Acknowledgement

This assessment could not be finished without the help and support of many people who are gratefully acknowledged here. At the very first, we would like to express our deepest gratitude to the director of the authority **Mr. Yewendwesen Mengistu**. He has put the most efforts to facilitate this assessment.

Secondly, we also extremely grateful to TaSBO, BeSBO, Federal, Amhara Benishangul and Oromia disaster offices for providing data and information related to risk, and Mr. Ayele Dilnessa, Habtamu Tamir, Birlew Abebe and Abatihun Ashenif who energetically helped us in motivation and given time in place of group meetings and also Ahmed Tadele for providing us his office for group discussion and valuable comments on document compilation.

Besides, we would also deeply indebted to National Disaster Risk Management Commission and its staff, especially Mr. Fikadu, a disaster expert who gave us a full data and information about disaster risk documents on woreda disaster risk profile which are found in the basin.

We would like to express our heartfelt thanks to Dr. Abraham Mebrat and Mr. Tarekegn Ayalew from Bahir Dar University, who provided us training on disaster risk assessment and shared us their knowledge as well as experience while we conduct the assessment.

Summary

Risk is the probability of a hazard turning into a disaster, with households or communities being affected in such a manner that their lives and livelihoods are seriously disrupted beyond their capacity to cope or withstand using their own resources. As a result affected populations suffer serious widespread human, material, economic or environmental losses.
These factors, coupled with naturally occurring hazards such as droughts, floods are currently exacerbated by climate change phenomena, pose extremely high and increasing disaster risks to the basin.

Disaster risk assessment will help decision makers at all levels to be better informed about the degree, magnitude characteristics and severity of potential hazards, vulnerabilities of communities and their potential exposure, and capacities and that can also be an input for Water related plans and area specific early warning tool. So, this study assesses and analizes major hazard, vulnerability, existing capacities and risk level in abbay basin.

Accordingly, results show that five major hazards are identified in the basin namely: - Environmental degradation, drought, flood, landslide and wild fire respectively.
The impact of flood and wild fire on sedimentation and deforestation respectively is critical and its likely hood is almost certain. Drought impact on crop loss is critical and its likelihood is very likely.

The impact of drought on livestock loss, flood on water quality deterioration, drought on displacement, environmental degradation on soil & high temperature is important and its likelihood is almost certain.

Acronyms

ABA	Abbay Basin Authority
ADSWE	Amhara Design And Supervision Works Enterprise
ANRS, DPFSCo	Amhara National Regional State Disaster Prevention & Food Security Coordination Office
BeSBO	Beles Sub Basin Organization
BC	Before Christ
BIS	Basin Information System
BM^3	Billion Cubic Meter
BNR	Blue Nile River
CBOs	Community Based Organizations
CCA	Climate Change Adaptation
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DPPO	Disaster Prevention and Preparedness Organization
ENSO	El-Nino Southern Oscillation
FAO	Food And Agricultural Organization
FPEW	Flood Preparedness and Early Warning
GCM	General Circulation Model
GERD	Grand Ethiopian Renaissance Dam
GoE	Government of Ethiopia
GSE	Geological Survey of Ethiopia
ha	hectare
HHs	House Holds
HIS	Hydrological Information System
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter Tropical Convergence Zone
IWRM	Integrated Water Resource Management
IWSM	Integrated Watershed Management
LT	Lake Tana

Mt	Mountain
NDRMC	National Disaster Risk Management Commission
NGOs	Non Governmental Organizations
NMA	National Meteorological Agency
PET	Potential Evapo-Transpiration
PFM	Participatory Forest Management
Pop	Population
SOI	Southern Oscillation Index
TaSBO	Tana Sub Basin Organization
TBIWRDP	Tana Beles Integrated Water Resource Development Project
TSB	Tana Sub Basin
UBNR	Upper Blue Nile River
WASH	Water, Sanitation and Hygiene
WDRP	Woreda Disaster Risk Profile
WMO	World Meteorological Organization

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Chapter one

1. Introduction

1.1 Background

Over the years, Ethiopia has been exposed to a variety of disasters such as natural and human induced disasters like drought and flood. Following recurrent drought hazards, Ethiopia has faced several famines and hungers since 250 B.C. There are no years in which we passed outshout drought the so-called drought, recurring in 1966, 1973/74, 1980-81, 1981-82, 1984/85 and 1994/96 seasons; Particularly the two great famines (1973/74, 1984/85), have given a trade mark for Ethiopia – a country of famine (refer the oxford dictionary).

Ethiopia, like many other countries in Africa and elsewhere in the world has experienced an increase in the diversity, intensity and frequency of occurrence of disasters over the past three millennium. In many cases disasters have resulted in an increase in the number of people affected and property damaged.

Disaster response reviews have indicated that response costs the government and other stakeholders more than would otherwise be the case if sufficient efforts had been put in place for effective disaster management especially responding to drought.

As per we search drought, flood, wild fires, environmental degradation and landslides have the highest occurrence frequency and affect a large number of people and their livelihoods in the basin.

Disaster risk assessment will help decision makers at all levels to be better informed about the degree, magnitude, characteristics and severity of potential hazards, vulnerabilities of communities and their potential exposure, and capacities and that can also be an input for Water related plans and area specific early warning tool.

1.2 Biophysical situation of the basin

Abbay basin is located in the north western part of Ethiopia between 7^0 40’ N and 12^0 51’ N latitude, and 34^0 25’ E and 39^0 49’ E longitude. The basin is the second in area coverage (199,812 km^2 and the largest in annual runoff (54.**5 BM^3**). The basin occupying 20% of the country’s territory and it covers an area of 60% of Amhara, 40% of Oromia and 95% of Benishangul-Gumuz regional states. The basin is subdivided into 16 sub basins based on the major rivers in the basin.

The authority has a mission to ensure that the water resources of the basin are used and managed in an integrated, participatory, equitable and sustainable manner, creating favorable conditions for the conservation of the basin’s natural resources by maintaining sustainability of its ecosystem; Being the center of knowledge and information. It operates under the basin councils and authorities proclamation number 534/99 and falls within the oversight of basin councils. It has vision to see the socio-economic welfare of the people as a result of the integrated development and sustainable management of the water, land and other related resources of the basin.

The topography of the Abbay basin signifies two distinct features; the highlands, ragged mountainous areas in the center and eastern part of the basin and the lowlands in the western part of the basin.

The climate of Abbay varies from cool highland to tropical type climates. The climate in basin is dominated by two main factors: the near-equatorial location, and the altitude, from about 490 m (Blue Nile at the Sudan border) to more than 4,230 m above sea level (Mt. Guna). The influence of these factors determine a rich variety of local climates, ranging from hot and nearly desert along the Sudan border to temperate on the high plateau or even cold on the mountain peaks. The highest temperature is observed in the north western part of the basin, in parts of Rahad, Dinder, Beles and Dabus, the maximum temperature being 28^0C - 38^0C and minimum temperature 15^0C - 20^0C. Lower temperature observed in the central and eastern part of the basin with maximum and minimum temperature ranges from 12^0C - 20^0C and -1^oC to 8^oC respectively.

The rainy season (Kiremt) in the basin contributes from about 50% up to nearly 90% of the annual rainfall. The small rainy season (Belg) is only significant in the extreme east of the basin while it is practically not known around Lake Tana with less than 10% of annual rainfall during this season.

Generally rainfall ranges between about 787 mm and 2200 mm per year. The lowest rainfall recorded less than 1000 mm per annum in the Beshilo, Weleka, Jemma, Muger, Guder, and parts of Dinder and Rahad.

Potential Evapo-transpiration (PET) in the basin ranges between 1056 mm and 2232 mm per year. High PET is observed between 1800 mm and 2232 mm per year in North Eastern parts of the basin, in Dinder, Rahad, and parts of Beles and Didessa sub basins. The Eastern and Southern parts having lower PET ranging between 1200 and 1800 mm per year and the lowest PET below 1200 mm per year is observed in the parts of the highlands. This is highly correlated with the temperature.

The dominant soil types in the basin are Alisols and Leptisols, followed by Nitosols,Vertisols, Cambrisols, Fluvisols and Luvisols.

Most of the climatic vegetation of the basin area has disappeared and much of the forest area has been cleared for agriculture, fuel wood and charcoal production and settlement purposes. The loss of vegetation is recognized as one of the basin's major natural resources problems.

The land cover of the basin essentially follows the highland and lowland pattern. Once dominantly covered with forest, almost the entire highland area is now under farmland.

Stastically bout 48 % of the areas is presently cultivated, 35 % is grassland, 10 % supports bush and scrub, 4 % is forest and the remaining 3 % is covered by lakes and swamps or built-up areas. The land part has experienced deterioration as consequence of population growth, over-grazing and removal of woody vegetation for fire wood and other purposes. As a consequence, environmental problems include those of soil erosion/loss of topsoil, decline in soil fertility, and reduced biodiversity with loss of genetic resources (Aster Denekew, 2009).

1.3 Socio economic situation

Presently, the population of Abay river basin can be distinguished in accordance with three main groups: the Amhara (64.5 %), the Oromo (29.3 %) and people who are usually referred to as autochthones of western Ethiopia, such as Jabelewis, Gumuz, Sinashas, Maos, and Koma.

In general, the total number of population in the basin is about 28,580,045. Among these 14,289,555 are Male and 14,290,090 are Female population (CSA and ANRS BoFED(2006 E.C Projected population data).

The characteristics of the basin population show great variation in terms of livelihood strategies (ranging mainly from nomadic to agro-pastoralist), religion (covering animist beliefs as well as the book religions), language, as well as social organization. This includes groups who were still known as hunter-gatherers or pastoralists some decades ago.

Almost half of the total basin area is cultivated as rain-fed agriculture. Irrigated agriculture within the basin is negligible in the present situation. The main crops grown in the basin are teff, maize, sorghum, oil seeds, pulses, coffee, barley, wheat, enset, etc.

The livestock population of the basin is a large proportion of that of the country: 34 % of cattle, 38 % of sheep, 29 % of goats and 60 % of equines.

The forest resource is diminishing rapidly with forests and woodlands covering less than 5 % of the basin due to wild fire and others. According to estimates, 3.8 million hectares plantation should be required to meet the industrial and fuel wood demand by the year 2020.

The Abay river has large water resources development potential. It has estimated the irrigable land potential is about 2.5 million ha of large and medium scale schemes, of which 526,000 ha would be economically feasible. As far as the hydropower development is concerned, a potential of 7,550 Gwh/year can be generated from the basin.

1.4 Environmental situation

In Abbay basin extensive land degradation has occurred because of deforestation, overgrazing and inappropriate agricultural practices. This has resulted in both soil erosion and loss of fertility in highland areas of the basin where half of the arable land eroded. Sheet and rill erosions are the most prominent features to almost all cultivated lands of the basin. Degradation of soil and vegetation resources leads to increased vulnerability to environmental shocks, decreased agricultural production, reduction in access to basic services (water and electricity), demographic instability, loss of carbon reserves, and loss of ecosystem resilience.

The population pressure, which is alarmingly increased, contributes a great share in expanding cultivation of marginal lands. Increasing human and livestock population on one hand, and diminishing of the existing arable lands on the other hand could help to increase the proportion of degraded lands. This problem is more aggravated on the highlands of the basin (ADSWE, LUPESP 2015).

1.5 Objective

The **general objective** of this study is to assess and analyse risks found in the basin for future integrated basin planning processes.

. **Specific objectives are:-**

- To identify hazards that most commonly happened and cause risks in the basin.
- To prioritize hazards in the basin based on frequency, magnitude, extent of damage.
- To assess hazard, vulnerability, existing capacity and risk level.
- To suggest possible strategies to mitigate the identified hazards to decision makers.

1.6 Scope of the assessment

Most studies were limited in their scope i.e depth and coverage of the study. In terms of coverage the study has been focused on hydrological boundary of Abbay basin and major hazards which is related to natural resources. This assessment is done to use an input for Abbay river basin planning process.

Chapter Two
2. Data and Methodology

2.1 Method of Data Collection

Review of secondary data: Available secondary data from Abbay basin master plan, relevant institutions that work on disaster risk are collected and reviewed to extract valuable information about risk relevant study to this assessment.

Secondary data collection: Secondary data were collected from different institutions and government offices that work on risk. The main sources of secondary data for this study were NDRMC, DPFSPCo (Amhara, Oromia and Benishangul Gumuz Regions), NMA, TaSBo, BeSBO and Geological Survey of Ethiopia. The information and data collected relevant to this assessment was screened for direct use.

2.2 Data processing and analysis method

For the identification of hazards in the basin we use descriptive statistical method. Problem tree analysis is also used to identify the root and immediate causes of hazards in the basin. On the other hand the analysis involved developing and understanding community based DRR/CCA of hazard, vulnerability, existing capacity assessment, risk analysis and strategy provides an input to risk assessment and evaluation. The likelihood of the hazard, severity of the impact, seasonality of the hazard and the risk level is analyzed using vram excel tool kit supported with risk matrix table.

Work flow of the assessment

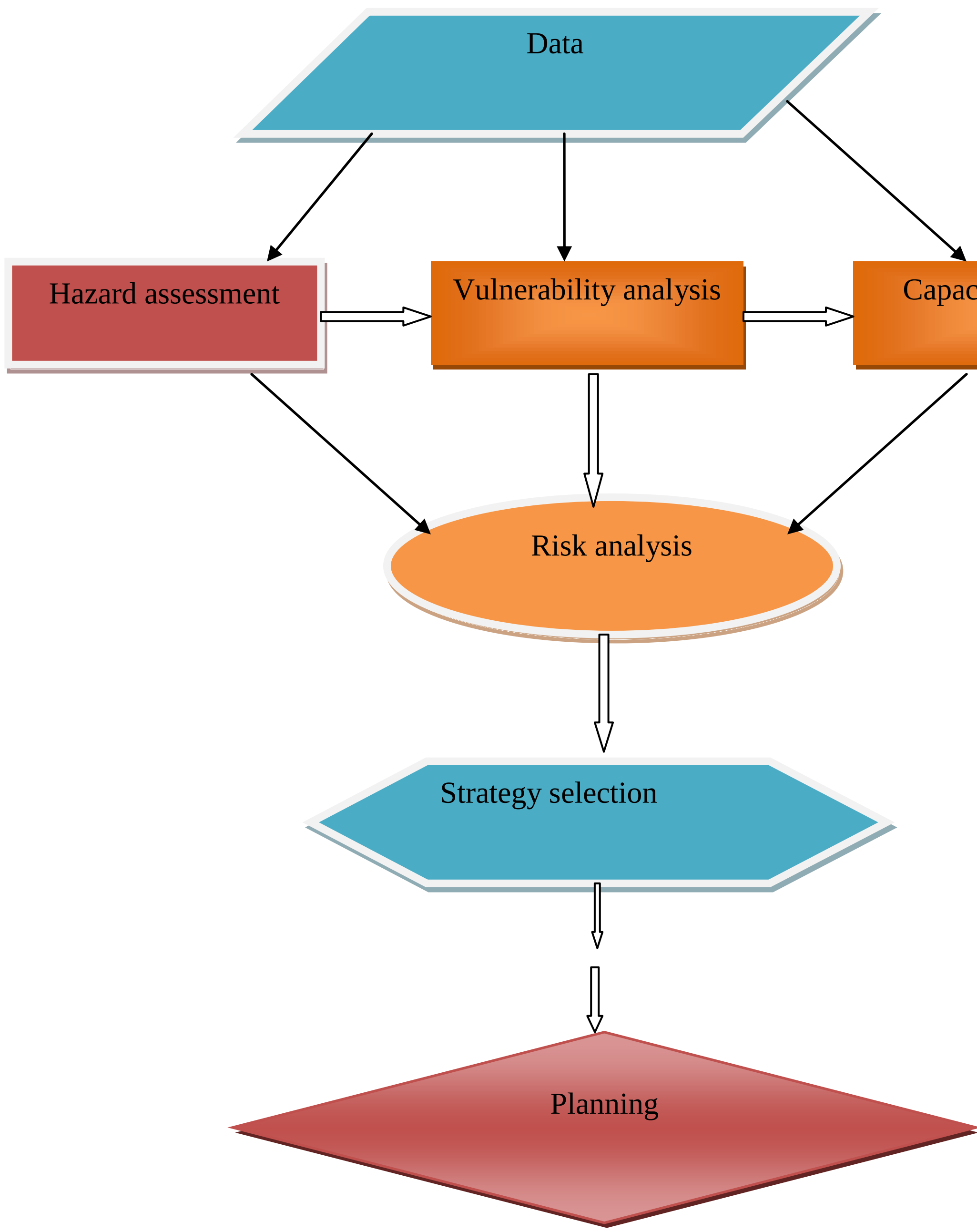

Figure 2. 1 A diagram showing the work flow of risk assessment

Chapter Three

3. Concepts of risk and disaster

3.1 Principles and concepts of risk

Definition of "risk" may vary in different research due to the field of application of the term. The "common sense" understanding of the concept is the notion which states that the risk connected to a particular hazard lies in the consequences caused by that particular hazard, and increase with both its frequency and severity; it is also clear that these consequences depend on what is exposed to the hazard and how much it is vulnerable to its damage (Fedeski, et al., 2007).

Concepts of risk assessment and management provide the basis for decision-making on both individual risk management measures, and also on a whole integrated programmed of measures and instruments.

Risk always has units. The units of risk depend on how the likelihood and consequences of an event are defined, and therefore may be expressed in a number of equally valid ways.

- Probability may be defined as the chance of occurrence of one event compared with the population of all events.
- Consequence represents an impact such as economic, social or environmental damage/improvement, and may be expressed
- Expected annual/lifetime damage: the consequences that are expected to occur within a given timeframe
- Expected event damage**:** the consequences that are expected to occur during a storm event – reflecting the consequences that would be expected.
- Frequency and probability are not the same**.** The return period relates to the number of times, in a given timeframe, that a particular condition is likely to be equaled or exceeded.
- The chance of a flood is not the same as the chance of the driving storm event**.** The return period typically refers to the hydraulic load or rainfall event, and not the response of ultimate interest: the flood.
- It gives an unwarranted perception of rarity**.** The T-year return period flow has a 63 per cent chance of being equaled or exceeded in any period of T years. It tends to be incorrectly

interpreted as a deterministic return interval**.** This is a common misconception which persists today (ABA, 2015, guideline of basin plan).

- ***Hazard* (*H*)** is the probability of occurrence of a potentially damaging event in a fixed time range (t) and in a fixed area. It is related to the "return time" T which expresses the time span in which the event happens at least one time:
- ***Vulnerability* (*V*)** is the degree of loss that a fixed element (people, buildings, infrastructure, and activities) would suffer from a certain hazard. This concept is the opposite of resilience, as it represents the territorial tendency to suffer damage from an event. It is expressed with a value between 0 and 1, where 1 means total loss.
- **Disaster**: A disaster is a serious disruption of the functioning of a community or society causing widespread human, material, economic or environmental loses which exceed the ability of the affected community/society to cope using its own resources.
- **Disaster Risk**: The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period.
- **Disaster Risk Management**: The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster.
- **Disaster Risk Reduction**: The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.
- **Risk assessment:** It is a systematic approach to identify hazards, evaluate risks and incorporate appropriate measures to manage and mitigate risk for any work process or activity.

The Disaster Risk Equation

$$DR=(H*V)/C$$

Where DR= is Disaster Risk

H= the Hazard

V=the Vulnerability

C= the Capacity, if we increase the capacity we can decrease the risk.

3.2 Types of hazards

Hazards can be natural - natural processes (drought, flood) or human-made (human-induced hazard –conflict, war, resource degradation, and climate change)

3.2.1 Categories of natural hazard

Natural processes or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

3.2.1.1 Geological Hazard

Geological process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

3.2.1.2 Hydro-meteorological hazards

These hazards are process of atmospheric, hydrological or oceanographic nature that may include thunderstorms, hailstorms, heavy snowfall, drought, flood, heat waves e.t.c.

3.2.1.3 Biological hazards

These hazards are driven by biological processes that may include various types of disease, such as pest infestation, epidemics, HIV/AIDS, malaria, e.t.c.

3.2.2 Categories of manmade hazard

3.2.2.1Technological hazard

A hazard originating from technological or industrial conditions, including accidents, dangerous procedures, infrastructure failures or specific human activities, that may cause loss of life, injury, illness or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

3.2.2.2 Societal hazard

A hazard related to armed conflict, civil unrest, terrorism, e.t.c.

3.3 Dynamic nature of disasters and their impacts

Population exposure and ability to respond to different hazards varies. For example, it is increasingly evident that where poverty is widespread and deep, people's abilities to cope with disasters are constrained or limited and requires greater investment in the systems of managing disasters.

As a result of the dynamic nature of the environment and disasters, as well as new approaches to disaster management. A strong policy should be prepared and need to embrace new concepts such as Disaster Risk Reduction and climate change.

Disaster Risk Reduction is the systematic process of application of policies, strategies and practices to minimize vulnerabilities and disaster risks through preparedness, prevention and mitigation of adverse impacts of hazards within a context of sustainable development. The DRR approach has become a worldwide practice since the Hyogo Framework of Action (HFA) and this approach should be adopted by all sectoral ministries as the dominant effort towards Disaster Management. DRR approach should be mainstreamed and integrated into the strategies and operations of every sectoral ministry rather than being left to be implemented by one Ministry.

Climate Change is a change of climate which is attributed directly or indirectly to human activity (especially carbon-emitting industries, fossil fuels, and deforestation) that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

On the other hand, climate change is the destabilization of normal climatic processes by man-made activities resulting in shifts in climatic systems, zones, extreme climate events and disasters. So, humans should adapt to the hazards emanating from climate change.

3.4 Baseline of hazards in the basin

3.4.1 Environmental degradation

Environmental degradation is an umbrella concept which covers a variety of issues including pollution, biodiversity loss & animal extinction, deforestation & desertification, global warming, and a lot more. Environmental degradation is the deterioration of the environment through depletion of resources such as air, water and soil; the destruction of ecosystems and the extinction of wildlife. It is defined as any change or disturbance to the environment perceived to be deleterious or undesirable.

Environmental degradation is one of the major hazards in the basin. The main causes are climate change and variability, deforestation and soil erosion. The causes of this hazard are discussed below.

3.4.1.1 Deforestation

The major part of the basin has abundant biodiversity where variety of vegetation and wild life exist. The basin has impressive landscapes and important for the conservation of biodiversity and home to wildlife migration. But recently, the resources are found diminishing at an alarming rate from time to time due to various human induced factors.

In the lower basin, deforestation and forest fire are the most important environmental problems due to deliberately set wildfires and significant destruction of the ecosystem and biodiversity, encroachments of farming and shifting cultivation on areas still covered with vegetation, settlement of people from highly populated highlands, and expansion of private agricultural investment activities. (Source, TBIWRDP, 2009).

The demand grown on forest products has also put pressure on the resource. This has caused considerable damage on the resource base and environment of the basin. The population pressure and consequently a rise in demand of land for settlement, agriculture, energy; illegal hunting, very traditional agriculture dominated by shifting cultivation; and illegal trade forest products like charcoal contributed to forest degradation, and the ecosystem services in the basin.

Fire wood is the most important among the biomass sources that facilitate the rate of deforestation in the upper basin.

Most parts of formerly forested areas have been converted to farmlands, and this has left the area devoid of vegetation cover. The original mountainous forest of the basin had been deforested even from the steep sloping mountains and hills that should have been considered as marginal lands for agricultural and settlement activates, especially in the middle and upper parts of the basin.

Despite the socio-economic importance, large scale irrigation agriculture developments like Tana-Beles and Arjo Didessa sugar project has environmental effects in the basin, which would also affect the vegetation cover of the area (figure 3.1). However, the sugar plantation will cause some micro-climate changes, and this change is expected to be slight and the corresponding effects would be beneficial.

Figure 3. 1 Vegetation clearance and sugar cane plantation around beles area, photo 2013

According to the study in beles-sub basin (on December, 2013) the quantitative analysis of changes in forest coverage between 2001 and 2012 show significant difference in the two years implying substantial decline in the forest coverage. The available dataset revealed that in the year 2001 the amount of vegetation cover is about 992,761ha while in the year 2012 the vegetation cover has decreased to 451,601.25 ha. From practical point of view it is understood that the amount of bare soil is increasing due to the increase in temperature and other environmental, social and economic factors (see table 3.1).

Table 3. 1 Change in vegetation coverage between 2001 &2012 in beles sub basin

Class	2001		2012	
	Area(ha)	**%**	**Area(ha)**	**%**
Mixture of Bare Soil and Vegetation	159,575.10	13.07	662,796.35	54.29
Vegetation Only	992,761.28	81.32	451,601.25	36.99

According to the data collected in October 2015 focusing on forest loss factors such as forest fire, investment expansion, production of wood charcoal, fire wood, timbering, shifting cultivation and resettlement are serious environmental challenges of the beles sub basin. Among these factors, forest fire (wildfire) is the most serious cause for forest loss in the sub basin. It removed about 8,716.3 ha of the sub basin forest coverage in 2015.

Figure 3. 2 Deforestation around beles sub basin area photo, 2012.

Furthermore other factors causing forest loss such as, illegal settlement, free grazing high demand for construction and agricultural land expansion are significantly affecting the basin forest coverage.

According to the study conducted to quantify forest cover changes in three watersheds (Gilgel abay (1,646 km^2), Birr (980 km^2), and Upper-Didessa (1,980 km^2) of the Abbay basin between 1957 and 2001. The total forest cover during the study period is increased in Gilgel abay (from 10 to 22 % cover) and decreased in Birr (from 29 to 22 % cover) as well as in Upper-Didessa (from 89 to 45 % cover)(Gebrehiwot,2014).

The increase in Gilgel abay was primarily due to the expansion of eucalyptus plantations on farm lands as a commercial forest. Natural forest cover decreased in all three watersheds. Wooded grassland decreased by two-thirds, dry/moist mixed forests decreased by half, and riverine forests had disappeared by 1975 in Gilgel abay and Birr. Major deforestation had already taken place in the northern watersheds, Gilgel abay and Birr, before the 1960s and 1970s, while in the southern watershed, Upper-Didessa, much of the deforestation occurred after 1975.

The southern watershed still remained by far the most forested watershed in 2001 despite the strong ongoing deforestation. The changes in forest cover could affect natural resource management, greenhouse gas emissions, water resources, and agricultural production including coffee production.

In low land areas of the basin natural wood lands have been devastating as a result of re-settlers encroachment, illegal encroachers coming from different highland areas of the basin, and investors encroachment for crop cultivation. This is also another most fragile ecosystem which can be easily faced to loss of biodiversity. The encroachment is also undertaking by clear cutting and burning of forest to clean the area or land preparation for cultivation that exacerbates the land degradation and biodiversity loss in the area as observed in the field.

Excess removal of forests is contributing to land degradation. Studies for pressure on tree resource indicates, based on population growth (demand) and forest increment (supply), much of the Amhara region of the basin recorded a deficit of about 16.6 million cubic meters of wood for fuel and construction in 1996 alone (BoA, 1997). About 20 thousand hectares of forest are harvested annually in the Amhara Region for fuel wood, logging and construction purposes as the region covers 60 percent of the basin.

The primary cause of deforestation in the highland of the basin has been extensive forest clearance for export-driven agriculture, over-grazing and the commercial exploitation of forests for fuel wood and construction materials, without replacement.

In general high population pressure, inappropriate agricultural practices, improper land-use planning, over-dependency on agriculture as source of livelihood and extreme dependence on natural resources, overgrazing, expansion of agriculture to marginal lands and steep slopes, declining agricultural productivity and resource-use conflicts in many parts of Abbay basin are inducing deforestation.

3.4.1.2 Climate change and variability

The IPCC report shows that extreme rainfall and an increasing frequency of rainfall in most areas are very likely to happen in the 21st century with different emissions scenarios. Major projected impacts of these changes are damage to crops, water logging, soil erosion, flooding, adverse effects on groundwater and surface water quality, water scarcity, contamination of water, disease outbreak, loss of properties, disruption of settlement, and different socio-economic challenges (IPCC 2007). As there are a number of climatic and non-climatic drivers influencing flood and drought impacts, the realization of risks depends on several factors. Floods include river floods, flash floods, urban floods and sewer floods, and can be caused by intense and/or long-lasting precipitation, dam break, and reduced conveyance due to landslides. Floods depend on precipitation intensity, volume; timing, antecedent conditions of rivers and their drainage basins (e.g. soil characteristics, wetness, urbanization, and existence of dikes, dams, or reservoirs). Human encroachment into flood plains and lack of flood-response plans increase the damage potential. Flooding is a familiar event in the Upper Blue Nile basin including Abbay basin and did cause a lot of destruction in the past years.

Climate diagnostics suggest that the El Niño–Southern Oscillation phenomenon is a main driver of inter-annual variability of seasonal precipitation in the basin. One-season (March–May) lead predictors of the seasonal precipitation are identified from the large-scale ocean–

atmosphere–land system, including sea level pressures, sea surface temperatures, geo-potential height, air temperature, and the Palmer Drought Severity Index.

Roughly 70% of annual precipitation in the Upper Blue Nile basin of Ethiopia is delivered during the *Kiremt* season, composed of the June–September months (Conway 2000); during this season, 85%–95% of annual crops are produced (Degefu 1987).

The highlands and Blue Nile basin are predominantly fed by moisture advected over the Congo basin, transported via a southwesterly flow, and released due to orographic effects. This pattern persists until September or October, when the northeasterly continental airstream is reestablished, and the ITCZ shifts south (Conway 2000). Inter-annual variability of precipitation within the upper Blue Nile basin has been investigated by previous researchers (see, e.g., Eklundh and Pilesjo 1990; Seleshi and Demaree 1995; Camberlin 1995; Conway 2000; Osman and Sauerborn 2002; Segele and Lamb 2005).

Factors influencing the variability include the El Niño– Southern Oscillation (ENSO) phenomenon, tropical depressions over the Indian Ocean, onset and cessation of the *Kiremt* rains, and periods of anomalous warming over the Indian Ocean. Temporal correlations of UBN boreal summer rains with ENSO have shown that warm ENSO periods (El Niño years) are typically associated with lower precipitation and drought years, while cold periods (La Niña years) are associated with higher precipitation quantities (Seleshi and Zanke 2004; Nicholson and Kim 1997; Beltrando and Camberlin 1993).

Precipitation in the basin is intrinsically tied to regional pressure and wind patterns; warm ENSO events alter these zonal circulation patterns, disrupting the flow of moisture to the basin, often resulting in drought circumstances (Camberlin 1995). Segele and Lamb (2005) also corroborate the critical influence of atmospheric circulation over the basin during the *Kiremt* season, and its important connection to large-scale tele-connections.

The effects of climate change on precipitation in the highlands of Ethiopia, as well as the whole of the Blue nile basin, have also been given attention recently. Potential climate change effects are not explicitly dealt. It is difficult to identify the impact of climate change in the Upper Blue Nile basin due to the uncertainty of projected rainfall patterns in various parts of the basin and the water management structure complexity. However, it is important to use spatially and temporally accurate data and a single station in a catchment does not provide reliable data (Di Baldassarre *et al*. 2011). It is also suggested by Di Baldassarre *et al*. (2011) that to analyze the climate change impact, it is more appropriate to use a framework selecting one or more IPCC emissions scenario, one or more general circulation models (GCM), downscaling GCM climate output for the basin scale, using a GCM model for hydrological modelling and comparing the hydrological modelling result with current and future climate.

Annual rainfall over the basin decreases from the south-west *(>2000* mm) to the north-east (around 1000 mm), with about 70 per cent occurring between June and September. Rainfall over the basin showed a marked decrease between the mid-1960s and the late 1980s and dry years show a degree of association with low values of the Southern Oscillation Index (SoI). Annual river flow, like rainfall, shows a strong association with the SOI.

There is little variation in temperature through the year, roughly between 3 and 6°C from the warmest month to the coolest months (between November and February). In summer, peak temperatures are reduced because rainfall, cloudy conditions and energy use for evapo-transpiration rather than sensible heat occur when the highest temperatures would normally be expected (July and August). The hottest period is, therefore, March to May, before the onset of the major rains. This produces a smaller annual range of temperature than might be expected and in some instances results in two cooler and warmer periods. The range in elevation within the basin (from roughly 500 to 4050m) has a major influence both on the climate and human activities. On average temperatures fall by 5.8^{o}C for every 1000 meters increase in elevation (the lapse rate is greater in the winter dry season from September to March whereas during the wet season from May to August it falls to roughly 5.3^{o}C per 1000m).

Mean monthly Penman potential evapo-transpiration (FAO, 1984) for the basin varies by only 50 millimeters between its lowest values in July and August and its highest values in April or May. The differences are driven by seasonal variations not only in temperature, but also in radiation, humidity and wind speed.

A review of the limited amount of hydrologic data available for the Upper Blue Nile highlights the strongly seasonal nature of runoff as a result of the rainfall regime, with many tributaries drying out in the dry season. During 1961 (the year with data at the largest number of sites) roughly **40** percent of Blue Nile discharge originated from Lake Tana, the Fincha Reservoir and Dabus wetlands during the dry season (November to April) owing to their storage effects. There is strong correlation between the basin wide rainfall series and the basin river flow. The river flow is, therefore, influenced by the same factors as rainfall over the region, namely association with the strength of the Indian Monsoon and the behavior of the SoI.

3.4.1.3 Soil erosion

The UBNR basin is experiencing significant problems related to erosion by water. Lack of relevant data and adoptable methods, combined with the great heterogeneity of environmental factors, have long hampered soil erosion studies in the region. Results show that the basin loses soil at an average rate of 27.49 (range = 0–200) t ha^{-1} yr^{-1} and has an overall absolute soil loss of ca. 473Mt yr^{-1}, of which ca. 10% comes from gullies and 26.7% leaves the country. Such losses threaten the sustainability of downstream reservoirs, including the GERD, by inducing excessive sedimentation and eutrophication (Nigussie Haregeweyn,2016).

Erosion mainly involves wearing-away of fertile soil and occurs in series of stages from detachment of soil grains on rain splash all the way down to rill, sheet erosion and finally formation of deep gully. Soil erosion and soil loss are the major challenges for sustainable agricultural development in the upper Blue Nile basin.

In Debre Birhan area there are many erosion sites. The areas are found mainly near rivers and streams. The slope gradient ranges from gentle to steep. All the erosion sites are active with scares to no vegetation cover. At some localities the areal coverage of the erosion sites are very large.

The intensive erosion features are found in vicinity of Bahirdar, Merawi, Shahura, Yismala, Addis Kidam, Dure Bete, Adet and Mambuk are some of the common areas affected by erosion.

Figure 3. 3 Erosion/ land degradation

Soil erosion by water is a major environmental problem in the basin. It has economic, social and environmental implication due to its on-site and off-site effect. On site effects of soil erosion leads to yield loss, which again leads to economic loss. As a demonstration the total amount of soil loss from the Tana sub basin is about 21,341,546 tons per year. Associated to soil loss, about 21,341tons of grain/year, which is worth of birr 1,311.32 million is lost every year.

Figure 3. 4 Cultivation of steep slope in Farta woreda *(Left)* and severe gully erosion in Dangila woreda *(Right)*

Findings indicated that, 0.3% (3908 ha) of land within the sub-basin is affected by gullies. The degraded areas accounted for 3.1% of the land. The trends of vegetation showed slightly decreasing tendency of about 84.2%. Slightly positive trend is observed only in 15.8% of the sub basin, most of it being observed in Gilgel abay major watershed.

Table 3. 2 Soil loss in TSB with respect to major watershed

Major watershed	Area(ha)	Soil loss tons/Year	Soil loss tons/ha/year	Soil loss proportion (%)
Gilgel abay	462,719	6,583,991	14	31
Gumara-Rib	411,208	8,481,770	21	40
Megech	322,316	6,275,336	19	29
Total/Average	***1,196,243***	***21,341,097***	***18***	***100***

Source: Integrated watershed management plan for Tana sub-basin, GIS analysis (CBNReMP, 2013)

The average estimate of soil loss in TSB is 18 ton/ha/yr (table 3.2). Comparison of the sediment transported in a year from one km^2 catchment area at Gilgel abay (2653 ton/km^2) (Picolo) and Koga (769 ton/km^2) (Picolo) showed that treatment of Koga catchment coupled with Koga dam has remarkably reduced the sediment transported into Lake Tana.

Rib major watershed accounts for 40% of the total soil loss in the sub-basin, while Gilgel abay and Megech major watersheds accounts respectively for 31% and 29% of soil loss within the sub-basin (Table 3.2). The main reason why soil loss in Gumara-Rib major watershed is high may be due to high slope steepness, which is one of the major determinant factors for soil loss estimation.

Nekemt, like many other towns in western part of Oromia is characterized by undulating landscapes where surface processes are most likely to occur. Erosion is favored by such topographic setup, high rainfall amount and relatively thick soil cover ubiquitously distributed in the town. Furthermore, mis-positions of roadside drainage system concentrate surface runoff leading to the development of huge gullies. Some of the houses have been damaged and yet others are on the verge of failure. The present study is then carried out in the town in response to the report that gully erosion have recently have caused property damages and on the way to cause many more in an anticipated adverse condition. Unless treated, the long-term effects of this erosion will be so severe that it can cause damages to many houses and infrastructures including the main asphalt road.

The main erosion problem in the beles is gully erosion**.** Based on MoARD data, more than 95% land in the basin characterized with low soil erosion at lower altitude of the area. High land area of the beles do have medium to high severity of soil erosion.

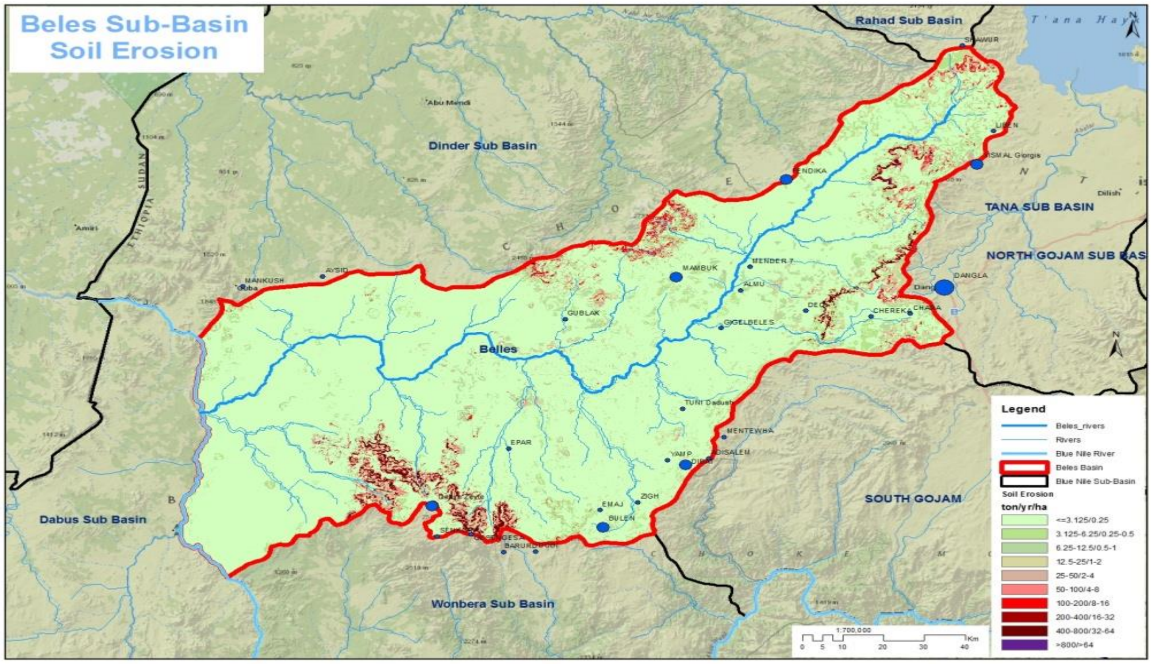

Figure 3. 5 Soil erosion in beles areas

Soil moisture affects the overland flow during periods of intensive rainfall and is a critical parameter for flood prediction. Moreover, soil erosion is an important aspect for the estimation of siltation in reservoirs, as well as a loss of fertile soil.

Pressure on the land from population growth and increasing numbers of livestock coupled with poor land and water management, are contributing to severe and widespread degradation of land and sediment deposition into rivers and streams in the beles area. Formation of severe gullies and land eroded and devoid of its topsoil is commonly observed in some parts of the beles sub-basin. Farmers have been farming steep slopes and riverbanks to compensate for increased population pressure and for the loss of soil productivity, and this practice has further increased the rate of soil erosion.

The collected data (2015) indicates that in most of the basin areas there is the effect soil degradation. The data indicates around 60,014.00 ha of land is degraded and gully.

Problem of soil erosion in Dabus were interrelated and one form of land degradation was a cause for the other form. Most of the time gully erosions were developed from sheet and rill erosion which intern formed as a result of termite's effect in most parts. Other cause of gully erosion and land degradation in the sub basin was untreated/carelessly/ design of drainage canals to removal flood from road side.

A potential soil loss of 0 to 1006.9ton/ha/year was estimated from the Dabus sub basin. The highest potential erosion is strongly allied to mountains areas. On the other hand after consideration of land use land cover and conservation practice factor soil loss from the area (actual soil loss) is estimated to range from 0 to 397.27ton/ha/year. Accordingly about 9.96% of the sub was subjected to high to very high soil loss. (*Sectoral studies 2013*)

Figure 3. 6 Soil erosion in Dabus areas (West Wollega Zone, Babo Gambel, 741632 E and 1027976 N) (gully form)

A potential soil loss of 0 to 1010.82ton/ha/year was estimated from the Dedissa sub basin. The highest potential erosion is strongly allied to mountains areas of the sub basin. On the other hand after consideration of land use land cover and conservation practice factor soil loss from the area (actual soil loss) is estimated to range from 0 to 533.52ton/ha/year. Accordingly about 47.12% of the sub basin was subjected to high to very high soil loss. (*Sectoral studies 2013*)

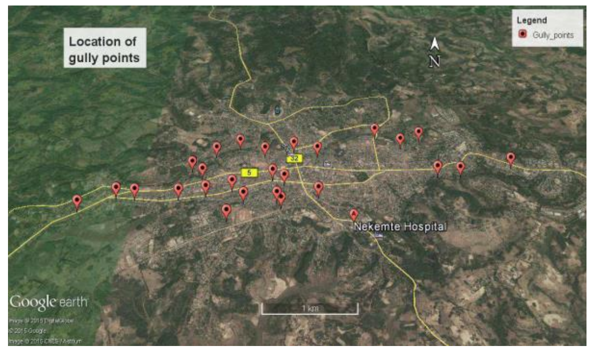

Figure 3. 7 Typical gully features observed in the town *(Left)* and location of some gully incidences with respects to road network in the town (Right).

3.4.2 Drought

Drought is an insidious natural hazard characterized by lower than expected or lower than normal precipitation that, when extended over a season or longer period of time. It is insufficient to meet the demands of human activities and the environment (WMO, 2006). Wilhite and Glantz (1985) cited by Rahel Sintayehu (2007) analyzed that drought is broadly grouped in to four categories:-

• *Meteorological drought*: A period of prolonged dry weather condition due to precipitation departure.

• *Agricultural drought*: Agricultural impacts caused due to short-term precipitation shortages, temperature anomaly that causes increased evapo-transpiration and soil water deficits that could adversely affect crop production.

• *Hydrological drought*: Effect of precipitation shortfall on surface or subsurface water sources like rivers, reservoirs and groundwater.

• *Socio-economic drought*: The socio economic effect of meteorological, agricultural and hydrologic drought associated with supply and demand of society**.**

Among the natural disasters drought is the least documented in scientific research. In addition to this, only few studies have been conducted. The present study aims to contribute to overcoming this potential shortcoming. Drought is widely recognized as a major climate hazard and a key development challenge in Ethiopia. While opinions vary on the severity and frequency of drought in the historical past, recent reports show that droughts have increase in frequency and intensity in recent times.

Farmers in drought stricken regions of Ethiopia are facing severe food shortages, with pre-famine conditions, including widespread human and livestock migrations, deteriorating livestock health and cases of livestock deaths, being reported in some areas, (FAO, 2006 cited by Rahel Sintayehu (2007)). Recent statistics shows that drought in Ethiopia drastically increased especially in the past five years.

A drought crisis in Ethiopia, triggered by erratic and severely depressed rainfall nearly 2015, has affected 9.7 million Ethiopians. The Government of Ethiopia (GoE) and international humanitarian community have mobilized to meet emergency needs, including water, sanitation and hygiene (WASH), food and nutrition. This has taken place through a $1.62 billion appeal, which has only been partially met to date (2016 Ethiopia HRD). In response to the current drought, the GoE has allocated more than $700 million of its own resources mainly to address needs not included in the appeal, including by reprogramming infrastructure programmes.

The increased frequency of drought in recent years in the Basin can be viewed as frequent minor and seasonal localized and severe droughts, erratic and uneven rains, general water stress and scarcity, increased heat waves and windy days, and increased land degradation and disappearance of some important indigenous tree species with medicinal and nutritional value for humans and animals, and decreased pasture availability.

The basin is also characterized as one of the most degraded mainly due to rapid population growth, poverty, poor watershed management, poor or absence of effective water use policy and frequent natural disasters. The population pressure in the highlands covering the upper basin of BNR, the land-use changes mainly for agriculture and the climate change impact on the hydrology of the region have contributed to the reduction of the flow from the river in recent years. Hydro-meteorological studies of the basin will benefit efforts to manage water and ecological resources of the basin.

High population growth, limited alternative livelihood opportunities and the slow pace of rural development are inducing deforestation, overgrazing, land degradation and declining in agricultural productivity. The absence of alternative sources of energy other than biomass has put the available forest resource at risk. Forest clearing in hydrological sensitive areas likes that of the head waters can lead to low dry season flows and reduction in recharge.

According to Wereda (District) Disaster Risk Profile (WDRP) which is a comprehensive disaster risk assessment programme led by the Government of Ethiopia with technical and financial support by development partners, from 237 woredas of the basin 64 Woredas have been covered by the Woreda Disaster Risk Profile (WDRP) study. As the study shows 60 woredas are semi affected by drought. However the severity of the drought is vary from 1% (Pawe) to 47.49 (Gondar Zuria).Among 60 drought affected woredas 46 woredas are vulnerable by more than 10% relative to other disasters and the rest 14 woredas are affected by below 10%. In general the upper catchment of the basin specially Beshilo, North Gojjam, Weleka, Jemma sub basins in the eastern part are more affected than others areas. The drought affected woredas in the basin are attached to the annex.

3.4.3 Flood

Flooding is the prominent natural disaster that causes potential hazard in Abbay basin. From a natural hazard perspective, there are important similarities between river flooding; lake flooding; flooding resulting from poor drainage in areas of low relief; and flooding caused by storm surges (storm-induced high tides), tsunami, avalanches, landslides and mudflows. All are hazards controlled, to some extent, by the local topography, and to varying degrees it is possible to determine hazard-prone locations.

The natural flow of a river is sometimes low and sometimes high. The level at which high flows become floods is a matter of perspective. From a purely ecologic perspective, floods are overbank flows that provide moisture and nutrients to the floodplain. From purely geomorphic, perspective, high flows become floods when they transport large amounts of sediment or alter the morphology of the river channel and floodplain. From a human perspective, high flows become floods when they injure or kill people, or when they damage real estate, possessions or means of livelihood. Small floods produce relatively minor damage, but the cumulative cost can be large because small floods are frequent and occur in many locations of the basin. Larger, rarer floods have the potential to cause heavy loss of life and economic damage. A disaster occurs when a flood causes "widespread human, material, or environmental losses that exceed the ability of the affected society to cope using only its own resources" (UNDHA, 1992).

The human consequences of flooding vary with the physical hazard, human exposure and the sturdiness of structures. Primary consequences may include:

a) Death and injury of people;
b) Damage or destruction of residences, commercial and industrial facilities, schools and medical facilities, transportation networks and utilities;
c) Loss or damage of building contents such as household goods, food and commercial inventories;
d) Loss of livestock and damage or destruction of crops, soil and irrigation works; and
e) Interruption of service from and pollution of water supply systems;

Secondary consequences may include:

f) Homelessness;
g) Hunger;
h) Loss of livelihood and disruption of economic markets;
i) Disease due to contaminated water supply; and social disruption and trauma.

3.4.3.1 Flood in Abbay basin

The hydrological boundary of the basin includes the political administrative regions of Amhara, Oromia and Benishangul Gumuz. Due to global climate change and local environmental pressure, the magnitude and frequency of flood hazards, has been increasing overtime. Due to its geography and river potential most of the flood occurred in the basin in particular Tana sub basin of Dembia, Fogera and Gilgel abay areas.

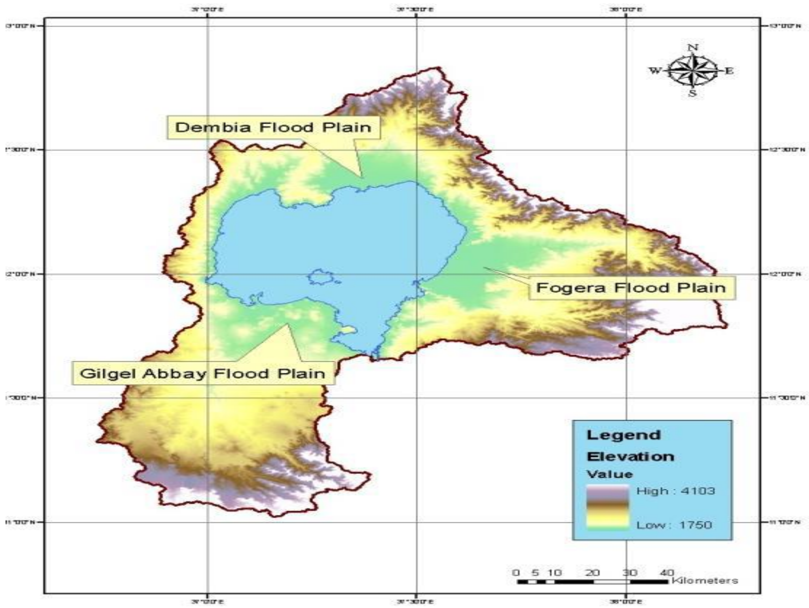

Figure 3. 8 Location of major floodplains around Lake Tana (SMEC, 2008)

Flood in Benishangul Gumuz region of the basin occurs as a result of overflow Dabus and Gilgel Beles rivers whenever prolonged rainfall duration happens. The issue of flood continues to be of a growing concern to people residing in lowlands, near rivers, as well as towns located at the foot of hills and mountains. In Benishagul-Gumuz region, some pocket areas have received heavy rains and experienced flood damages, (BeSBO, November, 2013). Normally the main Meher rainy season starts in May and ceases mid-October in all zones of the Benishangul Gumuz region. In 2004/2005 rainy season about 109 ha of cropland were damaged and as result of this 954 populations were affected by flood risks.

The communities in the districts of the Beles have also been occasionally threatened by flood. In these districts, the flood is induced by heavy rainfall. Unexpected flash floods have occurred from many tributaries of the Beles. The reason for frequent occurrence of flash flood incident in some part of the basin could has been be due to degradation of agro-ecological catchments or changes in its run-off and/ or reduction in its infiltration rate, and hence resulted siltation problem.

Table 3. 3 Flood hazard in Amhara region of the basin from 1998-2003

Year	Damage					Displaced			Death	
	No of Woreda	People	Crop in ha	livestock	Organization	HHs	Family	Total	Human	livestock
1998	22	118,618	18,447	544		12,127	27,544	39,671	3	
1999	16	133,295	34,052	39,515		4,472	7,330	11,802		
2000	2	3,356	1620	0				0		
2001	4		500	0				0		
2002	47	458,261	54,327	1613	101	3,230	14,767	17,997	85	
2003	33	17754	9515	0		47	235	282	20	

Source: ANRS DPFSCO

In Tana sub basin the cause of flooding are back flows of the lake when the lake volume raise and the over flow rivers such as Gumara, Rib, Megech and Gilgel abay in the flood plain. Even though the flood has benefited the local community in recession agriculture, it has been damaged lives and assets of the community. According to ANRS, DPFSCO (2010) report, flooding is becoming a recurrent phenomenon in TSB with a return period of one to two years. However, the magnitude of the floods varies from year to year, floods happened in 2006 have brought the most severe damage to properties and lives loss on the people living in the floodplain.

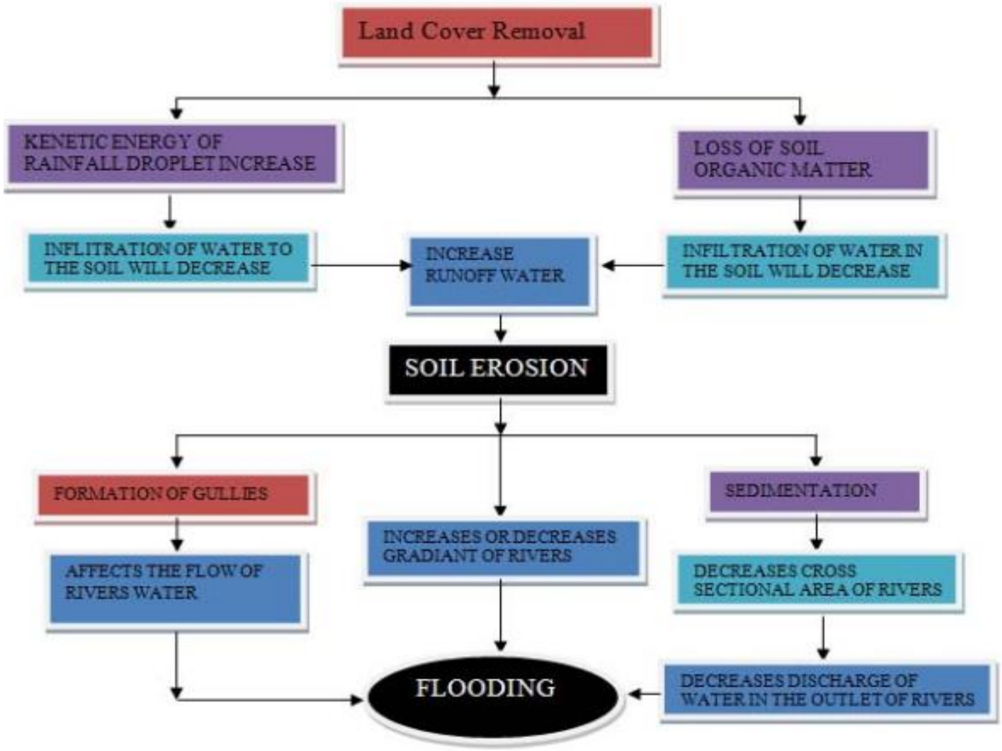

Figure 3. 9 A diagram showing the causes of flooding

Table 3. 4 Number of people affected by flood in 2006

Zone	Flood Affected People in 2006		
	Total affected people	Displaced people	House Holds
W. Gojjam	9620	437	327
S. Gondar	71430	23677	8849
N. Gondar	7567	1805	607
Bahir Dar Town	203	53	10
Total	88820	25972	9793

Source:*(DPFSCO, 2010)*

While on the contrary the 2007-2009 floods of moderate nature, characterized by high rainfall associated with LT back flows, overflow of rivers from Rib, Gumara, and Megech including flash floods from upper degraded watersheds, submerged many places causing certain damages on lives and livelihoods of people. Table 3.4 displays the overall impact of floods in 2006 in the floodplain of TSB. The flood occurred in the year 2006 has affected more than 88,820 and displaced 25,972 people. Similarly, the 2007 flood has affected 116,338 people and displaced 6,694 in habitants.

Table 3. 5 Flood affected areas and their damage in 2007

Zone	Total affected areas	Displaced		Damaged Crop land (ha)	Livestock affected	
		People	HHs.		Cattle	Goats
W. Gojam	2186	54	9	1447.00	0	0
S. Gondar	49872	3914	1477	8963.70	28,124	7543
N. Gondar *	64280	2726	2007	14800.00	75	606
Total	116,338	6,694	3,493	25,211.00	28,199	8,149

**includes flood damages outside TSB, sources: ANRS, DPFSCO, 2010) report*.

On the basis of lessons drawn from the 2006 and 2007 floods, prevention and preparedness measures are introduced to mitigate the adverse impacts of flooding. A flood alert has been established based on the National Metrological Agency Forecast that functions anticipating flood risk to provide early warning in connection with rainfall and high water stage level in major rivers. A flood contingency plan is set ready indicating the necessary preparedness and mitigation activities.

The major causes of annual inundation in the flood plains around Lake Tana are a) poor drainage conditions, b) bank overflow from rivers, c) direct rainfall and d) backwater flow effects resulted from high water levels in Lake Tana. In almost all cases it is a combination of factors that causes the flooding. The extent of inundated areas in the period 2001 – 2006 was estimated from remote sensing images in combination with ground trothing (SMEC, 2008). This study also states that most flooding occurs in the fogera plains where the average inundated area in July is about 210 km^2. In the Dembia floodplain and the floodplain of the Gilgel abay the inundated areas are on average about 30 km^2.

According to estimation using remote sensing technique, most of the high land areas of the Beles such as (Wombera, Semen & Debub Achefer, and Dangila) are more likely vulnerable to flood than lower area of the basin. However, based on World Bank data, more than half of the Beles area is less exposure for flood risks.

Table 3. 6 Number of affected people, damaged crop land by flooding in Beles area

Region	Zone	Woreda	Year	No. of Affected Pop.	Damaged crop land(ha)	Disaser
Benishangul Gumuz	Assosa	Bambasi	2004 - 2005	954	109	Flood

At the Oromia region of the basin around Jemma sub basin in 2006 flood has affected 21,900 people and has displaced 9,052 people (Flood assessment in ABA, 2007). Here, flooding mainly associated with land slide events which is a major problem in the Jemma sub basin particularly Werajarso, Debrelibanos, Kuyo and Abune gendeberet woredas.

3.4.3.2 Flood Risk Management

Flood management is concerned with managing the risk of adverse impacts arising from floods. It can therefore be termed "flood risk management". This requires definition of flood risk, and also of risk management in the context of flooding. Without all three of the elements of hazard, exposure and vulnerability there would be no risk. It is a useful definition of flood risk because all of the measures we adopt in flood risk management attempt to modify one or other of these three elements of flood risk. It is important to recognize that risk management is not only (or not always) directed at risk reduction. Management of flood risk may have other objectives too. More generally, management aims at deriving the greatest net benefit to society. This entails assessment of the positive and adverse impacts of flood management activities in economic, social and environmental terms. Small-scale structural flood mitigation measures are likely to emerge from the public education and training programs, initially around Lake Tana. Larger scale structural flood mitigation measures are not proposed for Lake Tana under the FPEW Project because of the mitigating effects on lake levels being achieved through current and past projects (Tana-Beles diversion, and reconstruction of Chara Chara Weir), and because flood mitigation on the contributing rivers can best be advanced through irrigation project developments currently under construction (SMEC,2007).

In general plenty of options are available for flood management and mitigation measures. These measures can be classified broadly into structural and non-structural measures. Many considerations have to be sought to select suitable flood mitigation measures. Some of the factors such as the type and characteristics of the flood (magnitude, return period, peak, damage, etc), cost implications and opportunity to maximize the benefit from the flood water must be considered in selecting feasible solution.

Structural measures (Engineering or Technical solution) are designed and constructed to modify the characteristics of floods before arriving to the flood damage area through various physical constructions such as reservoirs, diversions, levees, dykes, or channel modifications and river retaining works. Diversion or flood storage dam may be suitable to prevent the ravages of flash floods but the enormity of the financial, economical and ethical requirement undermines the importance of the flood prevention measures.

Non structural measures are designed to modify the damage potential of the flood without interfering to the characteristics of the flood (magnitude, peak, duration, etc). Such methods focus on software and hardware technological aspects, such as flood proofing, flood warning system, land use control, etc. For instance through flood forecasting and early flood warning mechanism, the potential of flood damage to properties and human lives can be reduced.

3.4.4 Wild fire

Wildfires are an ecologically important phenomenon in the low land savanna grass land areas of the lower basin and have occurred over so many years. A wildfire is an uncontrolled fire, consuming vegetation in the country side or a wilderness area, such as forest, woodlands, bush land, scrubland, and grassland. Humans are the common ignition source, either by accident, or where management fires while they are using for honey collection and rangeland management gets out of control.

Humans have used fire to clear forests for agriculture and maintain rangelands for grazing newly regenerating shoots & controlling exotic parasites, hunting & gathering honey from tree trunks and stone caves. There is a risk with management fires that if they get out of control, they could become wildfires. Wildfires pose a risk to lives and infrastructure and significant losses can occur. Losses are particularly severe where fires affect large areas and are of high severity. These fires are typically associated with dense live vegetation and dead vegetation, prolonged dry conditions prior to the fire, high temperatures and strong winds.

Climate and weather are key drivers for wildfire, with droughts and heat waves increasing wildfire risk. Recent changes in climate have already led to a lengthening of the fire season in some areas of the basin.

The average of fire density of the Beles sub-basin is taken depending on data produced over the period 1997-2010. According to world fire atlas dataset, average fire density is higher at middle area of the sub-basin at Dangur and west part of the Guba districts (Beles sub basin atlas, 2015). In the lower basin the majority of the area (80%) wild fire occurs at least once in the years. The middle and the upper parts of the Abbay basin are less occurrence of wild fire.

Therefore, the burning of the forests could contribute of the climate change by increasing the concentration of carbon dioxide in the local atmosphere of the lower basin.

Figure 3. 10 Uncontrolled forest fire in the Beles sub basin area, photo, 2012.

Among 237 woredas of abbay basin 64 weredas have a disaster risk profile compiled by NDRMC and this 64 woreda's has taken as a sample and from the sample wereda's wildfire was at the fifth hazard which are at the lower basin of abbay . The name of woreda's and their respective percentage of HHs affected by disaster with their impacts are shown on table 3.7.

Table 3. 7 *Locations of sample wild fire risk prone areas (woreda disaster risk profile)*

S.No	**Woreda**	**%HHs suffered from disasters**	**loss 1**	**loss 2**	**loss 3**
1	Kumruk	1.84	\Physical damage	Loss of access to social services	
2	Mandura	2.64	Deforestation	Crop damage	Damage on houses and property
3	Menge	4.38	Deforestation	Crop damage	
4	Pawe- special	1	"	Crop damage	
5	Sherkole	4.85	Crop Damage	Physical Damages on houses and property	Lost access to grazing land
6	Wombera	2.97	Forest damage	Crop damage	Physical damage on property and houses
7	Dera/Oromia/	1	Physical damage on property	Livestock damage	

(Source: WDRP 2016)

3.4.5 Landslide

Landslide is a sudden hazard that can cause huge damage to land, infrastructures and properties. They can be caused by either human activities or natural hazards like earthquakes and floods. The abbay basin is prone to such hazards and also the geology of the area favors for such geo-hazards. There are a lot of landslide occurrence sites in the basin. Heavy rainfall, environmental degradation, mining and geo-seismic process are the root causes that induces the landslide. The occurrence of this phenomenon (landslide) in the basin causes damage of crop land, loss of access to grazing land, loss of ground cover and damage on property. It also results for the displacement of local communities.

The data summarized in the table below was obtained from Woreda (District) Disaster Risk Profile (WDRP) which is a comprehensive disaster risk assessment programme led by the Government of Ethiopia with technical and financial support by development partners. 64 Woredas of the basin are covered by the Woreda Disaster Risk Profile (WDRP) study. As the study shows, 54 woredas were affected by landslide. Sample woredas affected by landslide and the primary effects in the basin are summarized in the table below.

Table 3. 8 Sample locations of landslide affected woredas and their loss

S.No	Woreda	Affected HH in percentage relative to other hazards	loss 1	loss 2	loss 3
1	Dessie zuria	3.98	Crop damage	Loss of grass land	Damage on roads and houses
2	Ada'a Berga	5.76	Crop damage	Physical damage on household and property	Damage on pastureland
3	Ambasel	7	"	Physical damage on property	Loss of access to grazing land
4	Dera	12	"	Migration	Physical damage on property
5	Goncha Siso Enese	3.2	Had to flee/ change residence	Crop damage	Lost access to grazing land
6	Jeldu	6	Physical damage	Displacement	
7	Kutaber	3.9	Crop damage	Loss of income	Damage on houses and property
8	Nejo	9.95	Crop damage	Loss of access to water resource	Loss of income
9	Quarit	12.7	Crop damage	Lost access to grazing land	Had to flee/change residence area
10	Were Jarso	5.4	Crop damage	Damages houses and property	Livestoke damage
11	Werebabu	6	Crop damage	Physical damage on property	Loss of access to grazing land

(Source: WDRP 2016)

3.4.5.1 Debre-Markos areas land slide

Mass movements like land slide, rock fall, debris flow, slope instability, surface and gully erosion are the major geologic hazards found in the area of Debre Markos. Most of the hazards occur in the aphanitic basalt lithology in the form of rock fall and toppling. This is seen to be caused by the cross cutting of joints and formation of thin soft undercutting layers.

Recent land slide within three localities of Dejen, Awabel and Aneded characterized by massive land mass movement, tension cracks, screen fall, mud flow have been active since long time. No loss of life has been reported as a result of the mass movements as in so far but the impact has become very significant over the years.

One of the landslide zones is along the main road from Addis Ababa to Bahir Dar in the Blue Nile River Gorge (figure 3.11). It is aggravated by the slope cut for road construction and subsequent traffic load and improper utilization of drainage appropriate for the area.

Figure 3. 11 Land slide in the Abbay river Gorge along the Main road from Addis Ababa to Debre Markos (*Left*) Debris collapse in the Gohatsion town side of the Abbay river(*Right*)

The slope instability adjacent to the road has been gaining due attention and is the first to be fully monitored with various automatic instruments (Borehole extensometers, Groundwater level gauge, surface and borehole extensometers and rain gauge). The same phenomenon of slope instability is anticipated along the new road alignment under construction between Ginde Woyin and Mekane Selam towns. This is because of the steep topographic disposition and similar lithological adversity of highly fractured basalt intercalated with soft sediments and frequent highly weathered zones which are easily destabilized by excavation and change in natural topographic geometry. The landslide phenomena in the Cheye River Gorge at Atemer locality south of Mertolemariam Town have forced local inhabitants to abandon their land and resettle on adjacent plots. It also results for property damage and agricultural fields.

3.4.5.2 Debre-Birhan areas land slide

In Debre Birhan area there are a lot of landslide occurrence sites which includes the main asphalt road between Addis Ababa and Dessie. Landslides damage engineering structures constructed over a landmass in such a way that it slides over the structures which falls into its way. The land slide occurrence in the area (figure 3.12) is closely related to the geological conditions. Highly weathered bedrock is a potential risk of landslide, an increased groundwater level due to the infiltration of rain water induce landslide. The slides are damaging houses, farmlands, infrastructures (road) and land use/land cover.

Figure 3. 12 Landslide area in Debre-Birhan area from Addis Ababa to Dessie road

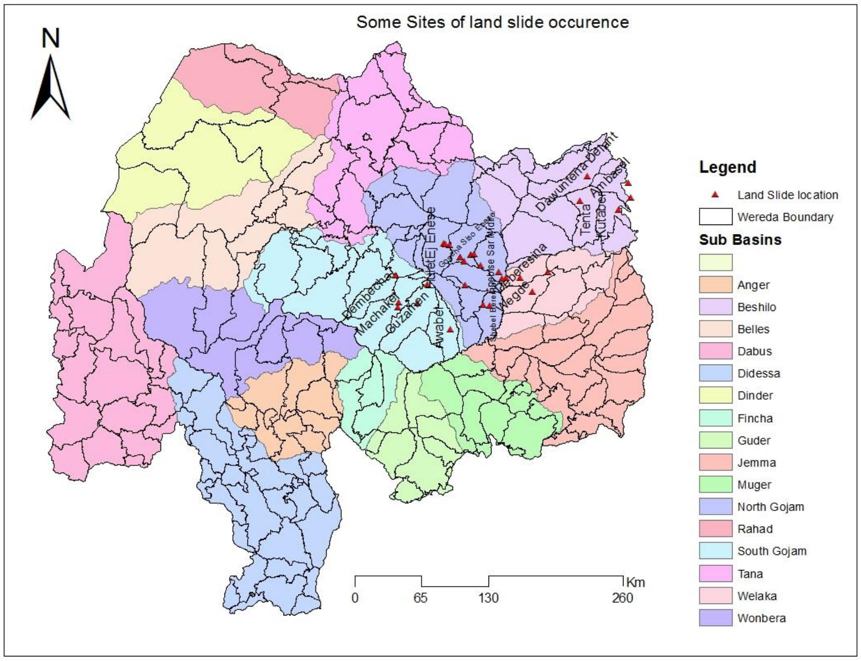

Figure 3. 13 Landslide sites in the basin

Land slide was more dominant in North, South, and East and South-East parts of the Dabus area. As indicated in figure 3.14 & 15 mainly Nedjo, Boji Chekora, Jimma Horo, Mana Sibu, Kiltu Kara and Ayia districts of the basin are highly affected by land slide. The slide destroyed rural roads in the area and numerous eucalyptus tree plantations and even houses.

Figure 3. 14 Typical landslide in Nedjo District 775989E, 1065281N of Dabus area

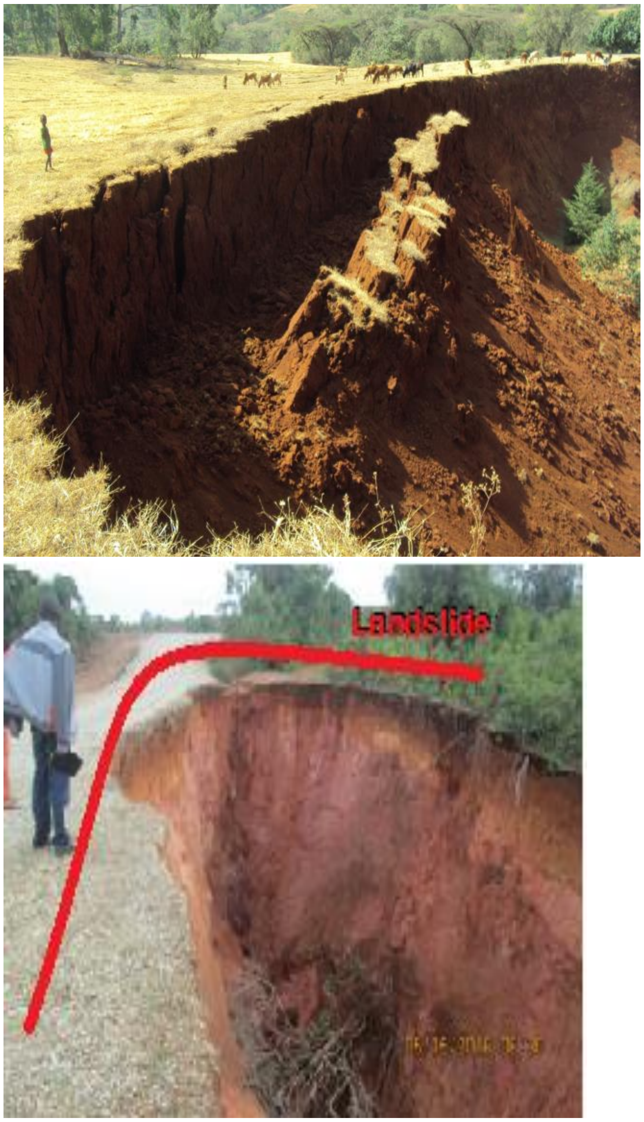

Figure 3. 15 Typical landslide in Boji Chekorsa District 783035E, 1033229N in Dabus area (*Left*) and Gimbi of Dedissa sub basin (*Right*)

3.5 Collaboration of stakeholders in disaster management

Government will play a lead role in the strategic planning and management of disasters in participatory collaboration with development partners, international agencies and other bodies. Government shall also play a key role to ensure availability of the various resources for disaster management at all levels from government sources and partners.

The contribution of these stakeholders in disaster management in Ethiopia as well as in the basin has been invaluable and the government will continue to encourage this collaboration and partnerships for the purposes of realizing synergies, providing linkages, promoting trust, goodwill and ownership of the disaster management system.

To achieve the second growth and transformation plan an integrated and co-ordinate disaster risk management that focuses on preventing or reducing the risk of disasters, mitigating their severity, improves preparedness, rapid and effective response to disasters and post-disaster recovery is important for sustainable development.

Chapter Four

4. Risk analysis

4.1 Hazard identification and prioritization

According to the current regional structure, the basin covers some parts of three regional states; namely Amhara regional state, Oromia regional state, and Benishangul-Gumuz regional state. The basin contains 22 zones (9 from Amhara and 8 from Oromia and 5 from Benishangul Gumuz) and 237 woredas from the three regions; of which 149 fall entirely within the basin and 88 woredas area partly in the basin.

For the identifications of hazards in the basin we collected secondary data for 64 woreda disaster risk profile assessment which fall entirely within the basin from the National Disaster Risk Management Commission (NDRMC). The list of woredas in which their disaster risk profile assessment made and used as a source in the analysis is attached to the appendix.

The 64 sample woreda disaster risk profile assessment data and information were used as a source and can represent to identify the hazards in the basin. As a result five major hazards were identified as shown in table 4.1.

Table 4. 1 Major hazards and their frequency identified from sample woreda level found in the basin

S. No.	Hazard	Number of woredas (Frequency)
1	Drought	60
2	Flood	57
3	Landslide	54
4	Environmental Degradation	64
5	Wildfire	12

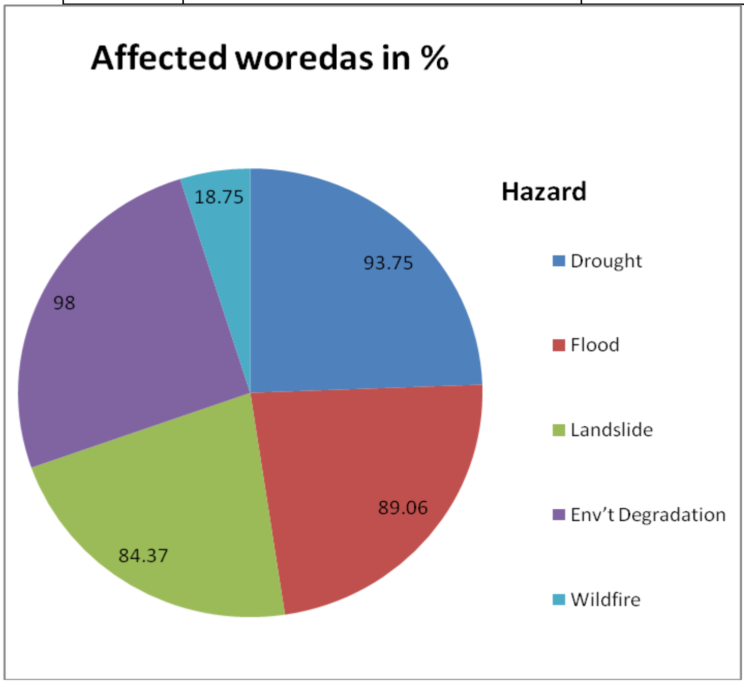

Figure 4. 1 *Affected woredas by hazard in percent in the basin*

To prioritize the above listed hazards found in the basin we assessed their likelihood determined by reference to the periodicity and the seasonality of the menace, frequency, area coverage, magnitude and potential scale of the event or impact as well as severity of the hazard in the basin.

As a result environmental degradation takes the first rank of in priority. Soil erosion, deforestation and climate changes are the major causes of environmental degradation hazards. Drought and flood takes second and third respectively while land slide takes the fourth place and finally wild fire in fifth place.

Table 4. 2 Hazard prioritization (1-5) in the basin.

Hazard	Likelihood	Frequency	Area coverage	Magnitude or impact	Total /score/	priority
Environmental degradation	5	5	5	3	18	1
Drought	5	4	3	3	15	2
Flood	5	5	2	2	14	3
Landslide	4	4	1	2	11	4
Wild fire	3	3	1	2	9	5

Remark:- Very high (5) ,High (4), Medium (3), Low (2), Very low(1)

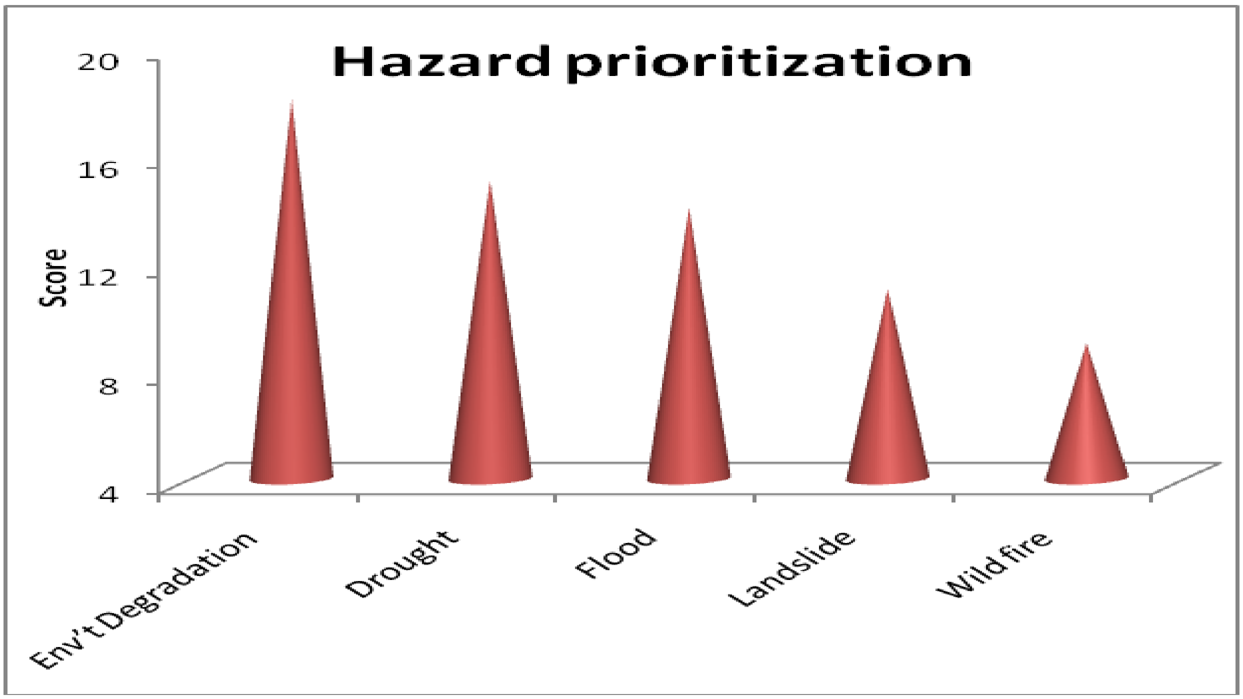

Figure 4. 2 *Hazard prioritization based on their total score*

4.2 Hazard characterization and assessment

Characterization of hazard is related to the periodicity and seasonality of the hazard. Seasonality is related to the climate. Assessing seasonality and periodicity of hazard is important for likelihood development.

Table 4. 3 Characterization and seasonality of the hazards

Type of the hazard	Periodicity of the hazards	Seasonality of the hazard	Major impacts of the hazard
Env't Degradation	Annual	Throughout the year	Drought, flood , global warming e.t.c
Drought	Recurring	March to August	Crop loss, livestock loss, human death and displacement e.t.c
Flood	Recurring	June to August	Sedimentation, Crop loss, livestock loss, and displacement e.t.c
Land slide	Recurring	May to August	Crop loss, loss of land, loss of infrastructure e.t.c
Wild fire	Annual	November to April	Deforestation (loss of biodiversity), crop loss & property loss

4.2.1 Hazard area map

Mapping hazards is important to know their exact location and for strategy as well as planning development. As shown in the figure below most river and over flow of Lake flood are occurred around Lake Tana and Finch lakes. Flash floods are also occurred in Beshilo, Weleka and southern tips of Dabus and Dedissa sub basin. Droughts are also appeared in Southern and Eastern parts of the basin. Land slide are occurred in Jemma, North Gojjam, Dedissa near Gimbi, Nedjo near Dabus sub basin. Wild fires are more prominent in Beles, Wombera, some parts of Dedissa and Dabu sub basins. Environmental degradation is most common in most of the basin parts.

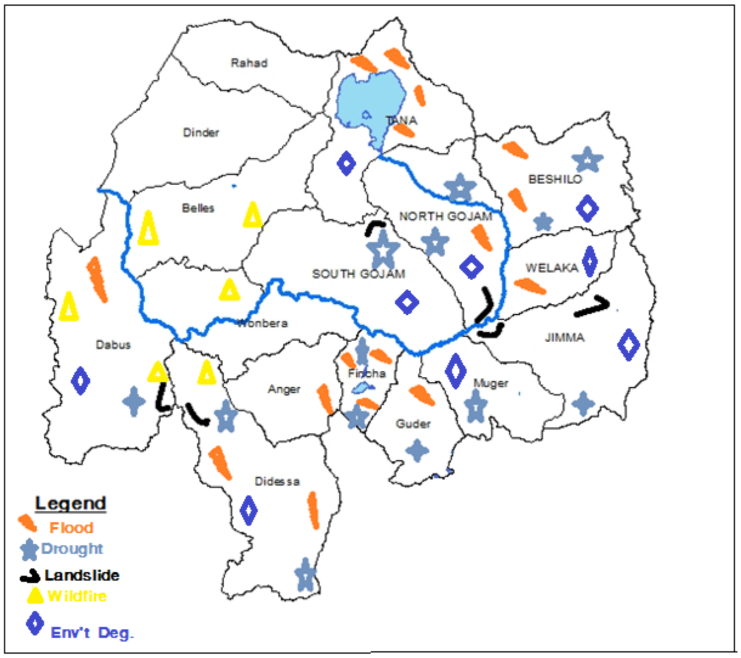

Figure 4. 3 Hazard area map in the basin

4.2.2 Causes of hazards

Soil erosion, climate change and deforestation are mostly taken as a cause of hazards. The primary or root causes of each hazard as well as secondary causes are summarizes in the table below. The details of the causes for each hazard and their impact in the basin with problem tree are attached to the appendix.

Table 4. 4 Root and immediate causes of hazards in the basin

Type of the hazard	Root cause	Immediate cause
Environmental degradation	Deforestation, soil erosion, chemicals	Land degradation, pollution
Drought	Climate change, deforestation and gas emissions	Shortage of rainfall, LaNina, ElNino
Flood	Climate change, less vegetation cover and squeeze of channels	High runoff, high rainfall and river outflow or backflow
Land slide	High rainfall, environmental degradation, mining and Geo seismic process	Slope instability, deforestation
Wild fire	Population pressure and lack of awareness	Agricultural lad expansion, traditional rangeland management and firewood and charcoal production

4.3 Vulnerability assessment

The degrees of vulnerability in each hazard are discussed below.

4.3.1 Environmental degradation

Most of the basin areas are vulnerable to environmental degradation. Deforestation or loss of flora and fauna, land degradation, increased temperature is the major risks associated with environmental degradation. The reasons for vulnerability of this hazard are expansion of farm land, lack of alternative energy, land use policy and strategy gap. The level of vulnerability on biodiversity as a result of deforestation is high and soil as a result of land degradation is also high. The detail of elements of risks and their vulnerability level are summarized in the table below.

Table 4. 5 Vulnerability assessment on environmental degradation

Who are vulnerable	**What is the risk**	**Why Vulnerable**	**Level of Vulnerability**		
			High	**Medium**	**Low**
Biodiversity	Deforestation, Loss of flora & fauna	Expansion of farm land, lack of alternative energy technology	√		
Soil	Land degradation	Land use policy and strategy gap, lack of land use study, Population pressure	√		
Crop	Loss of crop	Loss of fertility (poor Farming system directly dependent on natural environment)		√	

4.3.2 Drought

Major vulnerable resources due to drought effects are crops, livestock, water resource, income, human, etc and the risks encountered are damage, less productivity, loss of pasture, decrease quantity of water, poverty, displacement and death. Moisture stress, variability of rain fall, less drought resistant varieties, lack of adaptation is the main reason why those resources are highly vulnerable.

Table 4. 6 Vulnerability assessment on drought

Who are vulnerable	What is the risk	Why vulnerable	Level of vulnerability		
			High	Medium	Low
Crops	Damage, less productivity	Loss of water (lack of moisture)	√		
Livestock	Loss of pasture	Scarcity of rainfall	√		
Water resource	Quantity	Scarcity of rainfall		√	
Human	Death/displacement less to educ. health	Adaptation		√	

4.3.3 Flood

The vulnerability assessment of flood enables to clearly identify the vulnerable group, the risk, level and the reason of vulnerability. Among vulnerable community is the primary which risked and, crops in the field, animals and organization infrastructures used by the community affected by the hazard. This analysis helps to identify the intervention area during the planning to manage the disaster and risk.

Table 4. 7 Vulnerability assessment on flood

Who are vulnerable	**What is the risk**	**Why vulnerable**	**Level of vulnerability**		
			High	**Medium**	**Low**
Community	Loss of life, damage and disease	Un protected high land			√
	Loss of Asset	Lack of preparedness ,weak early warning		√	
	Displacement	Inappropriate settlement	√		
Organization	Damage	Inappropriate location		√	
Infrastructure	Damage	Design problem			√
Crop	Crop loss	Absence of crop calendar	√		
Animal	Death and damage	Lack of preparedness ,weak early warning			√

4.3.4 Landslide

Vulnerability to landslides depends on location, frequency of landslide events and type of human activity in the area, but there are also other factors that influence the size and frequency of landslide. Land, infrastructures and houses/buildings are the identified elements vulnerable to landslide in the Abbay basin. The main reasons for vulnerability are absence of geo-seismic and absence of land capability studies, absence of slop stabilization, groundwater investigation gap, inappropriate design and absence of detail study, inappropriate settlement(building on hilly areas or on slopes), absence of detail study (not using proper building codes) and its magnitude are summarized in the table below.

Table 4. 8 Vulnerability assessment on land slide

Who are vulnerable	**What is the risk**	**Why Vulnerable**	**Level of Vulnerability**		
			High	**Medium**	**Low**
Land	Loss of crop land and grass land, change surface landscape	Absence of geo-seismic and Absence of land capability studies, Absence of slop stabilization, Groundwater investigation gap	√		
Infrastructure	Damage	Inappropriate Design and absence of detail study		√	
House	Home damage Displacement	Inappropriate settlement(Building on hilly areas or on slopes), absence of detail study (Not using proper building codes)		√	

4.3.5 Wild fire

Wild fire hazard affects biodiversity of the water shed, climate of the region and crops& houses in the lower basins of the low lands. Loss of wildlife, deforestation, climate change, crop loss and property damage are the major risks observed by wild fire.

Miss use of the natural habitat is the major reason for the loss of biodiversity. High concentration of co_2 in the local atmosphere due to smokes from forest fire makes the area vulnerable to climate change. Lack of early warning, expansion of agriculture & settlement closed to the forest area are reasons increase vulnerability of crop loss and house damage.

Table 4. 9 Vulnerability assessment of wild fire

Who are vulnerable	What is the risk	Why Vulnerable	Level of Vulnerability		
			High	Medium	Low
Biodiversity	Deforestation ,loss of wild life	Miss- use of natural habitat	√		
Climate	Climate change	High concentration of Co2 in local atmosphere		√	
Crop	Crop loss	-Early warning problem - expansion of crop land closed to the privies forest and grass land by investors' & illegal settlers -Low preparedness	√		
Houses	Property damage	-Early warning problem -Low preparedness -flammability of the material			√

4.4 Existing Capacity assessment

Capacities refers to individuals and collective strength and resources that can be enhanced, mobilized and accessed to allow individuals and communities to shape their future by reducing disaster risk or adapting to climate changes . Capacity may include physical, social, institutional or economic means as well as skilled personal or collective attributes such as leadership and management. The existing capacity in each hazard is discussed below.

4.4.1 Environmental degradation

Concentrating on the deeper, underlying causes of environmental degradation will allow the goals and targets set out in international, regional and national agreements to be met in a more effective way.

Capacities are needed to decrease the vulnerability of hazards. If we increase the capacity for each hazard we can decrease the vulnerability of hazards. At the local level, reducing environmental degradation and ecosystem decline requires acknowledgement of the links between unsustainable development and poverty. Communities are often driven to degrade their natural environment as short-term coping mechanism for dealing with immediate problems; for instance, surviving a failed harvest by selling fire wood. The list of capacities to decrease environmental degradation at the basin is shown in the table below.

Table 4. 10 Existing capacity assessment on environmental degradation

Capacity/Asset	Available capacities addressing the hazard	Available capacities addressing vulnerability
Human capital	Knowledge Information Trained man power	Watershed management Plantation (Reforestation) Renewable energy technology
Social capital	Social, Cultural , Religious & psychic values	Religious power, community bay law
Physical capital	Weirs, dams, ponds	Conservation structures Maintenance
Natural Capital	Land Water resource	Environmentally friend tree species
Political Capital	Policy Strategy Structure	Government initiatives Commitment

4.4.2 Drought

The existing capacity for drought resistances are:-

- ✓ Human capital such as Knowledge & experience of farmers (traditional irrigation skills, traditional farming), reserving food for drought season, information for agriculture and health services) are available capacities addressing the hazards. Training, re-settlement, and producing short season crops are the available capacities for addressing vulnerability.
- ✓ Social capital such as cultural and religious values (borrowing, pray, gift,) are the available capacities addressing the hazards and local association and community organization are the capacities which are addressing the vulnerability.
- ✓ Physical capital such as infrastructures (accesses road, water points, market), and institution (health post, schools, FTCs) are capacities addressing hazarded and Water harvesting structures, deep wells, distribution of grain crops, animal feed, weirs and barrage and canal are capacities addressing vulnerability.
- ✓ Natural capital such as Water Resources and irrigable land are capacities addressing hazards.
- ✓ Political capitals such as policy, strategy, governmental and nongovernmental structures are capacities addressing hazarded and governmental initiatives and commitments are those capacities addressing vulnerability.
- ✓

Table 4. 11 Existing capacities for drought

Capacity/Asset	Available capacities addressing the hazard	Available capacities addressing vulnerability
Human capital	Knowledge of farmers (Traditional irrigation skill, Traditional agricultural production) Experience Reserving food crops for drought season Information Agricultural &Health services	A training on diversified income Adaptation Re- settlement Early maturing crops
Social capital	Social, Cultural & Religious values	Local Associations, Community organizations Borrowing
Physical capital	Infrastructures(access roads, water points) Institutions(health posts, schools, FTCs)	Water harvesting structures Deep wells Distribution of grain crops Animal feed Weirs and barrage, Canal
Natural Capital	Water Resource Irrigable Land	
Political Capital	Policy Strategy Structure Governmental and NGOs	Government initiatives Commitment

4.4.3 Flood

A combination of all the strengths and resources available within a community, society or organization that can reduce the level of flood risk or the effects of a disaster due to flood include physical, institutional, social or economic means as well as skilled personal or collective attributes such as leadership and management.

Table 4. 12 Existing capacities for flood

Capacity may also be described as capability. At the time of flooding crop, livestock, children and old people are under risk. The major capital to cope the disaster as well as

Capacity/Assets	Available Capacity to addressing the hazards	Availability capacities addressing vulnerability
Human	-Construction of tower -Organization of early warning committee -Community participation -Flood early warning system developed by TBIWRDP(weather radar, HIS/BIS)	-Temporary shade construction by TBIWRDP -Shifting to upland neighboring area -Using crop calendar -Information
Social capital	Organized in groups and CBOs	Settled in group
Physical capital		Construction of diversion structure, and dicks
Natural capital	Construct cutoff drain	Water treatment, temporary water supply
Political capital	Organization of DPPO,NGOs, Government structures at grass root	Organizing emergency response committee at all level of administration.

hazard in Abbay basin is listed in the table. This enables to identify the gap between the existing capacity and the level of capacity the need to develop flood hazard resilience community.

4.4.4 Landslide

Elements at risk are all of the elements that are affected by the occurrence of landslide. The consequences of a landslide and subsequently the risk depend on the type of elements that are present in an area. So, capacity assessment is important to address the hazard and vulnerability of different risks. The table below shows the available capacity to address the hazard and vulnerability in the basin.

Table 4. 13 Existing capacity assessment on land slide

Capacity/Assets	Available Capacity to addressing the hazards	Availability capacities addressing vulnerability
Human	Information, experience of routine farm visit	Reserving crop yield and seeds, Supporting the needy.
Social capital	Organized in groups and CBOs	Settled in group when displaced
Physical capital	Geological study, knowledge of structural design, Building codes	Maintenance, reconstruction and relocation
Financial Capital		Emergency response (food, cloth, tent, medicine, etc...)
Natural capital	Make free from production, settlement and others	Area closure (closed from any contact and intervention)

4.4.5 Wild fire

Existing capacity assessment for wildfire is viewed in five assets/capacities/ as human, social physical, natural and political capitals. Knowledge, information and man power are among the human capitals that can address wild fire. Prescribed fire and mechanical treatments are human capitals that address the vulnerabilities from wild fire. Socio cultural & religious values and bye-laws are social capitals; bare lands & non-flammability of objects are natural capitals that can address wild fire not to occur. Peoples cooperation's & local associations are among the social capacities, fire preventive instruments are physical capitals ,water bodies and gorges are natural capitals & government initiatives are political capacities that can address the vulnerabilities of wild fire.

Table 4. 14 Existing capacity for wild fire

Capacity/Asset	Available capacities addressing the hazard	Available capacities addressing vulnerability
Human capital	Knowledge of farmers Information Man power	Prescribed fire Mechanical treatments, such as mulching
Social capital	Social, Cultural & Religious values, bye-law's	Social cooperation's, local association
Physical capital		Fire preventive instruments
Natural Capital	bare lands and none- flammable objects,	Natural barriers (rivers, gorges
Political Capital		-Government initiatives -Fire brigade Organizations

4.5 Risk analysis

The impacts of each hazard, the major reason of vulnerability, the required capacity for hazard are discussed below.

4.5.1 Environmental degradation

The degree of the environmental impact varies with the cause, the habitat, and the plants and animals that inhabit it. Environmental degradation is a result of socio-economical, technological and institutional activities. The major impacts and reasons for hazard and vulnerability are discussed below.

Table 4. 15 Risk analysis on environmental degradation

Major impacts	**Reasons for vulnerability**	**Available capacities addressing the hazard**	**Available capacities addressing vulnerability**	**Required capacity**	**Non negative impacts**
Crop loss	Loss soil fertility Land degradation Soil erosion	Soil and water conservation Integrated water resource management	Watershed management Plantation (Reforestation)	Land use policy	
Flood	Deforestation Loss of soil cover	Soil and water conservation	Land use policy, Reforestation	Conservation structures	
Soil loss	Soil erosion	Reforestation	Conservation structures	Commitment	
Global warming	Deforestation, urbanization	Policy, Alternative energy source, Commitment	Use alternative energy source	Land use policy	

4.5.2 Drought

Scarcity of water, crop loss, livestock loss, displacement, food shortage and others are major impacts of drought risks. The main reason why those risks are vulnerable, because of less water use efficiency, low use of technology, rain fed agriculture, lack of alternative income generating activities and lack of preparedness.

Policy, strategy, water resource potential, supplementary irrigation, early warning, technology, settlement are the available capacities to addressed drought hazard. And also knowledge, adaptation to drought, organizations concerned with DRM, early matured crops; settlement program, government &NGOs commitment and storage are capacity to address vulnerability. To achieve effective drought risk management, there are several limitations like information gap, shortage of capital and technology, and also lack of preparedness and commitment.

Table 4. 16 Risk analysis of drought

Major impacts	Reason for vulnerability	Available capacity to address hazard	Available capacity to address vulnerability	Required capacity	None negative impacts
Scarcity of water	Less water use efficiency, low use of technology	Policy ,water resources potential	Knowledge, adaptation , organization	Information gap, Capital, Technology	IWRM
Crop loss	Rain fed agriculture	Supplementary irrigation, Early warning	Early matured crops, organization	Preparedness, Commitment	
Livestock loss	Traditional husbandry	Early warning, Policy, technology	Knowledge, adaptation, organization	Preparedness, Commitment	
Displacement	Lack of alternative income generating activities	Early warning, Strategy , settlement area	Adaptation, Settlement program, commitment, organization	Preparedness	
Food shortage	Low produce	Early warning, policy, strategy	Storage, organization	Preparedness commitment	

4.5.3 Flood

This analysis helps to identify the major impacts and the reason of vulnerability and the required capacity to address the vulnerability. Among the major impacts loss of life, economic loss, soil erosion and sedimentation, displacement and water quality deterioration considered in the analysis. Identification of the required capacity is important to for those who want to intervene in the flood prone area of the basin.

Table 4. 17 Risk analysis of flood

Major impacts	**Reason for vulnerability**	**Available capacity to address hazard**	**Available capacity to address vulnerability**	**Required capacity**	**None negative impacts**
Loss of life	Magnitude of flood, Settlement	Displacement, Flood alarm	Preparedness, Resettlement	Early warning, Strong preparedness	
Economic loss	Settlement, land use, poor construction design	Manpower, Knowledge, early warning	Preparedness, organization,	Strong preparedness & commitment	Avoiding sense of dependency
Soil erosion & sedimentation	Deforestation, traditional agricultural practice, upper catchment degradation	Policy, knowledge, organization & research institutions	Watershed management, awareness creation, livelihood improvement	Technology and capital, Awareness, commitment	IWSM
Displacement	Settlement pattern Loss of house	Resettlement organization	River retaining walls Temporary tower Temporary camp	Preparedness Commitment	Participatory
Water quality deterioration	Inorganic chemical ,derbies	Policy Knowledge Man power	Water filter Organization Water point/supply/	Quality monitoring /gap/ Tech /waste disposal/	

4.5.4 Landslide

The impact of a landslide includes destruction of infrastructure, damage to land and loss of natural resources. Landslide triggers increase with high seismic activity and excessive rainfall, both of which weaken the slope stability. The rapid growth of population leading to increased urbanization, deforestation, and unplanned land-use contribute to enhancing the vulnerability. Based on this, land-use policies & regulations and technology are required capacities to address landslide hazard and vulnerability in the Abbay basin.

Table 4. 18 Landslide risk analysis

Major impacts	**Reason for vulnerability**	**Available capacity to address hazard**	**Available capacity to address vulnerability**	**Required capacity**	**None negative impacts**
Loss of land	Nature of the soil parent material, topography, Poor management and lack of awareness	Information	Education, Training	Land-use policies and regulations	Public education, Conservation structures, Forest cover
Property damage	No application of building codes, use of poor material quality	Geological study, knowledge of structural design, Building codes	Maintenance, reconstruction and relocation	Land-use policies and regulations, Technology	Conducting a soil analysis before constructing, Build retaining walls in areas that are prone to landslides
Destruction of infrastructure	Use of poor material quality, weak stability analysis, geological study and technology gap	Organizations	Maintenance, Reconstruction and Relocation	Land-use policies and regulations, Technology	Build retaining walls in areas that are prone to landslides, Conducting a soil analysis before constructing

4.5.5 Wild fire

Based on the problem tree analysis deforestation, crop damage and property damage are major impacts of wild fire. Dryness and the flammability of the biomass, high temperature, land use system, and settlement pattern are factors for vulnerability. Policy, strategy, preparedness, resettlement, displacement &fire preventing materials are the capacities required to address the impacts of wild fire.

Table 4. 19 Risk analysis on wild fire

Major impacts	**Reason for vulnerability**	**Available capacity to address hazard**	**Available capacity to address vulnerability**	**Required capacity**	**None negative impacts**
Deforestation	-Dryness & flammability -Weather condition(high T^o) -High wind speed	Knowledge, information, organization Early warning	-Prescribed fire, -Mass media	Policy, strategy preparedness	PFM
Crop damage	-Closure to fire land - Similarity of firing season and crop harvest -Weather condition/high T^o/ -High wind speed -Dryness &flammability	Knowledge, information, organization Early warning Early maturing crops /Awareness/	-Prescribed fire -Fencing by none flammable live fences	-Policy/land use policy -Preparedness	
Property damage	Settlement pattern is closure to fired area	Knowledge, information, Early warning	Community cooperation/coordinatio n/	Resettlement, displacement Fire preventing materials	

4.6 Risk matrix analysis with vram excel tool kit

By using community based DRR/CCA technique from the above analysis the most possible hazards in the Basin are identified, prioritized and assessed their vulnerabilities &capacities. In addition to DRR technique the most possible hazards are analyzed by using vram excel tool kit to analyze the severity of risks within the risk matrix. Based on the risk matrix analysis the hazards with the corresponding impacts are identified into five categories as (very high, high, moderate, low and very low). So, the result shows:-

- The impact of flood and wild fire on sedimentation and deforestation respectively is critical and its likely hood is almost certain.
- The impact of drought on crop loss is critical and its likelihood is very likely.

- The impact of drought on livestock loss, flood on water quality deterioration, drought on displacement, environmental degradation on soil & high temperature is important and its likelihood is almost certain.
- The impact of wild fire on wild life species, environmental degradation on drought is important and its likelihood is very likely
- The impact of wild fire on crop loss is important and its likelihood is very important.
- The impact of flood on property loss and drought on human death is moderate and its likelihood is almost certain.

Table 4. 20 Risk matrix table

Risk Matrix

IMPACT					
Critical				4 -	9 - 16 -
Important			17 -	18 - 19 -	5 - 10 - 14 - 20 - 21 -
Moderate		6 -	1 -		11 - 13 -
Minor	7 -			2 - 12 -	
Negligible			3 - 8 -		
	Very unlikely	Unlikely	Likely	Very likely	Almost certain

Likelihood

Key to the risk matrix

5. Very high

04 - drought => crop loss

05 - drought => Livestock loss

9 - floods => Sedimentation

10 - floods => Water quality deterioration

14 - drought => Displacement

16 - Wild fire => Deforestation

20 - Environmental degradation => soil erosion

21 - Environmental degradation => high temperature

4. High

11 - floods => Property loss

13 - drought => human death

17 - wild fire => crop loss

18 - wild fire => wild life species

19 - Environmental degradation => Drought

3. Moderate

01 - landslide => Loss of land

02 - floods => crop loss

12 - floods => Loss of infrastructure

2. Low

06 - landslide => Destruction of infrastructure

1. Very low

03 - floods => Livestock loss

7 - landslide => Property damage

8 - floods => loss of life

4.7 Strategy assessment

Strategy development and assessment helps to decide possible ways of accomplishing disaster risk reduction and adaptation measures. Strategies are selected based on relevance to the purpose, capacity of the community and stakeholder implement it and the opportunities and threats in the strategy.

Table 4. 21 Strategy for the identified hazard and their score

Hazard type	Identified Risk Reduction and Adaptation Measures	Strategies/ways to achieve measures	Selection Score			No negative impact
			Urgent (High, Medium, Low)	Important (High, Medium and Low)	Feasibility (note where external resources needed)	
Environmental Degradation	Integrated watershed management	-Physical and biological conservation	High	High	Capital, technology	
		-Livelihood improvement	Medium	Medium		
		-Capacity building	High	High		
Drought	Irrigation	-Water harvesting	High	High	Technology, capital	
		-Dry land farming	Medium	High		
		-Application of efficient technology	Medium	Medium		
Flood	Integrated watershed management	-Physical and biological conservation	High	High		
		-Construction of dikes under flood plain areas	High	Medium		
		-Retaining wall	Medium	Medium		
		-Diversion	High	Medium		
Landslide	Integrated Watershed management	-Land use planning	High	High		Avoiding construction on steep slopes
		-Area closure	Medium	Medium		
		- Physical and biological gully treatment	High	High		
		-Water diversion structures	Medium	Medium		
		-Slope stabilization	Medium	Medium		
		-Awareness creation	High	High		
Wild fire	PFM (Participatory Forest Management)	-Integrated forest management	High	High		
		-Livelihood improvement	Medium	Medium		
	Land use planning	-Rangeland management	High	High		
		-Land capacity classification	Medium	High		

Chapter Five

5. Conclusion and Recommendation

5.1 Conclusion

Abbay basin authority is preparing basin plan in order to provide long-term framework for proper water resources management in the basin. Based on this risk assessment is carried out as one component of the basin plan. During the risk assessment five hazards (Environmental degradation, Drought, Flood, Wildfire and landslide) are identified as a major hazards in the basin and analyzed by using community based DRR/CCA method and vram tool kit. These hazards are prioritized based on the result obtained from vram tool kit output on the risk matrix. Vulnerability and existing capacity assessment also analyzed by identifying root causes and major impacts (primary and secondary impacts) for each hazards.

Flood, wildfire, drought and environmental degradation are the hazards that brought sever impacts on sedimentation, biodiversity loss (deforestation), crop and livestock loss, displacement, soil erosion and high temperature.

5.2 Recommendations

- ✓ Disaster risk reduction activities should be designed in line with climate change adaptation strategies. The early warning system should be comprehensive to include existing and new types of disaster with improved coordination and dissemination. Integrated and holistic disaster risk reduction requires a well designed early warning system and a practical action to prevent disaster from happening or reduce effectively the impact during and after the occurrence.
- ✓ Climate change adaptation and mitigation should be integrated in to the country's development agenda, across all sectors and all levels of government.
- ✓ Area mapping and trend analysis of all hazards in the basin is very important for proper risk reduction measurement and management. In this assessment both area mapping and trend analysis are not included due to the absence of GPS reading and statistical data (data not available in documents reviewed) respectively. Therefore, area mapping and trend analysis should be carried out by collecting primary data.
- ✓ Increasing information, education and raising awareness and developing alternative and complimentary livelihood activities. In order to ease the impact of population pressure and unsustainable resource uses, education and awareness creation campaigns concerning family planning.
- ✓ Data used for the analysis of hazards 64 woreda considered, all woreda data that are found in the basin should be included for a better result.
- ✓ Protect vital livestock, range and environmental resources in order to enhance local adaptive capacity and resilience, it is also necessary to diversify livelihood options that help to produce exposure to climate shocks.
- ✓ Encourage environment friendly and climate proof investments in water management for livestock and agriculture, develop new production system such as conservation farming based on organic crops, promote drought and heat tolerant crops, and improve social safety nets and crop insurance to smallholder farmers, especially in the drier area of the basin.

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Annex A Identified hazard areas with location around Debre-Markos area

S.No	East Long.	North Lat.	Lithology	Type of hazard	Remark
1	423104	1192689	Basalt	Rock fall	
2	403027	1200681	Silty clay soil	Erosion	
3	407091	1196824	Robe gebeya basalt	Rotational/rock fall	
4	392433	1212102	Basalt	Rock fall	
5	361569	1156112	Red residual soil	Erosion	
6	413800	1203200	Basalt	Land slide	
7	343461	1156657	Clay soil	Erosion	
8	447454	1180930	Limestone	Rock fall	
9	472813	1167202	Dark ,aphanatic basalt	Rock fall	
10	393659	1130891	Basalt	Toppling	
11	488298	1186244	Vesicular basalt	Rock fall	
12	387109	1214070	Aphanatic basalt	Rock fall	
13	431286	1153429	Basaltic unit	Rock fall	
14	461369	1180881	Basalt	Rock fall	
15	413288	1203074	Aphanatic Basalt	Rock fall	
16	403301	1200349	Basalt	Erosion	
17	416274	1203424	An aphanatic Basalt	Rock fall	
18	443650	1179664	Basaltic unit	Rock fall	
19	440374	1185988	Basalt	Rock fall	
20	342691	1152349	Fine grained Basalt	Toppling	
21	408202	1173184	Basaltic rock	Erosion	
22	425076	1154699	Basaltic unit	Rock fall	
23	388543	1212989	Aphanatic Basalt	Toppling	
24	340555	1183066	Basaltic unit	Rock fall	
25	371342	1174179	Light gray Rhyolite	Rock fall	

Annex B *Landslide affected woreda around Dessie area* with locations

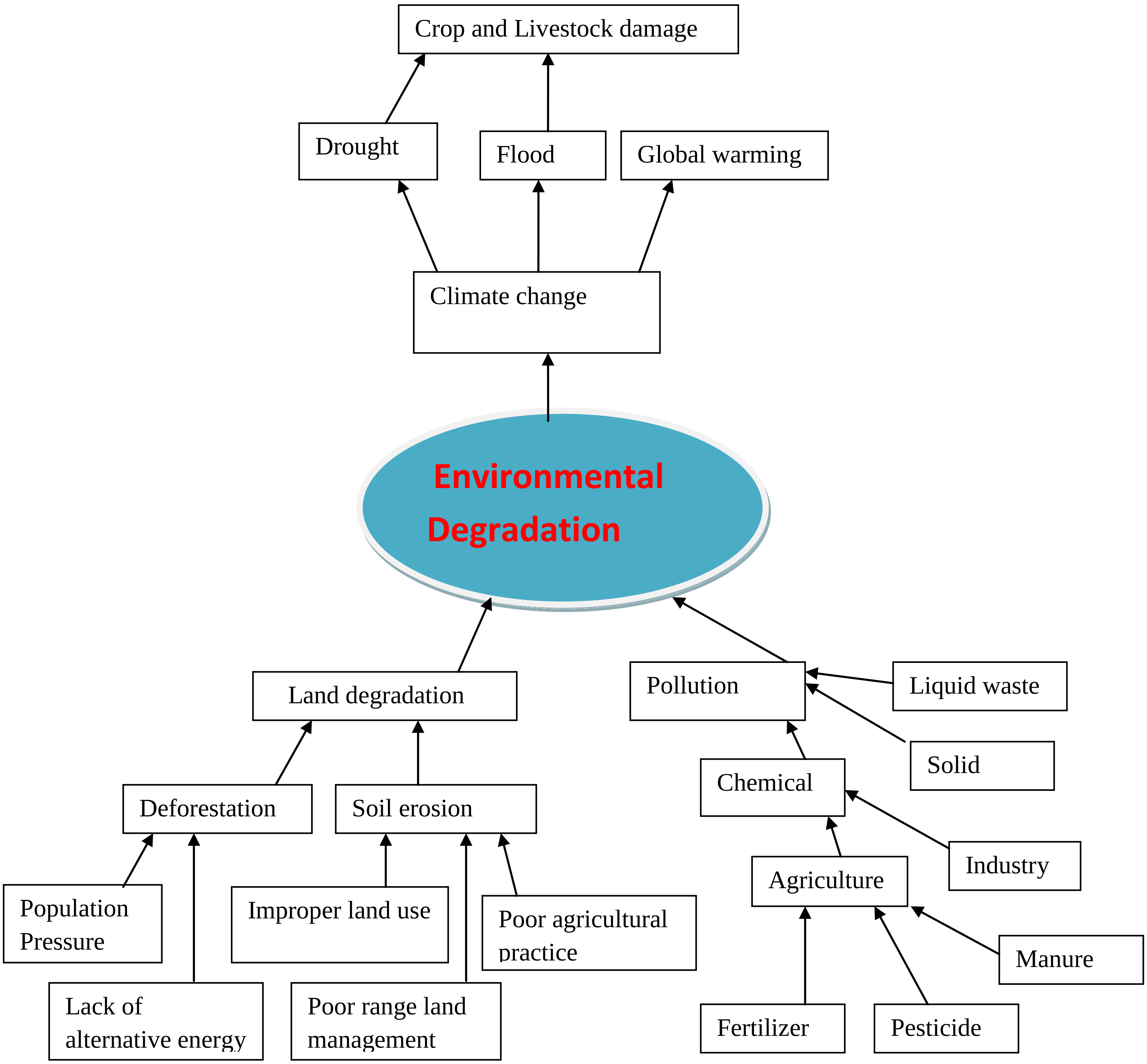
S.No	**Woreda**	**Easting**	**Northing**	**Elevation**	**Volume**	**Formation /Geology**	**Stage**	**Slope Gradient(^{0})**
1	Ambassel	568031	1258722	1998	Very large	Basalt_Ashangi	Active	20
2	Ambasse	566122	1272887	1931	Very large	Basalt_Ashangi	Active	25
3	Kutaber	556576	1246368	2410	Medium to large	Colluival deposit	Active	73
4	Tenta	518768	1255480	2668	Very large	Colluival deposit	Semi active	25
5	Delanta	526201	1279261	2409	Very large	Basalt_Ashangi	Very active	30

Annex C Woreda hazard Priority profile assessment

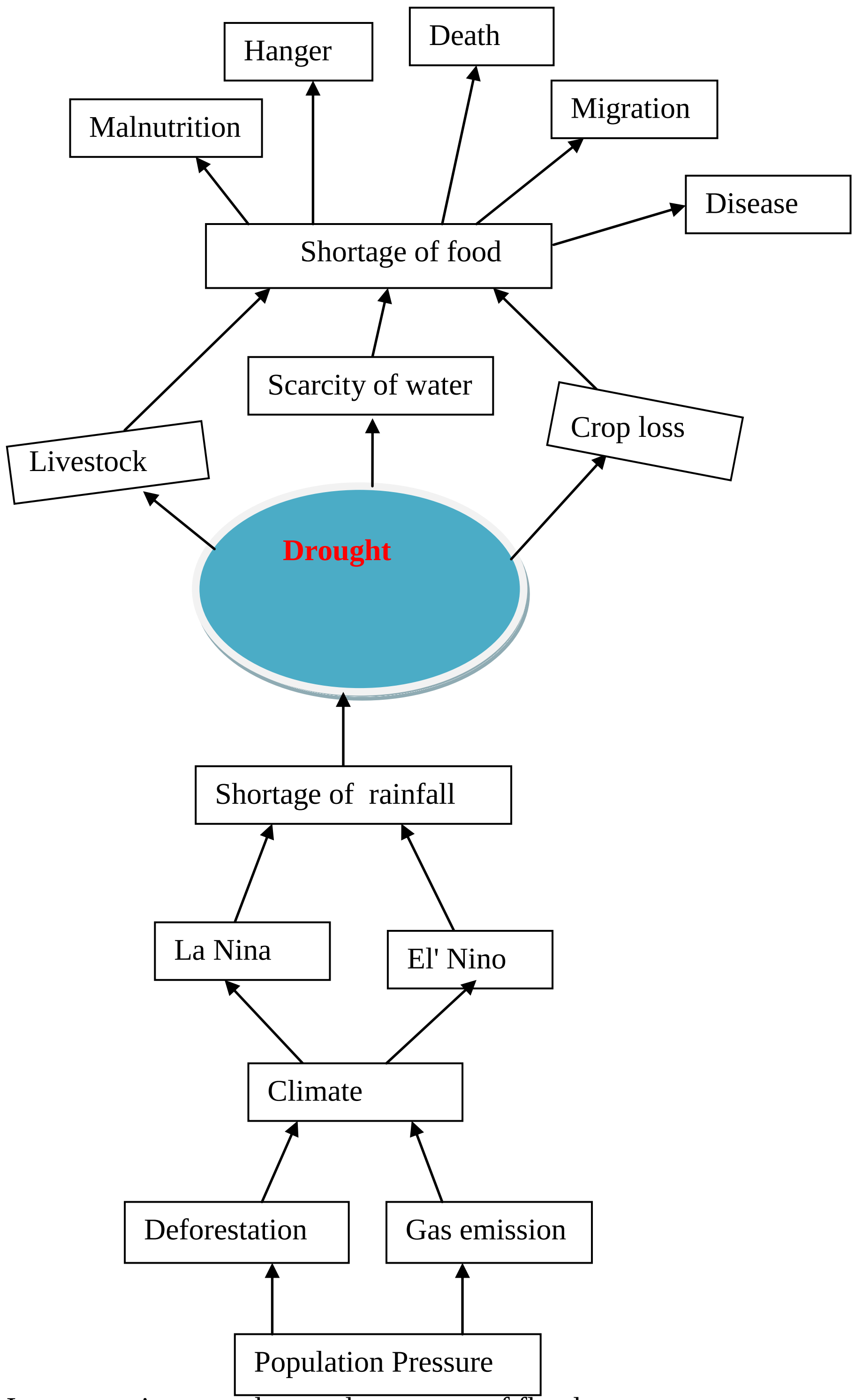
S.no	Woreda name	Hazard 1	Hazard 2	Hazard 3	Hazard 4	Hazard 5	Remark
1	Abbay chomen	Environmental degradation	Drought	Flood	Wild fire	Landslide	
2	Adda berga	Environmental degradation	Drought	Flood	Landslide	Wildfire	
3	Albuko	Drought	Flood	Environmental degradation	Landslide	Conflict	
4	Ambasel	Environmental degradation	Drought	Flood	Wild fire		
5	Bambasi	Willd fire	Environmental degradation	Flood	Drought	Confl ict	
6	Belogigonfoy	Environmental degradation	Drought	Flood	Landslide	Conflict	
7	Bullen	Drought	Flood	Environmental degradation	Landslide	Confl ict	
8	Dale sedi	Flood	Conflict	Wild fire	Environmental degradation		
9	Dawa Cheffa	Flood	Environmental degradation	Drought	Wild fire	Landslide	
10	Daga Damot	Environmental degradation	Drought	Flood	Landslide		
11	Delanta	Environmental degradation	Drought	Flood	Conflict	Landslide	
12	Dembia	Flood	Environmental degradation	Drought	Landslide	Conflict	
13	Dera	Environmental degradation	Drought	Flood	Landslide	Wild fire	
14	Dessie zuria	Environmental degradation	Drought	Flood	Landslide	Conflict	
15	Dibate	Environmental degradation	Conflict	Drought	Wild fire	Flood	
16	Diga	Environmental degradation	Drought	Flood	Landslide	Conflict	
17	Ejerie	Environmental degradation	Drought	Flood	Landslide	Wild fire	
18	Enemay	Environmental degradation	Drought	Flood	Landslide	Conflict	
19	Fagita lakoma	Drought	Flood	Landslide	Environment al degradation	Conflict	
20	Farta	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
21	Goncha siso	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
22	Gondar zuria	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
23	Guba	Drought	Wild fire	Environmental degradation	Landsl ide		
24	Guto gida	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
25	Hulet ej enesie	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
26	Jardga Jarte	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
27	Jarso	Environmental degradation	Drought	Flood	Confli ct		
28	Jeldu	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
29	Jemma	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
30	Jida	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
31	Kersa	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
32	Kimbi bit	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
33	Kurmu k	Drought	Environm ental degradatio n	Flood	Landsl ide	Confl ict	
34	Kutabe r	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	
35	Lalo kile	Environmental degradation	Drought	Conflict	Flood	Land slide	
36	Legam bo	Environmental degradation	Drought	Flood	Landsl ide		
37	Legehi da	Environmental degradation	Drought	Flood	Landsl ide	Confl ict	

S.no	Woreda name	Hazard 1	Hazard 2	Hazard 3	Hazard 4	Hazard 5	Remark
38	Leqa Dulecha	Environmental degradation	Drought	Landslide	Conflict		
39	Mana	Environmental degradation	Drought	Flood	Landslide		
40	Mandura	Environmental degradation	Drought	Landslide	Conflict	Wildfire	
41	Mekidela	Environmental degradation	Drought	Flood	Landslide	Conflict	
42	Meket	Environmental degradation	Drought	Flood	Landslide		
43	Menge	Drought	Wildfire	Environmental degradation	Flood	Landslide	
44	Mirab Estie	Environmental degradation	Drought	Flood	Landslide	Conflict	
45	Misrak Estie	Environmental degradation	Drought	Flood	Landslide	Conflict	
46	Nedjo	Environmental degradation	Drought	Flood	Landslide	Conflict	
47	Pawi special	Environmental degradation	Conflict	Drought	Flood	Landslide	
48	Quarit	Environmental degradation	Drought	Flood	Landslide	Conflict	
49	Seka Chekorsa	Environmental degradation	Drought	Flood	Conflict		
50	Sekela	Environmental degradation	Drought	Flood	Landslide	Wildfire	
51	Seyo	Environmental degradation	Drought	Flood	Landslide	Conflict	
52	Sherkole	Environmental degradation	Drought	Flood	Landslide	Conflict	
53	Simada	Environmental degradation	Drought	Flood	Landslide	Conflict	
54	Tehuledere	Environmental degradation	Drought	Flood	Landslide	Conflict	
55	Tenta	Environmental degradation	Drought	Flood	Landslide	Conflict	
56	Toke Kutaye	Environmental degradation	Drought	Flood	Landslide	Conflict	
57	Wayu Tuka	Environmental degradation	Drought	Flood	Landslide	Conflict	
58	Wegera	Environmental degradation	Drought	Flood	Landslide	Conflict	
59	Wegidi	Environmental degradation	Drought	Flood	Landslide	Conflict	
60	Wembera	Environmental degradation	Drought	Flood	Landslide	Conflict	
61	Were Jarso	Environmental degradation	Drought	Flood	Landslide	Conflict	
62	Werebabu	Environmental degradation	Drought	Flood	Landslide	Conflict	
63	Wuchale	Drought	Landslide	Environmental degradation	Flood	Conflict	
64	Yubdo	Environmental degradation	Flood	Landslide	Conflict	Drought	

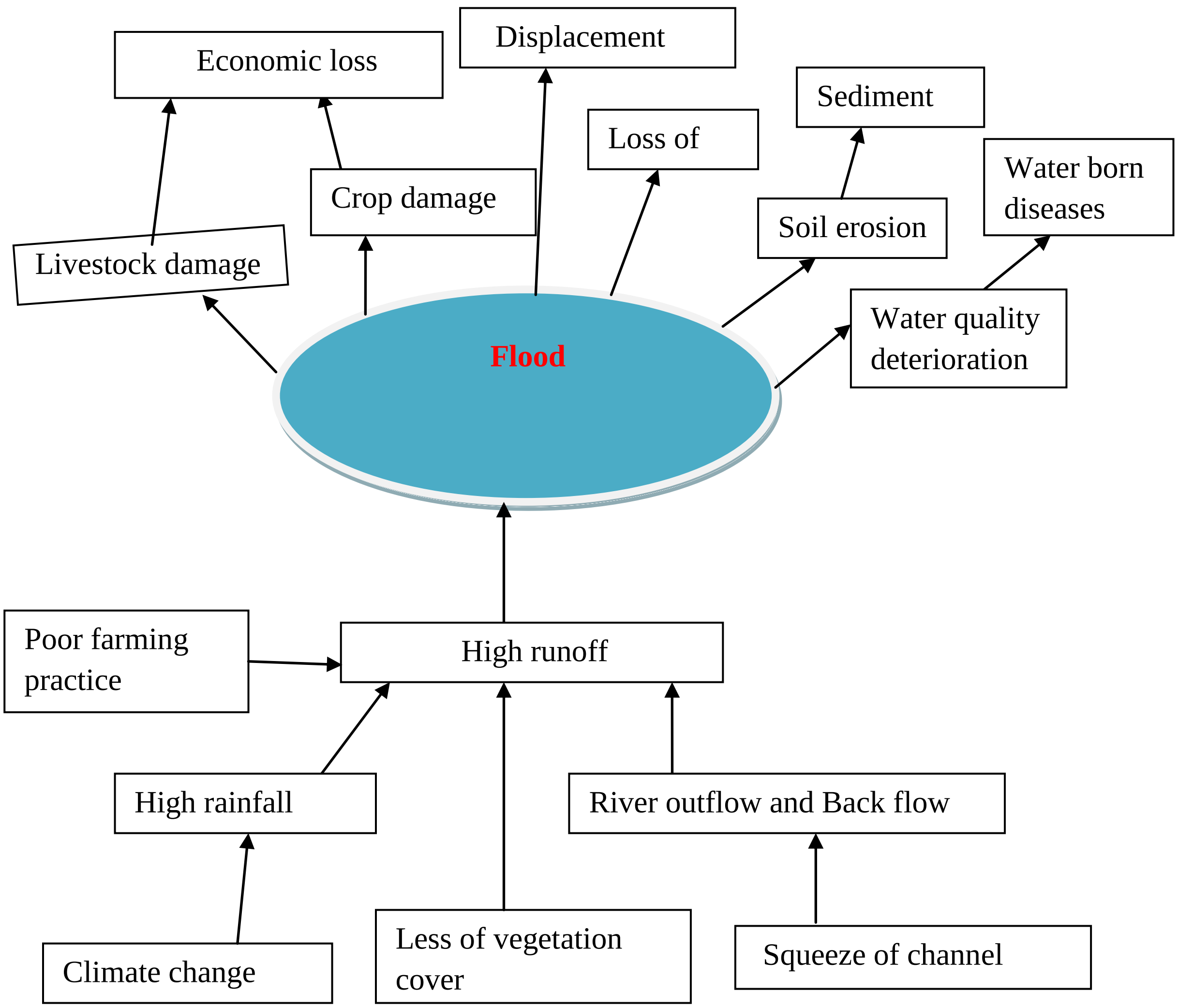
Annex D Impacts, primary and secondary causes of environmental degradation



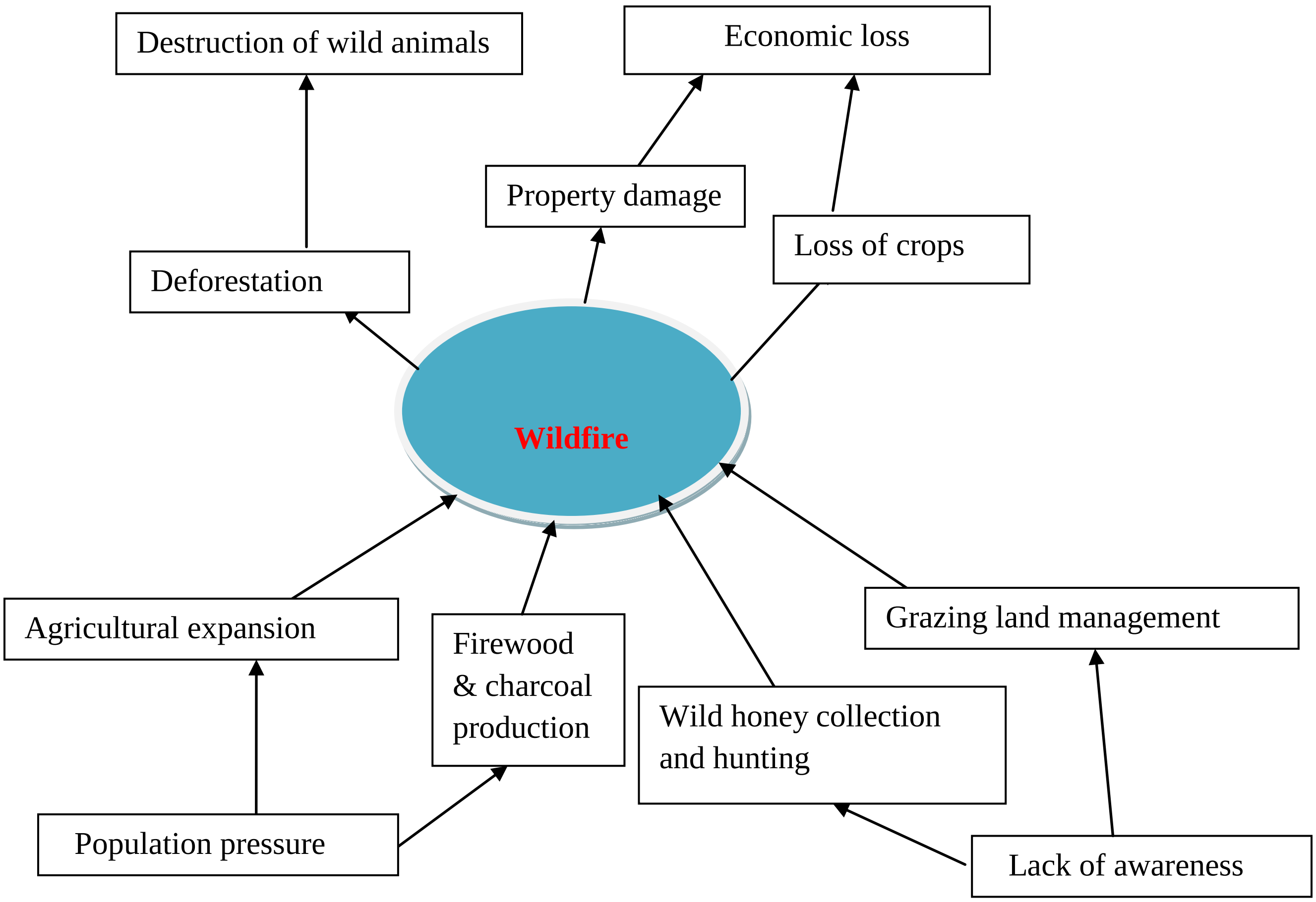
Annex E Impacts, primary and secondary causes of Drought



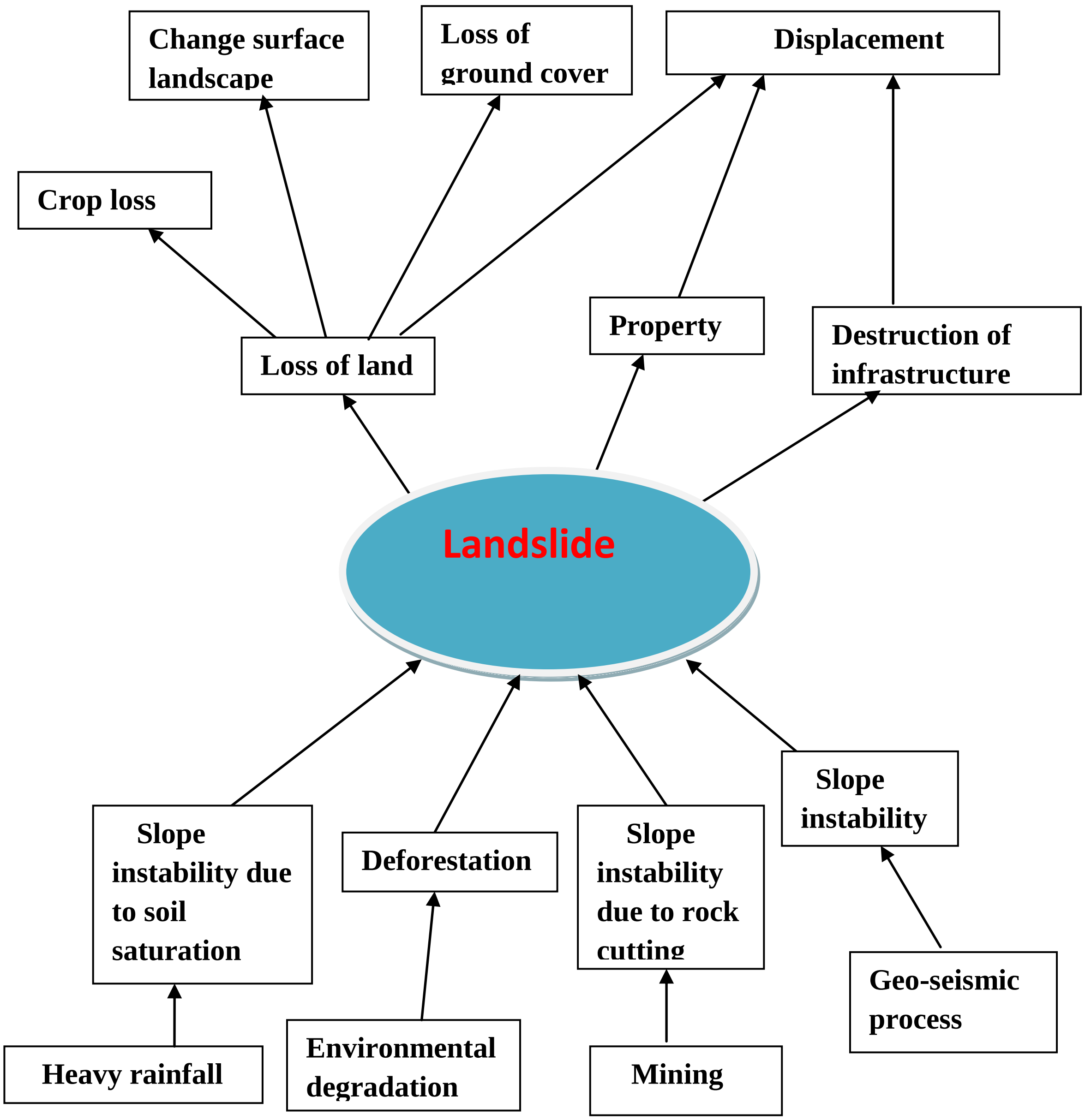
Annex F Impacts, primary and secondary causes of flood


Economic loss
Displacement
Loss of
Sediment
Water born diseases
Crop damage
Soil erosion
Livestock damage
Water quality deterioration
Flood
Poor farming practice
High runoff
High rainfall
River outflow and Back flow
Climate change
Less of vegetation cover
Squeeze of channel

Annex G Impacts, primary and secondary causes of wildfire hazard



Annex H Impacts, primary and secondary causes of landslide hazard



Annex I Data used to analyze impact and risk level

Hazards	Seasonality	Periodicity	Risk	Likeli-hood	Severity	Potential scale of the event	Capacities			Impact	Risk Level
							Strengths	Weaknesses	Capacities level		
landslide		Recurring	Loss of land	3	Low severity	1000 hectare of land loss	Geological survey study	Implementation gap	weak	Moderate	3. Moderate
floods		Recurring	crop loss	4	Low severity	50000 hectare of crop loss	Adaptation & crop calendar, early warning	no commitment	partial	Minor	3. Moderate
floods		Recurring	Livestock loss	3	Very low severity	5000 loss	Preparedness & earlywarning, displacement	lack of awareness	partial	Negligible	1. Very low
drought		Recurring	crop loss	4	Very high severity	0.5 million hectare	Drought resistant crop & short period crops	Preparediness	weak	Critical	5. Very high
drought		Recurring	Livestock loss	5	High severity	250000 loss		weak preparediness	weak	Important	5. Very high
landslide		Recurring	Destruction of infrastructure	2	Low severity	300 hectare of roadway	????	Low technology & level of knowledge	Very weak	Moderate	2. Low
landslide		Recurring	Property damage	1	Very low severity	6000000 birr		no early warning	Very weak	Minor	1. Very low
floods		Recurring	loss of life	3	Very low severity	100 human life loss	Earlywarning, displacement		partial	Negligible	1. Very low
floods		Recurring	Sedimentation	5	High severity	302.8 million tonn per annum	Beginning of watershed management	policy gap	Very weak	Critical	5. Very high
floods		Recurring	Water quality deterioration	5	High severity	2000000 people affected	emergency response	improper use of agrochemicals	weak	Important	5. Very high
floods		Recurring	Property loss	5	Moderate severity	30000000 birr	prepardness & earlywarning	lack of commitment	partial	Moderate	4. High

Hazards	Seasonality												Periodicity	Risk	Likeli-hood	Severity	Potential scale of the event	Capacities			Impact	Risk Level
																		Strengths	Weaknesses	Capacities level		
floods													Recurring	Loss of infrastructure	4	Very low severity	50000 000 birr		poor design & site selection	Very weak	Minor	3. Moderate
drought													Recurring	human death	5	Low severity	200 peopl e	displacement	weak earlywarning & preparediness	weak	Moderate	4. High
drought													Recurring	Displacement	5	Moderate severity	300000 people		weak response	weak	Important	5. Very high
Wild fire													Annual	Deforestation	5	High severity	100000 hectare per annum		policy gap	Very weak	Critical	5. Very high
wild fire													Annual	crop loss	3	Moderate severity	2000 hectare			weak	Important	4. High
wild fire													Annual	wild life species	4	High severity	50 species			weak	Important	4. High
Environm entaldegra dation													Annual	Drought	4	Moderate severity	34000 km square	soil & water conservation Irrigation	weak integrated watershed management implementation	weak	Important	4. High
Environm entaldegra dation													Annual	soil erosion	5	High severity	302.8 million tonn	soil & water conservation	weak conservation practice	weak	Important	5. Very high
Environm ental degradatio n													Annual	high temperature	5	Moderate severity	0.5-1.6 degree centigrade	Expansion of hydro electric power, carbon trade		weak	Important	5. Very high

Annex J Values of likelihood, impact, risks minimum preparedness and operational response capacity

Risk	Value			Preparedness actions required		
	Likelihood	Impact	Risk	Minimum preparedness	Additional preparedness	Operational response capacity and risk mitigation measures
5. Very high						
Wild fire => Deforestation	5	5	25	1	1	1
floods => Sedimentation	5	5	25	1	1	1
drought => Livestock loss	5	4	20	1	1	1
drought => Displacement	5	4	20	1	1	1
Environmental degradation => soil erosion	5	4	20	1	1	1
Environmental degradation => high temperature	5	4	20	1	1	1
drought => crop loss	4	5	20	1	1	1
floods => Water quality deterioration	5	4	20	1	1	1
4. High						
wild fire => wild life species	4	4	16	1	1	1
Environmental degradation => Drought	4	4	16	1	1	1
floods => Property loss	5	3	15	1	1	1
drought => human death	5	3	15	1	1	1
wild fire => crop loss	3	4	12	1	1	1
3. Moderate						
landslide => Loss of land	3	3	9	1	1	0
floods => Loss of infrastructure	4	2	8	1	1	0
floods => crop loss	4	2	8	1	1	0
2. Low						
landslide => Destruction of infrastructure	2	3	6	1	0	0
1. Very low						
floods => Livestock loss	3	1	3	1	0	0
floods => loss of life	3	1	3	1	0	0
landslide => Property damage	1	2	2	1	0	0

Annex K Table showing what the color of impacts show

Severity **x** capacity				Impact	Impact Value
From	1	To	3	Negligible	1
From	4	To	6	Minor	2
From	7	To	11	Moderate	3
From	12	To	16	Important	4
From	17	To	25	Critical	5

Annex L Periodicity indicator definition

Annual	Event happening every year with regular or seasonal picks during the year				
Recurring	Punctual event which occurs every	1	to	2	years
Frequent	Punctual event which occurs every	3	to	5	years
Exceptional	Punctual event which occurs every	6	to	10	years
Random	unpredictable event that can take place at any time				

Annex M Table showing what the color of risk show

Risk = Likelihood **X** impact				Risk level	Minimum preparedness	Additional preparedness	Operational response capacity and risk mitigation measures
From	1	to	3	1. Very low			
From	4	to	6	2. Low			
From	7	to	11	3. Moderate			
From	12	to	16	4. High			
From	17	to	25	5. Very high			