JIMMA UNIVERSITY

COLLEGE OF SOCIAL SCIENCE AND HUMANITIES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

FLOOD HAZARD AND RISK ASSEESMENT USING GIS AND REMOTE SENSING TECHNIQUES IN GAMBELLA REGION; A CASE STUDY MAKUEY WOREDA

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ABSTRACT

Floods can be explained as excess flows exceeding the transporting capacity of river channel, lakes, ponds, reservoirs, drainage system, dam, mountain torrents and any other water bodies, whereby water inundates outside water bodies areas. Human activities such as: land degradation; deforestation of catchment areas; sprawl and increased population density along riverbanks, poor land use planning, zoning and control of flood plain development, changing the natural drainage systems; inadequate drainage, poor infrastructures particular in cities, and inadequate management of discharges from river reservoirs can significantly increase the risk of flood damage. In the Horn of Africa (HOA), composed of Djibouti, Eritrea, Ethiopia, Kenya, and Somalia are suffers from the frequent of flood. In Gambella People's Regional State (GPRS) the Gilo, Baro and Akobo Rivers started to overflow in June due to continuous heavy rains in the central highlands of Ethiopia. The Makuey Woreda and Wanthoa Wored which situated between Baro River and Alwero river or Makuey River were mostly affected by flood hazard in to various degrees at various times during flood. The impartial of the study has been identify the areas which are chronically suffering from flood hazard, analyze the flood probabilities, magnitudes and the vulnerability of people living in floodplain and estimation the flood risk on resident, environmental, agriculture & infrastructure. The methodology was consisted of data collection and data basing required for flood hazard and risk assessment. The multiple Categories of Hydrology modeling Tools, GIS and RS Technologies software and Geo-Statistical data analysis tools where applied. The warning level and danger level of floodplain areas was calculated using the maximum instantaneous discharge data. Flood Hazard Water Depth was calculate to illustrate the total area under the water depth by identify the more than normal levels for consideration of the increase of flood magnitudes. The Flood frequency analysis was done using the Gumbel’s Method for predication of flood peaks, maximum rainfall and to calculate the peak discharge. In additional proposed methods , the several steps has been involved for analyzing the influences of physical parameters approaches specially Rainfall, slope/elevation, drainages density, stream flow, geological and land used data. The Flood vulnerabilities, floodplain map, flood inundate map and flood hazard maps was developed to carry out the final flood risk maps in study area. The study indicated that the extreme and land use change, which involved intensification of agricultural activities, increased the overflow magnitude that caused high flood hazard in downstream part of the river basins. Based on the flood hazard study in the woreda the very low, low, moderate, high, and very high flood hazards zones were estimated the Agricultural, Crop Vegetation, Building up , Grass land and forest Land areas are classify as 5, 4, 3, 3, and 1 respectively. The interpretation on assessment of the flood hazard and risk indicated that a large percentage of cultivation area lies under high hazard. Areas of high hazard need immediate attention, hence appropriate flood protection measures should be taken earlier and the onset of the flooding used to be more predictable and allowed farmers to plan for sowing crops at the optimal time

Key Words; GIS, Remote Sensing, Flood Hazard, Flood Risk

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ACRONYMS

CRED:	Centre for Research Epidemiology of Disasters
CSA:	Central Statistical Agency
DEM:	Digital Elevation Models
FAO:	Food Agency Organization
FHIDPG:	Flood Hazard Identification Program Guidelines
GCS:	Geographical Coordination System
GeES:	Geography and Environment Study
GPRS:	Gambella Peoples Regional State
GPS:	Global Positioning System
GRSBoLR:	Gambella Regional State Bureau of Land Resources
HEC-RAS:	Hydrological Engineering Center Geographical River Analysis Systems
HOA:	Horn of Africa
ITCZ:	Inter-Tropical Convergence Zone
LC:	Land Cover
LU:	Land Use
NE:	North East
NNZ:	Nuer Nation Zone
RS:	Remote Sensing
SRTM:	Shuttle Radar Topography Mission

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Chapter One

1. Introduction

1.1. Background of the Study

Floods can be explained as excess flows exceeding the transporting capacity of river channel, lakes, ponds, reservoirs, drainage system, dam, mountain torrents and any other water bodies, whereby water inundates outside water bodies areas (Aris, 2003).

Flooding is the unfamiliar presence of water on land to a depth which affects normal activities. It can result as overflowing Rivers (river flooding), Heavy rainfall over a short duration (flash floods), or An infrequent inflow of sea water onto land (ocean flooding). Ocean flooding can be caused by storms such as hurricanes (storm surge), high tides (tidal flooding), seismic events (tsunami) or large landslides (sometime also called tsunami) or human activities such as: land degradation; deforestation of catchment areas; sprawl and increased population density along riverbanks, poor land use planning, zoning and control of flood plain development, changing the natural drainage systems; inadequate drainage, poor infrastructures particular in cities, and inadequate management of discharges from river reservoirs can significantly increase the risk of flood damage (Prasad et al 2016).

According to the ICSU (2007) study, from 1900-2006, floods in Africa killed nearly 20,000 people, and also affected nearly 40 million more, with estimated losses about $4 billion USD. In the Horn of Africa (HOA), composed of Djibouti, Eritrea, Ethiopia, Kenya, and Somalia are suffers from the frequent of flood and drought natural disasters that commonly result in losses of life, destruction of infrastructure, and reduction of agricultural production due to the Climatic change.

Because, Ethiopia is both highland/mountainous and lowland country, the topography has made the country vulnerable to flood risk that result in destruction and damage to the properties, losing of life, economic, livelihoods, infrastructure, services, and health systems. Then, some parts of the country face major flooding. Include: extensive plain fields surrounding Lake Zeway and Meki and Rib Rivers in Oromiya Regional State; The areas in Oromia and Afar Regional States that constitute the mid and downstream plains of the Awash River; the Residence in Somali Regional State that fall mainly along downstream of the Wabishebelle, Genalle and Dawa Rivers; low-lying ranges subsiding along Baro, Alwero(Makuey River), Gilo and Akobo Rivers in Gambella Regional State and downstream zones of Omo River in the Southern Nations, Nationalities and Peoples Regional State (Kassahun and Afsaw, 2008).

In Gambella People's Regional State (GPRS) which is situated in the western part of Ethiopia. The Gilo, Baro and Akobo Rivers started to overflow in June due to continuous heavy rains in the central highlands of Ethiopia. Because of flooding, the areas along Baro Rivers, particularly Itang, Jikow, Makuey and Wanthoa Woreda, were largely affected by flooding. The Makuey Woreda and Wanthoa Wored which situated between Baro River and Alwero river or Makuey River were mostly affected by flood hazard in to various degrees at various times during flood. Also Gog, Jor and Akobo woreda along the Akobo and Gilo River/ Pibor River were flooding during heavy rain Season (summer season) (FDPPAoE, 2006.).

1.2. Statement of the Problem

Naturally, flood is a potentially damaging physical event, phenomenon or human properties, which may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation. The risks of flood not only disrupt people's lives each year in floodplains, but frequently create personal tragedies when people are swept away and drowned. (UNISDR, 2004)

In study area flood can result the distributed large amounts of water and suspended sediment over vast areas. Among most severe natural disasters in region, flood hazard are accounts for major proportion in the terms of losing soil by eroded the large amounts of fast flowing water, ruining crops, destroying agricultural land / buildings and drowning farm animals and associated damages to people properties. In Makuey Woreda due to long rainy season in the area and extreme rainfall water from Ethiopian highlands brought a great amount of rivers water or Lake to swell and causing water from diverse source to flood away into certain parts of the woreda. Especially during the rainy season (June-October), the major perennial rivers as well as their numerous tributaries forming the areas drainage systems carry their peak discharges. Besides that, in Woreda during flooding, it resulted on the displacement of the many people from their home, crops were damaged and others properties were destroyed. Furthermore, the management and ultimately to reduce the risks that floods pose to human health (communicable diseases), environment, infrastructure and property. Needs deliberation of the river basins and sub-basins drainage by develop the Preliminary flood risk assessment, flood hazard mapping (for vital component for appropriate intensity and probability in flood-prone areas), Flood risk maps (for the flood probability measures social-economic, ecological and exposure of flood impact) in flooding areas and offer the Flood risk management planning. Therefore, using GIS provides a broad range of tools for determining areas affected by flood and for forecasting areas that are likely to be flooded due to rise in water level in a river (Wilson et al., 2008)

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of study is to assess the flood hazard and risk in Makuey Woreda using GIS and remote sensing techniques

1.3.2. Specific Objective

The subsequent of the specific objectives has been delineated in the following.

- ❖ To identify the areas which are chronically suffering from flood hazard
- ❖ To analyze the flood probabilities, magnitudes and the vulnerability of people living in floodplain.
- ❖ To assess physical parameter approaches influences on flood risk.
- ❖ To estimate the flood risk on resident, environmental, agriculture & infrastructure.

1.4. Research Questions

In order to get the relevant information of the Baro River flood risk, flood hazard and flood vulnerability plus exposure damage, the following Research Questions will be cared out;

- ❖ Which areas are habitually suffering from flood hazard?
- ❖ At which month the flood become extreme in area and what are likelihoods for less vulnerabilities feature recycled during flooding?
- ❖ Are the flood risk has impact on Socio-economic activities, resident and agricultural factors.
- ❖ There are any influences of the flood causative factors on flood Risk?

1.5. Significant of the Study

The floods are natural Hazard occurring processes that are difficult to prevent but can be managed in order to reduce its social and economic impacts. Thus, the assessment of flood hazard and Flood risk is to understand the probability that a flood of a particular intensity has been occurred over an extend period of times. Develop the understanding and awareness of the Community Members for flood risks. allow neighboring communities in a flood risk task area to see factors that may impact them, fostering collaboration and Quantify potential future flood losses to existing structures or homes to the people living in the river basin. Support the governmental organizations, Floodplain Management, Hazard Mitigation Assistance (HMA) grants and Community Rating System (CRS) activities to reduce flood risks in the area. Enhance emergency and community planning by illustrating highest impacted areas. Help them to calls proper planning process in flood prone areas and the exposure and the adverse impact of the flood risk on human health, environment, cultural heritage and economic activity would be understood.

1.6. Scope and Limitation of the Study

Geographically, the Scope of study were stable only on the assessment of flood hazard and risk in Makuey Woreda, Nuer Zone, Gambella Regional State to cure-all the floods Hazard and risk. Some limitations result because, the Satellite Images resolution that shows the accurate of rivers drainages system or water storage are not very acute on water drainage system modify. Since, any flood hazard estimation, Flood Vulnerability and Flood risk mapping attempted to develop its request availability of high Satellite Images resolution (Raster DEM). The less availability of GIS and RS Hydrology models tools (Computational river flood models) used for flood hazard and risk analysis also drawback early finishing of the study.

1.7. Organization of the Paper

The paper has been organized into five chapters;- Chapter One; deals on introduction/the background of the study, Statement of the problem, Objectives (general and specific objectives of the study) ,Research Questions ,Significance of the study , scope and limitation of the study and organizations of the paper. Chapter Two; review the Literature that linked with flood hazard and risk assessment. Chapter three; deals on Research methodology, description of the study area, Sources and Types of Research data, Sample sizes and

Sampling techniques, Method of data analysis and Presentation, and Ethical considerations. Chapter four; illustrate the data presentation, analysis and interpretation. Chapter five; about treated the conclusions and recommendations of the paper.

Chapter Two

2. Literature Review of the Flood Risk

2.1. The important of GIS and Remote Sensing on Flood Risk

Geographical Information System (GIS) is a system collection of computer hardware, software, geographic data, and personnel to efficiently for capturing, storing, checking, manipulating, analyzing, displaying data which are spatially referenced to earth (Department of Environment –UK, 1987). Remote Sensing (RS) is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in physical contact with the object, area, or phenomenon under investigation (Lillesand & Kiefer, 1999). So, the protagonist of GIS and remote sensing technology to map flood areas that should be easy to plan essential measures which reduce the flood damages and risks to be a great benefit to implement a flood management program that consists of flood forecasting, flood hazard, flood vulnerability and flood risk mapping. Not only that, The Geospatial Technology (GPS, GIS and Remote sensing) are extensively used to assemble information from different spatial data, aerial photographs, satellite images and digital elevation models (DEM) for flood risk assessment, analysis and preparation of flood hazard mapping (vital component for appropriate intensity and probability in flood-prone areas), flood vulnerability mapping (vital component in mitigation for social-economic and ecological of the flood damage) and flood risk mapping (flood probability measures social-economic, ecological and exposure of flood impact) in flooding areas. GIS provides a broad range of tools for determining areas affected by flood and for forecasting areas that are likely to be flooded due to rise in water level in a river. The main benefit of GIS for flood management and planning is that, it generates visualization of flood prone areas that creates potential to further analysis the product to estimate probable damage due to flood(Alexander et al, 2011).

2.2. The Factors that intensify the Flood Frequency

2.2.1. Physical Factors on flood exaggerated

Around the global world, there are differences category that intensify the flood risk frequencies. The size and shape of a river's have influences on flooding, drainage basin dictates how much precipitation the river can receive and how quickly it will arrive (the lag time). A large drainage basin means that the river's catchment area is large so it will collect a lot of water, increasing discharge. If the basin is circular in shape, the precipitation will enter the river at roughly the same time because all points in the basin are equidistant from one another. This would produce a high peak discharge and can lead to flash floods. The relief and steepness of the basin affects how quickly water enters a river and so how likely a river is to flood. If the river's valley has steep sides, water will quickly enter a river increasing the river's discharge. The number of tributaries flowing into a river affects the likelihood of floods. If a river has a lot of tributaries, the river's discharge will be much higher because lots of water will be entering it from its tributaries. After heavy precipitation, the discharge will rise even more and floods are likely, especially at confluences (where a tributary meets the river) as this is where discharge is highest (Prosser, 2001).

2.2.2. Human Aspects on Flood Exaggerated

In addition to the risks to lives and property that people take by moving into flood-prone areas, development for human use often involves clearing land of its native vegetation and altering the characteristics of the ground cover. Vegetation works together with the soil to store rainfall, so when that vegetation is cleared, rainfall runoff can increase substantially. Rather than being absorbed by the soil and its natural vegetation, in areas where that vegetation has been cleared (either for construction or for agriculture), heavy rainfall is more likely to run off and pour into streams and rivers, increasing the potential threat from flash floods and river floods. Construction of roads and buildings also acts to increase runoff, and leads to an increasing likelihood of localized urban flooding. Such construction dramatically increases the fraction of the rainfall that runs off, regardless of antecedent rainfall. Human-caused fires can also produce at least temporary increases in the runoff potential in the headwater regions of streams and rivers. It is evident that human activities are increasing the potential for floods around the world (Agnone, 1995).

2.2.3. Climatic Influences on flood risk

As the globe warms, flooding could become a more widespread problem. Warm air holds more moisture than cool air, so the heaviest precipitation events could become heavier as air temperatures tick upward. These bursts of precipitation which usually fell as rain or snow, the tough on infrastructure cause flooding. Climate models suggest that global flood risk will change as the world warms. Climate change is likely to contribute to devastating floods more directly. Melting glaciers can put pressure on the natural dams that corral melt water into the stunningly beautiful high-altitude lakes that dot places like the Himalayas and the Andes (Apan et al, 2010).

2.3. Flood effects on dissimilar physiognomies

2.3.1. Flood Impressions on Humans and Animals

A flood has impact on both humans and animals individually. The consequence of flooding has both negative and positive, greatly depending on the location, extent of flooding and the vulnerability value of the environments it affected. A positive is that the water from the floods can spread silt and sediment that contains rich minerals and nutrients which have been washed down. This improves the fertility of the land for agricultural activities. The negative impacts are Loss of habitat for both plant and animal life, which causes a reeducation of biodiversity in the area, and may cause some species to become endangered. The Severe erosion and destabilization of the soil, hillsides and carried huge amounts of rubbish, debris and other forms of pollution down to the river mouth, where they empty out into the sea. Flood caused Loss of lives and properties (include loss of human life, damage to property, destruction of crops, loss of livestock, non-functioning of infrastructure facilities and deterioration of health condition owing to waterborne diseases), Loss of livelihoods (loss communication links), Decreased purchasing and production power, Mass migration and Psychosocial effects (The loss of loved ones can generate deep impacts, especially on children) (Chapman, et al, 2011).

2.3.2. Flood Effects on Social Aspects

The biggest, most obvious effect is death. Floods, especially flash floods, will kill people. Flood water can travel surprisingly quickly and weighs a lot, so people can easily get swept away by floods. Large chunks of debris and objects like cars can easily get picked up by floodwater and can easily kill a person should they get hit by the debris (FHIDP, 2011)

2.3.3. Flood Effects on Economic Features

The big economic effect of a flood is property damage. Water can cause a lot of damage to property and when it picks up large chunks of debris such as cars, it can act like a wrecking ball, taking out chunks of buildings when cars crash into them. Very large and powerful floods can even dislodge buildings from their foundations and move them. Floods can cause extensive damage to infrastructure such as power lines, roads, water pipes etc. Bridges frequently collapse during a flood as they aren't designed to withstand the high discharge of the river. So, repairing bridges and other types of infrastructure are very costly. Not only this, it can lead to a decline in the local economy as businesses are unable to operate without power or road connections. Unemployment can even increase if businesses are unable to fully recover from a flood (IBISWorld, 2011).

2.3.4. Flood Effects on Environmental Aspects

Floodwater that is contaminated with sewage will pollute rivers and land when it drains back into the river. Similarly, if the river floods onto farmland, the water can be polluted by pesticides and other chemicals sprayed onto the farmland that, when drained back into the river, can pollute it and kill off wildlife that inhabits the river (Bunn, et al, 2002).

2.4. Types of flood and their different floods pose comparable risks

2.4.1. Different floods pose comparable risks

Globally, floods can be recognized on the basis of the following; The Origin of the water source. One may differentiate between water from the sea (coastal floods), from rivers (fluvial floods), from above ('pluvial' floods) or from below (groundwater floods and sewage overflow). Differentiation in geography: Coastal and estuarine flooding: when the sea invades the land, Fluvial flooding: when rivers overflow their banks or cause the breaching of embankments, Areal flooding of catchments, urban areas or polders: when drainage capacity is insufficient to carry rainstorm water away fast enough. With cause, floods can be distinguished resulting from excess rainfall (inland), storms (coastal), earthquakes (tsunamis) and floods resulting from dam break (man-induced). With speed of onset, one may distinguish “flash floods” from slower flooding types. Flash floods can occur in mountainous area during intense rainstorms; they are characterized by high flood water velocity. Rapid onset can also occur where flood defenses are breached (e.g. a dam or dike failure). Low speeds of onset generally occur when flood waters accumulate slowly over days or weeks in large catchments or where the drainage regime (natural or artificial) cannot accommodate even low rainfall intensities, so that localized ponding results (Frans et al, 2009).

2.4.2. Types of flooding

2.4.2.1. Flash Flood

Water from floods can take time to build up, allowing the population in an area time to be warned in advance. But sometimes flooding occurs quickly. Flash floods gather steam within six hours of the events that spawned them. They are characterized by a rapid rise of fast moving water. Fast-moving water is extremely dangerous water moving at 10 miles an hour can exert the same pressures as wind gusts of 270 mph (434 kph), according to a 2005 article in USA Today. Water moving at 9 feet per second (2.7 meters per second), a common speed for flash floods, can move rocks weighing almost a hundred pounds. Flash floods carry debris that elevate their potential to damage structures and injure people (NASA, 2012).

2.4.2.2. Coastal flooding

Coastal flooding is caused by extreme tidal conditions including high tides, storm surges and tsunamis, waves driven by strong winds and surges of seawater caused by storms. The most severe coastal flooding often occurs when surges and high waves coincide with high tides (WMO, 2010).

2.4.2.3. Fluvial

Occurs when 'ordinary watercourses' (e.g. streams and ditches) are unable to contain large volumes of water falling or flowing into them, such as during or after heavy rain. There are numerous contributing factors to fluvial flooding. They include: Rainfall conditions, such as intensity, amount, and distribution; and Ground conditions, such as amount of soil moisture, seasonal variations in vegetation, depth of snow cover, imperviousness due to urbanization. Fluvial floods along large rivers occur in large catchments. They tend to cover the largest areas by flooding large floodplains at the lower end of catchments during prolonged periods, but can be foreseen days ahead allowing time for warning and are characterized by slow rise. They bring about huge damage and may affect many people, but generally cause few fatalities (Hays et al, 1981).

2.4.2.4. Pluvial

It occurs when rainfall or snowmelt is not absorbed into the ground forcing the water to flow overland. The area will remain flooded until water has drained away through storm water systems or waterways. In instances where there is no drainage system, such as the prairie pothole region, the water ponds remain until the excess water evaporates sublimates or transpires. Factors that contribute to pluvial flooding include: Rainfall conditions, such as the severity of rainfall; Ground and soil conditions, such as, soil type, amount of soil moisture, seasonal variations in vegetation, depth of snow cover, imperviousness due to urbanization; Sewer infrastructure, such as overland storm water flow conveyance capacity, the state of the sewer infrastructure. Pluvial' floods in upper catchments, urban areas and polders may be localized when resulting from summer storms, but can also be large-scale when caused by weather conditions related to huge low pressure areas. They can have devastating effects on densely occupied urban areas, but the consequences are usually limited to damage and seldom include fatalities (Jha et al, 2012).

2.4.2.5. Alluvial Flooding

Alluvial fans are naturally occurring deposits of unconsolidated sediment that have accumulated at the mouth of a mountain canyon. As sediment comes downstream it accumulates until the riverbed rises high enough that water spills over the banks and begins to create a new path for the river in a lower area. The process is then repeated in a new area. This process causes the alluvial fan river to move either gradually over time or rapidly during flash flooding (NIDMI, 2017).

2.4.2.6. Groundwater (Saturated Conditions Reaching the Ground Surface)

It occurs when rainfall makes the groundwater table rise above its normal level. This type of flooding can last for weeks or months and is most likely to occur in areas above an aquifer (BGSR, 2012).

2.4.2.7. Reservoir flooding

It occurs after the failure of the reservoir's walls or earth embankments. This may be caused by erosion due to seepage, overtopping of the dam or by accidental damage to the structure. Reservoir failure is extremely rare to happen (Kingsford, 2000).

2.5. Flood hazard and flood risk maps

Flood hazards and risks are to be mapped for the river basins and sub-basins with significant potential risk of flooding for three scenarios: Floods with a low probability or extreme event scenarios, Floods with a medium probability (likely return period > 100 years) and Floods with high probability, where appropriate The maps may show information on flood extent, depths and velocity of water, and the potential adverse consequences (FLOOD site, Article 6, 2013)

2.6. Floods Risk in Africa

Torrential rains and flooding in Africa affected 600,000 people in 16 West African nations in September 2009. The worst hit countries were Burkina Faso, Senegal, Ghana and Niger. This event closely followed the 2007 floods that displaced more than a million people in Uganda, Ethiopia, Sudan, Burkina Faso, Togo, Mali and Niger, and claimed over 500 lives, and the 2008 flooding in Mozambique (United Nations, 2009). These events, and the continually increasing number of people affected by flooding during the 2009–2010 rainy season, which numbered about 25,000 through April 20, are the most recent examples of the growing flood risk in Africa. In fact, the economic damage caused by floods as well as the number of people affected by this hazard has substantially increased in recent decades. The number of fatalities caused by floods in Africa during the period 1950–2009 (Centre for Research on the Epidemiology of Disasters (CRED), 2004) summarized that deaths have increased about one order of magnitude during the last 50 years. These indicate to understand the flood risk has strongly increased in Africa (Jonkman, 2005).

2.7. Floods Risk in Ethiopia

Ethiopia is one of the largest countries in East Africa, and its topography has made the country vulnerable to flood risk that result in destruction and damage to the properties, losing of life, economics, livelihoods, infrastructure, services, and health systems. The long rainy season in the Ethiopian highlands brought a great amount of rivers water or Lake to swell and causing water from diverse source to flood away into certain parts of the country (Kassahun and Afsaw. 2008).

2.8. Floods Risk in Gambella Region

In Gambella People's Regional State (GPRS) which is situated in the western part of Ethiopia separated by Baro River with south Sudan. Main populated by lowland indigenous people (Nuer, Anuak, Majeng, komo and Opo), the Gilo, Baro and Akobo rivers started to overflow in June due to continuous heavy rains in the central highlands of Ethiopia. Because of flooding, the Areas along Baro Rivers, particularly Itang, Jikow and Makuey Woreda, were largely affected by flooding. The Makuey Woreda and Wanthoa Wored which positioned between Baro River and Makuey River(also called Alwero river) were mostly affected by flood hazard in to various degrees at various times during flood. Also Gog, Jor and Akobo woreda along the Akobo and Gilo River (Pibor River) were flooding during heavy rain Season (summer season June- October) (FDPPAoE, 2006.).

2.9. Floods Risk in Makuey Woreda

In Makuey Woreda Most of the people live along the Bank of Baro river, Makuey River and Zure River (which is Baro River water source), this makes them susceptible to yearly flooding. Excessive rains in area, caused rivers to overflow. There are many others River drainage channels in the area that increase the flood extent, but the major rivers drainage in Makuey Woreda is the Baro and Alwero also named Makuey River which flow throughout the year, but their water source originating from the others highlands area Rivers and rainfall water. As a result, flooding is the most common natural disaster in the area. In Woreda during flooding, it resulted on the displacement of the many of people from their home, crops were damaged and others properties were destroyed. Furthermore, floods have often resulted in deaths, drowning, communicable diseases, and malnutrition and caused interruption of health services due to the damage to the health infrastructure in area (Woube M, 1999).

2.10. Flood risk management plans

Flood risk management plans are to be developed and implemented at river basin or sub-basin level to reduce and manage the flood risk where identified as necessary in the preliminary flood risk assessment. These plans are to focus on the reduction of potential adverse consequences of flooding for human health, the environment, cultural heritage and economic activity, and, if considered appropriate, with non-structural initiatives and/or on the reduction of the likelihood of flooding. They are to address all phases of the flood risk management cycle but focus particularly on:

- ❖ Prevention (i.e. preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas or by adapting future developments to the risk of flooding),
- ❖ Protection (i.e. taking measures to reduce the likelihood of floods and/or the impact of floods in a specific location such as restoring flood plains and wetlands) and
- ❖ Preparedness (e.g. providing instructions to the public on what to do in the event of flooding) (The EU Floods Directive, 2017)

Chapter Three

3. Material and Methods

3.1. Description of the Study area

Makuey Woreda is one of the 13 administration woredes in the Gambela Regional States. It's located in Nuer Nation Zone (NNZ) which is 2nd administration Zone in the Gambella Peoples Nation Regional State (GPNRS). The area has characterized under five Nuer Zone administration Woredas (Lare, Jekow, Makuey Wanthoa and Akoba).The geographic Coordination System of the Makuey Woreda is between 8°28' N-8°05' N latitudes and 33°30' E-33°51' E of longitudes. Makuey Worda it's bordered to the south by the Anuak Zone (Gog woreda), on the west by the Wanthoa woreda, on the north by the South Sudan (separated by Baro River), on the North-east by Jekow Woreda and on the South-eastern by Lare Woreda. The administration town of Makuey Woreda and Nuer Zone is called NGINE-NGANG. The distant between Makuey Woreda and Gambella town is 110 km which meant it cover 566 km with Jimma Zone. The woreda contains 21 administration Kebelle and 8 Community Member Participation administrative units (like: Tormorok, Adura, Konday, Koatgar, Warach, Block, Gier and Bildak) (Dereje, 2003).

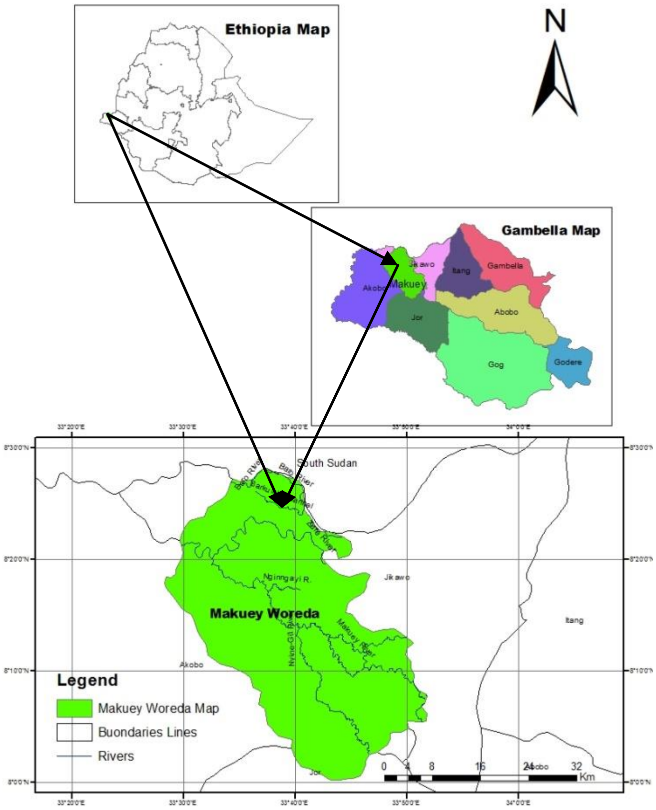

Figure 1: The Location Map of the study area

3.1.1. Demographics

Based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), the Woreda total populations were 23,528, of whom 12,235 are men and 11,293 women. With an area of 1,081.04 square kilometers, The Woreda majority inhabitants were Protestant with 90.28% they are protestant Christianity observed believer, while 6.08% practiced traditional religions, 2.48% were Catholic, and 1.16% of the population practiced Ethiopian Orthodox Christianity. The largest ethnic groups in Makuey Woreda were Nuer 97.96%, the other ethnic groups made up 2.04% of the population. Nuer language is spoken as a first language by 98.08%, others 1.88% and 0.04% are accounted as primary languages spoken, but Amharic is a working language in area. In the study area, the social activities are unique to others Ethiopian peoples. Permanently, the women are all ways queen to done home activities like cooking, prepare stew, collecting wood fire somewhere, fetching water, wishing all family the cloth and others. The men where get ready to cultivating the farm land, hunter, fisheries, cattle keeper and others domestically animals. The 18yr old girls or boys can participate in wedding activities as well as possible to be marriage (CSA, 2007).

3.1.2. Economic Activities

The economy of the areas is mixed farming (crop production complemented by livestock rearing).Crop production are rainfall feeding. The main crops grown for home consumption are maize, and sorghum. Maize and sorghum are long cycle. The livestock reared are cattle, sheep, goats, donkeys and chickens. Livestock are replaced through purchase and from within the herd. Men and women share the responsibility of looking after animals. Livestock's are the primary source of income in Woreda. In the Rural and Town people are mostly depends on agriculture, livestock, fishing, trade and administrative services (Peter, 2010)

3.1.3. Topographic and Climatic Conditions

The woreda extends hot lowland zones with extreme ranges of temperature and rainfall variation. There are two seasons in the Makuey woreda based on the movement of Inter-Tropical Convergence Zone (ITCZ), the amount of rainfall and the rainfall timing. The two seasons are Kiremt (summer), which is the main rainy season (June-October), Bega (Spring), which is the dry season (November-May). The mean annual rainfall varies from 879 mm in the high elevated areas to 435 mm in low elevation area of the woreda. In the same way, the mean annual temperature of makuey Woread ranges from 23°C in the summer to 39°C in the spring season. The terrain in Makuey Woreda consists of marshes and grasslands area; the elevations range from 390m to 412 m. a. s. l. According to the Atlas of the Ethiopian Rural Economy published by the Central Statistical Agency (CSA), around 10% and 90% of the Woreda is forest and Grass land respectively. The Several areas in Woreda become flooded during the rainy season (summer), this force the people to migrate to the medium highlands areas with their cattle until the waters recede. (GRSBoLR. 2011)

3.1.4. Land use, Land cover and soil

Area lies in moist every green forest and grass endowed with a vast marginal land which is suitable for Agriculture and other economic activities. The existing land cover (vegetation) types of the Woreda are identified as cultivated land, forest, woodland, bush land, grassland, wet (marsh land).The most common soil types in the study area are Cambisols and Vertisols. The Vertisols are dominated by the clay mineral. This clay mineral expands when there is a wet condition and shrinks when there is a dry condition, causing cracks at the surface in the dry season (FAO. 2014)

3.1.5. Vegetation

The woreda has a vast collection of savannahs, riverine forests and grasslands. The general landscape is flat but it has area of raised ground that supports deciduous woodlands and grasslands. Extensive areas covered by grasslands are inundated by water forming valuable seasonal wetlands in the rainy season. There are however extensive areas of permanently inundated wetlands especially near rivers. Grasses have lush growth and there are species which can reach 2-3 meters in height (Tesfaye et al., 2001)

3.1.6. Hydrology

The major river in the study area is Baro and Makuey and Zure. The Baro and its tributaries drain a watershed 41,400 km2 (16,000 sq mi) in size. The river's mean annual discharge at its mouth is 241 m^3/s (8,510 ft^3/s). The Baro River is created by the confluence of the Birbir and Gebba Rivers, east of Metu in the Illubabor Zone of theOromia Region. It then flows west through the Makuey Woreda join with the Pibor River after crossed area, both of them creating the Sobat. Other notable tributaries of the area include the Alwero and makuey Rivers. During the rainy season, between June and October, the Baro and Tributaries River contributes about 10% of the Nile's water at Aswan, Egypt. In contrast, the Baro River has very low flow during the dry season especially in February-May (Collins, (2002).

The main source of recharge for the vast groundwater system is the rainfall on the highlands during the rainy season. The major recharge occurs in the Eastern area where annual water rainfall is high from highland areas to the western low lands a long South Sudan, where annual rainfall is very low. These aquifers are recharged the Baro River and others channels streams that originate from the North-eastern part of the woreda. Seasonal floods occur in summer because of heavy rainfall from highlands. The all River in area are flows in western direction through Makuey and Wanthoa woreda territory and finally they drains in to main stream of Baro River and start flowing to White Nile in South Sudan. Kongdekuach River (from Abobo dam) crosses the Woreda and meet with Zure river (Baro river tributary) in Adura district (kebelle) they start flowing toward South Sudan along Wathowa Woreda and intersect again with main stream of Baro River in Wangnyang area before flowing to South Sudan (https//en.wikipedia.org/wiki/Makuey/jakiow#citiesnot-2).

3.2. Research Methodology

The methodology was consisted of data collection and data basing required for flood hazard and risk assessment. Based on the capability to work on the existing problems for achievement and predetermined the research objectives. The multiple Categories of Hydrology modeling Tools GIS and RS Technologies software (Arc GIS 10.3 Software package/ ERDAS 10) and Geo-Statistical data analysis tools (kriging) where applied. The warning level and danger level of floodplain areas was calculated using the maximum instantaneous discharge data. Flood Hazard Water Depth was calculate to illustrate the total area under the water depth by identify the more than normal levels for consideration of the increase of flood magnitudes. The Flood frequency analysis was done using the Gumbel’s Method, which is a most widely used probability distribution function for extreme values in hydrological and meteorological studies for predication of flood peaks, maximum rainfall and to calculate the peak discharge. In additional proposed methods , the several steps has been involved for analyzing the influences of physical parameters approaches (Rainfall data, slope and elevation, drainages density, stream flow data, topographic data as well as geological and land used data) on flood risk. By prepared, collected, stored and preprocesses them on the implemented in ArcGIS 10.3. Flood hazard maps of the study area for 5 year and 25-year return periods was prepared by overlaying flood grid depths with the TIN. Based on, the flood hazard and risk assessment proposes, the Flood vulnerabilities, floodplain map, flood inundate map and flood hazard maps was developed to carry out the final flood risk maps in study area.

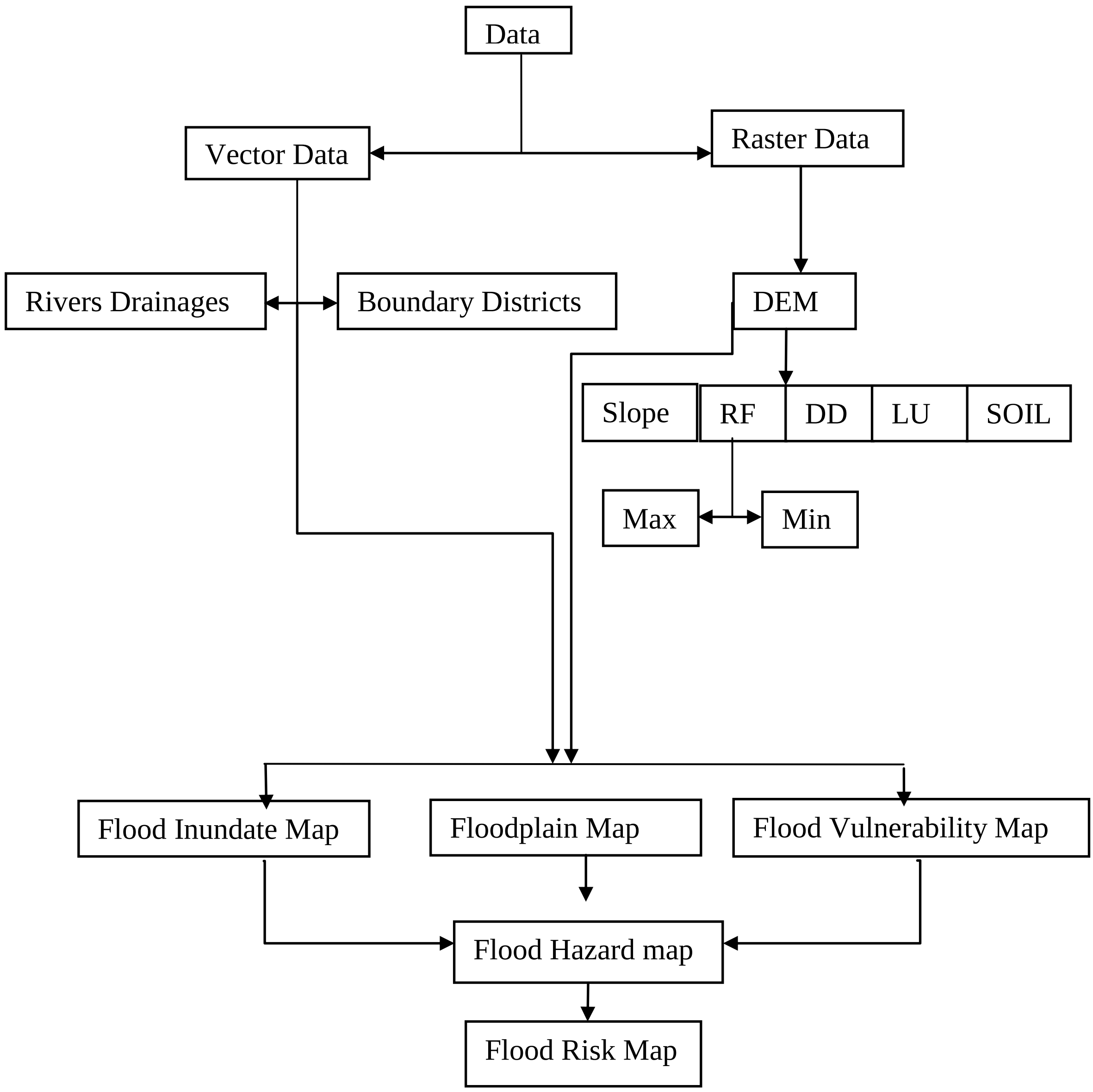

Figure 2 Flow Chart Research Methodologies

3.3. Source of the Data

The terrific information needed for flood hazard and flood risk assessment or mapping was obtained from the subsequent numerical data sources: a) maps, aerial photographs, and imagery; b) field survey and group discussions; and c) published and unpublished documents. The Meteorological data, particularly monthly annual and average annual rainfall where obtained from of the nearest gauge stationary and EMAs, and correspondingly, the hydrological old history data of Rivers and its tributaries were collected from the Department of Hydrology and Meteorology. The walkover survey was conducted for gathering information on study Area Rivers undercutting, debris flow, and flooding in the watershed.

3.3.1. Satellite Data

The topographic map and digital elevation model (DEM) produced by the Shuttle Radar Topography Mission (SRTM) at 30 m resolution has been extracted to generate a flood inundation map, Land use map, Soils map and slope map for the basin discharges in the main river and tributaries. The rainfall maximum/ minimum data of the Baro River Basin with average annual rainfall of 5 and 25 return periods where collected from the National Meteorological Agency (NMA), Ethiopia and Rainfall point data was attracted from Raster DEM. The soil type and stream flow data was obtained from the office of Water and Energy. The daily stream flow data was collected from the available gauging stations in Area. Drainage network map And Water shade map of the study area has been created using (Digital Contour Maps, Spot Heights, Land use maps, flow direction, flow accumulation and flow order). The rainfall and relative humidity data was gather the geographical location of meteorological stations as a point data and the single average value where used for surface interpolation in Arc GIS geospatial analyst tools.

3.3.2. Vector Data

The geographic database (geodatabase) is a core geographic information model to organize a spatial data in to thematic layers and spatial representations. Therefore, on the classification and storing of Vector Data, the two types of geodatabase architectures are available under ESRI's ArcGIS package (Personal Geodatabase and Multiuser Geodatabase) has been used. The Personal Geodatabase has been used for implementing and storing the necessary Vector data that was applicable to Multiuser Geodatabase and the final analysis of the designed objectives.

3.3.3. Field Survey Data

Questionnaire was design and distributed to the people of makuey woreda, especially those who living in the flood plain areas to get information of flood damages per household, agricultural damages, infrastructure, Socio-economic and environmental aspects in study area. The aspect field observation has been care out to determine what sort of flood destructed in human activities around the study areas. The GPS surveying was used for labeling the Flood pro-zone, catchment areas, flood damage (vulnerability areas) and shows the GCS (NE and Elevation) of districts/Kebelles. The Digital camera (i.e. high resolution android mobile phone) was used for photography and recording the flood areas during the field observations of the flood risk.

3.4. The data Analysis and Processing

prepare and facilitate on the flood Hazard and risk analysis, the researcher first was evaluate the achieving sequences from the questionnaire survey, Key Informants Interview, GPS survey, digital camera, and field observations to ensure clean data set, editing, coding and cleaning of the collected data.

3.4.1. Satellite Data Analysis Process

During satellite data analysis the environmental radiometric has been correction using histogram equalization, dark pixel subtraction, line striping, noise correction, haze correction and image contrast.The images were mosaic using feather overlap function of ERDAS Imagine and the study area map has been extracted using study area boundary. The satellite imagery was converted into False Color Composite (FCC). Based on the FCC a visual interpretation key (tone, texture, shape, size, color, association and pattern) has been generated and prepared a vegetation type/land use map using on-screen visual interpretation techniques in Arc map. Data Merging and GIS Integration, These procedures was used to combine imagery data for a given geographic area with other geographically referenced data sets for the same area in the context of a GIS.

3.4.2. Flood Hazard Mapping Analysis Process

For Analysis the flood hazard mapping, the selected flood generating factors, such as average annual rainfall, soil map, elevation, slope, drainage density, and land use was rasterized and classified in raster format and then weighted overlay using ArcGIS 10.3 during the development of the final flood hazard map.

3.4.3. Floodplain Mapping Analysis Process

A floodplain is an area of mostly flat land surrounding a river, stream or creek that experiences flooding when one of these waterways overflows its banks. In this study the two main portions types of the floodplain (Floodway which is refers to the main area affected by an overflow, where the majority of water gathers to create a new, stronger water path and The Flood Fringe meant the outer area that lies beyond the floodway, where less water gathers and it moves much slower) where used.

3.4.4. Flood Inundation areas mapping Analysis Process

The DEM (digital elevation model) was processed to create the TIN (triangular irregular network). After the RAS geometry data preparation, the HEC-GeoRAS model was used to generate the RAS GIS import file (final river geometry file) that can be used as input for HEC-RAS. Checking the cross-section; editing the river geometry, and making final correction of the river geometry file in the HEC-RAS model has been carved out. The water surface levels for each return period where exported in HEC-GeoRAS for final inundation area mapping along the river.

3.4.5. Software Analysis Processing

The following Software's has been used in this study to select, based on the capability to work on the existing problems in achieving the predetermined objectives. Therefore, during data entry procedures, the data was imported and exported using multiple Categories of Hydrology modeling Tools, GIS and RS Technologies software as well as others Geo-Statistical data analysis tools. The HEC-RAS 4.1.0 (has been used for Floodplain, Flood Stimulations and flood extents). Arc GIS 10.3 Software package for mapping development factors and Arc Hydro software extension on Arc GIS for delineated the watershed for which flood hazard analysis has been done. ERDAS 10 where used for Image processing activities on satellite image or computed change detection analysis of Land use map of classified images and to do accuracy assessment). MS Excel 2010 was trying to use but, because of error the Gumbel's distribution method where used to modifies the flood frequencies data and quantitative data during assessments of flood problem.

3.5. Ethical Consideration

To administering the questionnaire, the ethical concerns were taken into consideration. The careful approach of not harming people by disregarding their privacy, not respecting them as individuals or subjecting them to unnecessary research was been considered. Collected data from community members was keep confidential by not identifying them when giving a report. Consequently, the attitude or the full willingness of the respondents where understood before any actions. The gender quality thought and Environmental consideration of the respondents where extremely kept.

Chapter Four

4. The Result and Interpretation

4.1. The simulation of the flood probabilities and magnitudes

4.1.1. Flood Discharge Analysis

Warning level and danger level of flood within Rivers watershed was calculated using the maximum instantaneous discharge data. So this is the threshold value above which the flooding begins. Gauge height exceeding 4.2m causes flooding in the settlements, the inundation depth being greater than 1.5m. Therefore, gauge height of 4.2 m is demarcated as danger level and corresponding discharge for this water level is about 3250 m3/s. This Figure shows the corresponding gauge heights of maximum instantaneous discharge in comparison to the warning level and danger level at the station. It can be seen that the warning level is frequently exceeded and the danger level also exceeded at different times by annual instantaneous maximum floods and the trend of discharge has been consistently increased, this might be due to change in precipitation pattern and change in river flow direction of the study area.

4.1.2. Flood Frequency Analysis

Flows required for the study have been estimated based on empirical and one probability distribution methods. Peak designs have been determined by comparing the two year return with each other for greater reliability designs and the Gumbel's distribution method have been used to determine peak flows. The result of 5 and 25-years Return Period Flood Frequency Analysis based on Maximum Instantaneous flow recorded at Baro River(Nyine-Nyagn Gauge Station) from year 2009-2017 using Gumbel’s Method are summarized below in Table 1. Comparing all the methods, maximum peak flow is obtained by Gumbel's method. Therefore peak flows for 5yrs designed flood and peak flows of 25yrs designed flood are 8007.84 m3/s and 9148.31m3/s respectively. Therefore, those value exceeds the danger level discharge of 3200m3/**s**. this intended that there might be catastrophic flooding on the watershed because the discharge value for 4.2m height water level is only about 3200m3/s and it is very small with compared to 5 years designed flood and 25 years designed flood discharge.

Table 1: Flood frequency analysis for various return period using Gumbel's method

Return Periods	Flood frequencies	Methods using
5	8007.84m3s	Gumbel's method
25	9148.31m3/s	Gumbel's method

4.1.3. Flood Hazard Water Depth

The below calculation illustrate that the total area under the water depth of more than 3.0m increased considerably with the increase in the intensity of flooding. For 5 year flood, it is observed that >3, 2-3, <2 meter were 16.92, 14.13&28.25 sq. km respectively and for 25 year flood were 14, 14.2 & 31.5 sq. km respectively. These shows that high hazard of flood is increased in 25 years flood.

Table 2: Calculation of the Flood Area based on Flood Hazard Water Depth (m)

Water Depth(m)	Total flood areas(km2)			
	5yr return Period flood		25yr return Period flood	
	Areas	**%**	**Areas**	**%**
<1(Low)	16.92	28.53	14.0	23.5
2-3(Moderate)	14.13	23.83	14.2	23.8
>3(High)	28.25	47.64	31.5	52.7
Total	**59.30**	**100.00**	**59.8**	**100.0**

The above classification of flood depth areas indicated that 47.64% & 52.7% of the total flooded areas has water depths greater than 3 m. The total area under the water depth of 2-3m was 23.83% on 5 year flood and 23.8% on 25 years flood. The table shows us that much area under high risk, moderate and low risk are >3m, 2-3m and <1m respectively.

4.2. Flood Vulnerability Analysis

Flood vulnerability analysis is the process of determining the degree of susceptibility and exposure given place to flooding. These issues include people, goods and socio-economic activities likely to be affected both quantitatively and qualitatively by a natural phenomenon. In this study, the flood vulnerability areas were identified by intersecting the flood risk levels with the flood meter of each districts/kebeles and the depicted of vulnerability on different aspect of the flood risk in the particular area has been calculated using flood vulnerability score.

4.2.1. The Flood Vulnerability Areas

The degree of danger or threat and the levels of exposure and resilience to threat are closely associated with the following vulnerabilities. Therefore, spatial vulnerability is a function of location, exposure to hazards, and the physical performance of a structure, whereas socioeconomic vulnerability refers to the socioeconomic and political conditions in which people exposed to disaster are living. The districts/Kebelles wise flood Vulnerability is show below table.

Table 3: The Districts/Kebelles under flood hazard Zone

S/N	Kebeles/Districts Names	2015 flood Risk Levels			2017 flood Risk Levels		
		<2m	2-3m	>3	<2m	2-3m	>3m
01	Gerguer			*		*	
02	Batokdol			*		*	
03	Bildak			*		*	
04	Nyine-Nyagn 01		*		*		
05	Nyine-Nyang 02			*			*
06	Adura (Dom-biel-row)		*	(**)	*		(**)
07	Toromorok(Puldaar and Mandoar)	*		(**)	*		(**)
08	Kondey(Gokjaak and Pibor)		*	(**)	*		(**)
09	Bilker(Thilik)		*	(**)		*	(**)
10	Donyrier(Biltunyal,koapand Riek)		*	(**)		*	(**)
11	Liet-Nyaruach(manjagndiit,wiy and kokgnolkuet)		*	(**)	*	(**)	
12	Poukueth (Madign 1-4)	*		(**)	*		(**)
13	Kogndekuach (Yual)	*	(**)		*	(**)	

Note: Inside of ( ) are villages which is highly affected by Flood, (**) Double stars meant the villagers which is very highly vulnerability to the Flood hazard (flood-prone areas) while (*) one star show the district/kebelles flood level in 2015 and 2017.

From the above table it is concluded that madign 1-4, Bilker(Thilik), Donyrier(Biltunyal, koap and Riek), Liet-Nyaruach(manjagndiit,wiy and kokgnolkuet), Adura (Dom-biel-row), Toromorok(Puldaar and Mandoar) and Kondey(Gokjaak and Pibor) areas are higly affected during flooding. This was indicated that the villager households are most vulnerable because these villages lie in low elevation zone of the watershed. Since, the Floods occur each year in these areas, with most of them being "exceeding" floods. The height of the flood is between 0.5 meter in the village, and up to 3 meters in the cultivation fields. Discussions in villages revealed that the most recent flood that caused serious damage occurred in 2015 & 2017, but more exceed value in 2015. The office of Risk and management in Woreda reported that, in year 2015, about more than 35, 00 refugees, 360 household and different NGO were displaced by floods. Local villagers reported that flood characteristics have not changed significantly in the last 2 years. However, they noted that damaging floods appear to have occurred with greater regularity in recent years. Losses of property increased and villagers suffered from flood each year, but according to responds are added mostly 2015 and 2017 are exceeding" floods.

4.2.2. Vulnerability Score

Vulnerability score for the study area was calculated using a standard method provided by Exploring Adaptation Options" a manual published by Livelihoods & Forestry Programme. The different values were assigned through the questionnaire survey, key informant discussion and according to people's perception. All the rated values were analyzed using following an empirical formula. The results show that agriculture system is in much vulnerable. **(Frequency + Area of Impact)*Magnitude = Vulnerability Score)**

Table 4: Vulnerability Score

Sector	Vulnerability Score	Vulnerability in %
Agricultures Areas	50	45.87
Residents Areas	21	19.27
Environmental aspects	2	1.83
Infrastructure	8	7.34
Socio-Economics Activities	28	25.69
Total	100	100%

Different 5 variables were identified from people's perception during field survey. The variables were than ranked with rating value and final vulnerability score were calculated. In vulnerability assessment it was found that Agriculture system, Socio-economics, Residents areas and Infrastructure respectively are reported as much more vulnerable than other sector in Study area.

4.3. The 2015 and 2017 flood extreme

4.3.1. Flood Impacts on Economic Activities

The majority of people's in Makuey Woreda livelihood is agriculture, Cattle keeper and fishery. It is about 75%, 20%, and 5% respectively. Many respondents said their land is very fertile and very suitable for the agricultural productions (maize, sorghum and wheat). Other than agriculture, Cattle keeper and fishing employments the income generating activities of the people in study area, however when the flood happen it caused died of many animals which might decrease their income generation. Losing livestock and cultivation field damage is a common and immediate impact on the household economic activities, most villagers agreed that losing livestock was the most serious blow to long-term livelihood and family income. Since in both rural and urban area, the cattle and Goats are used as a savings mechanism for family living standard and income generation. The destroying of housing at the study field takes consideration of resources, time and effort to rebuild the shelters.

4.3.2. Flood impact on residents and spread of diseases

Many of the houses in Makuey woreda are built from wood, grasses and mud walls, which are easy to reconstruct. These building materials are not strong enough to withstand an extreme flood. More than 75% of the householders are announces that severely houses where damaged by flood during 2015 and 2017. Participants in focus group discussions mentioned that many elderly people, pregnancies women, children and livestock got sick and dies during flood. Due to flood risk, disease (diarrheal) caused the deathless children because of the intrusion of river water into wells and boreholes. The respondents mentioned that some children drowned in rivers while playing outside river bank during the 2015 flood.

60% of the respondents reported that this negatively affected the milk production. Moreover, they indicated that the flood severely limited their possibilities to engage in other income earning activities, because the lands were inundated. The river overflow lasted longer than usual, and therefore overlapped with the period of recession crop cultivation. According to majority of respondents among both the officials and flood victims, flooding has been a problem in the woreda for many years. However, they were all of the opinion that the flood frequency and magnitude has increased rapidly over the past two years. The four rivers were mentioned as main contributors to flood in the Makuey woreda (Baro River, Makuey (Alwero rivers), Zure River and Konngdekuach River. but Baro River is longest and biggest one. Poor road constructions and blocking the water channel by investor are the primary causes for the land use change and increase of flood frequencies. The flood victims, government departments, and NGOs indicated that deaths, diseases and, crop destruction were the main impacts of flood in woreda. Health officials emphasized that malaria epidemics were a common phenomenon in many parts of area following floods. The destruction of crops was mentioned by most respondents, particularly the flood victims and those from the disaster prevention and preparedness agencies, as a further impact of flooding. The Floods damage crops and inundate farm land can lead food shortages that cause malnutrition. For instance, the 2015 and 2017 flood in the makuey Woreda caused damage to 1,650 and 921 ha of maize crops. Most of the people affected by these floods were very poor and considered highly vulnerable in terms of food security. Makuey woreda has been repeatedly affected by flash floods whenever rivers draining down to the region from the western highlands of Ethiopia fill up and burst their banks. In 2015 heavy rains and the flood from Baro River created an emergency situation at the camps of Leitchuor and Nipnip. "Flash floods following heavy rains for more a week have caused major rivers in Makuey Woreda to burst their banks, submerging residential areas, farmlands and forcing more than 37,000 Refugees and 1800 households to be displaced. Makuey woreda faces seasonal flooding between June and October after heavy rains drench the highlands during the rainy season.

4.3.3. Flood Impacts on Agricultural activities

In Makuey woreda, more than 80% of people livelihood is based on agriculture and the economy of the woreda is also dominated by agriculture. More than 80% people live in rural areas dependent upon subsistence farming, and the economy is based almost entirely on agriculture. During winter season maize crop dependent on the easterly monsoon of downstream of Baro River. During one focus group discussion in study area, villagers estimated that 60-70 per cent of the cultivation area are destroyed by flood. Many respondents reported that Most floodplain land the animal where always use to graze was destroyed by flooding. From the field survey and discussion with local people they reflected that most of the cultivation land or grasslands were under high risk from flooding (Floodplain).

4.4. Flood Generating factor maps (influence of Physical Parameters Approaches)

The major flood generating factors used for flood hazard assessment are slope, elevation, average rainfall, drainage density, land use, and soil type. The flood generating raster layers have been classified based on their flooding capacity of the area. The DEM was converted into slope and elevation raster layers using the ArcGIS conversion tool. Based on their susceptibility to flooding; slope and elevation have been classified into five classes (very high, high, moderate, low and very low). The soil classification is the basis for efficient land suitability evaluation, planning, and management. Soil classification is important in identifying the most appropriate use of soil, estimating production, extrapolating knowledge gained at one location to other often relatively little known locations, providing a basis for future research needs and required to classify soil and determine chemical and physical properties not visible in field examination.

4.4.1. Risk maps based on Slope/Elevation

In the below classification, an area at the lowest elevation/ slope, very highly affected by flood and then ranked to class 4, which is less than 362 **m and <8%,** respectively. Following the high hazard class, there was a class high (396-402 m) ranked 3, class moderate (402-408 m) ranked 2, class low (408-444 m) ranked 1. In case of slope, there is class high (0-8%) ranked 4, moderate (8-15%) ranked 3, and low (15-24%) ranked 2 and class very low ranked 1 (24-90%)

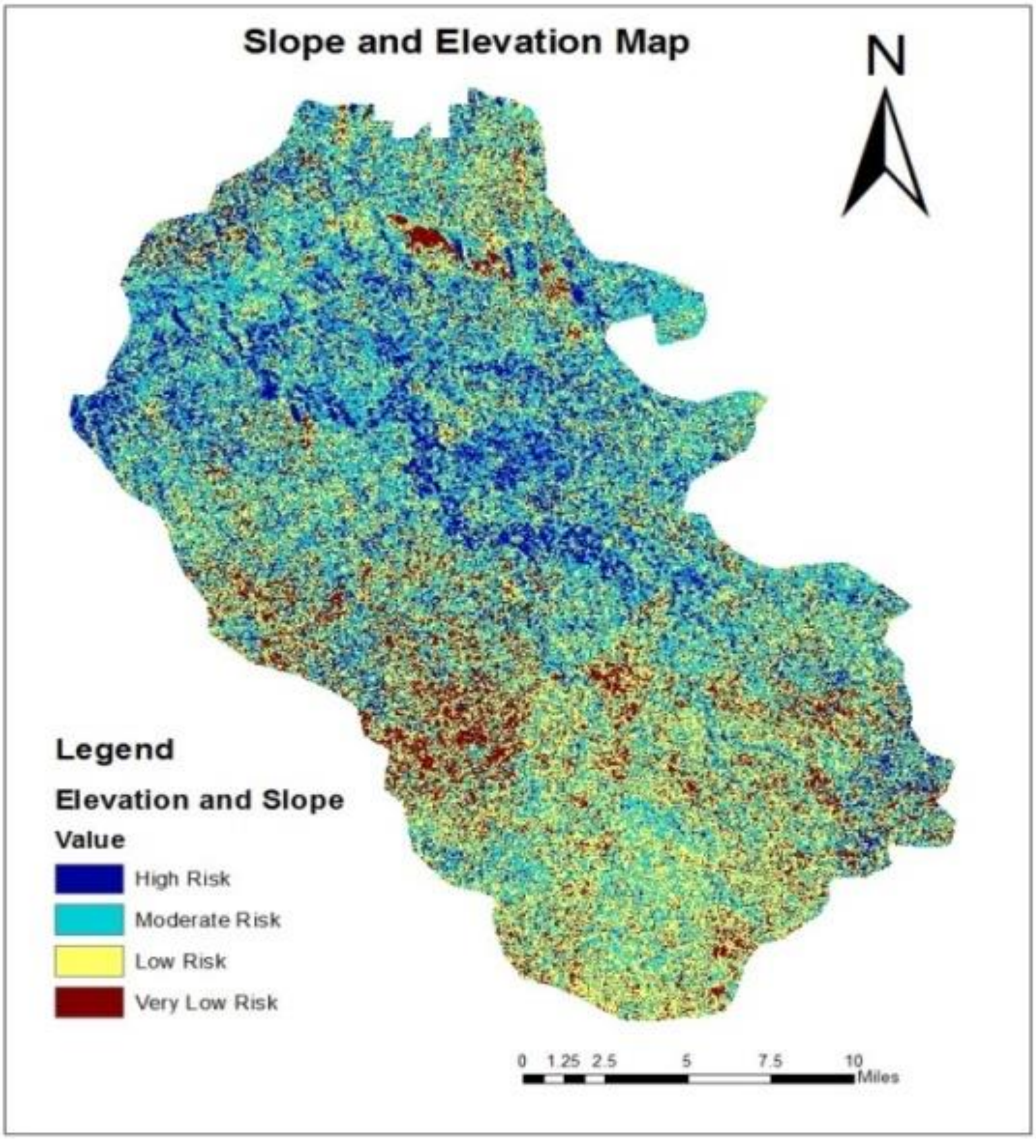

Figure 3: Map slope and Elevation and classification.

4.4.2. Soils Types

Although there is a wide range of soil types, four main soil classes were distinguished based on the hydrologic soil grouping system of Woreda Water and Energy office. The major soils of the Woreda District include Dystric and Eutric Plinthosols, Dystric and Chromic Cambisols, Eutric Vertisols, and Planosols. The Cambisols occur at the upper slope area (Middle of Woreda) while Eutric Vertisols exist at the middle and lower slopes area (North-East and South-East of Woreda) respectively. The Eutric Vertisols are the dominant soil type in the Baro River Basin. These, four groups of soil types were converted into raster and reclassified based on the flood generating capacity. The soil type that has a very high capacity to generate a very high flood rate is ranked as class 5, high ranked as class 4, moderate ranked as class 3, low ranked as class 2 and very low ranked as class 1. Therefore, Eutric Vertisols are assumed to have a very high flooding capacity class 4, Eutric Planosols are assigned as high class 3, Eutric Plinthosols are assigned as moderate class 2, Chromic Cambisols are assigned as a low class 1 on flood Harard

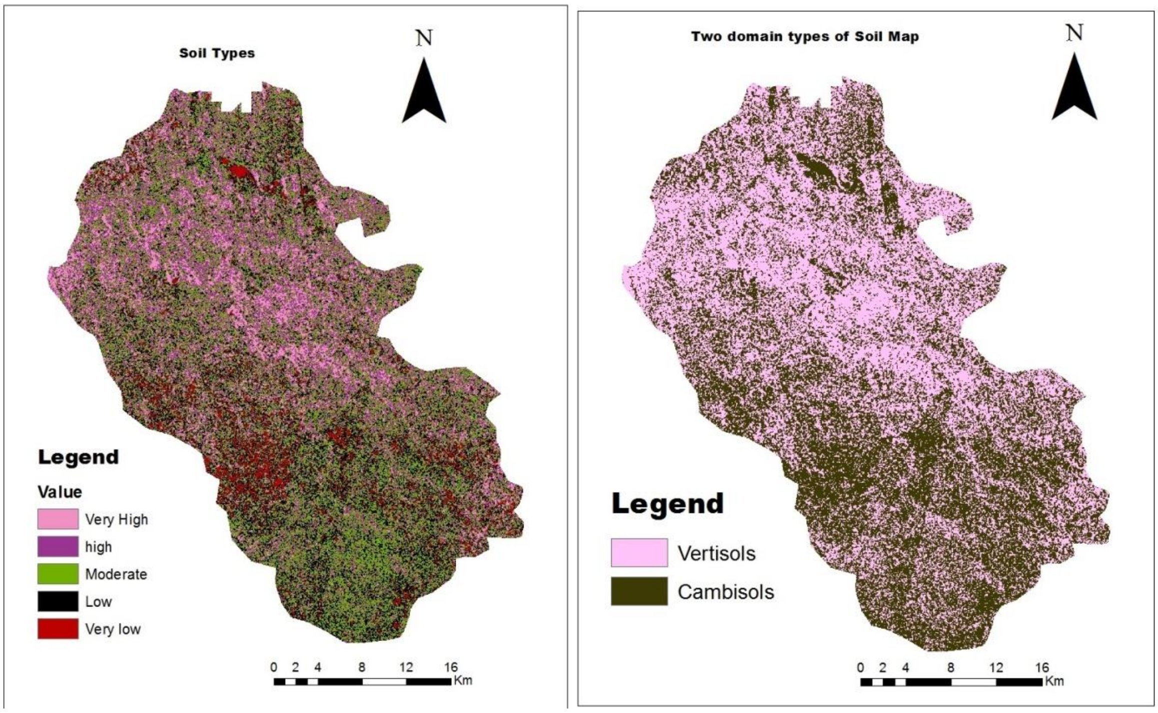

Figure 4: Susceptibility to flooding: The four common soil types (at left) and two domain soil (at right)

4.4.3. Rainfall

The intensity of rainfall is a measure of the amount of rain that falls over time. The intensity of rain is measured in the height of the water layer covering the ground in a period of time. It means that if the rain stays where it falls, it would form a layer of a certain height. Thus, floods are related to extremes in precipitation (from tropical storms, thunderstorms, orographic rainfall, widespread extra tropical cyclones, etc.). Therefore, I this study ensued that a combination of precipitation characteristics (e.g., the amount of rainfall, intensity, duration and spatial distribution) are influences the flood events which are caused converge impact to the catchment area. The heavy rainfall raises the amount of discharge from rivers and causes overflowing of Baro River Basins. This was interpolated by the Kriging Method from20 point's observation in nyine-nyang Prefecture during extreme rainfall.

Table 5: Classification of the rainfall intensity

Classification	Rainfall intensity in mm/year	Rank
Very High	>879 mm/year	5
High	745-879 mm/year	4
Moderate	586-745 mm/year	3
Low	435-586 mm/year	2
Very low	<435 mm/year	1

In the classification process of Rainfall intensity, an area with higher rainfall, is very highly affected by flood and then ranked as class 5, which is greater than 879 mm/year. Following the very high hazard class, there is a class high (745-879 mm/year) ranked as class 4, moderate (586-745 mm/year) ranked as class 3, low (435-586 mm/year) ranked as class 2 and (<435 mm/year) was ranked as class 1. Based on the above classification the average rainfall, raster layer was classified into four classes. The long-year mean rainfall pattern indicated that there is high precipitation in the Ethiopia highlands, South-East (Kongdekuach River) and southern (Makuey River) peripheries, while there is low rainfall in the North-western and western lowlands (South Sudan) of the Baro river basin.

4.4.4. Drainage density

The drainage density is the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin. The line density module calculates a magnitude per unit area from polyline features that fall within a radius around each cell. The DEM was used to compute the drainage density (river tributary) using the spatial analyst extension. However, all the river tributaries do not necessary carry larges capacity of water since, some of them has been blocked by Dam, cutting by poor construction and relocate of water flow by investors, like Kongdekuach River around Abobo town, Mazurekuey River in Adura Village and Makuey River in Kongdekuach area. The drainage density layer was classified in 4 classes. In the classification process an area with a higher drainage density is very highly affected by flood and then ranked as class 4, which is greater than 3.15 km/km2. Following the high hazard class, there is high (1.97-3.15 km/km2) ranked as class 3, moderate (1.25-1.97 km/km2) ranked as class 2, and low (0.056-1.25km/km2) ranked as class 1.

Table 6: Drainage density classification

Classification	Drainage Density Values	Rank
Very High	>3.15 km/km2	4
High	1.97-3.15 km/km2	3
Moderate	1.25-1.97 km/km2	2
Low	0.056-1.25km/km2	1

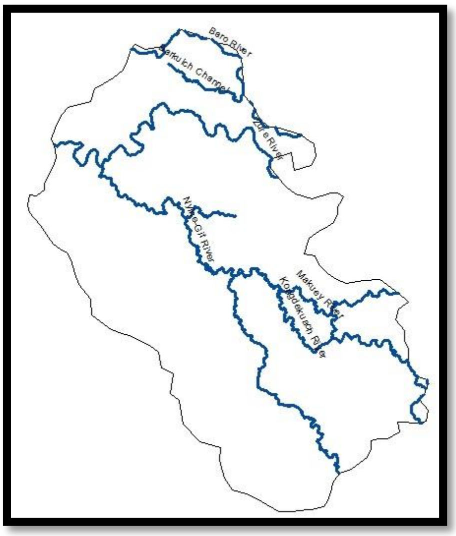

Figure 5: Drainage density map.

4.4.5. Land Use

Land use is the surface cover of the earth in a specific location (e.g., vegetation type, a manmade structure, etc.). It can be derived directly from remote sensing data and it needs to be verified by survey. Furthermore, the land use can represent the socioeconomic condition in a certain area .The land use of the study area was classified into five main classes and converted into a raster layer. Based on below the flood generating characteristics of the land use type, agricultural bare land was assigned as very high flooding(5), crop/vegetation land as high(4), grass land as moderate(3), Building Areas(2) and forest land(1) as low and very low respectively.

Table 7: Land use pattern of the study area

S/N	land uses types	Area(sq.km)	%	Classes
1	Agricultural areas	556.07	43.334	5
2	Crop/Vegetation Areas	14.06	1.0960	4
3	Built Up Areas	2.27	0.178	2
4	Grass land Area	586.48	45.7059	3
5	Forest Areas	64.63	5.0371	1

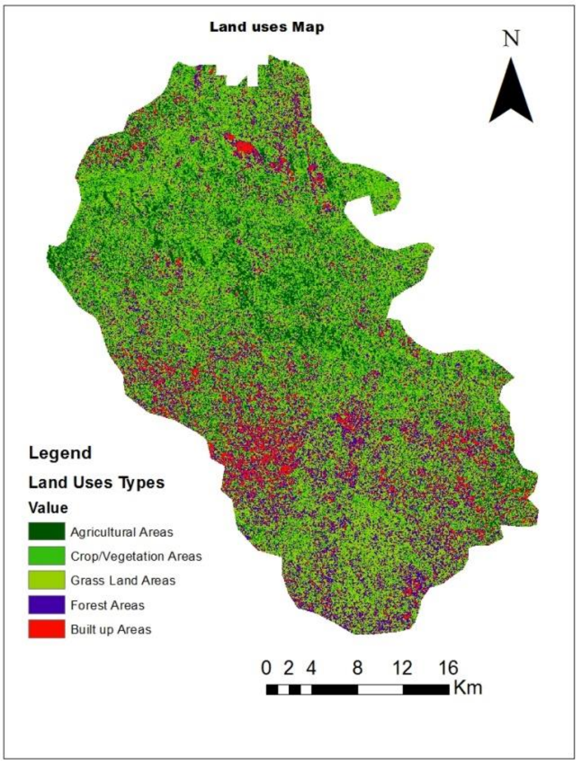

Figure 6: Land use Maps

According to the above table show as that, the Agricultural, Crop Vegetation, Building up , Grass land and forest Land areas are classify as 5, 4, 3, 2, and 1 correspondingly. Therefore, the land use map of the Baro River Watershed derived from the 2009-2017 top sheets along with field verification is shown in Figure 8. Agricultural land occupies the largest area of the watershed 43.3% of the total area, while forest land occupies lowest area about 5.03 % of the total area.

4.5. Floodplain and Inundation area

The inundation area map along the Baro River was produced by low to highest flow from the selected gauging stations for 5 and 25 different return periods using ArcGIS model tools. The hydrology model tools consider a high flow (flood inundation) from a gauging station in a specific return period as representative flow along the baro and makuey river bank. More than 75% respondent and The woreda Water and Energy reported that there are some areas along the BaroRiver Basin that have been frequently floodway after the main rainy season, such as around block down to the Baro River, between Nyine-Nyang town and batokdol kebele around flood inundation area of Zure River 10km north of the Bildak kebele.

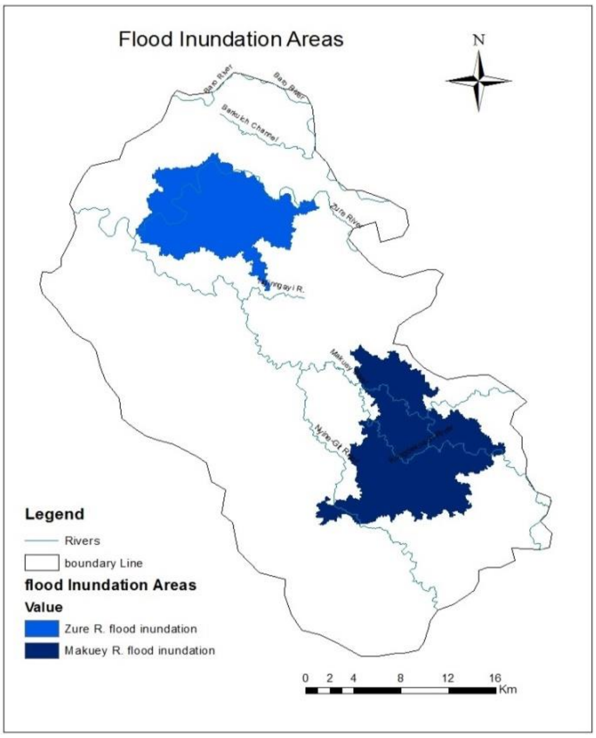

Figure 8 flood inundation areas

Below maps shows the seasonally flooded areas along the Makuey and Baro River Basin are the Koatgar Districts (Dognrir, Lietnyaruach and Bilker kebeles) and Block districts (Gerguer and Batokdol kebeles). The Nyine-Nyagn 02, Bildak Kebelles, Tomorok, Adura and Konday kebeles near the tributary of Mauey and Zure Rivers are largely affected by seasonally flooded. The lower plains areas around koatgar down to Baro and Zura River are flood inundation and north of Biltunyal village. Based on the field investigation and land use maps most of the area close to the River Baro is agricultural land. A large part of these areas that are very close to the River are flooded after the main rainy season (summer). Both 5 and 25 year return period flood plain map using the flow data from the Nyine-Nyagn gauging station indicated a large inundated floodplain in the lower part of the Baro River Basin approximately covers 54 km2and in the upper and middle part of the Baro River Basin the flooded area approximately covers 22 km2, and 24 km2 and in the lower and middle part of the Makuey and Zure River Basin the flooded area approximately covers 17 km2 respectively.

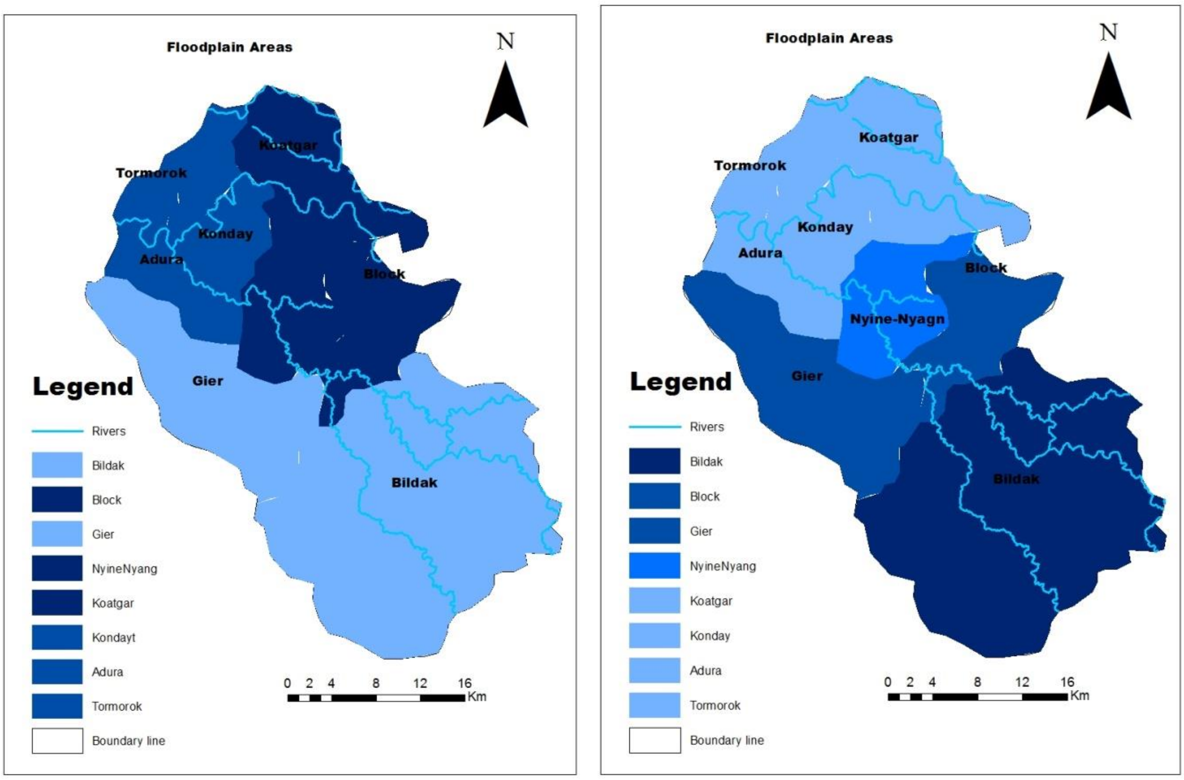

Figure 9: floodplain in lower part of the Baro River (left) and floodplain in the lower part of the Makuey and Zure River (Right).

4.6. Flood risk map

Flood risk is determined by the probability that a flood may occur, the potential adverse consequences and cause danger, stress, social disruption, property damage and financial impacts. In this study a risk map has resulted on combination of the following components: Hazard map, vulnerability map, floodplain/Inundation map and physical parameter elements. Using suitable model for most natural hazards given by this equation 7: Risk= Hazard * Vulnerability (E). In mapping procedure, weight were assigned to the different thematic indicators classes and layers based on their relative influence and contribution to the hazard and vulnerability. The overlay technique was employed to the indicators to determine hazard and vulnerability first of all and by crossing hazard and vulnerability to obtain the goal which is flood risk area identification and zoning. Consequently, the all processes were done in ArcGIS using raster calculator in spatial analyst tools. In identification of the chronically affected areas, floodplain/Inundation, flood hazard and flood-prone; The Flood Risk are Characterized in to three zones (which described the area of land which is all flood and last flood if there is river or coastal flooding).

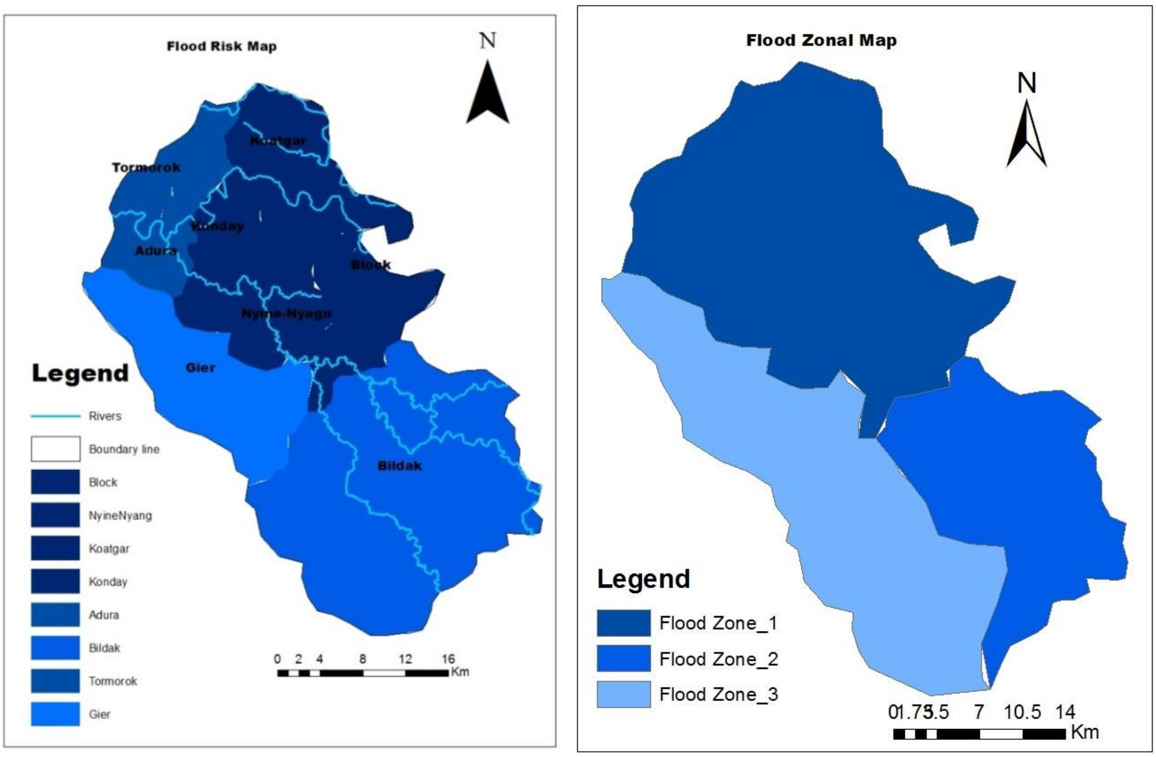

Figure 9: Districts Flood risk Map (Left) and Flood Zonal Map (Right)

according to the above Flood Zonal mapping, Flood Zones are grouped into three categories: Flood Zone 1 – Low probability < 1 (an area that is not considered at risk or lowest of flooding) are showed by white blue colors, Flood Zone 2 – Medium probability 2-3 (an area that is considered as high flooding areas) are indicated by blue Colors and Flood Zone 3 (an area that is considered at very high risk of flooding) is shows by dark blue colors. Therefore, Flood Zone 3 has been used as a “functional floodplain” or used as a flood storage area it’s very high flood risk area.

Chapter Five

5. Conclusion and Recommendation

5.1. Conclusion

The elevation, land use, soil type, rainfall, and slope have been used to derive the flood hazard map using a GIS and Remote sensing techniques. A study in selected area using available topographical, land use and demographic data along with GIS indicated that most of agricultural areas were in the high flood hazard zone. A study carried out in the Baro River basin, based on different environmental factors showed that there was high flood hazard threat in the downstream area of the Baro river basin. The study indicated that the extreme and land use change, which involved intensification of agricultural activities, increased the overflow magnitude that caused high flood hazard zone in downstream part of the river basins. Based on the flood hazard study in the woreda the very low, low, moderate, high, and very high flood hazards zones were estimated the Agricultural, Crop Vegetation, Building up , Grass land and forest Land areas are classify as 5, 4, 3, 3, and 1 respectively. Moreover, the study indicated that Agricultural land occupies the largest area of the watershed 43.3% of the total area, while forest land occupies lowest area about 5.03 % of the total area. The flooding due to excessive rainfall in high land areas of Ethiopia is a challenge in the Baro River Basin, so that based on the study in the river basin the flood prone areas were identified and the flood hazard zone of the 5 and 25 year return period was show flood plain map using the flow data from the Nyine-Nyagn gauging station indicated a large inundated floodplain in the lower part of the Baro River Basin approximately covers 54 km2and in the upper and middle part of the Baro River Basin the flooded area approximately covers 22 km2, and 24 km2 and in the lower and middle part of the Makuey and Zure River Basin the flooded area approximately covers 17 km2 respectively. Most respondents from the householder, government departments and others attributed that, the extreme of rainfall is the main contributing factor for increased frequency and magnitude of floods in woreda. While the main impacts of flooding on human health in the area are deaths, malaria, and diarrheal diseases. Another notable consequence of flooding is crop destruction and subsequent malnutrition. The Makuey River Basin hazard prone area considerably increased from the 2015 to the 2017 flood and the agricultural land was the most affected by high flood hazard zone. Due to the intense rainfall has increased tremendously causing extreme floods in the Baro River. More than 75% respondent reported that there are some areas along the BaroRiver Basin that have been frequently floodway after the main rainy season, such as around block down to the Baro River, between Nyine-Nyang town and batokdol kebele around flood inundation area of Zure River 10km north of the Bildak kebele and The seasonally flooded areas along the Makuey and Baro River Basin are the Koatgar Districts (Dognrir, Lietnyaruach and Bilker kebeles) and Block districts (Gerguer and Batokdol kebeles). The Nyine-Nyagn 02, Bildak Kebelles, Tomorok, Adura and Konday kebeles near the tributary of Mauey and Zure Rivers are largely affected by seasonally flooded. The lower plains areas around koatgar down to Baro and Zura River are flood inundation as well as north of Biltunyal village. The study of a flood hazard map using GIS environment and remote sensing techniques Baro River Basin showed that the flooded areas are likely to increase due to inappropriate river management and high intensity of rainfall, which results as low land areas high intensity of flood.

5.2. Recommendation

Flood Risk and Flood Hazard mapping should be carried out in a large scale to make an inventory of the stability of areas such that developmental activities can be placed at proper (stable) area.

- ✓ Areas of high hazard need immediate attention, hence appropriate flood protection measures should be taken earlier.
- ✓ Conservation work in the watershed.
- ✓ Conservation of the existing forest by involving the local community.
- ✓ Agro-forestry and conservation farming may be introduced in the upper part of the watershed.
- ✓ Grazing land should be properly managed.
- ✓ Afforestation along banks of stream with gradients less than 150.
- ✓ the onset of the flooding used to be more predictable and allowed farmers to plan for sowing crops at the optimal time

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