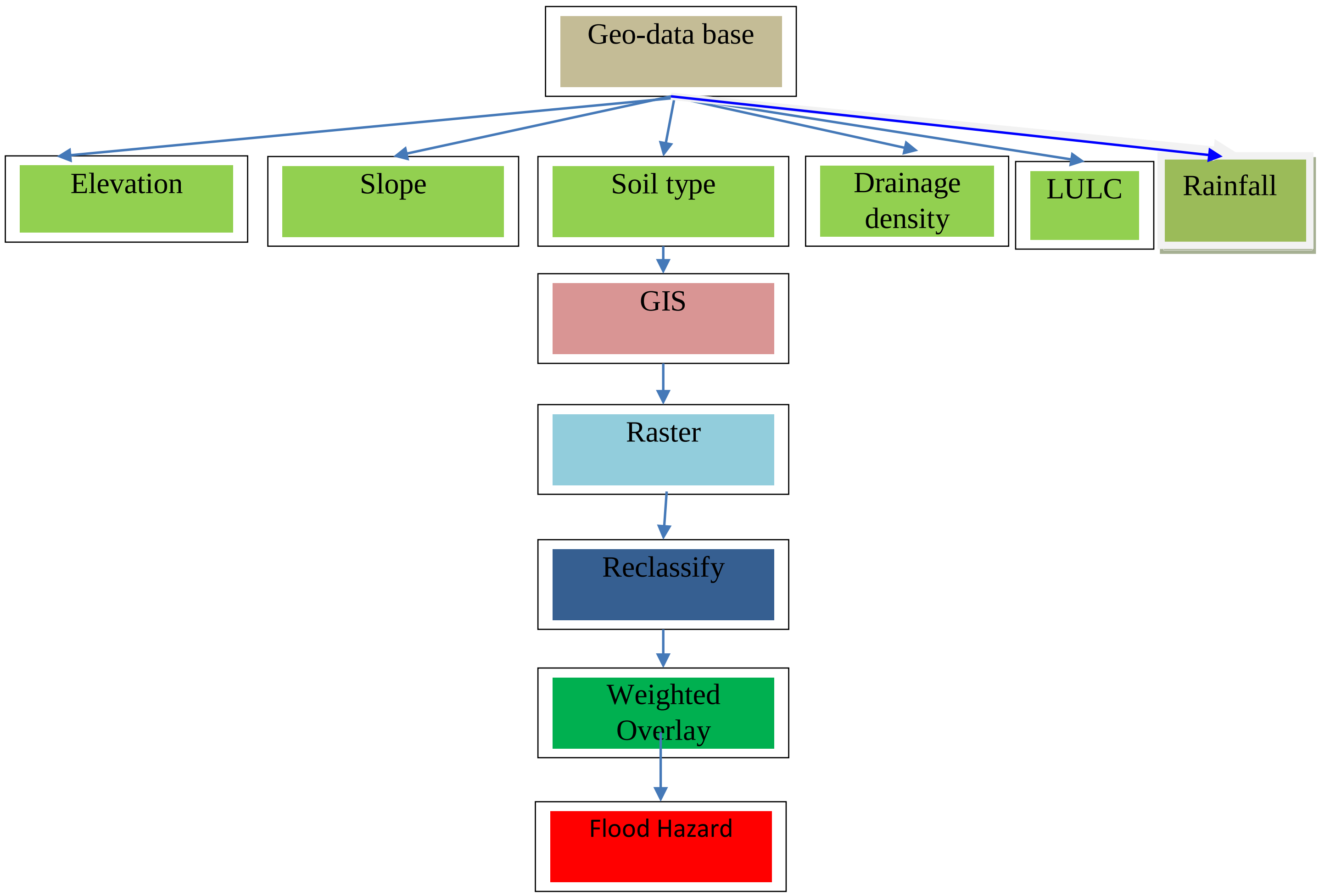

FIGURE 3: WORK FLOW OF FLOOD HAZARD AND IMPACT ANALYSIS

3.3.1. Instruments and techniques for research

Questionnaires were developed in both open-ended and closed-ended formats, and sample respondents were asked to complete them. The questionnaires were developed and conducted in English and translated to the native or local language that the community used as their first language in order to have an easy means of communication with the respondents and obtain reliable data. The interviews were arranged up with government officials and district administration teams, as well as disaster and risk office workers and residents of the flood-affected areas. Observations have also been conducted in selected areas of the district, particularly along river banks, in order to gain a better understanding of the causes and effects of seasonal flooding in the district and as a result, to have a better understanding of how to address these issues in the future.

3.4. Procedures for Data Collection

3.4.1. Data availability and sources

Important data, such as hydrological data and a digitized map of the basin were gathered from a variety of sources including the Ministry of Water, Irrigation, and Electricity (MoWIE)'s and GIS department. The National Meteorological Service Agency (NMA) provided meteorological data including temperature and rainfall while the digital elevation model (DEM) of the catchment area was extracted from the country DEM. For the planned aims, it was critical to have trustworthy data. The research was based on both primary and secondary sources of information. Furthermore, for the delineation of the watershed, frequent field observations were combined with GPS measurements to generate information such as the coordinates of the Jikawo river.

The primary data source gathered by distributing a structured questionnaire to informants, observing the current situation, and conducting a structured interview during the data collection process. Secondary data obtained and collected from a variety of sources, including relevant books and reviews of various literatures, previous researches conducted, online sources, unpublished materials, and other related documents such as policies and legislations.

3.5. Data Processing and Analysis

To prepare the data for flood hazard analysis, the researcher first assessed and organized the sequence of data from the field survey questionnaire, field observation, key informant interview (KII), Global Positioning System (GPS), and digital camera to determine the data set's cleanliness, cleaning, and editing.

3.5.1. Data analysis from field surveys

Based on the nature of the data obtained, both qualitative and quantitative data analysis were undertaken while assessing the field survey data. Tables and percentages were used to analyze and interpret the quantitative data that was then narrated with discussions. Photographs were used to assess and interpret the qualitative data (plats). Respondent's data was prepared after checking the data collected from the sampled households, disaster and risk management officials, the district administrator, and senior administration officials of the district.

Microsoft-Excel was used for some constructive summary tables. The following are the general techniques for data analysis in the research work:

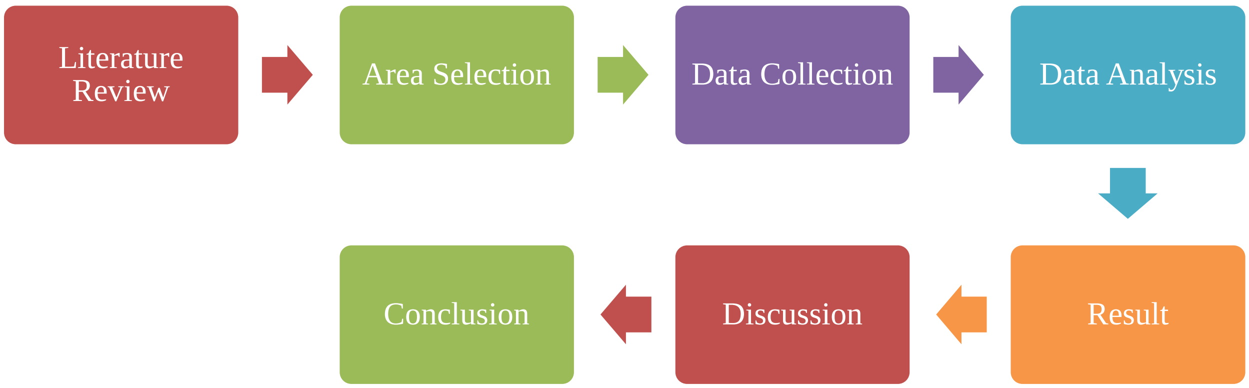

FIGURE 4 : FLOWCHART FOR THE GENERAL PROCEDURES OF THE RESEARCH WORK

3.6.2. Mapping of flood hazard analysis procedures

During the preparation of final flood hazard mapping, the following flood generating factors were generated first: elevation, slope, soil, land use/cover, rainfall and drainage density maps, which were converted to raster format and reclassified. In addition to this, a Multi Criteria Decision making (MCD) method was used. This method of Multi criteria decision making (MCD) known as Analytical Hierarchy Process (AHP) was selected for this study. The Analytical Hierarchy Process (AHP) was used for the calculation of the weighted coefficients or criteria weights in order to choose the most preferable criteria and reclassified the flood generating factors and then weighted overlay with their respective weighted coefficients by using Arc GIS 10.4.1, Arc toolboxes and selected spatial analyst tools for the development of flood hazard map.

3.6. Tool for this Study

The researcher employed the following software to achieve the study's objectives, based on its ability to work on the current problem and meet the pre-determined objectives. The study's tools, such as the Geographical Information System (GIS), was used to determine the areas affected by floods. Arc Hydro 10, a software extension for ArcGIS 10.4.1 was used in this research study. In the delineation of watershed, the major steps were involved such as creation of ArcMap project, add DEM data, Fill, create flow direction data, create flow accumulation data, create watershed pour points (outlet), create watershed, watershed boundary and streams. Elevation, slope, soil type, land use/land cover, rainfall and drainage density maps were developed and all employed in the final flood hazard mapping analysis. For the development of the flood hazard map, the ArcGIS 10.4.1 software package was used to determine flood generating factors such as elevation, slope, soil type, land use/land cover, drainage density and rainfall maps. The factors used in multi-criteria analysis were preprocessed to meet the requirements for generating or preparing the flood hazard analysis map. Furthermore, a Multi Criteria Decision making (MCD) method known as Analytical Hierarchy Process (AHP) method was used for the calculation of the weighted coefficients or criteria weights in order to choose the most preferable criteria and then weighted overlay in Arc GIS 10.4.1 for the flood hazard mapping.

As a result, certain relevant GIS analyses were applied to convert the obtained shape files using 3D Analyst and Spatial Analyst extension. The information on the structures severely impacted by the recent flood was gathered using the Global Positioning System (GPS). It was also used to gather information on training locations for land use/cover classification.

4. RESULT AND DISCUSSION

4.1. Watershed Delineation

A watershed is a land area that acts as a water catchment. The surface water from the watershed enters a common exit in the form of a lake, wetland, or stream, or it infiltrates into the groundwater. It is basically a drainage system that transports surface water from high to low elevations. The watershed is the hydrological unit that is modeled, and it is used to aid in the study of the movement, distribution, quantity, and quality of water in an area. The watershed analysis is a strategy used in the management, conservation, and planning of earth's resources.

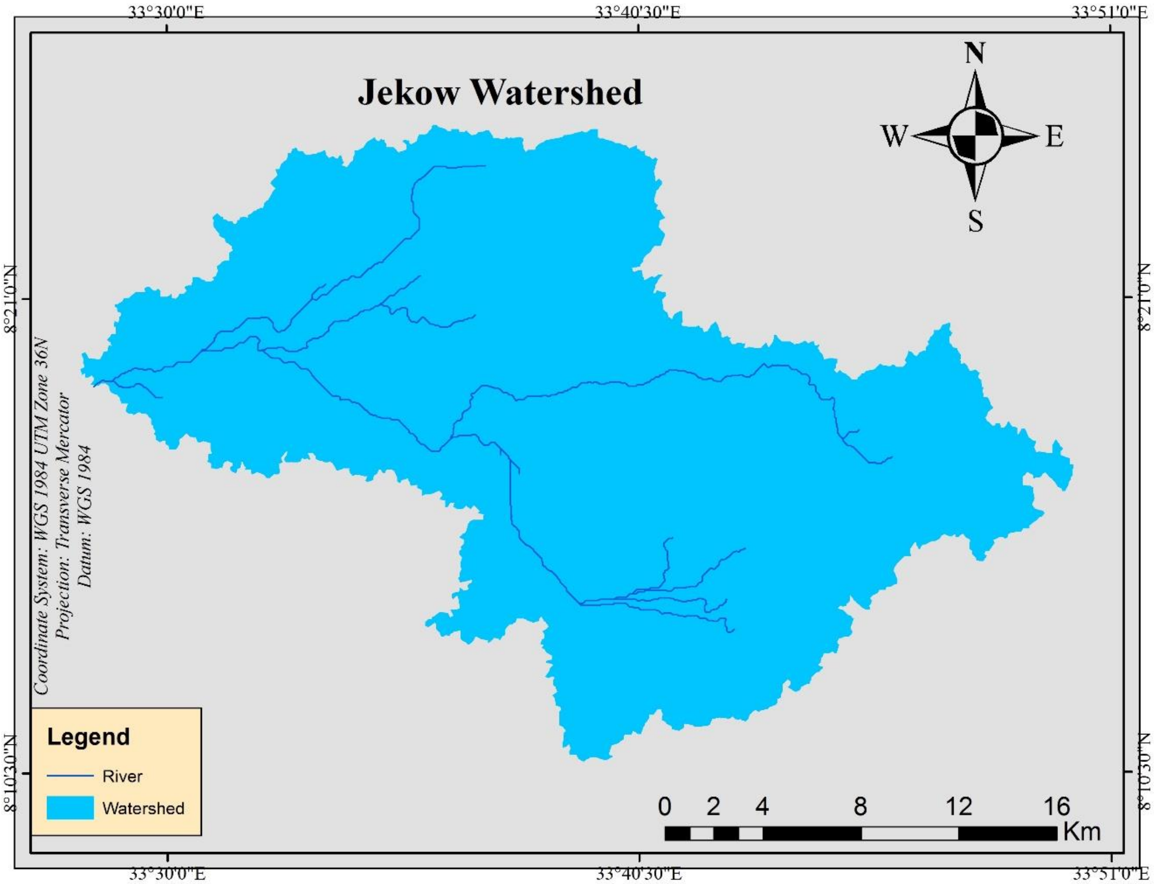

FIGURE 5: JEKOW DISTRICT WATERSHED

4.2. Flood Generating Factors Maps

The flood generating factors were used for the flood hazard assessment map and the following factors that were used such as elevation, slope, soil type, land use and land cover, rainfall and drainage density. The raster layer of the flood generating had been classified based on their flooding capacity in the district. The Digital Elevation Model (DEM) was converted in to elevation and slope raster layer by using ArcGIS conversion tools. Elevation and slope each had been classified in to five classes based on their susceptibility to flood as very high, high, moderate, low, and very low. The soil classification plays a great role for efficiency of land suitability evaluation, planning and management. Therefore, soil classification was very important for the identification of the most suitable soil use, production estimation, extrapolating knowledge at one location to other often relatively with the little known location, provision for the basis in the near future research needs, conduct and required for the soil classification and the determination of the chemicals and physical properties that are not known and visible in the field.

4.2.1. Flood map based on elevation

The elevation of the Jekow district range from 398-435m. The classification of the elevation that was given below shown very high, high, moderate, low and very low elevation areas. The area highly affected by the flood ranked to class 5 (398-405m) which is less than this number. Following the very high affected area, there was class high (405-413m) and ranked as 4, moderate class (413-420m) was ranked as 3, low class (420-428m) was also ranked 2 and the class very low (428-435m) ranked 1.

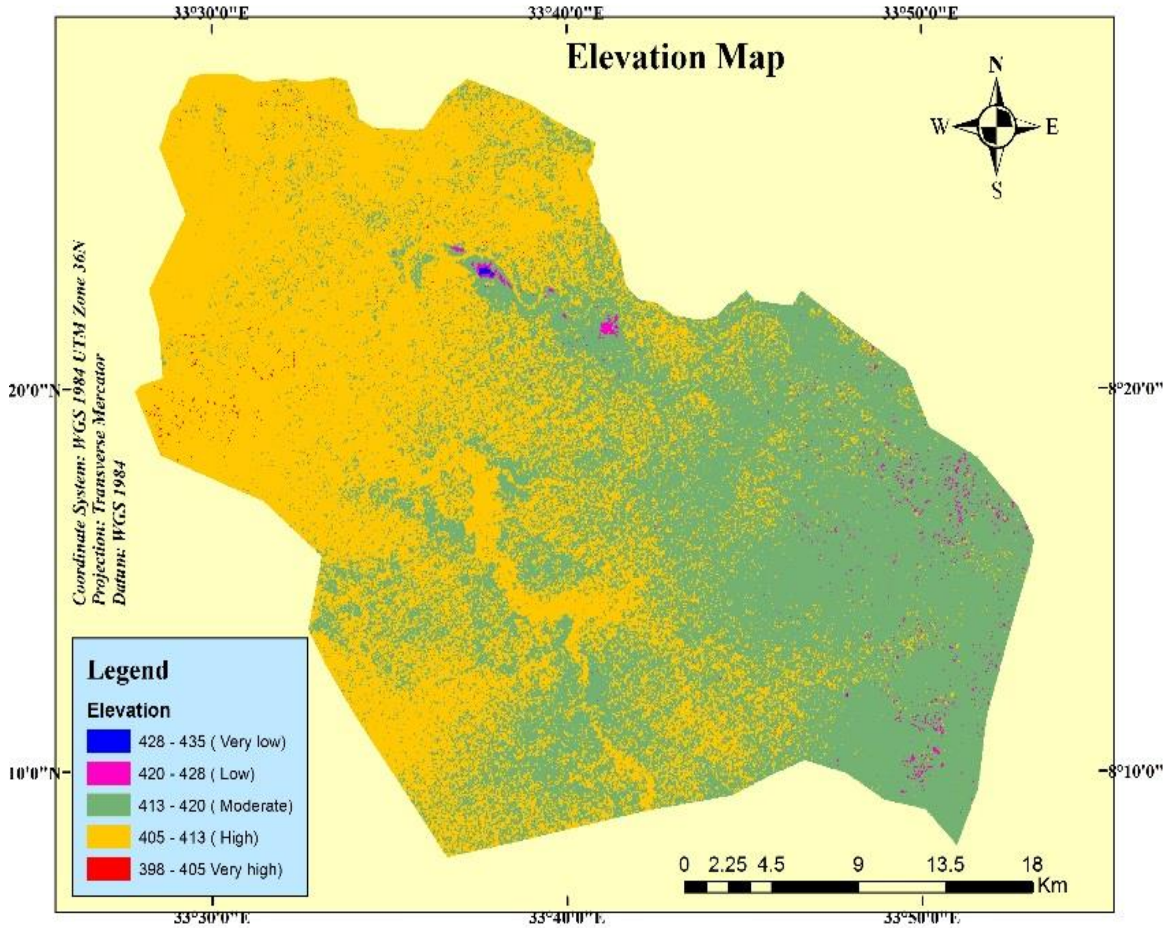

FIGURE 6: ELEVATION MAP AND ITS CLASSIFICATION

4.2.2. Slope factor

Slope factor had a contribution in the flood hazard mapping. As the slope is the rise or fall of the land surface, it is very importance for the people (farmers) of the Jekow district to identify the slope of the land but it is very easy to identify and recognize the slope in the hilly area. In the below slope classification, it had been classified in to 5 different classes of the slope based on their degree. The following 5 classification of slope in degree ranged from very low to very high slope degree as follows; very low (0 – 2), low (2 - 8), moderate (8 – 15), high (15 – 45) and very high slope (45 – 90).

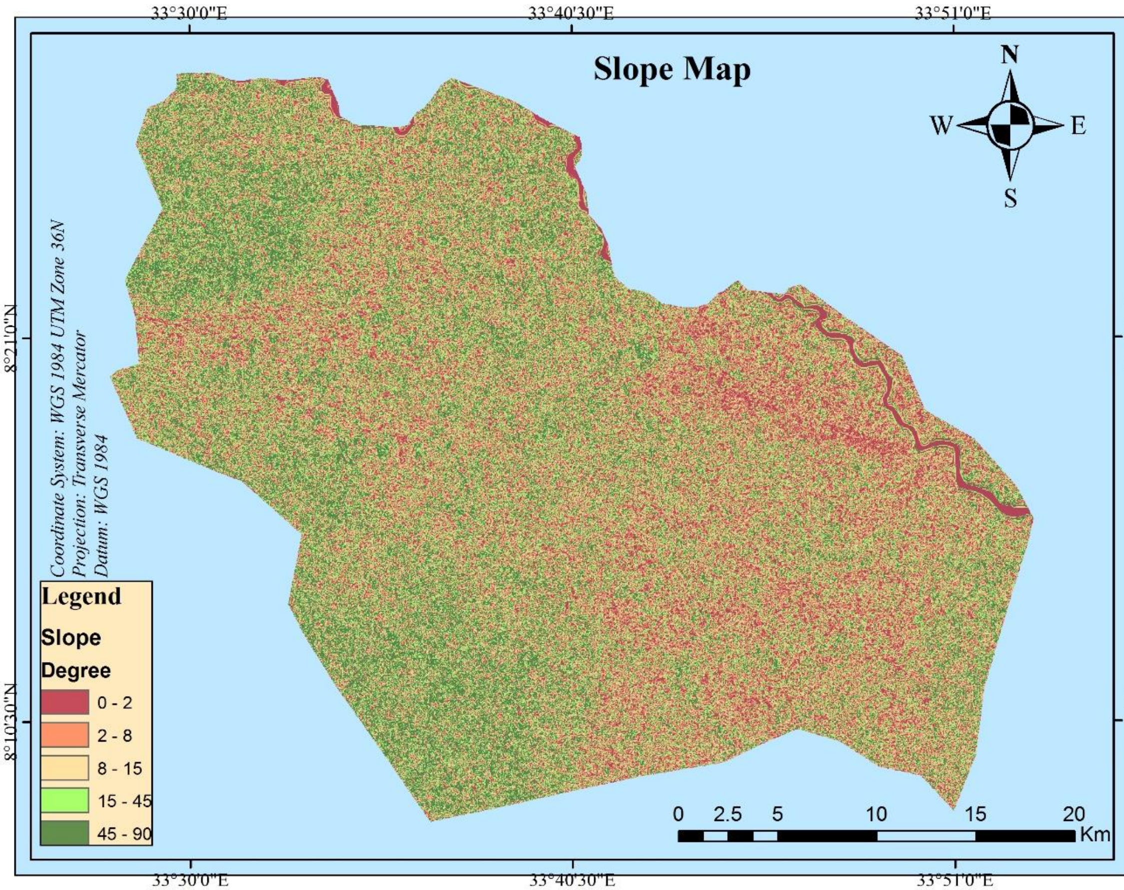

FIGURE 7: SLOPE MAP AND ITS CLASSIFICATION

4.2.3. Soil type

Based on the soil type classification, the most two dominant soil type in the study area are chromic vertisols and the eutric fluvisols. The other soil type data was not available in the district and classified this soil type as no data. Chromic Vertisols soil type occur in the North-West, South-West and South-East in the district. The Eutric Fluvisol soil type mostly occurred in the Northern and South-Western part of the district. The chromic Vertisols are the most dominant soil type in the Baro river basin. These two dominant soil type were converted in to raster and reclassified them as high and low. The soil type that had a high capacity to generate high flooding rate was classified as high and the other one with the low capacity to generate low flooding rate was classified as low. Therefore, Eutric fluvisols are assumed to be high flooding rate and ranked as 2 and the Chromic vertisols are ranked as 1 based on its flooding rate.

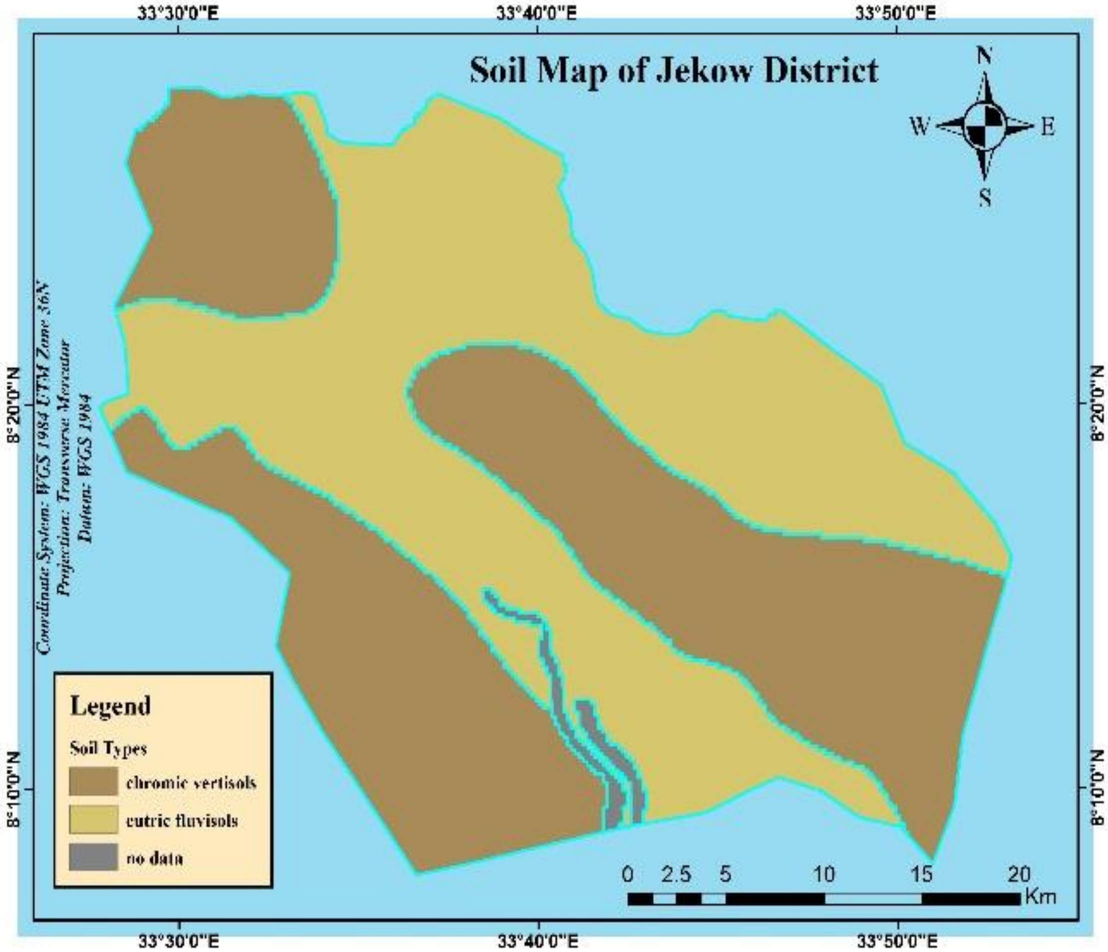

FIGURE 8: *SOIL TYPES AND ITS CLASSIFICATION*

4.2.4. Drainage density

As it is very known that to calculate the drainage density, this formula given below should be used. The drainage density is the total length of all the rivers and streams in the drainage basin divided by the total area of the drainage basin.

Drainage density of the study area (DD) = Total length of the stream/ Total area of the basin. The total stream length = 245.312626 Km and the total area of the drainage basin = 1110.16 Sq.Km.

Therefore,

$DD = L/A = 245.312626\ Km/\ 1110.16\ Km^2$

$DD = 0.220971\ Km/Km^2$

The drainage density was classified in to 5 main classes. The classification criteria were used to classify higher drainage density as very highly flood affected area and ranked as class 5 with the drainage density of 0.012358 Km/Km^2. As the classification was still continued, the high drainage density was ranked as class 4 (0.009967 Km/Km^2) and highly affected area, the moderate drainage density was ranked as 3 (0.009475 Km/Km^2), the low drainage was ranked as 2 (0.009317 Km/Km^2) and the drainage density (< 0.008798 Km/Km^2) was classified as very low and ranked as 1. The table below shown the drainage density classification with ranked values.

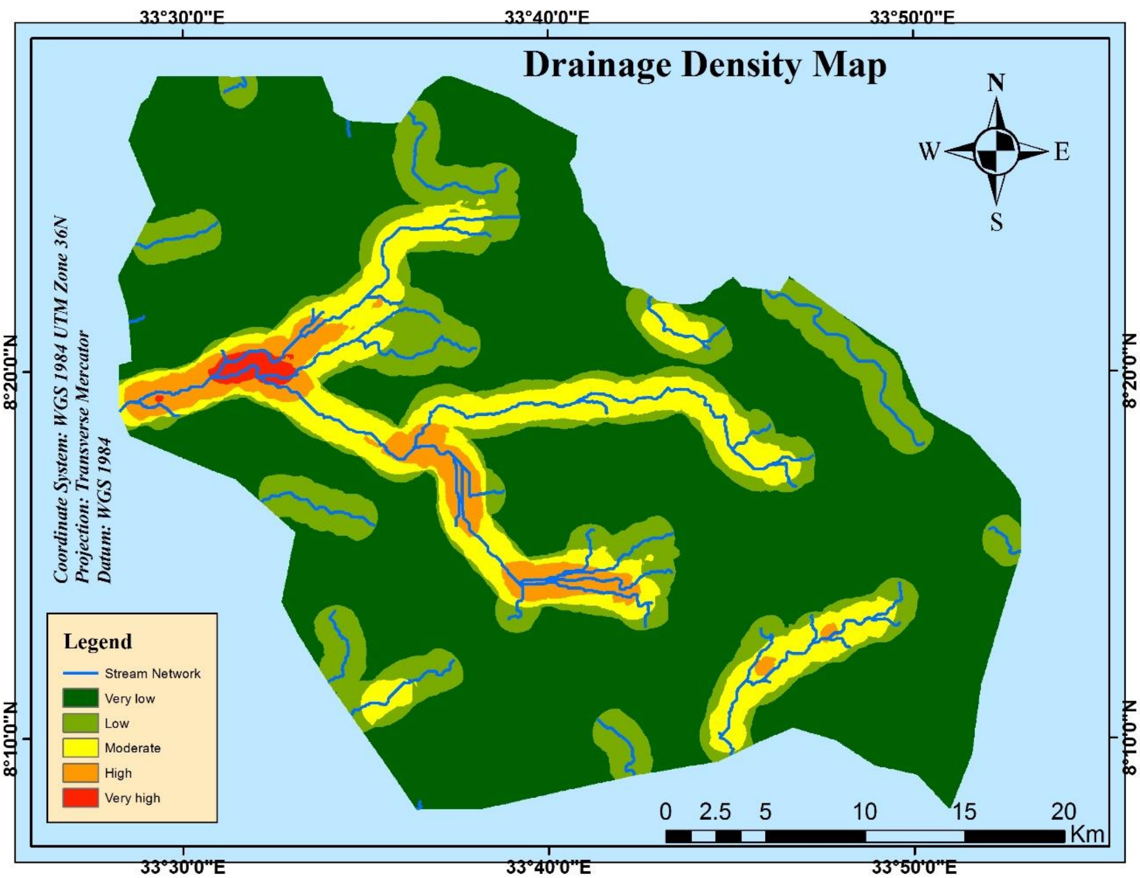

FIGURE 9: DRAINAGE DENSITY

The table 1 below shows the five different classification of the district drainage density with their ranking values.

TABLE 1: CLASSIFICATION OF DRAINAGE DENSITY

Classification	Drainage density values	Rank
Very high	0.012358 Km/Km2	5
High	0.009967 Km/Km2	4
Moderate	0.009478 Km/Km2	3
Low	0.009317 Km/Km2	2
Very low	< 0.008798 Km/Km2	1

4.2.5. Factors of land use/land cover

Land use/cover is the surface cover of the earth within the specific location such as vegetation cover and human made structures. Vegetation cover can help the infiltration rate of the soil surface for the water to goes deep down under the soil surface. In addition to this, the land use/cover represented the socio-economic condition in some part of the area. The land use/cover of the study area were reclassified in to five main different classes based on their criteria selection and they were also converted in to raster layers.

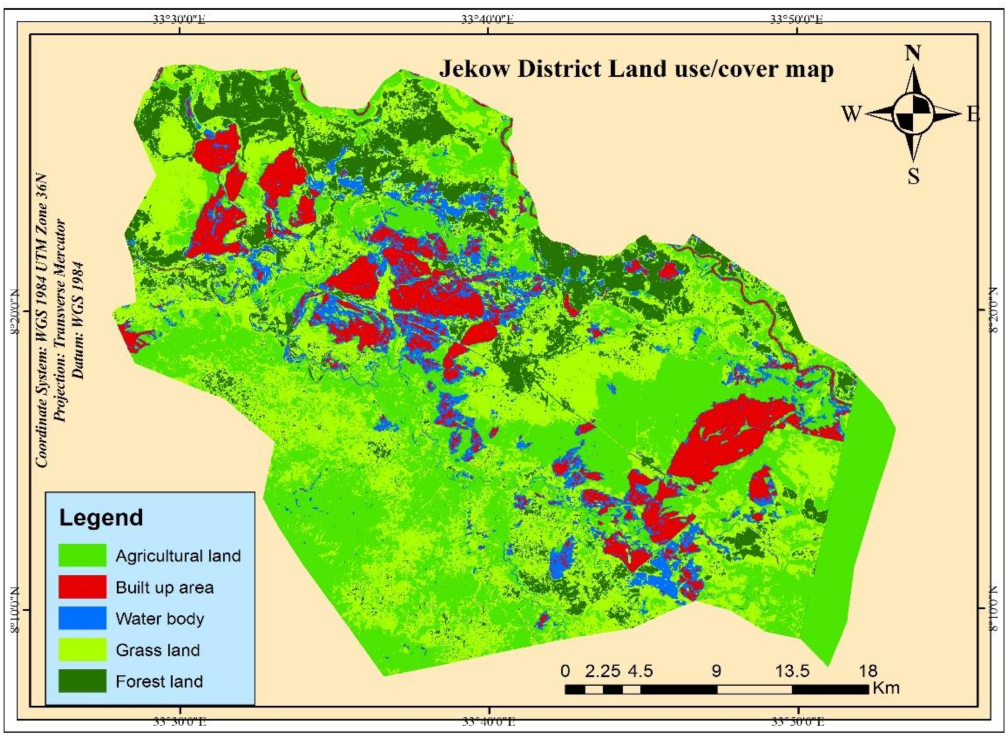

FIGURE 10: LAND USE/COVER TYPES

The classification of flood generating characteristics of land use/cover type was based on the land cover. The table below used to classify the land use/cover types in to five classifications; Agriculture area ranked as 5, grass land ranked as 4, forest land 3, built up area ranked as 2 and water body ranked as 1. The table below shows the land features of the study area (table 2).

TABLE 2: AREA COVERED UNDER DIFFERENT LAND USE/COVER FEATURES OF THE STUDY AREA

S.no	Land use/cover type	Area (Km^2)	Area (%)	Scale/ranked
1	Agricultural land	509.50	45.90	5
2	Built up Area	92.06	8.29	2
3	Water body	40.71	3.67	1
4	Grass land	359.32	32.37	4
5	Forest land	108.48	9.77	3
Total		1,110.16	100	

Therefore, the table above shows that, agricultural area is the largest land cover area with 45.90% and following the agricultural land, it is the grass land area that is the second largest area with the total land cover of 32.37%. Agricultural land occupied the largest area compared to the others of the total area of the land cover. The built up area, water body and forest land of the areas are 8.29%, 3.67% and 9.77% respectively.

4.2.6. Rainfall map

Rainfall is one of the flood generating factors that contributed a lot for the flood hazard occurrence on the people living downstream. The amount of rain that falls over time is measured by the intensity of rainfall. The depth of the water layer covering the ground over time was used to determine the severity of rain. It means that if the rain falls where it falls, it builds a layer of a specific thickness. Floods are thus referred to precipitation extremes such as tropical storms, thunderstorms, orographic rainfall, widespread and extra tropical cyclones. The study shows that, the following combination of rainfall characteristics such as the amount of rainfall, rainfall intensity, duration of rainfall and spatial distribution of rainfall are generated the flood events that caused large impact to the people after filled the catchment area. The heavy rainfall increased the amount of discharge from rivers and causes overflowing of Baro river basins. The district rainfall map was developed using Spatial analyst tools, then interpolated by using the Interpolation Distance Weight (IDW) method and observation during extreme rainfall events. From the figure 11 below, shows the Jekow district rainfall map that was interpolated between Tirgol rainfall station and Lare station.

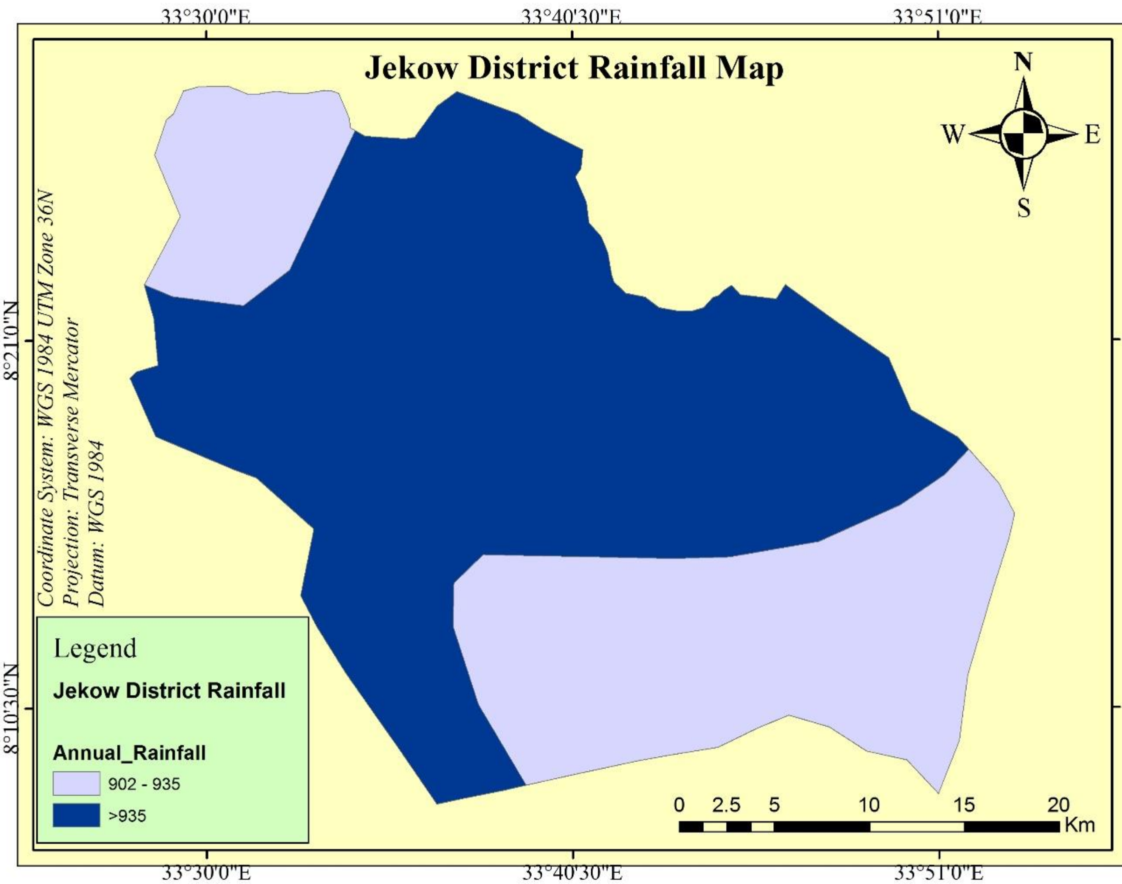

FIGURE 11: RAINFALL MAP

As a result, the researcher concluded that a combination of precipitation features such as rainfall amount, intensity, duration, and spatial distribution effects of flood occurrences it also caused the converge impact to the catchment area. Heavy rains increase river discharge and caused the Baro river basin to overflow the area. The long-year mean rainfall pattern revealed that high precipitation occurred in the Ethiopian highlands, central part of the district, south-east and southern (Jekow river) parts, whereas low precipitation occurred in the Baro river basin's north-western and western lowlands (South Sudan).

4.2.7. Population Density

Population Density represents the average number of individuals per unit of geographical

area. In simple terms it is the ratio between the population and area. It is a useful means of assessing over population

and under population

It is a measure of the incidence of population concentration in terms of persons per square

kilometer or per square mile. In Jekow district, the population density used in term of person per square kilometer. The district population density is shown below

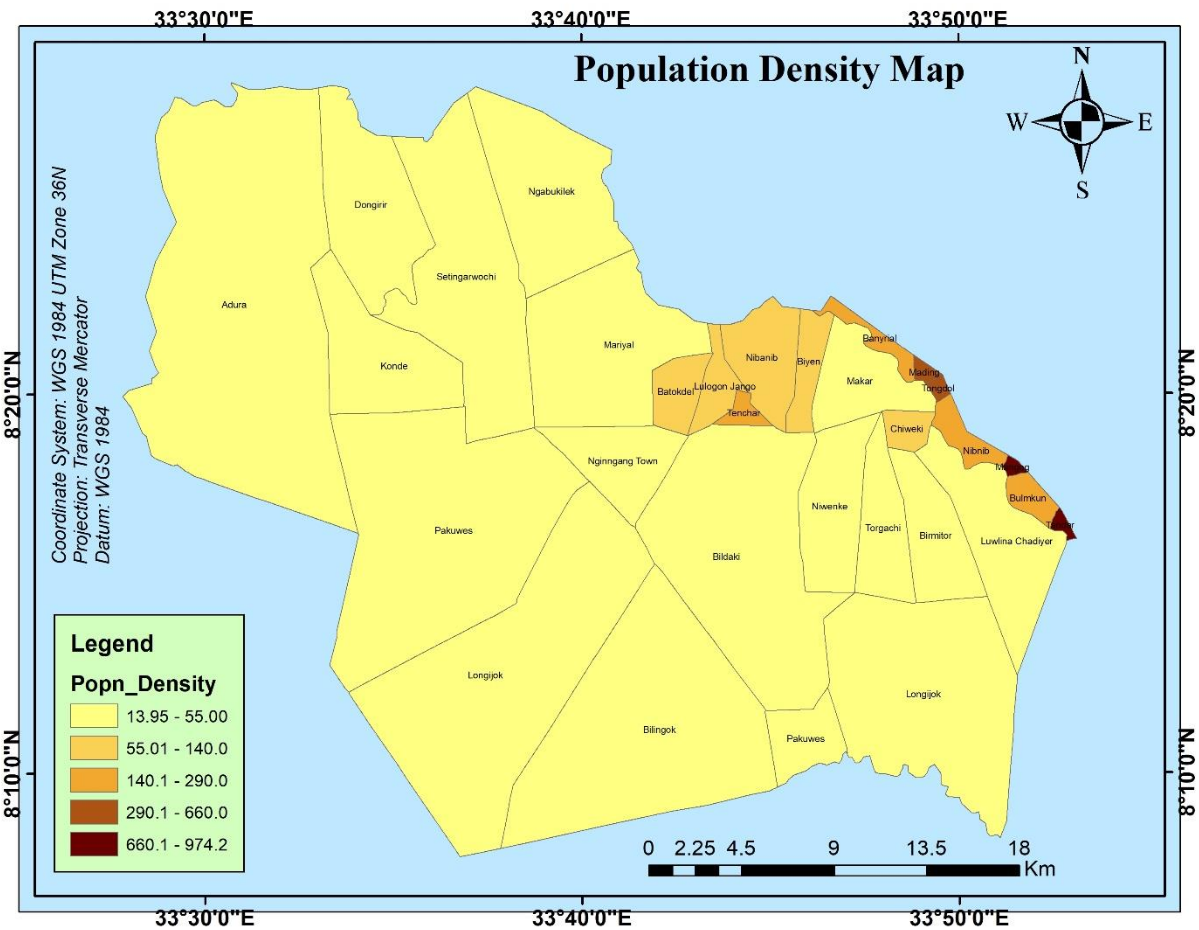

FIGURE 12: POPULATION DENSITY

4.3. Flood Hazard Analysis

The analysis of flood hazard was computed by weighted overlay of slope, elevation, drainage density, land use/cover, rainfall and soil types development factors. Before the development of the flood hazard map, the flood generating factors converted to raster format and reclassified them. After the reclassification of flood generating factors, the spatial analyst tools used and expanded on the Arc toolbox. The overlay tools also selected and expanded, then the weighted overlay tool opened and added the flood generating factors with their respected weighted coefficients on the weighted overlay table for the development of the Flood hazard map. The tools used in this study was the ArcGIS software and the techniques used was the pair-wise comparison matrix for the computation of weighted coefficients and developed by Prof. Saaty's (1977) in the context of decision-making process known as Analytical Hierarchy Process (Eastman, 2001).

According to Prof. Saaty's technique (1977), the weights of this nature can be derived by taking the Eigen Vector's principal of square reciprocal matrix of pair-wise comparison between the given set of criteria. The raster layers that was standardized were weighted overlay by using Eigen Vector that shows the importance of each flood generating factor as compared to other flood factors for their contribution in the flood hazard. The 9 points continuous scale was used for weighted coefficient calculation in the pair-wise comparison matrix. The Eigen Vector principal of pair-wise comparison matrix was used for the calculation of the flood generating factors of the flood hazard. The consistency ratio values of less than 0.1 (10%) that is 0.0347 (3.47%) was calculated that shows the given pair-wise computed weights are standardized or acceptable values.

The calculated Eigen Vectors were used as weighted coefficients for the flood generating factor and combined in weighted overlay in ArcGIS. The following equation was used for weighted overlay in the Arc GIS environment.

Flood Hazard = 0.378*[Rainfall] + 0.212*[Land use] + 0.154*[Elevation] + 0.104*[Slope] + 0.086*[Soil type] + 0.066*[Drainage density]. The detail is from the given tables below.

TABLE 3: SAATY'S SCALE FOR PAIR-WISE COMPARISON MATRIX FOR THE FLOOD GENERATING FACTORS

1/9	1/7	1/5	1/3	1	3	5	7	9
Extremely	Very strongly	Strongly	Moderately	Equally	Moderately	Strongly	Very strongly	Extremely
Less importance					More importance			

The following numbers 2,4,6 and 8 were taken as intermediate values that are found between 9 points continuous scale. Based on questionnaire survey paired comparison, several comparison matrices were made. Paired comparison matrix of 6 by 6 was made as shown in the tables below. The green color cells in upper triangular matrix indicated the parts that can be change in the spreadsheet. The diagonal was filled with the yellow color cells and always 1 and the lower triangular matrix was filled with the blue color cells. The following table below shown the computation of criteria weights or weighted coefficients of the flood generating factors (slope, land use/cover, soil type, rainfall, elevation and drainage density) for the development of flood hazard map.

TABLE 4: PAIR-WISE COMPARISON MATRIX (FRACTION VALUES)

Flood generating factors	Rainfall	Land use/cover	Elevation	Slope	Soil type	Drainage density
Rainfall	1	3	3	4	3	4
Land use/cover	1/3	1	1	3	3	4
Elevation	1/3	1	1	1	2	3
Slope	¼	1/3	1	1	1	2
Soil type	1/3	1/3	1/2	1	1	1
Drainage density	¼	1/4	1/3	1/2	1	1

TABLE 5:PAIR-WISE COMPARISON MATRIX (DECIMAL VALUES)

Flood generating factors	Rainfall	Land use/cover	Elevation	Slope	Soil type	Drainage density
Rainfall	1	3	3	4	3	4
Land use/cover	0.33	1	1	3	3	4
Elevation	0.33	1	1	1	2	3
Slope	0.25	0.33	1	1	1	2
Soil type	0.33	0.33	0.5	1	1	1
Drainage density	0.25	0.25	0.33	0.5	1	1
Sum	2.49	5.91	6.83	10.5	11	15

TABLE 6: NORMALISED PAIR-WISE COMPARISON MATRIX

Flood generating factors	Rainfall	Land use/cover	Elevation	Slope	Soil type	Drainage density
Rainfall	1/2.49	3/5.91	3/6.83	4/10.5	3/11	4/15
Land use/cover	0.33/2.49	1/5.91	1/6.83	3/10.5	3/11	4/15
Elevation	0.33/2.49	1/5.91	1/6.83	1/10.5	2/11	3/15
Slope	0.25/2.49	0.33/5.91	1/6.83	1/10.5	1/11	2/15
Soil type	0.33/2.49	0.33/5.91	0.5/6.83	1/10.5	1/11	1/15
Drainage density	0.25/2.49	0.25/5.91	0.33/6.83	0.5/10.5	1/11	1/15
Sum	2.49	5.91	6.83	10.5	11	15

TABLE 7: COMPUTED CRITERIA WEIGHT OR WEIGHTING COEFFICIENT

Flood generating factors	Rainfall	Land use/cover	Elevation	Slope	Soil type	Drainage density	**Criteria weights**
Rainfall	0.4016	0.5076	0.4392	0.3809	0.2727	0.2667	**0.378**
Land use/cover	0.1325	0.1692	0.1464	0.2857	0.2727	0.2667	**0.212**
Elevation	0.1325	0.1692	0.1464	0.0952	0.1818	0.2000	**0.154**
Slope	0.1004	0.0558	0.1464	0.0952	0.0909	0.1333	**0.104**
Soil type	0.1325	0.0558	0.0732	0.0952	0.0909	0.0667	**0.086**
Drainage density	0.1004	0.0423	0.0483	0.0476	0.0909	0.0667	**0.066**

TABLE 8: CALCULATION OF CONSISTENCY RATIO

Criteria weights	**0.378**	**0.212**	**0.154**	**0.104**	**0.086**	**0.066**
Flood generating factors	Rainfall	Land use/cover	Elevation	Slope	Soil type	Drainage density
Rainfall	1*0.378	3*0.212	3*0.154	4*0.104	3*0.086	4*0.066
Land use/cover	0.33*0.378	1*0.212	1*0.154	3*0.104	3*0.086	4*0.066
Elevation	0.33*0.378	1*0.212	1*0.154	1*0.104	2*0.086	3*0.066
Slope	0.25*0.378	0.33*0.212	1*0.154	1*0.104	1*0.086	2*0.066
Soil type	0.33*0.378	0.33*0.212	0.5*0.154	1*0.104	1*0.086	1*0.066
Drainage density	0.25*0.378	0.25*0.212	0.33*0.154	0.5*0.104	1*0.086	1*0.066

TABLE 9: COMPUTATION OF WEIGHTED SUM VALUES

Criteria weights	**0.378**	**0.212**	**0.154**	**0.104**	**0.086**	**0.066**
Flood generating factors	Rainfall	Land use/cover	Elevation	Slope	Soil type	Drainage density
Rainfall	0.378	0.636	0.462	0.416	0.258	0.264
Land use/cover	0.1247	0.212	0.154	0.312	0.258	0.264
Elevation	0.1247	0.212	0.154	0.104	0.172	0.198
Slope	0.0945	0.070	0.154	0.104	0.086	0.132
Soil type	0.1247	0.070	0.077	0.104	0.086	0.066
Drainage density	0.0945	0.053	0.0508	0.052	0.086	0.066

TABLE 10:THE RATIO OF WEIGHTED SUM TO CRITERIA WEIGHT

Flood generating factors	Rainfall	Land use/cover	Elevation	Slope	Soil type	Drainage density	**Weighted sum values**	**Criteria weights**	**WS/CW**
Rainfall	0.378	0.636	0.462	0.416	0.258	0.264	**2.414**	**0.378**	**6.3862**
Land use/cover	0.1247	0.212	0.154	0.312	0.258	0.264	**1.3247**	**0.212**	**6.2486**
Elevation	0.1247	0.212	0.154	0.104	0.172	0.198	**0.9647**	**0.154**	**6.2643**
Slope	0.0945	0.070	0.154	0.104	0.086	0.132	**0.6405**	**0.104**	**6.1587**
Soil type	0.1247	0.070	0.077	0.104	0.086	0.066	**0.5277**	**0.086**	**6.136**
Drainage density	0.0945	0.053	0.0508	0.052	0.086	0.066	**0.4023**	**0.066**	**6.0954**

Prof. Saaty proved that for consistency reciprocal matrix, the largest Eigen value is equal to the size of comparison matrix or $\lambda max = n$. Then a measure of consistency was introduced, known as consistency index as a deviation or degree of consistency

$\lambda max = (6.3862+6.2486+6.2643+6.1587+6.136+6.0954)/6$

= 37.2892/6 = 6.2149

λmax = **6.2149**

TABLE 11: RANDOM INDEX TABLE

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

The degree of consistency was calculated by using the following formula as shown below. In this study, λmax = 6.2149 and the size of comparison matrix or number of criteria, n = 6.

Thus, the Consistency Index (C.I.) = (λmax - n)/n -1 = (6.2149-6)/6-1 **= 0.2149/5 = 0.0430.**

According to Prof. Saaty, he proposed that we used the consistency index by comparing it with the appropriate one after knowing the consistence index. The appropriate consistency index is called Random Consistency Index (RI). Thus, Consistency ratio (C.R) = Consistency Index (C.I)/Random Index (R.I)

Consistency ratio (CR) = 0.043/1.24 = 0.0347 < 0.1 or CR = 3.47% < 10%. Therefore, in this study, the criteria evaluation preference is consistent.

TABLE 12: EIGEN VECTOR WEIGHTS OF EACH FLOOD GENERATING FACTOR OBTAINED AFTER PAIR-WISE COMPARISON

Flood generating factors	Criteria weights or weighting coefficient	Criteria weights or weighting coefficient (%)
Rainfall	**0.378**	**37.8**
Land use/cover	**0.212**	**21.2**
Elevation	**0.154**	**15.4**
Slope	**0.104**	**10.4**
Soil type	**0.086**	**8.6**
Drainage density	**0.066**	**6.6**
Sum	**1.00**	**100.00**

The flood in the Jekow district is very unique from the flood of other areas because it's come in two different directions. The overflow of the Baro river was the most hazardous in the area. The flood hazard zones are classified in to five different classes ranged from very low flooded area to very high flooded area. The least flood affected area was classified as very low and the other flood affected areas were classified as low, moderate, high and very high flood affected areas and also ranked as 1, 2, 3, 4, and 5 respectively. As a result of this, the finding shows that most parts of the district are occupied by flood hazard but the areas which are the most suffering (very high) flood areas are located in the south-east part of the district. The most suffering areas are identified as Banyrial, Mading, and Kalkich kebeles that are located on south-east part of the district.

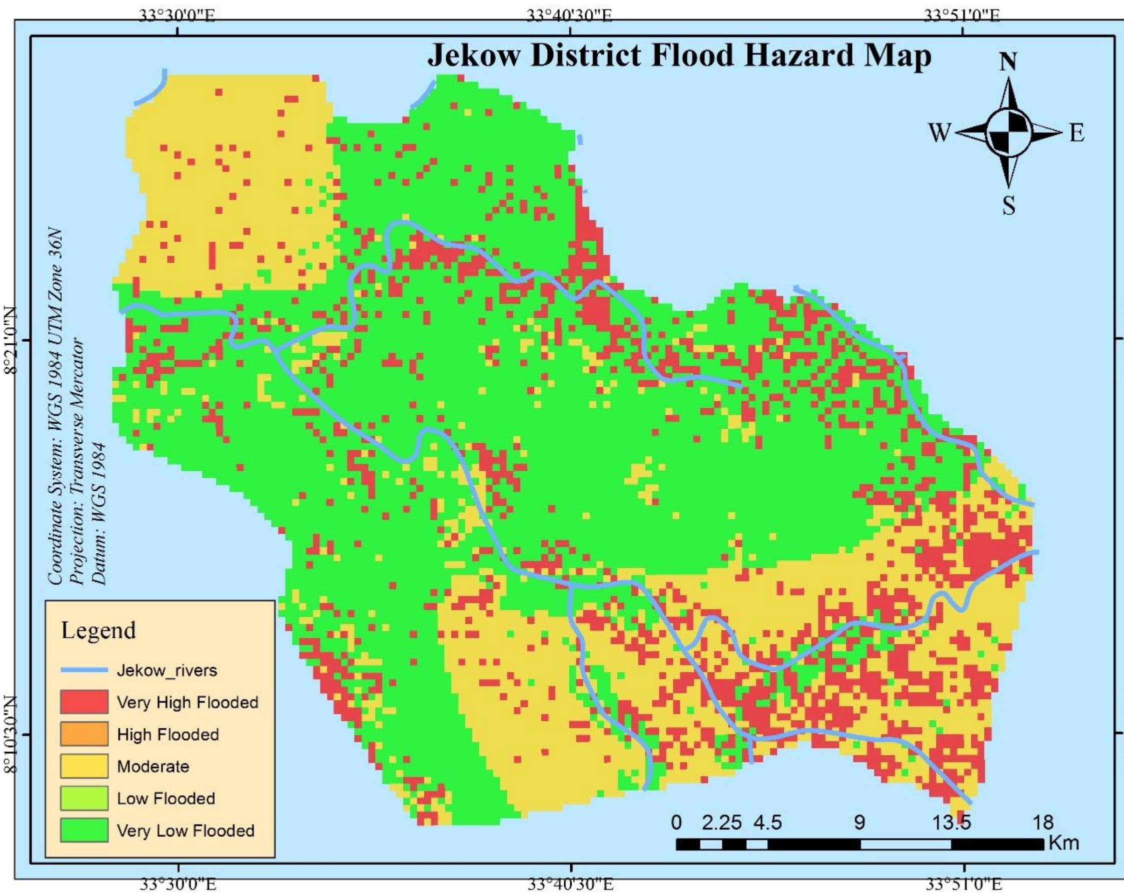

FIGURE 13: FLOOD HAZARD MAP OF THE STUDY AREA

4.4. The Possible Causes of Flood and its Mitigation Measures

Based on the respond of respondents on questionnaire survey and the discussion with the observation of the last year flood level, most of the respondents mentioned that, the cause of the flood in the district was the overflow of the Baro river and filled the Jikawo river which is the tributary of Baro river basin. In addition to that, the Baro river overflow caused by the heavy rainfall in the highland areas and affected the people living downstream of the Baro river.

The following flood mitigation measures were taken before, immediately and after the floods occurrence in the district. In order to deal with its prevention before the occurrence of its consequences, the district chief administrator, government official and the district's youths organized themselves to construct the flood protection on the road site. Because of the lack of interest from the regional government on flood hazard and its impact on the district, the flood level was not recognized due to the lack of flood measurement instrumentation and the regional government pay no attention on the flood affected areas.

Therefore, the study finding found that, the main causes of the flood in the district was the overflow of the Baro river caused by the heavy rainfall from the Ethiopia's highland and affected the lives of people in the downstream of the river. In addition to this, from the study finding, lack of interest from the regional government to take possible mitigation measures and not paying high attention to yearly flood affected areas and fail to comes up with good plan of flood hazard mitigation measures.

4.5. Flood Extreme Impacts in the District

4.5.1. Flood impacts on socio-economic activities

Agriculture, cattle keeping, and fishing are the main sources of income generation for the residents of Jekow district. It was also mentioned that the percentage of people used the agriculture, cattle keeping and fishing was around 80%, 15%, and 5%, respectively. Many respondents stated that their land was extremely fertile and ideal for agricultural development (maize, sorghum and wheat).

Other than agriculture, individuals in the study area earn money by keeping cattle and fishing. However, when the flood occurred, many animals died, potentially reducing their incomes. A common and immediate impact on household economic activity was the loss of livestock and damage to crop in the fields. According to the majority of the villagers, the loss of cattle was the most devastating impact to long-term economy and family income. Cattle and goats were utilized as a savings strategy for family living standards and income generation in both rural and urban areas. The destruction of housing at the study area consume the resources, time, and effort required to restore the shelters.

4.5.2. The impact of flooding on inhabitants and the spread of disease

Many of the houses in the Jekow were made of wood, grasses, and mud walls, which are simple to rebuild after flooding but reconstruction in every year cost a lot from the owner. These construction materials aren't durable enough to resist a huge storm. More than 80% of households have reported that floods had badly damaged their homes in 2019 and 2020 floods.

During focus group discussion, participants indicated that many old people, pregnant women, children, and cattle became infected and died as a result of the flood. Because of the likelihood of flooding, diseases (diarrhea) caused high death to children due to the entry of river water into wells and boreholes that are used for drinking water supply. During the 2019 flood, some children drowned in rivers while playing outside on the riverbank, according to the respondent.

According to 60% of respondents, this flood impact had a detrimental impact on milk production. Furthermore, they stated that the flood severely curtailed their ability to engage in other income-generating activities due to the inundation of the fields. Because the river flood continued longer than usual, it coincided with the recession crop cultivation period. Flooding has been a concern in the district for many years, according to the majority of respondents, both officials and flood victims.

Moreover, they all agreed that the frequency and magnitude of floods have increased dramatically in the last two years. The two rivers mentioned as major flood sources in the Jekow district are the Baro river and its sub-basins, such as the Zure (Jikawo) river but Baro river is the largest one.

Land use change and increase of flood frequency are mostly caused by poor road construction and investor blockade of water channels. The main problems of the flood in the district, according to flood victims, government departments, and NGOs, were deaths, diseases, and crop devastation. Malaria epidemics were a typical occurrence in many parts of the area following floods, according to health officials. Most participants, notably flood victims and those from disaster prevention and preparedness agencies, noted crop devastation as a secondary effect of floods.

Floods caused food shortages and malnutrition by destroying crops and inundating farmland. The majority of those who were displaced by the floods were poor and considered to be extremely vulnerable to food insecurity. When rivers draining down from Ethiopia's western highlands fill up and swell their banks, flash floods hit the Jekow district frequently.

According to the discussion with the district Chief Administrator, "Flash floods caused by torrential rains for more than a week have caused major rivers in the Jekow district to burst their banks and flooding residential areas and farmlands, and displaced more than 20,000 South Sudanese refugees relocated in the formerly camp known as Nip-Nip camp in the jekow district and 1500 internally displaced household in the year of 2015." Between June and October, the Jekow area experiences seasonal floods when heavy rains deluge the mountains throughout the rainy season.

FIGURE 14: FOCUS GROUP DISCUSSION (SOURCE: JUNE, 2021)

4.5.3. Flood impacts on agricultural activities

Agriculture provides a livelihood for more than 80% of the people in the Jekow district, and agriculture also dominated the district's economy. More than 80% of the population lives in rural areas reliant on subsistence farming, and agriculture accounts for nearly all of the economy. Maize crops are based on the easterly monsoon downstream of the Baro river during the winter season.

During one focus group discussion in the study area, residents assessed that floods had ruined 65-75 percent of the crop land. Many respondents stated that flooding destroyed the majority of floodplain land where animals used to graze. This flood hazard problem was concluded from the field assessment and discussions with locals that the majority of the agricultural land or grasslands were at high danger of flooding.

4.5.4. Flood impacts on governments infrastructures and others

Flood in jekow district had caused a lot of problems and damage to the people, such as damage of water supply schemes, schools and health facilities and environmental impacts. There were also major challenges related to health impacts faced by the people due to the flood hazard. Some of these challenges were mentioned below such as road inaccessibility that was unable to supply drug (damage of the main road that passed from Gambella town to the Jekow district), shortage of emergency drugs, transportation related issues (vehicles, fuels and inaccessibility due to road problem) and the absence of network access that made it difficult to communicate on time.

4.5.4.1. Flood impacts on water supply scheme

According to the discussion on flood hazard assessment and impacts, there was a shortage of safe/potable water supply in the district that caused by the heavy rainfall and damaged the water supply scheme. The main reason for the lack of safe water in the district was the non-functionality of most schemes and the damages caused by the current flood that made a lot of destruction in the areas. In the other hand, poor sanitation condition was observed in those flood affected areas and this may lead to water related disease.

Regarding household water collection and storage among observed households, most of them used Jerrican for collecting and storage of water supply but there was a demand of water treatment chemicals in kebeles where their water schemes are non-functional and currently using unsafe water from ponds and rivers.

According to the observation made during the field visit, in jekow district, there were 111 water schemes counted during the current flood assessment. Among them, 83 of water supply schemes were still currently functional. Out of these 83 functional water supply schemes 80 of them were untreated. The remaining 28 non-functional water supply schemes need partial and full maintenance.

4.5.4.2. Flood impacts on sanitation

Concerning sanitation, there was poor sanitation based on the data gathered from both health and water resource office sectors but during field visit in some villages observed that, there was rare latrine facilities and most of the people use river side and village side for open defecation where as some people are currently consuming river and other surface water without any treatment.

4.6. Flood Hazard Situation

According to the focus group discussion, in the last year flood in jekow district, the first rain started in the third week of April. At the beginning, the rain fall was medium in amount and started distribution in different parts of the area but at the end of May, the rain was starting increased which caused flash flood in the district. The district experienced with flood situation for long period of time from May up to July and damaged maize crops at growing and flowering stage. The amount of rain in jekow was very high and heavy starting from August to September. The ongoing rainfall caused flooding and damaged the crops in the field, affected homes, infrastructures damage, the main road damage that is the road from Gambella to the Jekow district and displaced a number of people in 13 kebeles (Mading, Banyrial, Burgile, Tognonack, Tongdol, Guthtik, Kalkich, Biyien, Nyabukelek, Wow, Chatyier, Luel, Biromtul). Anytime when the flood comes, the displaced people are settled on the road sides for their safety. These flood affected kebeles were classified in to five different flood classification based on level of floodability as very low, low, moderate, high and very high floodable areas. The figure below shows the flood's displaced people searching for the dry area to rescue their lives and properties.

FIGURE 15: *THE FLOOD DISPLACED PEOPLE EVACUATED FROM FLOODED AREA (SOURCE: BANYRIAL KEBELE)*

From the figure 14 shown below, showed the flood displaced people settled on the road side. Based on the respondents and the flood affected households, mentioned that people living around this area suffered most any time the flood occurred in the area.

FIGURE 16: *FLOOD DISPLACED PEOPLE SETTLEMENT AREA ON THE ROAD SITE (SOURCE: MADING KEBELE)*

4.7. Flood Hazard Preparedness

The assessment was conducted and observed that as the district officials, the community members and the kebeles who were highly affected by the flood know the time of flood's occurrence but the preparedness for flood hazard was very low and no one put it in to consideration as the best way to minimize the flood hazard. Almost the district has no active action plan as well as preparedness for the flood. According to the respond of the key informant interviews (KII), the district administrators did not strengthen the flood committee and failed to conduct regular meeting. In general, the sectors of preparedness and action plan were not active in their assigned duty. From the findings of this study, flood preparedness was not taken seriously by the government as the serious task to do for the prevention of the flood hazard.

4.8. Crop Condition

According to the group discussion conducted with the farmers for the degree of flood damage on the crop production, the group mentioned that the major crops cultivated in the field by the farmers in the district were maize and sorghum. The land preparation and planting activities of main crops such as maize was done at the time of cropping season. In the cropping season, a total of 5,000 hectare of maize were planned to cultivate but the achievement was only 4,992 hectares that is 99.8% from the plan. In general, due to the flooding, the production of crops decreased in every year because the flood increased yearly and damaged more crops. As a result of the yearly flood increase in the area, in the near coming years, the flood is going to be the worst natural hazard in the district.

FIGURE 17: CROP AFFECTED BY FLOOD (SOURCE: BANYRIAL KEBELE)

4.9. Livestock Condition

As the livestock was among the first income generation in the district, the rain contributed a lot in facilitating the availability of flood water for the flood impact on livestock. However, starting from August, there was high rain that caused overflow of the Baro river and it also has flooded the grazing land used for the livestock's feeding in most kebeles. There were also flood related livestock's diseases and because of this condition; 351 livestock, 103 sheep, 107 goats and 132 chickens were affected to death because of different diseases caused by flood.

FIGURE 18: CATTLE GRAZING AREA AFFECTED BY THE FLOOD (SOURCE: MADING KEBELE)

The figure above shows that the cattle grazing area affected and inundated by the flood around the bank of the Baro river. The people living around this area were relocated in another place for the safe of their lives and their livestock.

FIGURE 19: LIVESTOCK GRAZING IN THE FLOOD AFFECTED AREA (SOURCE: BANYRIAL KEBELE)

FIGURE 20: FLOOD DAMAGED HOUSE IN THE JEKOW DISTRICT (SOURCE: KALKICH KEBELE)

The figure 17 and 18 shown the flooded livestock grazing areas and the flood damaged houses in Banyrial kebele and Kakich kebele respectively. The flood displaced people and livestock were relocated on the road side for their safety. As a result of the flood situation in the most flood suffering areas, the only safe place for the relocation of both people and livestock was the road side of Jekow district.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

From the findings, the aim of this study is to fulfill the objectives stated for the identification of the areas that are most affected and the possible cause of flood hazard with its possible mitigation measures. By using Arc GIS software, the following flood generating factor maps were created during the development of the flood hazard map: slope, elevation, soil, land use/cover, rainfall and drainage density maps. Analytical Hierarchy Process (AHP) method was used for the calculation of the weighted coefficients or criteria weights in order to choose the most preferable criteria and overlay it for the flood hazard mapping. According to the study, agricultural land accounted for 45.90 percent of the land, and the area was extremely flood-prone. A research conducted in the selected area in the case of the Baro–Akobo river basin indicated considerable flood hazard consequences on individuals living downstream of the Baro river based on several environmental parameters. According to a study, there were only two types of soil in the targeted study area: chromic vertisols and eutric fluvisols types of soil. Eutric fluvisol was ranked 2 and chromic vertisol was ranked 1 based on their flooding rate. Because no data for the other soil type could be obtained, this type of soil was classed as "no data." The majority of the districts were determined to be in the lowland area, with elevations and slopes ranging from 398-435 meters and 0-90 degree, respectively. The sites identified at 398 and 435 meters above sea level were classified as from very low up to very high elevation. The rains arrived on time in the district, and agricultural activities were carried out as planned. As a result, the plan to produce more crops was always failed by the unexpected arrival of the flood in the crops field. During the cropping season, the flood primarily affected the crops and cattle. Summer was cropping season, and the flood had a significant impact, destroying crops, killing livestock, and drowning of the children.

Overall, the lives of individuals living in flood-affected areas are at high risk due to a variety of causes, including the deterioration of the flood-prone area's food security status. As a result, the district faced a significant risk of food scarcity for several months before the next seasonal crop.

5.2. Recommendation

- Flood hazard maps should be provided and distributed by the Disaster Prevention and Flood Security Agency (DPFSA) so that people are aware of flood hazard locations.
- Collect flood data from the past, then use a flood height/depth marker to indicate the most flood-affected locations.
- Flood awareness and preparedness programs in public places and schools should be implemented.
- Whenever a flood emergency occurs, the flood hazard areas should be marked, warning signs need to be introduced, and a plan for the relocation of the public should be implemented.
- The District Flood Task Force (Committee) should take their given responsibility seriously and actively.
- Regional support is strongly needed before, during and after the occurrence of the flood and should take the flood hazard as a serious problem on the lives of people living downstream of the Baro river.
- Further researches in this district are needed to be conducted on the same topic of flood hazard assessment and its impacts on downstream dwellers.

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APPENDIX

Questionnaire survey form

Instruction: the following questionnaire is data collection instrument to be filled in my study area, Jekow district. The questionnaire does not require your name so as to ensure confidentiality. You are required either to tick or circle one response for each of the question asked. You should answer all questions truthfully. Please note that there is no wrong or right answer and whatever response you give will be of use.

Appendix 1A. Multiple choice (question 1-25) from the given alternatives choose one alternative or two if it is necessary.

1. Sex: A. male B. Female
2. Age of respondent: A. 18-40 B. 41-50 C. 51-64 D. 65+ years
3. Marital status: A. Single B. Married C. Widow/Widower D. Divorce
4. Religion: A. Christian B. Muslim C. Pagan D. Other (Specify) _______________
5. Level of education: A. Non formal B. Secondary C. Diploma D. Bachelor Degree E. Master degree
6. Occupation/Job: A. Crop farming B. Cattle keeping C. Fishing D. Government employee E. Non-governmental employee
7. How long have you stayed in Jekow district? A. Born and raised in Jekow district B. Less than 10 years C. 10 years D. More than 10 years
8. Do you live in flood affected area? A. Yes B. No
9. Does the map show that you live in a flood hazard area? A. Yes B. No C. I don't know
10. Does the government put it concern on flooding? A. Not concerned B. Low concerned C. Concerned D. Moderately concerned E. Greatly concerned
11. Is there any outbreak of water born disease caused by flood? A. Yes B. No
12. Which part of your house was mostly affected by flood? A. Bath room (including latrine overflow) B. Garden C. Kitchen D. Living space E. Other (specify) ________________
13. Where did the water that entered your house come from? A. Overflow of Baro river B. Zure river C. Rain water D. Heavy rainfall from Ethiopia's highland E. I don't know
14. Does flood water has impact on your business activities? A. Yes B. No

15. If question No. 14 is Yes, what type of business activities affected by flood water? A. Agricultural land B. Small shop B. Grocery D. Other (specify) __________________
16. What is the major problem caused by flood jekow district? A. Loss of livestock B. Damage of agricultural production C. Drowning of children D. water born disease outbreak
17. Do you receive any flood warning? A. Yes B. No
18. If question No. 17 is Yes, before the flood occurrence, how did you first become aware that water might reach your home? A. Television B. Radio C. Observing river water level D. Announcing by Macro phone
19. If you buy new land, do you use flood map for spatial planning before constructing new house? A. Yes B. No
20. What was the maximum flood water level entered your house last year?

    A. Less than 10 cm B. 10-15 cm C. 15-20 cm D. 20-25 cm E. 25-30 cm
21. If government prepare the relocation place for flood affected people, it would be very useful.

    A. Agree B. Strongly agree C. Neutral D. Disagree E. Strongly disagree
22. In the last year flood, I was more aware about the high risk of flood hazard in Jekow district. A. Agree B. Strongly agree C. Neutral D. Disagree E. Strongly disagree
23. What is the effect of flood on water quality and its sediment for the area? A. Low B. Very low C. Medium D. High E. Very high
24. What is the effect of flood for your children when they go to school while living on the other side of river? How did they cross the river and effect on their school? A. By using boat B. Swimming C. Crossing river with someone who know swimming D. Dropout school during flood period
25. Does the regional disaster and risk prevention provide enough facility in order to reduce flooding water? A. Yes B. Not much C. No D. I don't know

Appendix 1B: Short answer question from (26-32)

Instruction: read and write your response based on the question you are asked

26. What is the distance between your house and Jikawo river, and the distance between your Baro river and your house _________and ________ respectively (meter or in kilometer)?

27. If flood is the main problem in the Jekow district, what are the possible measures do you think should be taken for the flood hazard reduction?
    a.____
    b.____
    c.____
    d.____
    e.____
28. Which months does the flood occupy most parts of the district? ____________________
29. What were the flood mitigation measures that had been taken for the last year flood hazard reduction?
    a.____
    b.____
    c.____
    d.____
    e.____
30. What are the negative impacts during and after flood and what are those impacts? ____
31. Does the flood has positive impacts during and after flood and what are those impacts? ____
32. In the last year flood, how many households were displaced and how many livestock you lost because of flood ____