Forum for Environment

ETHIOPIA
BETWEEN THE SHARP SCISSORS

Climate Change & Environmental Degradation

Report on the 2006 Flood Disaster in Ethiopia

Editor: Ensermu Kelbessa (PhD)
Principal Researcher: Daniel Kassahun (PhD)

December 2006, Addis Ababa, Ethiopia

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No.	Name	Organization	Responsibility
1	Negusu Aklilu	FfE	Chairperson
2	Ensermu Kelbessa (Dr.)	NH, AAU	Member
3	Wondwossen Sintayehu	EPA	Member
4	Daniel Kassahun (Dr.)	FSS	Principal Researcher
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9	Wondafrash Genet	AAU, Student	Researcher: Fogera Flood Plain
10	Mekonnen Adnew	AAU, Student	Researcher: Omo Basin
11	Yonas Tadesse	AAU, Student	Researcher: Dire Dawa
12	Tadesse Woldemariam (Dr.)	AAU, ECFF	Member
13	Biruk Asfaw	WGCF, Student	Researcher: Omo Basin
14	Feyera Senbeta (Dr.)	WGCF, ECFF	Member
15	Dawit Desta	FfE	Member

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4:00-5:00	The way forward: Policy and action recommendations	Participants

PREFACE

Dear Colleagues,

The heavy and sporadic 2006 flood disaster in Ethiopia is still fresh in our minds and the rainy season is at the door with some flood being reported in the past few weeks. How much more prepared we are to face the upcoming 'kiremt' is something beyond my information and knowledge box.

Various reasons were put forward last year for the flood disaster and one of the notable reasons was the severe environmental degradation, which was believed to have exacerbated the whole thing more than ever before. Such kinds of hypothesis were voiced by some prominent ecologists and institutions even before this study was conducted.

Forum for Environment, as an environmental advocacy group has taken this opportunity to test the hypothesis. The idea was that if the studies reveal any substantial relationship between the floods and environmental degradation, we would advocate for measures that go beyond rehabilitating the affected people to rehabilitating the environment and also promoting environmentally sound development initiatives.

To this end, we established a taskforce of scientists and researchers and decided to commission a study. Taking the time constraint at hand into account, the taskforce agreed to pick some graduate students from Addis Ababa University and Wondo Genet College of Forestry. The TOR was developed by FfE and endorsed by team members of the taskforce. Selection of sites was also proposed by the research team and endorsed by the taskforce.

The whole rapid assessment exercise took about six weeks and two mini-workshops took place thereafter with a selected audience of professionals to get useful comments and eventually enrich the document.

The final workshop took place on 13th December at the Hilton Hotel in the presence of H.E. Girma Woldeghiorgis, President of F.D.R.E., MPs from three standing committees and participants from a wide range of governmental and non-governmental organizations. We used this opportunity to further enrich the reports.

The bottom line is that the flood was largely triggered and exacerbated by the age-long environmental degradation, which got worse in the past few decades. Coupled with the negative impacts of climate change, the severe environmental degradation in the upper catchments of the study sites and poor environmental integration into development activities in some areas were key contributors. Well, the solution to the global climate change is not in our hands although we are located in one of the most vulnerable areas in the globe. Nevertheless, local environmental governance is still in our hands and it is high time that we should think about our unsustainable practices, seriously consider the environmental degradation, and of course, do something urgent about it.

"The opposite of love is not hate, it is indifference." Let do something about our deep-rooted indifference about our environmental resources, stop our usual green-washed hypocrisy and work for survival and, of course, development. Development without sustainable environment is only short-lived and greedy.

Negusu Aklilu,
Coordinator, FfE

OFFICIAL OPENING SPEECH BY ATO GIRMA WOLDEGIORGIS, PRESIDENT OF THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

On

THE WORKSHOP ON THE 2006 FLOOD DISASTER VIS-À-VIS ENVIRONMENTAL DEGRADATION IN ETHIOPIA

Ethiopia has been confronted with the most extreme flooding affecting almost all the administrative regions claiming hundreds of human lives and affecting about 600,000 people out of which 242,000 are displaced. The flood has also reportedly resulted in a considerable loss of vital livestock and farming land. Some establishments were also destroyed by the flood and there has been a fear for aggravation of vector-borne diseases such as diarrhoea and malaria.

Our government and various other stakeholders have been responding to sporadic flood disasters that have happened earlier than 2006 through taking some actions to counteract the impacts and prevent further disasters from happening. Such endeavors include, among others, the establishment of river training units and reafforestation activities in some localities.

Furthermore, there has been an immediate response by our government and many other national and international partners following the nation-wide flood disaster. One notable event was a telethon that was organized whereby more than ETB 100 million was generated to rehabilitate the victims of the flood.

FfE has been involved in conducting public meetings and dialogues on various environmental issues as they relate to the sustainable development of the country. As a country faced with heavily intertwined ecological challenges that are also negatively impacting on the process of sustainable development, such kinds of deliberations would create an avenue to come up with recommendations that would simultaneously contribute to sustainable development.

The study commissioned by FfE that will be launched this day could be instrumental in bringing about long-term solutions by pinpointing the root causes of the flood disaster and the factors that exacerbated it. I hope the outcome of this study will be very useful in this direction.

I, hereby, declare the workshop officially open and also wishing you fruitful deliberations.

SYNTHESIS OF RESEARCH FINDINGS ON THE 2006 FLOOD DISASTER IN ETHIOPIA VIS-À-VIS ENVIRONMENTAL ISSUES

1. BACKGROUND AND OBJECTIVES OF THE RESEARCH

In the aftermath of the nationwide flood hazard in August 2006, a Core Taskforce, drawn from academic and research institutions, was formed under the auspices of Forum for Environment. Based on recommendations from the Core Taskforce, FfE commissioned a rapid assessment of flooding in selected sample sites. The study created a platform for a fact-based dialogue among stakeholders, and generated recommendations for future sustainable management of natural resources alongside with floods in Ethiopia.

Eight graduate students from Addis Ababa and Hawassa Universities were engaged in the undertaking the rapid assessment of flooding. The overall research was overseen and supervised by the Core Taskforce and technical aspects by an environmental researcher.

The tragic 2006 floods have been naturally perceived by many as an outcome of higher rainfall. However, the flood generation potential of a given rainfall level could either be triggered or diminished by factors such as land cover condition, soil characteristics, river management, and topographic conditions. During the inception of the project, it was hypothesized that apart from rainfall, environmental conditions along with management practices have significantly contributed to the devastating impact of floods in 2006.

2. SURVEY METHODOLOGY

In 2006, most of the regions of Ethiopia were affected by floods. Four characteristic flood sites were identified, these including the *Awash* basin, *Dire Dawa* town, the *Fogera* plains, and the *Ghibe-Omo* basin. The sites were selected based on fair representation of the commonest factors of flooding, which, among others, include riverbank overflows, urban flashfloods, and lake backflows. Besides, an attempt was made to maintain fair geographical distribution of flooded areas in the country.

Within each survey area, three sample case study sites, composed of an impacted (lowland) area and two other upland sites of watersheds were purposively chosen.

Focused group discussions, key informant interviews, direct personal observations, and review of secondary sources of information were used. Dynamics of the local biophysical, demographic and socioeconomic attributes, which are directly and indirectly linked to floods, were captured from memories of elders. In addition, trend analysis of rainfall data (*for three decades*) was undertaken, using monthly data obtained from National Meteorological Services Agency (NMSA).

The Taskforce was mandated to decide on the study approach, the modus operandi with regard to data collection and analysis by the surveyors. After this was done, the surveyors were deployed. Upon the completion of the draft report, two mini workshops were organized to appraise the validity of the findings and examine the generated recommendations, with the support of invited scholars with expertise in the fields of natural resources, hydrology, and sociology.

However, this study is not without limitations. Due to the urgency of the issue, the time allocated for the survey was short. As a result, it was not possible to adequately capture the realities of larger catchments, such as the *Ghibe-Omo* basin. This study also had to rely on knowledge and perceptions of sample respondents on the biophysical changes rather than on solid quantified analyses of satellite imageries.

Data on rainfall intensity, as well as daily and decadal rainfall data were not obtainable from NMSA. This study, therefore, based its analysis exclusively on monthly rainfall data. Besides, the study was constrained by the problem of time lag in the acquiring of the meteorological and river flow data.

3. SUMMARY OF THE FINDINGS

Impacts of the 2006 flood

Unlike previous years, the 2006 *Kiremt* flooding was unique in many respects. The wave of floods hit not only traditionally flooded areas of the country, but also new areas where floods were hardly experienced before. More than 700 people lost their lives, more than 674,000 people affected, more than 242,000 people displaced, and property worth hundreds of millions of birr was washed away. In addition, quite a number of domestic and wild animals were drowned and thousands of hectares of farmlands were damaged. Apart from the tangible losses, the psychological impact on the survivors was incalculable.

In the Middle and Lower *Awash*, where 70% of Ethiopian large–scale irrigated agriculture is concentrated, the river overflow displaced over 15,000 people from Zone 3 of *Dulecha (Afar)*, devastated over 400 ha of cropfields, endangered the riverine trees, inundated 674 ha of land owned by farmers' irrigation association, and damaged property on cut flower company valued at over $6.8 million in Middle *Awash*.

In the business city of *Dire Dawa*, 256 people died and over 9,027 people were displaced. The flood also killed over 1,036 livestock, totally destroyed 398 houses, damaged 5,000 houses and destroyed over 230 ha of cultivated lands. The losses due to the flood in the *Dire Dawa* area are estimated to be worth over 50 million Birr.

In the *Fogera* plains, found in the neighborhood of *Lake Tana*, floods killed three persons, made 35,889 people homeless, inundated over 6,673 ha of cropland, destroyed more than 320 beehives, damaged a school and several water points, spoiled stored seeds, and deposited large volume of gravel and sand on farmlands.

The greatest tragedy occurred in *Dasenech wereda* of *South Omo* where floods reportedly killed 364 people, trapped 14 villages, displaced 18,000 people, and drowned over 3,000 cattle. About 1,300 people were airlifted out of their flooded homes. Moreover, the flood destroyed the settlements, stored grains, the limited infrastructures available and all crops. In addition, more than 3,000 livestock were drowned and the remaining suffered from shortage of pasture and clean water, and waterborne diseases. To some extent, the existing inter-group conflicts were intensified. The extreme remoteness of the flooded areas has aggravated the problem in the area.

Patterns of flood frequency

In *Dire Dawa*, flooding in the past used to happen at long intervals with limited casualties. These days, the interval has significantly shortened to a yearly basis. Prior to 1996, the *Fogera* plains were never flooded on a significant scale. Since then seven flood incidences were experienced. In *South Omo*, "normal" floods used to regularly happen in the past and this was considered a "blessing" for crop production, grass growth, and water by nomadic pastoralists. The floods used to happen in September and people used to evacuate the area in late August. In 2006, however, the floods peculiarly came in August before the evacuation period. In Awash, flooding has been a perennial problem. The higher silting up of *Koka* dam has contributed to recurrent release of water.

Causes of the 2006 floods

Several causes can be identified for the 2006 floods. Rainfall in the 2006 *Kiremt* season was not the highest of all time in all sample areas. Historical weather data (*for the last 30 years*) as well as accounts by elders confirm that there were several years in the past with higher rainfall levels than in 2006.

On the other hand, massive forest and soil degradation was observed in *Awash*, *Ghibe*, *Dengego* and *Fogera* catchments. Rapid depletion of forest resources due to population pressure, especially on steeper slopes, was responsible for most of the flood hazards.

Settlements and investments were staged up to the brim of river banks of the *Awash*, *Gumera* and *Rib* (*Fogera* plain), and tributaries of *Dechatu*. Narrowing of the floodplains due to the allocation of floodplain to investment and settlement was partly responsible for the enhanced velocity of water flow observed in *Dire Dawa* and the *Awash* areas. In *Dire Dawa*, even the old "flooding zone" delineated by the Italians during 1936 – 1941 was put to use as there was no expectation of such high risk. Backflow of lake water was observed in the *Fogera* plain (*Lake Tana*) and *South Omo* (Lake *Turkana*).

Appraisal of good practices

Apart from the environmental mismanagement, quite interesting good practices were observed in the study areas. The most notable one is the active engagement of high level government officials to closely monitor the operation in vulnerable dams. Compliance with EIA at Gilgel Ghibe 1 is exemplary. In Awash, a "River Training Unit", specializing in maintaining the river's carrying capacity through de-silting was set up as the first of its kind in the country. The operational committee set up in the *Koka* reservoir area is the second. Large-scale soil conservation and reforestation works by Jerusalem Children and Community Development Organization (JECCDO) in *Dire Dawa* is a notable practice. The environmental protection activity undertaken by the Ethiopian Wetlands and Natural Resources Association in the *Fogera* plains can be viewed as another good practice. Similarly, the watershed management practices observed in upland parts of *Ghibe* in *Sekoro wereda* deserves a special mention. Lastly, the involvement of the Ethiopian defense forces in rescuing of flood victims of *Dasenech wereda* is a notable exemplary practice.

Flood management

In all the surveyed areas, the approach to flood management was mainly reactive rather than proactive. Of course, the establishment of dams could be considered a proactive measure to regulate floods in the downstream areas. The reactive activities were spearheaded by Disaster Preparedness and Prevention Bureaus (DPPB) of the respective regions. The major focus was mainly on the provision of tents, blankets, foodstuff, mosquito nets, and the like to flood victims. In this respect, it is to be noted that the early warning system of DPPB is entirely geared towards the prediction of upcoming food deficits mainly related to drought, but not flood hazards.

4. CONCLUSIONS

Given the rising scale of extreme weather events, alarming degradation of environmental conditions, and mounting demographic pressure on fragile ecosystems, this study concluded that, unless immediate and concerted efforts are made to ensure the environmental wellbeing, there would be a likely shortening of flood recurrence intervals, coupled with augmented risks of life and property damage in years to come.

Furthermore, based on the findings of the rapid assessment in the sample areas, it can be concluded that increased rainfall intensity was not the sole factor behind the extraordinarily high magnitude of flood in 2006. In all the study areas, recorded rainfall level in 2006 was not the highest in 30 years. There were several years with higher rainfalls, without a corresponding scale of flood incidence. Rather, it was the cumulative effect of environmental mismanagement and degradation processes that contributed to turning heavy rainfall into perilous floods.

5. RECOMMENDATIONS

The government, donors, and citizens at large, have done commendable work in terms of rescuing and rehabilitating tens of thousands of flood victims. However, in the event of future floods, there are several measures to be considered to address the root causes of the problem. The following are indicative recommendations of the study:

I. Both government and NGOs should recognize the growing magnitude of environmental degradation in the country as a major triggering factor for flooding. Hence, a paradigm shift is needed from grossly factoring rainfall as a major cause of flood risks. In this regard, more space for action oriented, targeted research and continued debate are indispensable.

II. Enhanced environmental rehabilitation and protecting the existing forests should be promoted in the upper catchments of dams where enormous volumes of sediments could be generated. Modjo, *Dengego*, *Ghibe*, and several watersheds of the country require immediate intervention through integrated watershed management practices. In this regard, introducing alternative livelihood strategies in the sensitive ecosystems of the country would be beneficial.

III. The environmental impact of population resettlement programs, especially in the south western part of Ethiopia, is not only confined to the loss of remnant forests and soils. The adverse impact could reduce the regulative capabilities of Hydro-Electric Power (HEP) dams and the eventual exacerbation of flood hazards on defenseless pastoralists of lowland areas. Therefore, it is wise for the government to rightly implement its resettlement policy especially in the buffer zone.

IV. Flood prone rivers and urban centers of the country should be effectively protected from the potential and recurrent flood hazards through various preventive measures. The emphasis should compose both physical and biological measures.

V. Enforcement of land use zonation should be promoted in urban, as well as river bank corridors. As zoning restrictions limit flood damage, urban master plans should delineate flood prone areas and limit them from structural intrusion. Rivers should also be legally delineated for the benefit of dynamism in river morphology and reduced accumulation of siltation. Accordingly, the federal, regional and *wereda* investment bureaus should work towards the protection of delineated zones from investments.

VI. Compliance with the requirements of EIA should be given serious attention. While it is important to embed EIAs in newly conceived development projects, it is equally important to undertake strategic environmental analysis and environmental auditing for projects that are already operating. In this regard, making EIAs of projects open for public discussions would not only make the system more transparent and efficient, but also contribute to the sustainability of the development project and the environment at large.

VII. The early warning system of the country is "drought -biased". This system should be reoriented to capture other emerging disasters in the country such as floods. Therefore, DPPA should broaden its functions by harnessing modern technologies and databases for efficient early warning measures including flood hazards.

VIII. Effective management of resources, sustainable development planning, and efficiency of early warning system are partly dependent on the quality and timeliness of hydrological and meteorological data. In this regard, measures such as expansion of new observation sites, upgrading of existing stations with the temporal resolution and diversity of data, and facilitation of timely data dissemination schemes are very important.

IX. At last, synergy among various institutions, operating in flood prone areas, should be created and improved, both laterally and vertically. Flood management should follow proactive rather than reactive intervention measures to effectively cope with the disaster.

THE 2006 FLOOD HAZARD IN FOGERA PLAIN: CAUSES, EFFECTS AND ISSUES FOR EFFECTIVE MANAGEMENT

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1. INTRODUCTION

Flooding, as one of the most common natural hazards, has caused lose of life and property in Ethiopia. In particular, the floods of August 2006 made thousands of people homeless and caused a huge economic damage in many regions of the country. Any flood has the potential to cause intangible effects both physical and psychological (Menne, 2000). It has also direct (mortality from drowning, heart attacks and injuries) and indirect (infectious diseases, post-traumatic stress disorder) health effects (Brilly and Polic, 2005). Generally, the floods that occurred in Ethiopia have left a massive and an irreversible impact on the society and the environment.

Among many places, Fogera plain is the one, that has faced severe flooding problems. The plain is found in the Amhara National Regional State, 613 Km away from Addis Ababa, along Lake Tana Shore. This area is frequently flooded mainly when the two rivers, *Ribb and Gumara*, have high flows (WMO/GWP, 2003; EWNRA, 2006). Unpublished sources indicate that, in the last ten years (1996 - 2006), in Fogera plain flood has occurred seven times. The intensity and magnitude of the flood and damages caused by it varies from year to year, depending upon different causative factors.

There are different paradigms on the causative factors that trigger flooding in this area. Some sources say that it is after the Lake Tana outlet (*Chara - Chara Weir*) was built, which raised the Tana water level and caused more intensive flooding on this area. Others associate the flood with environmental degradation. This group said that, the forests of the surrounding highlands had been cleared. As a result, the soil easily leached out and deposited in the riverbanks and on the margins of Lake Tana, in which the water holding capacity of the rivers is decreasing and the depth of Lake Tana is diminishing. Other sources have also related the cause of the flood in Fogera plain in relation to global warming. This group said that due to greenhouse gas emission to the atmosphere by developed nations the global climate is affected. Such changes have influenced and affected the local rainfall patterns. Therefore, these days, the rainfall pattern in the highlands that surround Fogera plain is affected. An overflow of *Ribb* and *Gumara* Rivers occur even after a mild intense rainfall. Overall, these opinions indicate that, the trends and causes of flood impacts on the society and the environment are relatively poorly understood. Therefore, the development of improved understanding of the basic processes causing floods and getting ready to reduce vulnerability is an essential effort.

To be effective, flood disaster management should be implemented as a comprehensive and continuous activity, not as a periodic reaction to individual disaster circumstances (Carter, 1991). Moreover, there must be also a shift of emphasis from reactive to proactive action and it deserves continuing attention in the policy arena. Until and unless the root causes and the factors that trigger flooding are adequately dealt with, there will be little prospect for meaningful changes in disaster management, no matter how well intentioned the motives of the policy makers. Therefore, generating data to develop and implement long term and sustainable solutions to the problems associated with flood causes and impacts on society and the environment in Fogera plain is important. This case study has dealt with the different causes and effects of flooding in Fogera plain to provide information to policy makers, environmentalists and hydrologists to find long term and integrated solutions to reduce the risk of flooding.

The specific objectives of the study are:

- To identify and assess the major causes and flood triggering factors in Fogera *Wereda*;
- To analyze the impacts of the flooding hazards that happened in the survey area;
- To appraise the available flood disaster management practices at the survey area; and
- To generate policy relevant recommendations.

2. LITERATURE REVIEW

2.1 Flooding in the Fogera Plain

The occurrence of floods in the study areas is predominantly due to meteorological factors. That is, floods occur as a result of heavy *kiremt* (summer) rainfall. Floods are generated from variable source areas overflow channels such as a river, stream or depressions. As a result high rainfall inundates down stream areas and causes several damages.

Flooding regularly occurs in the particular areas of *Nabega*, *Wagetera*, *Shesher* pond, *Shaga*, *Shina* and other areas in the Fogera plain. In 1996, the total area inundated was over 5,000 ha. In addition, about 2,500 – 2,600 ha area of land was inundated at the eastern shore of Lake Tana as the level of the lake rose (MoWR, 1999).

These areas have been suffering from severe floods. According to MoWR (1999: 5), the main cause of flooding in the area, particularly east of Lake Tana, was the rise in the lake level. It stated that, *"Lake levels (Lake Tana) vary between +1784 and +1787.5 and especially during flood flows and high lake levels the area in the lower reaches of the plain face drainage problem."*

But, WMO/GWP (2003: 9) argues that such a natural tendency of rise or fall in the lake level was not a regular cause of the flooding in the area. It actually related the flooding of the area to the construction of a low weir at the outlet of Lake Tana at a spot known as *Chara Chara*. Thus, it explains that, *"After the completion of the weir the level of the Lake rose above the intended level and caused severe flooding along its shores, especially on the eastern and southern parts."* Ones such rise in the lake level was attained all the sediment load was compacted along the river channel, especially at the mouth of the rivers. Then, at the next flood the rivers could not discharge their flows into the lake as the channel elevation at the mouth rose up. In one way or the other, flooding is a serious problem in the flat down stream areas of the two catchments.

2.2 Causes of Flood Variations

Several factors could be responsible for the variations and/or occurrences of floods. The significant factors that control flood generation are physical and climatic characteristics of the catchments such as storm duration and intensity, land use and land cover (Admasu, 1989; WMO/GWP, 2003, 2005; Sokolovskii, 1971).

High flood occurrences are related to rainfall duration and intensity. There is a more linear relationship between these set of factors in the one hand and flooding on the other. Thus, rains of longer duration with higher intensity cause higher flood. This is due to the effect of these factors on infiltration capacity of soils. They both reduce infiltration rate in soils, hence, generate greater rate of runoff and eventually flooding (Wisler and Brater, 1959; Nemec, 1972).

The most important factor capable of exerting significant variation in flooding is land use and land cover change in a watershed. Changes in land use and land cover usually involve altering the land cover through intensive vegetation removal. Different studies reveal that land use changes can increase or decrease the volume of runoff and the rate and timing of flooding. Viessman and Lewis (2003) pointed out that afforestation, owing to its effects on infiltration, increases interception. As a result, forests increase dry season transpiration and reduce dry season flow. Deforestation, on the other hand, has the converse effect. It increases quick overland flow and delay in subsurface flow (De Moraes *et al.*, 2006). Due to the latter case base flow is reduced. Thus, deforestation creates high flood peaks and increases soil erosion.

Therefore, some research findings, although unavailable in the study catchment area, from elsewhere confirm the effects of afforestation and deforestation on the hydrological cycle. As a result, Calder (1999) figured out a rate of 300 - 380 mm per year reduction in streamflow after afforestation took place in Transvaal area of South Africa. Fohrer *et al.*, (2005), on the other hand, found an increase in total streamflow by 27 mm per year due to deforestation in a 60 km^2 watershed in Germany. Meanwhile, Woldeamlak (2003) found a 1.7 mm annual decrease in streamflow in *Chemoga* watershed in the *Abbay* (Blue Nile) basin of Ethiopia.

2.3 Environmental Degradation in Northwest Ethiopia

The NW Ethiopia is among the most severely degraded areas in the country (MNRDEP, 1994). In this regard the most serious concern is soil erosion. Extremely large amount of soil is being washed down from the highlands. MNRDEP (1994) estimated that at a national scale 1,900 million tons of soil was annually eroded from the highlands. Among the areas with the highest rate of erosion identified by the same source is North and South Gonder Zones in which this study area is found.

Soil erosion imposes losses on agricultural production through the acceleration of surface runoff (Negley *et al.*, 2006). Thus, its economic cost is a heavy burden on poor farmers like ours in Ethiopia. In line with the potential economic costs upon farmers, FAO (in Woldeamlak and Sterk, 2002) predicted a 30 percent income reduction by the year 2010 due to soil erosion. This is inevitable because from these highlands about 100 tons of soil is being lost from a hectare cropped land and 8 mm soil depth being reduced per year from the same plot of land (MNRDEP, 1994; Woldeamlak and Sterk, 2002).

As a result, gully induced environmental degradation is a common feature of the highland. Several damages correspond to gullying. Hence, Nyssen *et al.*, (2006) identified major effects of gullies such as loss of soil volume and arable land, accelerated landslides, off site sedimentation problems and lower ground water table.

Another most pressing environmental concern in the region is the level of deforestation. According to MNRDEP, (1994:22 - 23) "the central and northern parts of Ethiopia are almost completely deforested." In this regard, in the study catchment area deforestation took place long before ten years. According to MoWR (1999) the last remnant of bushland, about 0.6 percent of the area, found in a pocket part of Fogera plain in 1980 was totally removed in 1996. During the same period grassland diminished from 14.95 percent to 3.42 percent. And previously non existed eucalypt covered 4.78 percent of the land in 1996. Cultivated land decreased by more than ten percent from 78.44 percent in 1980 to 64.14 percent in 1996 where as wetland increased more than three fold from 5.15 percent to 18.61 during the same period.

As a result of such degradation strong effect is being felt on the land. According to EWNRA (2006), the continued population pressure on the land and land use change, especially the plantation of eucalypts in Fogera plain have been reducing its sustainable use.

3. METHODOLOGY

3.1 The Study Area

The survey area (Fogera plain) is found in the Amhara National Regional State, in South Gonder Administrative Zone, 613 km away from Addis Ababa, along the Bahir Dar to Gonder high way (Figure 1). It is bounded by *Gumara* River in the southwest, *Ribb* River in the north and Lake Tana in the west. Geographically, it lies between 11°50' to 12°00'N and 37°38' to 37°43'E. The total area of the *Wereda* is estimated at 1,174.14 km^2 in which 76 percent of the area is plain, 11percent is mountainous and 13 percent covers valleys and gorges. The average altitude of the survey area is 1820 m a.s.l. The dominant soil type of the study area is vertisol (EWNRA, 2006). The mean minimum temperature and mean maximum temperature of the study area is 10.3°C and 27.2°C, respectively. It receives mean annual rainfall of 1284.2 mm.

The national population and housing census estimated the population to be 241,848 in 2006, out of which 206,767 people live in rural area whilst the remaining 35,081 people reside in urban centers (FWRDAO, 2006). The livelihood of the rural population is established on crop production and livestock rearing. Starting from 1993 rice is becoming the dominant agricultural crop.

3.2 Sampling Techniques

Synthesis of different literature and media reports indicated that Fogera plain is the one, among many others, which is frequently affected by flood hazard. Therefore, based on this information the study site (Fogera plain) was selected. Sampling sites within the *Wereda* and the surrounding highlands in this survey were selected through integrating information from the *Wereda* agricultural office, using geographical maps that indicate the sources and tributaries of *Ribb and Gumara* and Rivers, catchment areas and by asking key informants in the locality who have knowledge about the flood history.

For observatory assessment, peasant associations that had high flood hazard frequencies (*Nabega, Shina, Shaga, Kidist Hana and Wagetera*), were selected. In sampling, site selection of *Ribb and Gumara* river banks, sites which were accessible, and those areas in which overflow of rivers happened were selected. Areas in which deposition and siltation occurred along rivers were assessed. Sites which are damaged by the flood and irrigation activities done along rivers were also observed. Major highland areas that the two rivers cross (*Libo Kemkem, Debre Tabor, and Dera Wereda*) were selected for observatory assessment on the vegetation cover, Soil conservation activities.

3.3 Data Collection

In this survey different techniques were used to collect data to identify the causes of flooding, flood triggering environmental factors and its impacts. Personal observation of the flood prone areas (*Nabega, Shina, Shaga, Kidist Hana and Wagetera*) and catchments of *Ribb and Gumara* rivers and the surrounding highlands was also another technique that is used to collect the data.

Closed type questions to interview key informants (government officials who work on agricultural offices, flood upraising committees, administrators of the *Wereda*), were contacted. They informed the team about the frequency and characteristics of floods, expected causes, opinions about countermeasures, and extent of environmental degradation, ongoing reclamation activities, and watershed management activities, development activities along river catchments, certain early warning characteristics and the like. The key informants were also asked to provide the names of highly threatened areas by floods in the *Wereda*. In this technique six people were entertained.

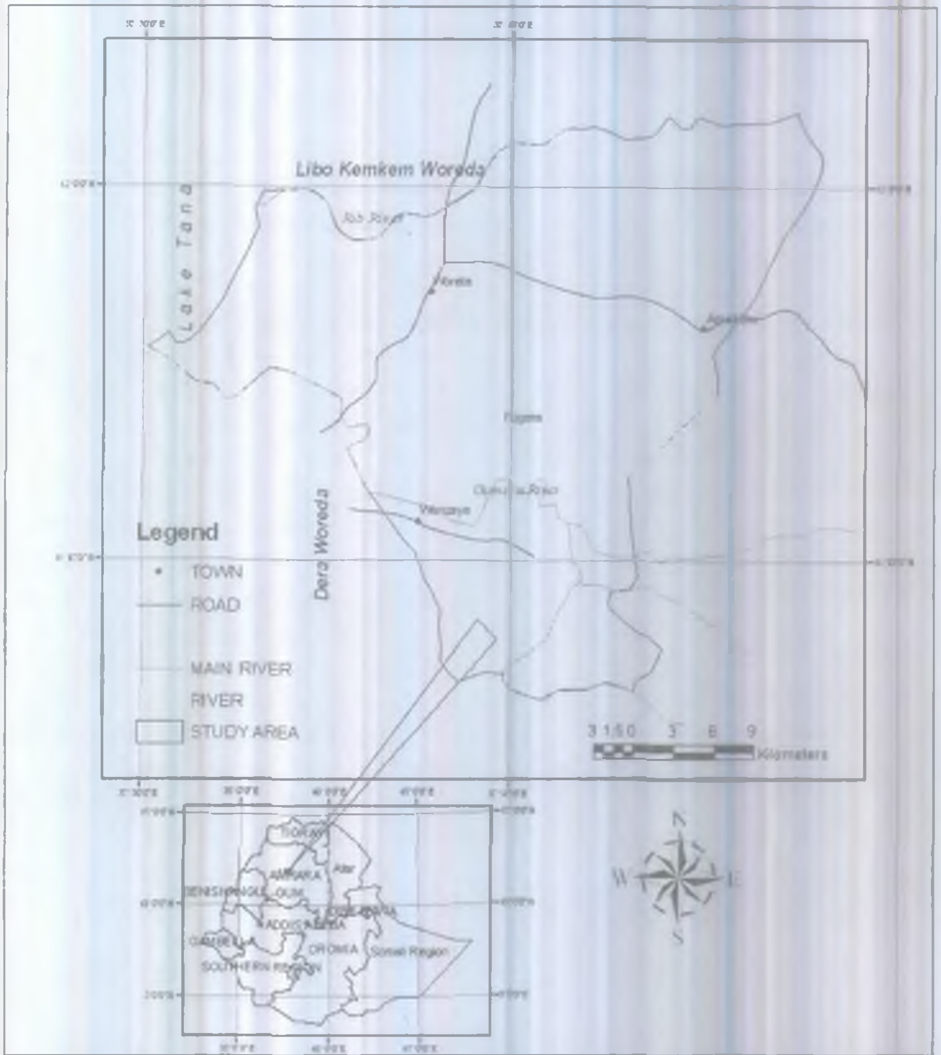


Figure 1. Map showing the location of Fogera *Wereda*.

Focused group discussion was the third technique used for data collection in the survey area. In the group discussion forty two farmers who were found in the refuge camp because of flood displacement hazard and aged above 35 years were randomly selected. Among these, ten were females. The reason for the higher number of males was three times larger than females in this group discussion is that males were engaged in agricultural activities, cow keeping, and deforestation activities. Therefore, it was expected that males have better exposure to the outside environment than females (mostly they are limited to indoor activities). Farmers selected for group discussion were those who had experience with past flood events, and were therefore not responding out of the stress caused by a recent flood event Each PA (Peasant Association) was represented by seven farmers. The farmers were asked general attitudinal questions about the causes of flood, environmental factors that triggered flooding, history of flooding, its impacts, deforestation rate, land degradation, management activities, the present depth and width of *Ribb and Gumara* rivers and their tributaries in comparison with ten years back, and their suggested solutions to reduce the flood hazard were also entertained.

Conducting an extensive review of both published and unpublished papers was the last method used to collect data on case histories of the flood, impacts of the flood, forest coverage, development activities along river banks and catchments, physical characteristics of the rivers, etc., overall primary and secondary data were used in this case study.

3.4 Data Analysis

The key factors contributing to flooding hazard were generally identified through perception method. Anthropogenic factors that contribute to flooding were identified.

Risk perception analysis method that allows a description of the past and present situation of the flood, its causes and effects were used to compile socioeconomic data. Secondary source data about the impact of the flood on agricultural lands and humans were directly compiled and common issues were picked up.

Moreover, data pertaining to rainfall and streamflow were obtained from the Ministry of Water Resources' National Meteorological Services Agency of Ethiopia and Hydrology Department respectively. These data sets were analyzed using trend analysis method and by producing hydrograph.

Translation of Amharic documents and reports to English is another method that was used to compile data.

3.5 Limitations of the Study

This survey was carried out to identify the causes and effects of flooding in Fogera *Wereda* in order to offer some future directions to the concerned bodies to mitigate flooding hazards in the area. Although the data gathered from the survey area and secondary sources could in general help to reach at the intended research objectives, the quality of the survey would have been of a higher standard had there not been some limitations encountered in due course of the survey. The most important one is that the survey was carried out with the intention to report findings while flooding was a big issue in the country. To this end, rapid assessment was taken in the affected sites. Thus, within the limited short field observation and write up time, detailed data could not be gathered and all essential hydrometeorological analysis methods could not be pursued.

Moreover, the paucity, absence and lack of up to date hydrometeorological and other related data is another limiting factor. Thus, it hindered us from giving a clear picture of changes in the hydrological processes in the study catchments at the most recent time. For instance, data on rainfall intensity, runoff and sedimentation yield are either not available or found to of some years before the recent flood has occurred.

4. RESULTS AND DISCUSSION

4.1 Description of Flood Related Factors

4.1.1 Settlement history

The *Ribb and Gumara* catchments are among the most densely populated areas in ANRS. Favorable climatic and physiographic conditions of the area attracted large human settlements over centuries. As a result of this Fogera *Wereda* became the most densely populated *Weredas* in South Gondar Zone. Currently with 205 persons per square km, it leads the other *Weredas* of the zone in population density (FWARDO, 2006).

In addition, in the upland sites of the catchments human settlements established very long time ago. However, at recent times the population has been increasing very rapidly in this part of the catchments. For instance, in the period between 1994 and 2006 the total population of Fogera *Wereda* increased by 56,208 people. This shows that the population grows at a rate of about 2.9 percent per year. As a result of such an accentuated growth in population, the environment is being adversely affected. The human impact is so high resulting in the rapid depletion of natural resources of the survey area. Thus, human activities as will be discussed in the subsequently sections, are triggering flood hazards and other disasters through deforestation and soil erosion. Consequently, the availability of suitable land for agriculture is shrinking. Due to high population pressure on the land, every plot of land is under crop cultivation mainly at the expense of forest land.

4.1.2 Rainfall regime

Different views were reflected on the group discussions regarding rainfall regime of the catchments. People from the impact areas reflected the view that this year's (2006) rainfall was 'unusually' high. They argued that the frequent flooding and the vast coverage of the current flood must have been due to an increase in rainfall. Whereas those from the upland sites explained that this year's rainfall was not much different from the previous years. They concluded that rainfall of high magnitude equivalent to July or August 2006 used to fall in the area in previous years.

However data analysis pertaining to rainfall from flood contributing areas of *Addis Zemen* and *Debre Tabor* reveal important findings as discussed below.

Interestingly, the results of data analysis match with the judgments of people from the upstream areas. The rain began to fall in the catchments as usual in May. The highest concentration of rain in both stations occurred mostly in July. Therefore, the total amount of rain in July 2006 was not found to be the peak at both stations (Table 1). It was just the 8th maximum at *Addis Zemen* station and it was only the fourteenth at *Debre Tabor*.

On the other hand, the long term annual total rainfall as portrayed on Figure 2 is declining at a rapid rate. Therefore, at *Addis Zemen* annual variation of rainfall from the mean was about 9 percent. While at *Debre Tabor* the variation ranges by about 18.59 percent. Hence, there is significant decrease in rainfall at both stations with a rate of 10.79 mm and 18.89 per annum.

As can be seen from Figure 2, a more decline in rainfall is observed at *Debre Tabor* station than at *Addis Zemen*. In general, such finding is congruent with earlier findings of other authors. For instance, NMSA (2001) reported a declining trend in rainfall over the northern part of Ethiopia.

Table 1. Maximum rainfall and month of occurrence of the study catchments

At Addis Zemen Station				At Debre Tabor Station			
Event Year	Maximum RF (mm)	Month of Occurrence	Rank	Event Year	Maximum RF (mm)	Month of Occurrence	Rank
1975	525.80	July	7	1975	501.90	August	9
1976	487.60	July	9	1977	598.90	July	3
1977	913.50	July	1	1978	564.60	July	5
1980	581.00	July	4	1979	554.70	July	6
1985	535.80	July	6	1980	571.60	July	4
1988	675.20	July	2	1982	670.60	July	1
1990	539.00	July	5	1983	506.70	July	8
2000	598.70	July	3	1988	512.93	July	7
2003	461.30	July	10	1994	633.30	August	2
2006*1	513.20	July	8	2001	496.10	July	10

*1 Data range is up to July 2006

4.1.3 Deforestation regime

From the field observation along different sites in the study area, it can be concluded with great certainty that the area is devoid of vegetation. Respondents from the two upland sites also explained that all the natural forests of the areas have been cleared out within the past few decades. According to them, over the past three decades a rapid deforestation took place. However, the worst of all is the deforestation that has taken place since the 1990s.

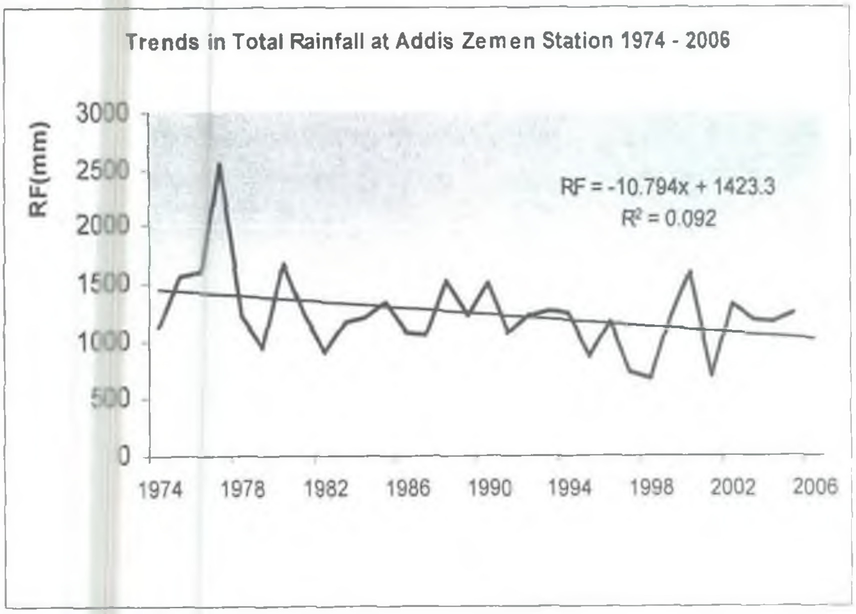
In a group discussion we made with an elderly people in upland sites at *Debre Tabor* and *Ambessamie* areas, we understood that such an accelerated rate of deforestation was aggravated at the transition periods of government change in Ethiopia. Therefore, as soon as the reign of Emperor Haile Selessie I was overthrown in 1974, the landless members of the society occupied the land owned by the feudal lords. After they occupied the land the farmers removed all the vegetation cover for farming purpose.

However, there was important development in reforestation afterwards during the *Derge* regime. As a result community forests were established at mountainous and hillsides. Nevertheless, another transition period in 1991 resulted in the removal of the community forests. This is related to a rapid population growth, following the lawlessness that occurred during the change over of government. In this case, large numbers of landless youths were also given land to plough as far as the slope allowed them.

According to the group discussion, most of the grazing lands, formerly community forests and hillsides, were all occupied by landless youths. This has resulted in a complete removal of the forests of the upland sites. An old man, aged 70, from *Debre Tabor* area recalls, "These all mountainous areas you overlook were all covered by trees like *dokma (Syzygium guineense)*, *wanza (Cordia africana)*, *weira (Olea europaea* subsp. *cuspidata)* and *zigba (Podocarpus falcatus)*. They are now completely removed. You don't even find their stumps. Our children, today, know only the names of these trees. They have never seen their leaves. It is only the eucalypts that we have today."

As result of such deforestation, says a wetland expert from Fogera *Wereda*, "numerous wetlands particularly those found in the upper part (east) of the main highway that runs from Bahir Dar to Gonder dried up". In the mean time, people have planted eucalypts in a great number in those areas. Thus, such land use change might have been a factor for the drying up of the wetlands as well as for the accelerated rate of flooding.

Moreover, from the discussions we conducted in both the upland and impact area in the lower part of the catchments, we understood that every person in possession of the land does not have an obligation to protect his/her land or has never been taught to protect it. However, it would have been quite advantageous if they had been informed, taught or enforced to protect their lands. Through their participation, it would be possible to avert deforestation and thereby to reduce floods.



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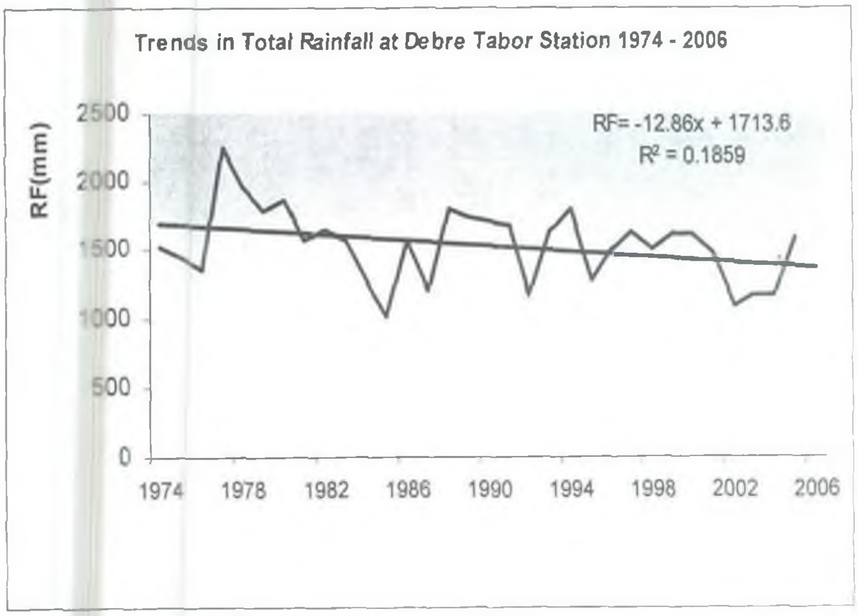


NB: Data range is up to July 2006

Figure 2. Trends in rainfall of the catchments.

4.1.4 Soil erosion regime

The fact that the study catchments are distinctly divided into rugged upland terrain and lower flood plain clearly depicts soil erosion regime. A continued *sedimentation* of the lower Gumara and Ribb rivers is the result of the rapid erosion that is taking place at the upper sites.

In those upland sites that have been assessed there are so many gullies. According to the local residents, the gullies are widening in dimension. The informants stated that gullies of that extent were not known in the area some two decades ago. However, very rapid runoff capable of washing down hillsides and farmlands is very common in the area at present. They also realized that rainfall of a mild intensity is taking away their soils in a greater proportion than heavier rainfalls used to do when the areas were under vegetation cover. On the other hand, in the down stream areas huge sediment is brought with the flood. It was also confirmed that, along a vast plain in Fogera and *Libo Kemkem Weredas*, there existed huge fresh deposit of sediments. An elderly key informant said that, in just one rainy season (2006), sediment of more than half-meter depth was deposited over the area in *Shaga Mariam* PA of Fogera *Wereda*.

Therefore, deforestation is the single most responsible factor for the continued soil erosion in the study area. Furthermore, people from the lower floodplain have now begun wondering why sediments of a bigger size being deposited on their farmlands during this flooding season. From the group discussion made with people from those areas it was discovered that, usually over the previous *kiremts* (rainy seasons), only fertile sediments used to be deposited when the *Ribb and Gumara* rivers inundate their farmlands, which was of course very beneficiary for them. But this time they said that the rivers have brought gravels and sand in huge amount. Their worry is that if such a situation continues in the future their fertile farmlands will be permanently damaged. As a result, the accelerated rate of soil erosion that is taking place at the upper sites has also an adverse impact on the down stream areas.

Plate 1. Total depletion of forests in the upper part off the catchment has aggravated flooding at plain parts.

4.1.5 Flooding Regime

The main cause of flooding in the study catchments is the overflow of the *Ribb and Gumara* rivers. Therefore, vast areas that lie below the point where there is a sharp decline in slope (below 2200 m) are prone to flooding in the rainy season.

According to the key informants, those drawn from Fogera flood plain, flooding has a short time history in the area. They informed the study team that flooding, which was the first of its kind in the area occurred some ten years ago, in 1996. The flooding of that year affected eight PAs of Fogera *Wereda*, namely, *Wagetera, Nabega, Kidist Hana, Shaga Mariam, Shina, Wereta Zuria. Kuhar Michael and Abathua*. Other three PAs from *Libo Kemkem*, that are – *Banbiko, Gende Wuha and Teza Amba* were also affected by the flooding during the same year.

From 1996 onwards, flooding has become a regular incidence in some areas, especially in those PAs of Fogera *Wereda* adjacent to Lake Tana. These are *Nabega, Wagetera and Kidist Hana* PAs. Such frequency of the flood is related to a high level of streamflow as portrayed on Figure 3. The flooding, which has occurred in this Kiremt (2006) is the most severe of all the flood events experienced in the area so far. Due to the flood 35,889 people or about 15 percent of the population of the *Wereda* were affected (FWARDO, 2006).

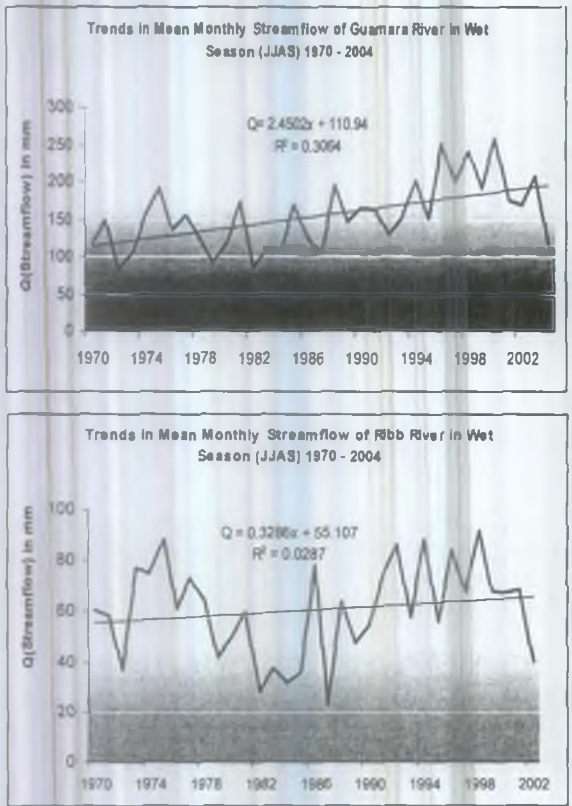


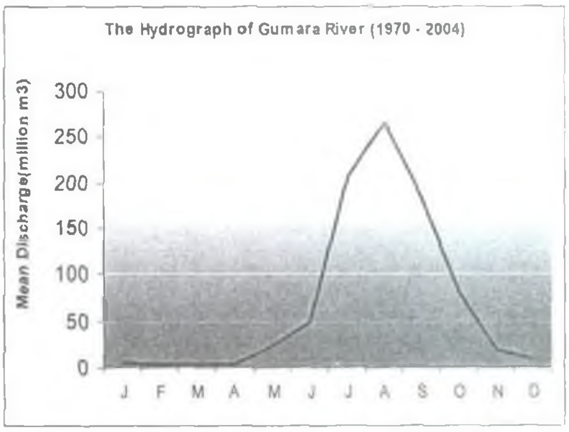
Figure 3. Mean monthly runoff of *Ribb and Gumara* rivers

4.1.6 Trends in flooding in Fogera Plain

Analysis of runoff data of more than thirty years shows a significant increase in the runoff. As indicated on Figure 3, the wet season (June, July, August and September) flows from the two rivers are increasing at a rate of 2.4 and 0.3 mm per annum.

A pronounced rate of increase in the runoff is observed in the decade between 1990 and 2000. During the decade flood incidence was very high. The floods resulted from high runoff that occurs during the months of the wet season. Therefore, the patterns of streamflow in the catchments reflect the contributions of changes in the physical characteristics particularly land use and land cover changes. This can be evident from the comparison of trends in the rainfall and streamflow in the catchments. Therefore, while rainfall was relatively high in the1970s and 1980s and the streamflow was low (Figure 3). As a result, lower runoff coefficient is expected during the period. This implies small proportion of the rainfall turns into runoff possibly held by some abstractions such as vegetation and infiltration into the groundwater table. Meanwhile, during the previous and the present decades there have been an increase in streamflow while the rainfall was decreasing showing clearly the reduction of water abstractions from the rainfall and an increase in runoff.

As the hydrograph of the rivers show on Figure 4, the wet season contributes the dominant share of runoff into the rivers.



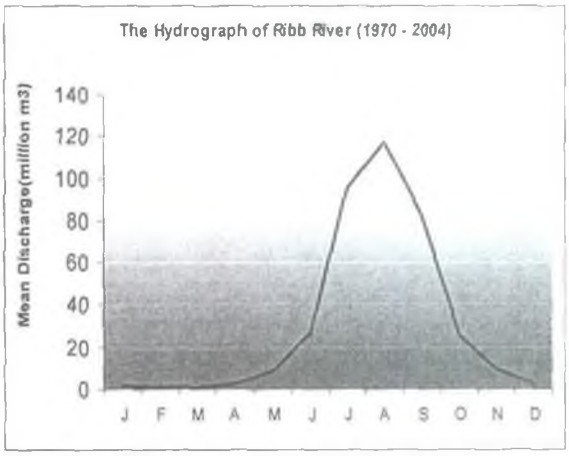


Figure 4. The hydrograph of Gumara and Ribb rivers.

During the rest eight months the runoff is extremely small. This indicates a lower contribution of the base flow into the rivers. On the other hand, this shows runoff during rainfall is dominantly overland flow, subsurface flow processes generally being minor. Such highly peaked hydrograph in the wet season or small base flow is closely linked to very low infiltration and quick overland flow. In other words, it shows the absence of water abstractions.

According to Figure 3, a slight decrease in runoff is seen in early 2000. The wet season of 2006 could not be incorporated into the analysis due to lack of data. However, it is expected that the season would be the first season where the highest runoff probably has occurred. This can be ascertained from the flood and rainfall regimes of the study catchments as discussed in the preceding sections.

4.2 Impacts of the Flood

The recent floods of August 2006, in Fogera *Wereda*, made more than 35,889 people homeless. This accounts for about 92 percent of the total population affected in the regional state (ERTO, 2006). There are different contradictory reports on the death of people. The *Wereda* authorities said that deaths on humans did not happen. The focused group discussion result with the flood affected peoples indicated that one boy and two girls passed away from drowning. Whereas press reports figured out that only one death has happened (Capital 20, Aug. 2006). Overall, compared with the earlier years, this summer (2006) flooding hazard was so severe in terms of area coverage and property damage, but the causalities to human life is minimal. Meanwhile, in 1996 the flood hazard took away 40 human lives in which, thirty-two were children, five women and three were men respectively. Depending upon different flooding causative factors the number of households displaced by its impact which varies from year to year (Figure 5).

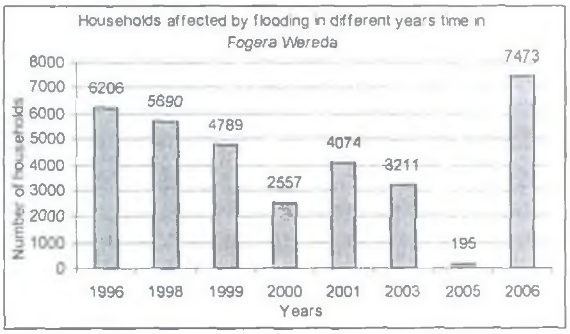


Figure 5. Graph showing households affected by floods in Fogera *Wereda*.

The flood of 2006 has also caused a physical damage on women and children. The reason behind such impacts on this group of the society is that, they could not swim or withstand the challenges posed by floods. From the group discussion with people from impact areas, it has also been learned that the flood has created a post-traumatic stress disorder, including anxiety, depression, and psychosocial problems on the community. Direct health effects (heart attacks and injuries) occurred during the flood occurrence and indirect health effects like diarrhea also happened latter on. Large number of people is expected to be victims of malaria since the flood will be a good ground for mosquito breeding. This may indirectly affect the hospital treatment cost, the labor force, the productivity, etc. The DDT which will be sprayed on marsh areas to eradicate malaria may bring long term effects such as biomagnifications and bioaccumulation problems on amphibians and birds which may in turn affect the ecosystems food chain.

Besides such events and expected effects, the flood has killed nine cows and one sheep. Moreover, 322 beehives were also destroyed. Most of the hats have been drowned by the flood. Cattle have been evacuated from the area. This was as a result of environmental degradation caused by overgrazing that occurred in areas where there were too many animals. Grains, which have been inside traditional containers, were spoiled by the flood. As a result of this, people from the impact areas are forced to depend on food aid. The food aid might bring long term impacts on the working power, creativity potential, culture and on agricultural development activity.

The flood has frequently devastated agricultural crops. A total of 6,673 ha of land, which were covered by different types of agricultural crops were drowned by the flood in the year 2006 (Table 2). The expected crop production loss was estimated at 148,005 quintals. The reduction in agricultural production because of flooding may elevate prices in agricultural crops in the coming year, which in turn may lead to poverty that forces people into a vulnerable position causing great loss of life and damage. From 1996 - 2005, in different years time, the country has lost 69,929,760 Birr due to loss of agricultural crops caused by flooding in Fogera *Wereda* (Table 3).

Plate 2. The flat topography has greatly contributed to the flooding at Fogera.

Flooding has also aggravated rilling, gullying and other forms of accelerated soil erosion on agricultural lands in Fogera *Wereda*. Therefore, most of the agricultural lands have been wasted. Because of sedimentation problem and the rise in river depth, the rivers breached their channels at many spots and formed new trench lines. Transported sediments and dissolved substances are being deposited in the river channels, Lake Tana, on adjacent flood plains and wetlands. The transported sediments diminished the rivers water holding capacity and the rivers depth and their aesthetic value. The sediments also damaged the rivers fauna and flora. The dissolved substances (particularly phosphorous and nitrogen fertilizers leached from the upland sites), may create eutrophication problem, which in turn might affect the lake's, rivers' and wetlands' fauna and flora. Information from the *Wereda* agricultural office indicated that the wetlands found in Fogera plain support lots of migratory birds which came from Israel. This year (2006) the flood affected the feeding ground and season of these migratory birds.

It is important to note that the Fogera plain is one of the important bird areas in Ethiopia. It is found adjacent to the main International Bird Area (IBA) of Lake Tana. According to EWNHS (1996), the Fogera plain hosts the globally threatened species of birds such as Wattled Crane as well as Black Crowned and Common Crane. In addition, the plain is an important site where other near threatened species such as Lesser Flamingo, Pallid Harrier and Great Snipe appear in spring on a migratory basis. However, the expansion of the farmlands and the farmers' negative attitude towards the birds has become the biggest threat to the birds of the area EWNHS (1996).

Plate 3. Flooding has drowned several houses at Fogera plain. (Photo by UNICEF).

4.3 Analysis of Flood Causative Factors

Different environmental and anthropogenic factors trigger flooding and aggravate its impact in Fogera plain. Among many factors the major ones are:

1. Deforestation- Focus group discussion result from the local communities, information from the *Wereda* agricultural offices and literature indicated that most of the area was once covered by forest, the river banks have been covered by long grasses; however, this days the area is devoid of vegetation. Local communities said that the forest cover has largely dwindled after the fall of the *Derg* regime. When they explain the extent of deforestation in the locality one old man said that during this time their young children do not know the structure, morphology and leaves of different tree species what they know is only the names of the tree species. This has happened because of deforestation. Literature indicates that at present the forest cover of the *Wereda* is only 1.8 percent or 2,190 hectares (EWNRA, 2006). Some areas which are considered as forests by the agricultural offices are highly disturbed and there is a problem of encroachment to the small patches of highly disturbed forest. Most people have planted *eucalypt* and it is invading the area along riverbanks and home gardens.

Forests are important in reducing soil erosion. They reduce landslide, floods and can facilitate infiltration of water. Crowns reduce the velocity (kinetic energy) of rainfall thus minimize splash erosion. It provides organic matter to the soil hence facilitating infiltration. However, land clearance through deforestation along river catchments exposes the soil to high amount of rainfall, and leaching of sediments and runoff water facilitated and joins the river channels at a short period of time which causes flooding.

During the group discussions the people pointed out that deforestation is the major cause of flooding in the survey areas. They also noted that earlier the uplands were covered by forest, and the water was clean (no siltation). These days, rivers bring lots of sediments because there are no plant roots to hold the soil in place. Therefore, because of deforestation leaching of soil was aggravated and the soil was deposited in river banks which has reduced the water holding capacity of rivers. As a result, the discharge of water into Lake Tana has decreased; this in turn caused the flooding of the lower plain in Fogera. In general, Figure 6 illustrates the role of deforestation in aggravating flooding.

Table 2. Agricultural crops damaged by the flood in the year 2006.

Type of crop damaged by flood	Area covered (ha)	Expected production loss (Quintals)
Rice	4482	121014
Millet	608	6810
Maize	567	13608
Pepper	263	2038
Niger seed	209	836
Teff	544	3699
Total	6673	148005

Source: Agricultural and Rural Development Office of Fogera *Wereda*

Table 3. Agricultural crops damaged by flooding in Fogera *Wereda*.

Year	Damaged cropland (ha)	Expected production loss (*quintals*)	Loss in terms of Birr	Number of PAs affected by the flood
1996	4557	21722	3258300	8
1998	4516	36519	5477850	6
1999	3583	12754	1658020	5
2000	1566	14562	21843000	5
2001	3697	21617	2594040	7
2003	1155	22937	34980550	3
2005	39	590	118000	2
2006	6673	148005	NA	6

Source: Agricultural and Rural Development Office of Fogera *Wereda*.

2. *Upstream soil erosion and downstream sedimentation*: The land cover by forests in both upland sites and the flood plain area has tremendously decreased. Therefore, there is high soil erosion in the upstream sites. As a result, sediments and dissolved substances cumulatively called river load are being deposited in the river channels and on adjacent flood plains. During the assessment of the catchments, heavy soil erosion has been observed in the upland catchments (*Debre Tabor, Addis Zemen and Ambessamie* areas) through the gullies formed there. In the mean time there are no strong soil conservation activities in the farmlands. Therefore, most of the sediments washed down from those areas are deposited at the riverbanks and flood plains in the downstream areas. Fortunately (in view people residing in the lower catchment area), the river load benefited the farmers of Fogera plain by bringing fertile soils. As a result the farmers of the flooded areas have not been using fertilizers on their farm lands.

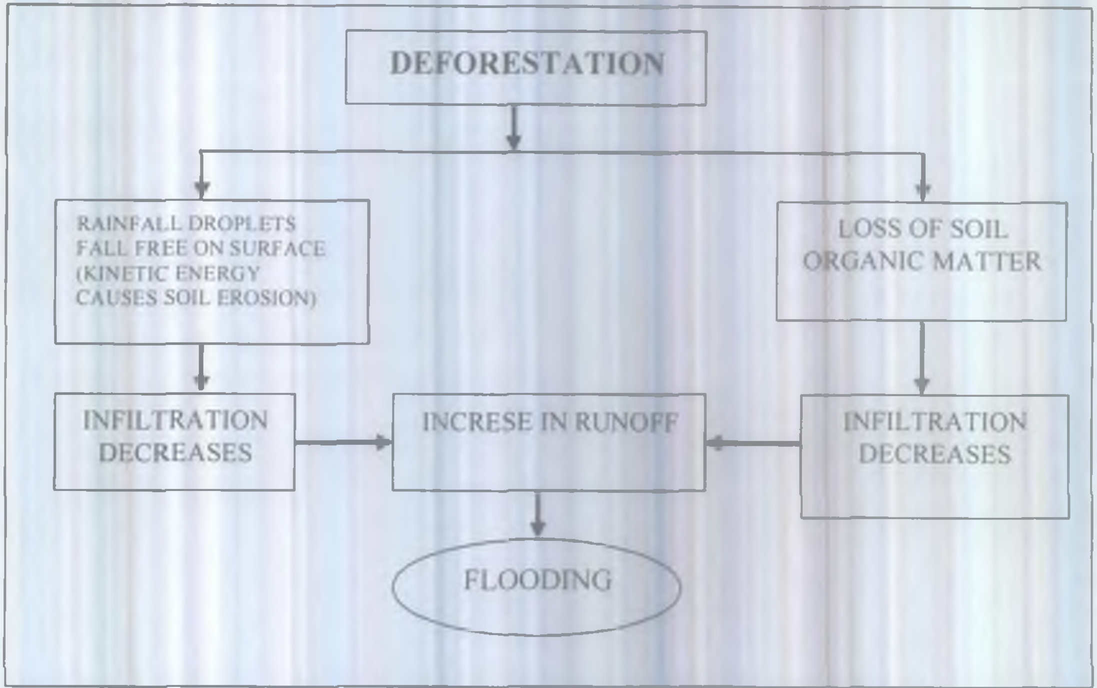


Figure 6. The effects of deforestation on flooding.

However, sediments deposited in the rivers affected the rivers gradient, cross sectional area, average velocity of water flow and discharge of rivers. Therefore overflow of rivers occurred and flooded the local communities. The group discussion result indicated that the cross sectional area of *Ribb and Gumara* rivers decreased from time to time because of sedimentation problem. In some areas the depth of *Ribb* River diminished from 35 meter to 11 meter. Deep rooted and tall grasses that used to grow along river banks have been buried by sediments. Crops are also buried by the sediments. Overall the river channels' depth and width decreased and their water discharging capacity got minimized which in turn leads to overflow of water and frequent flooding.

In general, these processes indicate that the rate of erosion and soil loss in the upstream is very high due to lack of watershed management activities in the catchments. Moreover, ploughing of land up to the edge of the riverbanks and within the river channel facilitated the deposition of huge amount of soil in the rivers.

Furthermore, the sedimentation problem has far reaching consequences. It not only triggers flooding in Fogera plain, but it may also be a threat to the depletion of Lake Tana. It is unaffordable to lose the great economic and cultural values of the lake. It is obvious that the lake is an important tourist site possessing several attractions such as birds and monasteries. The effects of soil erosion on flooding are summed up in Figure 7.

3. Traditional irrigation practices: Irrigation is very important to alleviate poverty and improve the livelihood of the society. When irrigation is done in a wrong way and unsustainably it will damage the environment, particularly the soil and it may also lead to flooding problems. This is one case that triggers flooding in Fogera *Wereda*.

During 2006, in Fogera *Wereda*, 1,384.44 hectares of land have been irrigated through water pumping. This much hectare of land was cultivated through drawing water from *Ribb and Gumara* Rivers using 164 water pumps. It is not irrigation that is a problem of flooding, but choking of rivers to accumulate water for the water pumps using mud, woods, etc. facilitates flooding. During the dry season (*Bega*) the volume of flowing water in Gumara and Ribb rivers significantly decreases. People block the rivers using mud and woods to accumulate water for the water pumps. As the rainy season commences, this blockages are not removed. Rather they are left there to accumulate the water and sediments. Sometimes the people dredge out the sediments from the rivers and use them as a fertilizer for the next rice cultivation season.

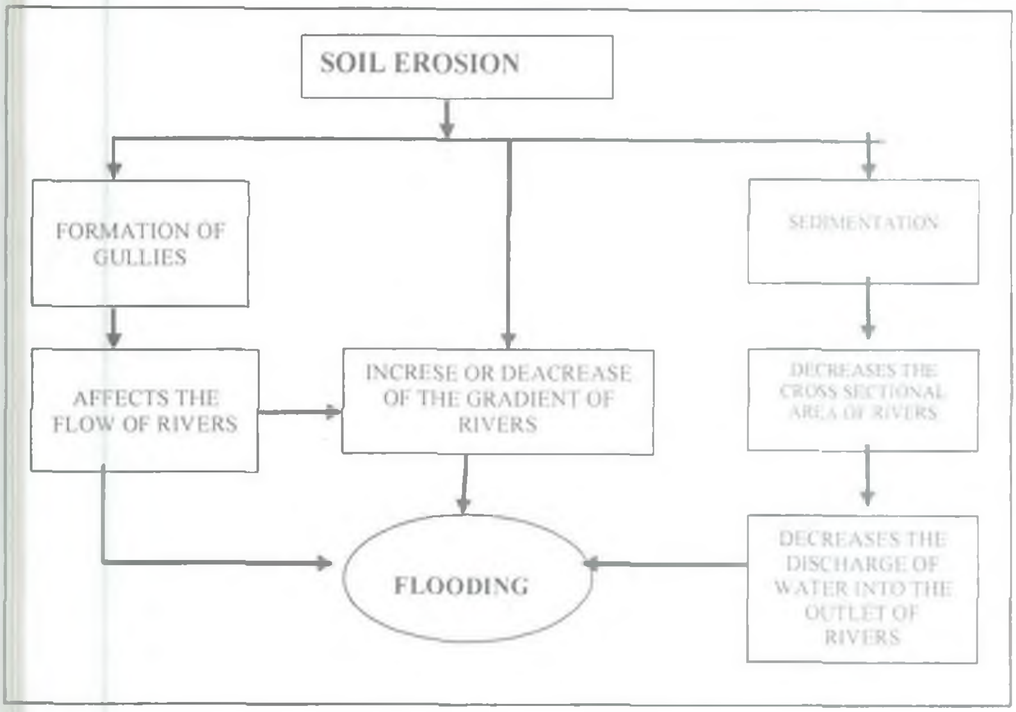


Figure 7. The effects of soil erosion on flooding.

However, the blockages of rivers further accumulate sediments and reduce the cross sectional area of rivers and the velocity of water in the channels. During group discussion with the local communities, most considered the blockage of rivers as a serious problem. They underscored that the blockage of water by upper PA users for irrigation is the major cause for the overflow of rivers. They related the problem with the farmers' unwillingness to remove the blockages of water at the beginning of the rainy season.

Unpublished report from the agricultural office indicated that using *Kokit* (tributary of *Ribb*) 50 hectares of land is irrigated in Fogera *Wereda*. Every year, the flowing water is blocked using traditional dams constructed from woods, mud and straws by the local communities for irrigation purpose. To take out the stream water for irrigation every year the flowing water is blocked using traditional dams constructed from woods, mud and straws by the local communities. To block the water 2,500 – 3,000 *farmers are involved in the dam* construction. Such dams would not be removed before onset of the rainy season. During heavy rains the dam materials are taken away by flood.

This in general, indicates that the traditional method of choking of rivers within the drainage network for irrigation purpose affects the water discharging capacities of the rivers and triggers flooding in the surrounding localities.

Moreover, the intensification of rice cultivation at recent years coincided with the high flood incidences in Fogera *Wereda*. Thus, rice became the dominant land use (Table 2) with all its defective cultivation method. Therefore, rice cultivation using inappropriate method is among the land use changes in the *catchments which has been* exacerbating flooding in the survey area.

4. Type of soil: Heavy black soils (Vertisols) are the dominant soil types in the *Wereda*. This type of soil accounts for 65 percent of the soils of Fogera *Wereda*. Such type of soil has a property of poor drainage. When rain comes the soils easily become saturated and overflow of rivers happen because of low infiltration rate by the soils. The rain water accumulates on the soil surface and stays for 15 – 20 days as surface storage before it fully evaporates right after the rain stops.

5. Back flow of lake tana: The local communities around *Nabega, Shina and Kidist Hana* Peasant Associations, who are residing at the eastern shore of Lake Tana, said during the group discussion, that these days the volume of water in Lake Tana is increasing and the lake's water outflows and floods their agricultural lands and residential areas. They have given two pre-assumptions for its back flow. One group said that it may be associated with the establishment of *Chara Chara* Dam on the outlet of *Abay* River. Other groups said that starting from 1997 the volume of sediments that join Lake Tana through different rivers has increased; as a result, the sediments deposited in the lake and reduced the volume of the lake which also affected the water holding capacity of the lake.

6. High amount of rainfall: During the group discussion, some people said that compared with the other years, in this summer (2006) there had been high amount of rain fall. Therefore, they concluded that the rain fall should be one factor for flooding, which was aggravated by other environmental factors.

4.4 Survey of Good Practices

Responding to the question whether there was any good practice to mitigate the effects of flooding in the study area, contrasting views was reflected by *Wereda* officials and our key informants.

According to EPD officer of the Fogera *Wereda* Rural Development and Agriculture Office, attempts have been made to educate farmers on the mechanisms of environmental protection. He said practical demonstrations were carried out on farmers' lands, so as to show them the ways of soil erosion reduction in both upper and lower parts of the *Wereda*. This includes how to make *fanya juu* and stone bunds to reduce soil erosion.

On the other hand, the key informants from the upstream areas disclosed that the Rural Development Officers are not taking significant steps to reduce soil erosion. They are neither engaged in afforestation nor physical erosion control. They also related such shortcomings to the shortage of farmlands.

However, the existence of the branch office of the Ethiopian Wetlands and Natural Resources Association (EWNRA) in Fogera *Wereda* is just one good sign of environmental protection. The EWNRA operates in the *Wereda* with the objective of training farmers and development assistants on the principle of an integrated and sustainable wetland and watershed development. Such activity of the Association would be considered a good beginning for proactive measures of flood risk reduction.

4.5 Appraisal of the Adapted Flood Disaster Management

Before the occurrence of such devastating floods during both major flooding years, there was no effective preparedness to flood risk reduction. As a result a huge damage occurred to human life, property and the ecosystem (MoWR, 1999, FWARDO, 2006). However, as soon as the floods occurred during the 2006 flooding, the Amhara National Regional State government and the respective *Wereda* administrations in the flooded areas quickly responded to minimize the risks of the flooding. Thus, people from the flooded areas were evacuated and settled in camps on safer areas. The largest of the camps was made near *Wereta* town, which accommodated about 10,000 people.

At the beginning, it was a great challenge for the *ad hoc* committee in charge of handling the evacuees from Fogera *Wereda* to safely accommodate them. According to the coordinator of the camp, food and material aid reached them late, about a week later. They had nothing for an emergency. But things improved as food and material aid began reaching them.

Another challenge they faced in the camps was lack of potable water. The evacuees were forced to drink unsafe water from the nearby spring. Although it was not unusual for them to drink such type of water before the flood hit them, the problem was the outbreak of water borne diseases, especially diarrhea in the camp. There was acute shortage of medication as well. These problems were solved latter on as the Ethiopia Red Cross Society and other humanitarian organizations such as MSF and Food for Hunger International got involved. A place to keep their cattle was another problem faced by the evacuees.

Finally, although post disaster management requires large capital, time and an integrated flood management practices, the effort underway by the state's DPPB is encouraging. As soon as the flood recedes, the evacuees' are promised to be given seeds to replace the damaged fields as well as food relief until they recover. But, these are all reactive measure. When shall proactive flood management measures be taken?

5. Trends of Flooding in Fogera Plain

This survey unveiled that flooding has very high frequency and magnitude in the study area. The increasing incidence of flood events have been exacerbated by human induced environmental degradation and ignorance of land and water resources management. It is more apparent that this situation is likely to continue in the near future in the study catchments. The possibility is high because of multiple factors. This makes it difficult to regenerate the environment within short time although it is possible to create awareness about land and water resources management as a remedy for flood protection.

Nevertheless, neither of these broad response measures is now underway in the study area. Moreover, other specific results of the survey show no sign of future decrease in flooding. Rather massive deforestation of the catchments, a considerable change of land use pattern, the continued soil erosion and the resulting downstream sedimentation and reduced river depth, the increasing trend in streamflow are some of the factors that amplify flood intensity in the area.

6. CONCLUSION AND POLICY IMPLICATIONS

6.1 Conclusion

The results the survey indicate that the flooding of the Fogera plain in the summer (2006) is the result of the cumulative effects of environmental degradation. That is, rainfall is not the only single responsible factor for the occurrence of the flood. Both the results of the meteorological data analysis and group discussion confirmed that the last summer rainfall was not so unique in the area. In addition, high rainfall does not necessarily yield flooding. Rather the mismanagement of the environment, misguided land use and lack of land use policy has aggravated the magnitude of the flood.

6.2 Policy Implications

Ethiopia has suffered from the most severe flooding in its history this year (in 2006). The floods affected almost all the regional states including Dire Dawa Administration, except Benishangul- Gumuz and Harari National Regional States. Over 1,000 people died as a result of the floods and tens of thousands of people were left homeless (Capital 20, Aug. 2006). Wide ranges of areas across the country have been affected. One among these areas is the Fogera plain in the *Ribb and Gumara* catchments of Amhara National Regional State.

As discussed in section four of this study the incidence of floods and the damage incurred consequently is becoming so severe in the study catchments. Environmental degradation through deforestation and soil erosion coupled with increased pressure of population on the land has accelerated the incidence of flooding in the study area.

Such a magnitude of flooding and the worsening condition of the environment urge for an immediate intervention, sooner than latter. Any delay rendering complication in any future disaster would reduce the overall benefits of water resources management to the society.

Therefore, to mitigate any future disaster and for a sustainable development of water resources, there has to be a policy pertaining to water in general and flood management in particular. To this end the country has embarked on a new policy on water resources in 1999 (MoWR, 1999). The policy is based on the principles of integrated water resources management. This principle also incorporates flood management. But, flood management in the policy has not been treated separately on a sustainable manner. In addition, just a few elements of an integrated flood management (IFM) are addressed on the water sector strategy of the country (MoWR, 2001). As a result, only four out of sixteen main aspects of IFM were practiced in Ethiopia in 2005 (WMO/ GWP, 2005). Nevertheless, even those literally found in the document are rarely seen being put into practice.

IFM is an essential approach that needs to be practiced to a full extent, if possible, to prevent flood hazard. It promotes the integration of cross-functional teams in the planning and implementation of flood policies and a participatory approach to flood management, including a representative range of stakeholders into the decision making process.

Based on this IFM approach and depending on the major findings of the survey study the following recommendations are forwarded:

1. There should be strong action on the protection of the environment primarily through reforestation of the already degraded areas. To this effect there should be soil and water conservation (SWC) activities in the upland and downstream areas and hillsides. Other SWC measures such as soil banding, *fanya juu*, sedimentation storage dams and the like should be widely practiced.
2. There should be sustainable land and water resources utilization in the area. Regarding rice cultivation, until detailed cost benefit study is carried out and recommendations are made, the current cultivation method should be improved. The cultivators should drain the water they hold during high flows back into the river channels before the next high flow starts.
3. Some buffer zones or free corridors should be created along the riverbanks where tilling is restricted so that the morphology of the rivers is maintained. On such corridors it is important to plant trees or grasses to protect further silt add up into the channels. These activities require land classification and planning. Therefore, there should be effective land use planning in the area.
4. It is important to consider Ramsar Convention on wetlands and the benefit of being a member. It may earn us in the delineation of Fogera area as a protected IBA site. As a result of this an alternative economic activity like tourist service rendering may emerge in the area whereby the plain plays its role of flood regulation and siltation take up and reduce the siltation of Lake Tana.

5. As a short term solution, actions that reduce flood damage such as building dykes and river training through dredging out of silt should be implemented.
6. There should be a viable preparedness where integrated monitoring and early warning system with a coordination and exchange of information among concerned bodies from the federal, regional and *wereda* levels.
7. There should be strong laws and regulations pertaining to land and water resources utilization. Where protection measures are deemed necessary the communities in such areas comply to fully participate or cooperate, and there should be law enforcement. More importantly the communities should be taught about the benefits of protecting their land.
8. Progress in the system of protection against flood hazard reduction depends highly on collecting and analyzing hydrological and meteorological data. The most important benefit of this process is to provide a timely warning or preparedness to mitigate flood hazards. Therefore, the organizations in charge of collecting and distributing these data should be reassured the importance of timely collecting and dissemination of the required data

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FLOOD HAZARD ASSESSMENT IN THE GHIBE-OMO BASIN: THE CASE OF 2006

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1. INTRODUCTION

1.1 Background of the Study

Flood is an unusual high stage of the river or the stage at which the stream channel becomes filled and overflows its bank. It occurs when the drainage basin experiences an unusually intense or prolonged water input and the resulting stream flow rate exceeds the channel capacity. It is also important to understand that floods are natural events that occur fairly frequently on virtually all streams. A stream that is unaffected by dams or other hydrologic modifications will typically over-flow its banks every one to three years (Dingman, 1994; Wisler and Brater, 1959).

From the human viewpoint, floods are relatively rare events and the gentle terrains of flood plain are commonly attractive sites for various types of development. However, flooding becomes a management and planning issue when it threatens the human life and property associated with such development.

The occurrence of higher flood magnitude has the implication on the amount of water which is leaving the catchment per unit time, the amount of soil that is removed, and on the destruction of material infrastructures. Thus, the occurrence of highest flood (maximum discharge) in certain specific area and time could tell us the higher probability of soil erosion, high damage on agricultural production, flooding of reservoirs, and loss of human and animal life. Besides these, it provides valuable information on the dry season water flow. In times of maximum flood, little fraction of the rainwater is left to recharge the groundwater and maintain the dry weather flows of the streams (Woldeamlak, 1998).

In the recent years, records of loss of life and damage caused by floods worldwide show a steady rising trend. In this regard, the response has been to call for increased efforts to protect life and property (WMO, 2005).

Even though the flood hazard is not a new phenomenon in Ethiopia, its magnitude and frequency has been increasing in recent decades. According to WMO (2003), the rainy season in the country is concentrated in three months, between June and September, in which 80% of the rainfall is received. Ethiopia has rugged topography with distinctly defined water courses. Torrential down pours are common in most parts of the country like lower Awash, *Ghibe-Omo*, *Baro-Akobo* and *Wabe Shebelle* river basins. Intensive rainfall in the highlands could cause uncontrolled soil erosion and land degradation, which leads to flooding by transporting heavy sediment into water bodies and reducing the capacity of the reservoirs (WMO, 2003).

According to Reuter (31 August 2006), all regions of Ethiopia were affected by the flood except, Harari and Benishangul-Gumuz Regional States. Overall 900 people were confirmed dead and about 199,900 people are estimated to be affected from which 35,000 were displaced.

Continuous heavy rainfall in the central highlands is responsible for the flash flood of *Omo* River, which caused massive destruction in *Dasenech* and *Nyangatom Weredas* (Districts) of South *Omo* Zone of SNNPRS.

In South *Omo*, government and NGOs have attempted to respond to the flood disaster which includes rescuing and provision of food and shelter to the displaced. The affected areas were visited by Prime Minister Meles Zenawi, the President of the SNNPRS, and other regional and federal higher officials on 18 August 2006. The government declared "state of emergency" in South *Omo* Zone.

Flood hazards of *Ghibe-Omo* basin claimed much lives and property loss. Therefore, assessing the causes is very important to formulate sustainable ways of minimizing the flood hazard around the *Omo–Ghibe* basin. Based on this, baseline survey was conducted in the basin by focusing on representative sample sites.

1.2 Objectives of the Survey

1. Identify and assess the major flood – triggering factors in *Ghibe-Omo* basin;
2. Analyze the impacts of the flood hazard in *Ghibe-Omo* basin;
3. Appraise the available flood disaster management practices at *Ghibe-Omo* basin; and
4. Generate policy relevant recommendations.

2. LITERATURE REVIEW

2.1 Environmental Degradation in the Ghibe-Omo Basin

The diverse land structure and climatic conditions of the *Ghibe-Omo* basin is ideal for biodiversity richness and diverse human activities. However, the current major environmental issue shows a considerable interconnection between the socio-economic developmental and its conservation. Today, increased human population caused increased deforestation, which leads to soil erosion, land degradation and reduction in biodiversity (MoWR, 1996).

In the basin there is a serious environmental degradation. The root cause of this degradation in both highland and lowland areas is the increased pressure on natural resources as a consequence of human and livestock population growth. According to the above study, population pressure in the basin has been mounting through time. In the coming 30 years human population density in areas of low soil degradation are expected to triple based upon current rates of increase coupled with anticipated in-migrants by people from heavily degraded areas.

Deforestation, which is exacerbated by population growth and increasing amount of land under cultivation or livestock husbandry, is leading to increased soil erosion. In the basin 9,000 km^2 area (11% of the basin) is covered with forest (MoWR, 1996). However, with progressive loss of forest cover, a pressure on the remaining forest is increasing. According to this study, in parts of the highland firewood supplies have been very scarce so that dung and crop residues are used as a fuel instead of used being as organic fertilizers. The presence of serious soil erosion was also reported by MoWR (1996). In the North-Western highland, areas where human population density is between 200 and 500 persons per square km, soils are eroded; in other highland areas where densities are less than 120/km^2 soil erosion is slight. According to the study, there is an exception in the densely populated Welayita-Sodo area (up to 450/km^2), where soil erosion is minimal because of the successful work of a local agricultural development unit.

Land degradation has also been exacerbated by fragmentation of plots. In addition to this, farmers have reiterated that their land plots are insecure, which has the effect of discouraging investment and land improvement. As a result, farmers are reluctant to invest in rehabilitating bare lands, which they suspect the likelihood of loosing it in the future reallocation (MoWR, 1996).

According to official reports (MoWR, 1996), human health problems in the basin are dominated by water-born diseases. The major diseases are malaria, bilharzia and onchocerciasis. On the other hand, trypanosomiasis in the highland areas and Tsetse infestations occur throughout the basin. Such kinds of disease outbreak commonly occur following summer rainfall and the resulting floods.

The collected environmental degradation and problems which are caused by human activities have an adverse negative impact on human beings. The major once are decline in agricultural productivity, shortage of fuelwood, flood hazard and widespread disease and loss of biodiversity.

3. SURVEY METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location

The *Ghibe-Omo* river basin is located in the Southwestern part of Ethiopia, between 4°30' and 9°30'N and 35° and 38°E. It is located in two Regional States, namely Oromia and Southern Regional States. The basin includes all or parts of 81 *Weredas*. It covers almost 79,000 km^2 area, which extends approximately 550 km in the north-south and 150 km in the west-east, which makes it one sixteenth of the whole country (MoWR, 1996) (Figure 1).

3.1.2 Physical characteristics

Climatically, there is a clear dichotomy of highland and lowland areas in the basin. Over the highlands, found in the northern part of the basin, the rainfall is higher, with mean annual rainfall exceeding 1,500 mm. In the lower part, the mean annual rainfall ranges from 400–500 mm. There is a distinct relationship between temperature and altitude, where highlands are cooler and the lowlands are hot and relatively dry, with low humidity and high evaporation.

Geologically the *Ghibe-Omo* basin consists of pre-cambrian crystalline basements. The geology of the basin underlies many of its most critical parameters such as topography, soils, land uses and related socio-economic characteristics, as well as potential mineral exploitation and hydro-electric power development (MoWR, 1996).

The soils are generally deep, well drained clays over volcanic rocks in the highlands; shallow on steep slopes and imperfectly drained in the gently slopping or flat upland basins and plains. In the southern lowlands of the basin, the soils include sandy, clay and loam over granite rocks with alluvial soils.

The vegetation in the *Ghibe-Omo* basin has been greatly modified by the effect of land use. About half the area is wooded grassland or shrub and the other half is partly under cultivation and partly fallow or grazing (Figure 2). In south of latitude 7⁰ N, the grasslands are scanty or denuded where the pastoralist graze their livestock. The most extensive forest areas are on highland, particularly to the west of the basin.

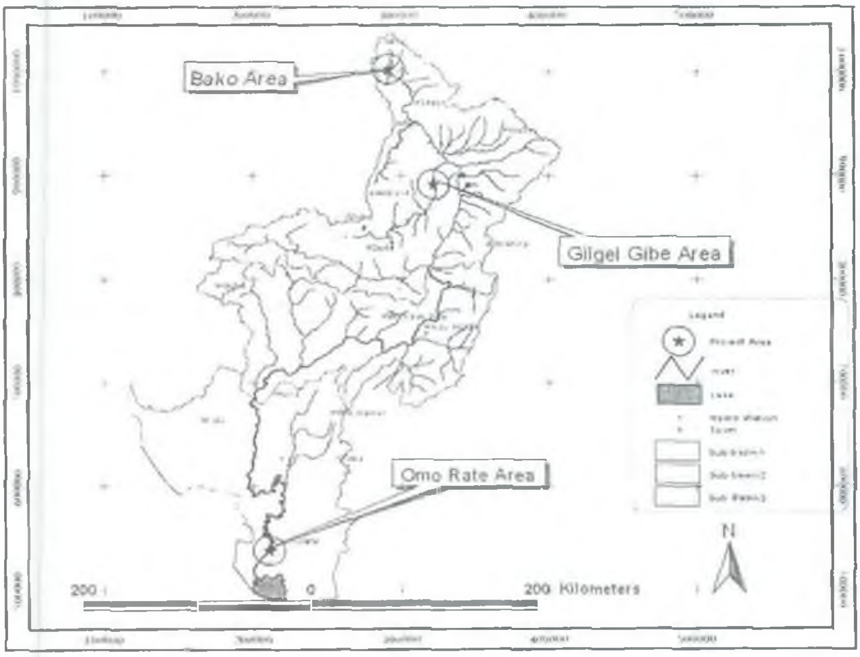


Figure 1. Map of Ghibe-Omo river basin.

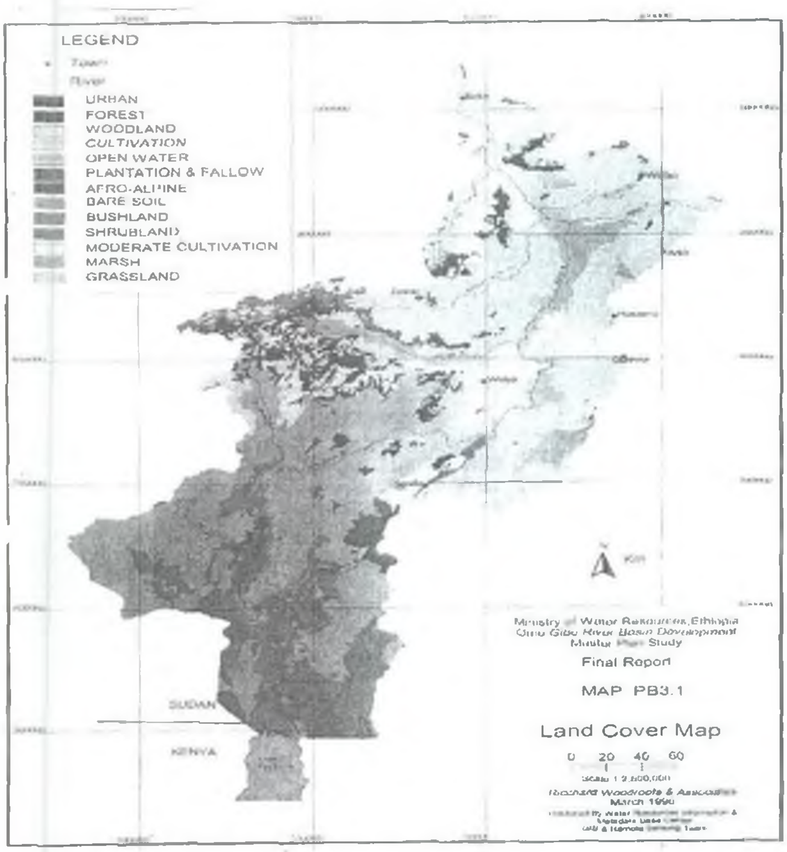


Figure 2. Land cover map of Ghibe-Omo basin.

3.1.3 Demography and economic activities

The *Ghibe-Omo* basin is inhabited by more than 6 million people having annual growth rate of 3%, out of which more than 80% live on highland areas and involved in crop cultivation and mixed farming, whereas the remaining percentage of population are living the lowland areas. The lowland parts of the *Ghibe-Omo* basin are utilized for pastoral farming. Generally land use within the basin reflects the land cover change with certain years. The highland is used primarily for cultivation, some times mixed with grazing (agro-pastoral). Patterns of land use change from 1973 to 1994 show an extensive conversion of forestland into farmland on the highlands and overgrazing in the lowland, which is due to rapid population growth (MoWR, 1996).

3.2 Data Sources and Types

The data used in this study are composed of primary and secondary. The primary data were collected through direct field observation, acquisition of pictures, interview with key informants, and focus group discussion with local community. The secondary data were gathered from books, newspapers, meteorological and hydrological Organizations.

Interviews of key informants were conducted at selected sites. In addition, participatory survey technique, i.e. Rapid Rural Appraisal (RRA) was employed. Five group discussions were held, in which three groups were selected from the affected area (lower *Omo* basin) and the remaining two were in the upper *Ghibe* basin. The focus group discussions were consisted of 7-10 members, which is composed of both sexes and different age groups (20-92 years old).

3.3 Procedures of Sample Site Selection

The flood hazard that occurred in the lower *Omo* basin in the *Dasenech* and *Nyangatom Weredas*, was caused by rainfall in the upland areas and the backflow of Lake Turkana. Of the two affected *Weredas*, the loss of human and animal life and the damage in property was the worst in the history of *Dasenech Wereda*. The *Wereda* has thirty administrative *Kebeles* with 44,729 resident populations. From the thirty *Kebeles* 14 have been reported flooded. Consequently, people from the 10 *Kebeles* were forced to leave the areas and sheltered at six temporary centers. The temporary sheltering centers are the *Agolches*, the *Awoga*, the *Selle*, the *Toltalle*, the *Langaton* and *Corengat*. Being relatively accessible, three shelters from the lower basin were selected for the field assessment. These were the *Awoga*, the *Agolches* and the *Toltalle*. Whereas *Amerti* village was selected for it is one of the flooded areas in the upper Ghibe-basin, where 116 households were displaced.

In the upper Ghibe *catchment field assessment was conducted in the* Bako *area,* Amerti *village and in* Sokoru Wereda *along the* Gilgel-Ghibe *dam and its surrounding areas.* Bako *area is selected because it is the source area of the basin. This area is characterized by steep slope. The areas around* Gilgel-Ghibe *are selected to survey the impacts on environment due to the dam and its related effects on flood events. The study sites in the upper* Ghibe-*basin are generally characterized by high population density, mixed farming (but mostly crop cultivation) and rugged topography.*

3.4 Method of Data Analysis

The data gathered were analyzed in qualitative and quantitative methods, while observations and focused group discussion were analyzed through descriptive method, rainfall and runoff data were analyzed using quantitative methods (mean probability of occurrence and recurrence time). Linear regression method was also employed to see changes in rainfall and runoff in the area. The probability of occurrence is calculated using the standard Hazen method (Viessman and Lewis, 2003).

3.5 Limitations of the Study

In the course of study some limitations have happened. The major constraint was time shortage. In a large river basin like the *Ghibe-Omo*, several days are required to collect data from several sample sites but that was not the case. Shortage of data was another constraint. There were no satellite images which was readily available to capture land use/cover changes in the study areas. In addition, incompleteness and the erratic nature of the rainfall and runoff data on were other challenges. At last, accessibility in the lower *Omo* basin (*Dasenech Wereda*) was challenging especially in the coastal area of Lake Turkana. Therefore, this survey has to dwell on the temporary sheltering centers.

4. RESULTS AND DISCUSSION

4.1 Flood Causing Factors in Ghibe-Omo Basin

As depicted in Sokolovskii (1971), WMO (2005), Dingman (1994), and Wisler and Brater (1959), causes of flooding are meteorological (mostly rainfall) and underlying surface conditions. Surface condition determines the amount of infiltration, the rate and the time of overland and channel flows. Since the most important underlying factors are settlement, urbanization, deforestation, and agricultural intensification, this section will focus and describe the background and characteristics of these factors in the study area.

4.1.1 Human settlement

According to the information obtained from *Bako* and *Sokoru Weredas*, resettlement program has been carried out in the *Ghibe-Omo* basin since the *Derg* regime. In the 1980s, the first larger settlers came from the drought affected areas of Wello. They settled in *Gojeb* and *Sailem areas*. In addition, 2,476 households were affected by the *Gilgel-Ghibe* project, who were latter settled in Jimma area (MoWR, 1996). According to the *Bako Wereda* Administrative Office, in 2005 more than 200 households, who have come from Harar, were settled in *Amerti* village. Similarly, more than 200 households were resettled in the *Selamago Wereda* of South *Omo* Zone from the *Konso Wereda*.

Almost all settlers are engaged in crop production and rearing of animals. This has caused a greater degree of land cover/use change in the basin. The information obtained from the group discussion have indicated that population pressure has been increasing at an alarming rate in the basin even due to the natural increase. The worst impact was experienced by re-settlement during the *Derge* resettlement program as it was carried out on the steep slope areas.

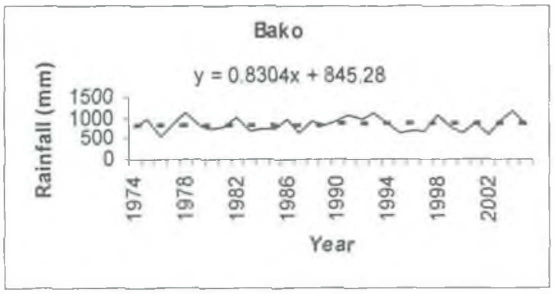
4.1.2 Rainfall regime

According to the FGD held at *Bako* and *Sokoru Wereda*, about 20 years ago, the rainfall amount and distribution was "normal". They said "although there were heavy rains, the area had never experienced such a heavy flood hazard." However, over the last 20 years, the rainfall was said to be significantly varied in the time of occurrence and intensity. As elders in the upland areas described, rain used to start falling early and continued falling for several months. In some other time, it started later and continued only for few months. According to them, the rainfall in 2006, which had caused the flood in August started early in April and continued until September. They also describe it as "unusual" and they said that "it rained day and night with high intensity."

Data obtained from the National Meteorology Agency for the two stations show that there has been an increasing trend of rainfall at *Bako* station and, in the contrary, a decreasing trend at *Sokoru* station (Figure 3). However, the change in the amount of rainfall was not statistically significant. These opposing trends of rainfall at the two nearby stations might have resulted from local factors such as rain shadow differential.

4.1.3 Flooding regime

Flooding in the lower *Omo* basin is not a new phenomena. Every year, the river outbursts from its bank. However, its magnitude, frequency and area coverage has been increasing from time to time. One of the informants told the survey team that large flood hazards occurred in 1998 and 2000 at lower *Omo* basin. With regard to the 2006, informants unanimously described that the flood in August 2006 was totally different in its amount, extent, and damage.



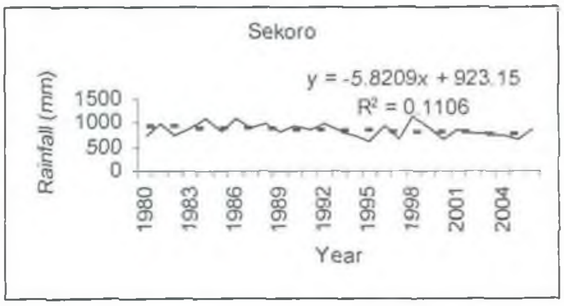


Figure 3. Trends of rainfall at *Bako* and *Sokoru*.

According to informants, in the upland areas of *Sokoru* and *Bako Weredas*, flood was not a common phenomenon. It was since 2004 that flood hazards become serious phenomena in them.

Runoff data obtained from MoWR for the *Amara* and *Gilgel-Ghibe* rivers revealed an increasing trend of maximum flow (Figure 4). Runoff in the summer season (June – September) has increased from 6.7 mm and 27.2 mm in 1981 to 42.8 mm and 44.6 mm in 2004 in *Ghibe* near *Bako* and *Amara* rivers, respectively. The rate of rainfall increase is 1.5 mm and 0.73 mm per year. The R^2 on the trend line show about 14.5% and 7.1% long term change during their period of records.

4.1.4 Deforestation in Omo – Ghibe Basin

According to MoWR (1996), large forestlands of the upland area was converted into farmland between 1973-1994. Moreover, information from the Natural

Resource Conservation Office of the *Weredas* of *Bako* and *Sokoru* and Jimma *Zone*, indicates that the deforestation practice in the area has continued at an alarming rate. According to these sources, before 25 years forest in the area was at good condition. For example, the Natural Resource Department of Jimma *Zone* reported that the forest coverage 25 years ago was about 25%. Much of the slopes and river courses were covered by forests, shrubs and grasses. However, since 1991 the forest resource of the area has been degraded and now the percentage of forest covered land is reduced to 16%. According to the office, the reasons for the alarming rate of forest degradation are two folds:

1. Agricultural land expansion including the slope lands; and
2. The 1987 forest proclamation that abolished check points, was leading to the cutting of prohibited species for timber production e.g. *Cordia africana* and *Hagenia abyssinica*.

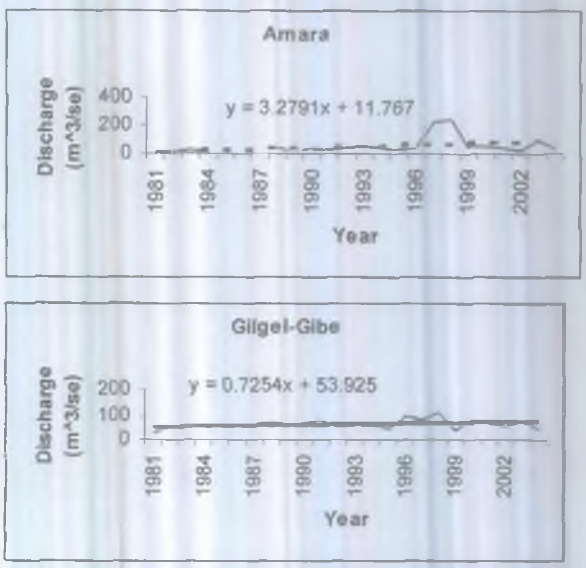


Figure 4. Patterns of discharge at Amara and Gilgel Gibe.

Such deforestation and its problems have not been restricted to the upland areas, it has also been happening in the lowland areas. According to the informants, the forest resources of the *Hammer*, *Benna* and *Dasenech Weredas* have been reduced significantly since the last 10 years. Informants ascribed the sharp reduction to overgrazing and the newly introduced crop farming. They added by saying "rapid population growth, absence of an alternative livelihood, lack of market for their cattle (off take) are also exacerbating the situation. Thus, the shrub, bush and forest coverage of the areas reduced, which exposed soils to wind erosion (Figure. 5).

4.1.5 Soil erosion

In the study area, large scale deforestation or land use/cover change are the major causes of soil erosion. Information obtained from group discussion indicated that soil and water conservation measures are hardly employed in the study area (Figure 6). One of the informants stated that "when I was a child I used to swim in a clear river water of Alenga, but these days the Alenga river water is muddy and not good for swimming." This key informant also recounted that there was extensive vegetation cover on the steep slope areas and the riverside. Presently they are gone and therefore higher rate of soil erosion is taking place (Figure 7).

Figure 5. Photo showing absence of vegetation and exposure of soils to wind erosion; Omorate area.

During the field survey, it was observed that the *Gilgel-Ghibe* Hydroelectric Power Generation Project has given inadequate attention to the preservation of natural resources. The landslide problem around the dam areas has generated huge sediments to enter to the dam.

Figure 6. Land disturbance due to dam construction: *Gilgel Ghibe*.

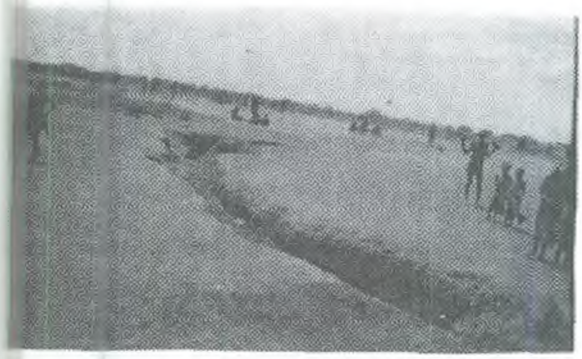


Figure 7. Development of gullies: South *Omo*, *Omorate* area.

4.1.6 Socio-economic development

Among the various socio-economic activities in the region, the *Gilgel–Ghibe* Hydro-electric Power Generation Project, the Addis Ababa–Jimma asphalt road construction, and the expansion of urban centers are the major developments. The *Gilgel-Ghibe* HEP Project was completed in 1994. Its construction was envisaged to respond to the increasing power demand of the country by annual production of 722 million KWH, regulate water flow for down stream areas, and bring about socio-economic development (MoWR, 1996). The project was also committed itself to implement the World Bank's Environmental Impact Assessment (EIA) guidelines.

In accordance with the EIA, the HEP project has undertaken a rehabilitation work on the degraded environment. According to the Environmental Monitoring Unit Report (2004), in lieu of the 300 hectares of deforested around the reservoir area, about 400 hectares of land was reforested in the buffer zone in the period between 2001 and 2004. So far about 775,000 trees of various species have been planted especially on the soil erosion prone areas. According to this report, about 75% of the planted trees have survived, which is encouraging. Landscaping operation and final clearing up of the abandoned construction facilities in the areas were also conducted.

However, according to the information obtained from an informant, some of the damaged areas were not rehabilitated. Those areas include quarry sites and the road construction areas. These areas are now vulnerable to soil erosion. However, it has also been reported that the quarry was left open because it was needed by the local administration to use it for quarrying for the Addis Ababa-Jimma Road Construction Project.

The resettlement program which was carried out by EEPCO was considered a "successfully accomplished", which was appreciated by the Ethiopian Parliament in January 2001, the World Bank in June 2001. According to the Environment Monitoring Unit report (2004), all members of the households were given 2.5 hectares of land during the resettlement phase, which is one hectare more than the previous farmland in the area of origin. It also indicated that about 231,900 trees were planted in a communal forest and homesteads of the nine resettlement sites. After completing the resettlement program, EEPCO has handed over all the resettlement development activities to the local government of Oromia, Jimma Zone.

However, despite all those efforts, there were self initiated settlements who resided in areas above the dam site. These people do not undertake environmental protection measures, such as soil and water conservation and afforestation. According to the informants, in *Sokoru Wereda* those settlers cultivated the steep areas and river banks. In this regard, the resettlement program seems to be successful in its process of operation. However, the absence of successive evaluation on the potential impacts of the settlement on the dam the area is being seriously degraded which would have a potential impact on the dam.

In addition to these, according to one of the informants, more than 1000 km gravel road was constructed to link different towns in the basin (mainly in the upland areas), which could significantly reduce the forest or natural land cover, facilitate soil erosion and change channel of streams in the watershed.

4.2 Impacts of the Flood

Although floods in the region were benefiting people in many ways, the 2006 flood has caused unprecedented damage on human life, material properties and economic activities and disturbed the ecosystem. It also caused further damages on human behavior such as moral and psychology.

4.2.1 The damage on human life

According to the government report on Aug. 21, 2006 and the field observation from *Dasenech Wereda* administrative office, about 364 people were confirmed dead, and more than 18,000 people were displaced from 10 villages. However, according to the Reporter English weekly private Newspaper (Aug. 19, 2006), the number of dead people was more than 400. However, the life rescue operation was not carried out in four *Kebeles* due to the inaccessibility of the areas. It is, therefore, simple to speculate that there were even more number of dead and displaced people than what had already been reported. To further complicate the flood disaster, there were outbreaks of water-born and related diseases. The major diseases are presented in Table 1.

The most affected group of the society was children. According to a key informant in Omerate health center, medical treatments have been undertaken by medical staff as much as possible to the out reach of the affected people. However, it was reported that there was a serious shortage of drugs for children.

In fact what the survey team has observed was a totally different situation. People were not provided with mosquito nets while there was malaria outbreak. In addition to this, the food items were inadequate. According to the informants, women, elders, children and disabled people were affected more by the flood hazard.

Table 1. Types of diseases and number of affected people in lower *Omo* basin.

No.	Types of diseases	No. of affected people
1	Malaria	184
2	Diarrhea	146
3	ARI	121
4	Dysentery	25
5	Measles	9
6	Skin and subcutaneous infection	8
7	UTI	7
8	Ameobiasis	5
9	Otitsmedia	4
10	Injury	3

4.2.2 Damage on material properties

Since the flood occurred over larger stretches of areas (about 14 villages) in *Dasenech Wereda*, the existing poor infrastructure and material assets were substantially destroyed. According OCHA (22 Aug. 2006) and the *Dasenech Wereda* Administrative Office, over 3000 heads of cattle were confirmed dead. In the group discussion held at *Awoga* and *Agolches* sheltering centers, people told the survey team about the death of their cattle due to water-born diseases. The flood victims have lost all their stored crops in granaries, houses, clothes, utensils and other properties. They said "now we have nothing in our hand, we are waiting for the government for every thing that we need." It should be noted that prior to the flooding, the people were living under extreme poverty. The damage of the basic social services such as schools, clinics, water supply schemes and veterinary centers has aggravated the problem.

4.2.3 Impact on ecosystem

Flood in the study area had both negative and positive impacts on the ecosystem. To begin with the positive impacts, the flooding of the *Omo* River over the vast and dry area serves as a source of water for the vegetation and animals. It also bring abundant amount of soil to the flooded area from the uplands. It was learnt that sometimes the flood brings fishes to the people. The flood also helped for the enhanced growth of pasture for cattle and other wild animals. However, in 2006 its negative impact outweighed the above positive impacts. The floods have caused serious repercussions on plants and animals.

Since recently, the river water brought larger amount of sand and silt with it from upland and deposited them in the river channel of its lower course, in the lake, and other flooded areas. The new silt and sand buries the fish and other aquatic animals. On the other hand, the death of over 3000 heads of cattle (OCHA, 23 Aug. 2006) and other domestic and wild animals certainly affected the local ecosystem.

4.2.4 Impact on human settlement and economic sector

In the *Dasenech Wereda* flood occurred in 14 villages located in 10 *Kebeles*. These villages were seriously affected. People were forced to move to the temporary shelters or to higher grounds. Of course, in normal condition, pastoralism is the people's economic activity, hence people used to move with their cattle in search of water and pasture. This was before the flood of this year, 2006.

This time, however, there was not enough grazing and settlement lands spared from the flood. Following the flood event, there was an outbreak of animal diseases. According to the information obtained from the group discussion at *Agolches* temporary snelter, the cattle were infected with diseases and died out of it. Despite the seriousness of the problem vaccination was started after 20 September 2006. According to one of the informants, due to the difficulty of movement within the affected areas the number of dead and infected cattle by the outbreak of diseases was not known. According to the *Dasenech Wereda* Agriculture and Rural Development Office, animal diseases such as anthrax, pasterellosis, CBPP, CCPP, trypanosomiasis, and external and internal parasite were identified in the area.

The flood hazard also has affected and damaged the agricultural sector. The flood washed away many hectares of cropland from the upland areas and deposited it on the farmland in the plains. The best example is the damage of 90 hectares of agricultural crop in *Amarti Kebele* (upland area). The flood has also damaged more than 150 hectares of farm land in the *Dasenech Wereda*. According to the *Dasenech Wereda* Agricultural and Rural Development Office, "these are the only farmlands that cultivate sorghum and maize, but now destroyed."

Moreover, the affected people become unable to cultivate sorghum, their staple food crop. This is because of the loss of their houses, agricultural tools, and the stored seeds. In this regard, the *Dasenech Wereda* Agricultural and Rural Development Office reported that more than 1,500 hectares of cropland remained uncultivated.

The survey team was also informed that the *Dasenechs'* who lived in the island, local and cross boundary (with Kenyans) trading relations are interrupted. The *Dasenech* in the right side of *Omo* river were unable to sale their cattle to the Kenyans at reasonable prices. This is because the Kenyans (the Turkana) feared the cattle would die and could transmit water bom diseases to theirs. The flood event has also posed negative impacts on tourism in the region as the Mago National Park become inaccessible.

Although minor conflicts over resources are common in the region, flood has aggravated them. According to Pact Ethiopia (Local NGO working on conflict resolution), about 16 donkeys were taken away through raids by a group of *Hammer* people from the the *Dasenech*. In addition, the Turkanas of Kenya have feared the outbreak of water-born cattle diseases at *Dasenech*, and there was enhanced tension between the two. However, those conflicts were not as such serious to the extent of costing human life. Rather, negotiations were through the support of Pact Ethiopia and EPaRDA from the Ethiopian side and Ream-Ream from the Kenyan side.

4.3 The Flood Causative Factors

Often floods are triggered by meteorological events combined with topographical features, such as slope, soil, vegetation and human activities (land use/cover change) (WMO, 2005).

In the study area, it was reported by the National Meteorological Agency (AFP, 23 Aug. 2006), and OCHA, on 22 Aug. 2006, the heavy rainfall in the upland, the release of water from *Gilgel-Ghibe* dam, and the back-flow of water from the Lake Turkana were mentioned as the major causes of the 2006 flood hazard at the lower *Omo* basin.

At the time of flooding, there was no rainfall in the area, but the river and the lake have received more water from the rainfall in the upland (*Kaffa*, *Jimma* and Western Showa) areas. The community (elders) in *Bako* and *Sokoru* areas informed us that the summer rainfall in 2006 was unique. They explained this by saying "it rained day and night" continuously. They also confirmed that the rain started unusually early in April and extended up to September. According to them, the intensity was also higher than usual. It was said that "at times it was raining as if the sky was torn apart."

The high amount and intensity of the rainfall in the upland areas, combined with the steep slope physical features of the study area has resulted in a severe flood hazard in the lowland areas. The timing of the flood event was also unusual as compared to the previous years. This is explained by key and group informants at *Awoga* and *Aaolches* temporary centers that in the previous time, flood used to happen in September. Thus, they used to leave the flood vulnerable areas right before the onset of flood, usually at the end of August. In 2006, the flood started so early (i.e., early August), which caught the people at the island before moving out.

Equally important, the physiographic characteristics of the basin and human activities such as land use/ cover changes are partly responsible to the recent flood. Rapid environmental degradation (deforestation and soil erosion) has become a major phenomenon in the basin. Especially, the unsustainable human settlement, poor agricultural practices, uncontrolled timber production, emerging urbanization and the rapidly increasing human population are exacerbating the environmental degradation in the area, which in turn aggravated the flood hazard.

Deforestation at upland areas reduces the rate of soil infiltration and reduces the lag time of surface runoff and facilitates soil erosion. Deforestation also reduces the amount of water that would be intercepted which would have been later converted into vapor. It also reduces the water holding capacity of the soil due to the reduced organic matter in the soil. The cumulative effect of all these has caused a serious flood event.

In the study area, as has been observed, steep slope areas are already cleared and used for crop cultivation. Thus, voluminous soils are washed away by the rivers and deposited in the lower course of the river channel and the bottom of Lake Turkana. Such phenomena causes two major events in the flooded areas.

1. Reduction of the depth of the river channel, which leads to river outburst and flooding the surrounding area, and
2. The over flow of Lake Turkana, followed by back flow.

On the other hand, the reduced vegetation cover due to overgrazing in the lower basin has exposed the soil to wind erosion. As one informant explained the rate of occurrence of the speed of wind has been increasing from time to time. Consequently, the elevation of the river bank has been reduced and made it easy for the river to overflow (Figure 8).

According to the Environmental Impact Assessment conducted by (MoWR, 1997) the *Gilgel-Ghibe* Hydroelectric Power Project has imposed environmental destruction during its preparation, construction and operation phases of activities. According to the report, about 300 hectares of riverine forest have been destroyed. It has also reduced the down stream riverine forest located 16 km away from the dam. In the report it was mentioned that most affected environmental areas were left without rehabilitation. The survey team has also ascertained the issue through the information obtained from the Natural Resource Department at *Sokoru Wereda*.

Figure 8. Flood affected parts of lower *Omo* area, mainly due to wind erosion of the bank.

According to Wisler and Brater (1959), rapidly urbanizing areas are responsible for the increment of flood flows. According to them, every new home reduce the infiltration capacity of these residential areas near to zero. As the result storms collect and convert this water into stream channels with the possible increase in peak flows.

Moreover, the release of water from the dam has aggravated the magnitude of the flood hazard. Water from the dam was released officially through the spill-way on 16 August 2006, which was 3 days after the flood event took place in the lowland area. The released water amounted to 113.92 m^3/s on August 16, 213.6 m^3/s on August 17. From 18-24 August, 128.16 m^3/s water was released and from August 25-31 160.20 m^3/s of water was released. In this regard, on average 146 m^3 water per second has been discharging as spill-way during August 16-31, 2006. The maximum water level of the dam is 1671 m above sea level. The water reached at its highest level on 17 August 2006 which was 1671.62 m above sea level. On this day about 213.60 m^3/s water was discharged as spill-way and 88.72 m3/s as turbine discharge, together about 302.32 m^3/s water was discharged to the down stream flow.

In addition to the spill-way, there was also turbine discharge. In this regard, the total amount of water discharged as spill-way and turbine discharge to the down stream increased from 85.63 m3/s on 15 August 2006 to more than 201.08 m^3/s during August 16-31, 2006. As it is compared to the long-term average which is 164.74 m^3/s recorded during 1967-1997, the stream flow during August 16-31/2006 is greater by 74.39 m^3/s or 45.16 % (Table 2, Figure 9).

From the above discussion it is possible to boldly state that the released water from the dam contributed its part in exacerbating the flood hazard of August 2006. It exerted its own impact in the rescue operation carried out in lower Omo.

4.4 Survey of Good Practices

In the *Ghibe-Omo* basin, there were some important practices that have been carried out to deal with the reduction of flood and the damages that would be caused. In this connection, watershed management activity in the upland area was observed during the field survey. This is the *Abelti* watershed management in *Sokoru Wereda* financed by German Bank with Sun-Oromia. The management activity is done by introducing and implementing watershed management through community participation. However, the project is limited to small area (in two villages of the *Sokoru Wereda*). Besides, the dam itself has a role in regulating the river water across the year.

In the lower *Ghibe-Omo* basin there are also some good practices undertaken by government and NGOs. In the last three years, they introduced afforestation and soil conservation programs to the local people. The other good practice is on the social aspect. Conflict resolutions by Pact Ethiopia and EPaRDA are worth mentioning for they were successful. This was explained well by an informant who said "we know when conflicts are to happen so that we prepare ourselves to reduce the risks." Often flooding is responsible for causing conflicts in the area. According to the informant, "it is during flood hazards that the Turkana and the *Hammers* raid the cattle of the *Dasenech*." In spite of the devastating flooding in August 2006, the *Dasenech* people were not exceptionally raided by these people. It seems that less magnitude of raids took place as a result of the existence of conflict resolution practices in the area.

4.5 Appraisal of the Adopted Flood Management

4.5.1 Flood management institutions

In the study area there were no responsible institution that was managing the flood disasters both at the upland and lowland areas. In fact, the Agricultural and Rural Development experts at *Bako* and *Sokoru Weredas* felt that they are responsible for soil and water conservation, activities. They informed the survey team that there are no budget and experts assigned to the work. In addition, there was no communicated and coordinated work during the pre- and post-flood management between the upland and lowland areas.

On the other hand, the participation of non-governmental institutions in the watershed management is also limited. The GTZ with Sun-Oromia has been involved in limited areas of afforestation and soil and water conservation activities.

While there have been flood events every year in the *Dasenech Wereda*, the situation was not considered as a problem since it brings water and soil to the area, which helps crop production and pastureland. In general, it can certainly be said that the practice of flood or watershed management in the basin has been limited.

Table 2. Water level (meter a.s.l.) at *Gilgel-Ghibe* dam and the amount of released water (m^3/s).

Date	July			August			September			October	
	Water level (m)	Spill-way Disch. (m^3/S)	Total Disch. (m^3/S)	Water level (m)	Spill-way Disch. (m^3/S)	Total Disch. (m^3/S)	Water level (m)	Spill-way Disch. (m^3/S)	Total Disch. (m^3/S)	Spill-way Disch. (m^3/S)	Total Disch. (m^3/S)
1	-	0.00	45.87	1664.62	0.00	78.62	1671.37	50.00	147.55	23.93	104.18
2	-	0.00	30.36	1663.05	0.00	79.98	1671.37	50.00	144.43	21.44	112.47
3	-	0.00	51.88	1665.42	0.00	75.23	1671.32	50.00	132.86	16.73	108.53
4	-	0.00	62.08	1665.74	0.00	80.92	1671.31	106.80	192.75	13.12	103.98
5	-	0.00	53.23	1666.05	0.00	85.03	1671.29	50.00	143.69	10.45	90.52
6	-	0.00	39.81	1666.24	0.00	65.44	1671.35	50.00	142.04	9.19	95.29
7	-	0.00	54.25	1665.53	0.00	76.09	1671.42	156.64	251.29	7.99	91.89
8	-	0.00	41.32	1666.86	0.00	77.26	1671.50	192.24	282.80	6.85	83.07
9	-	0.00	29.07	1667.17	0.00	82.57	1671.49	50.00	135.24	6.30	88.73
10	-	0.00	47.03	1667.48	0.00	71.36	1671.46	50.00	142.56	6.85	89.94
11	-	0.00	51.96	1667.94	0.00	87.05	1671.42	50.00	127.34	7.42	92.52
12	-	0.00	49.10	1668.49	0.00	78.79	1671.42	50.00	118.68	8.59	98.32
13	-	0.00	54.25	1669.00	0.00	64.74	1671.41	50.00	113.08	7.99	96.64
14	-	0.00	59.87	1669.6	0.00	80.62	1671.39	50.00	112.74	6.85	92.53
15	1659.1	0.00	70.06	1670.13	0.00	85.63	1671.36	50.00	120.72	5.25	80.88
16	1659.6	0.00	34.61	1670.62	113.92	201.28	1671.13	135.28	224.22	4.27	91.18
17	1660.0	0.00	64.52	1671.05	213.60	302.32	1671.26	50.00	123.55	2.13	72.29
18	1660.3	0.00	78.63	1671.28	128.16	213.20	1671.46	50.00	126.62	0.15	89.34
19	1660.6	0.00	55.59	1671.38	128.16	214.30	1671.53	50.00	134.47	0.00	90.95
20	1660.9	0.00	68.03	1671.38	128.16	207.45	1671.62	50.00	135.53	0.00	90.95
21	1661.2	0.00	69.67	1671.38	128.16	219.38	1671.66	50.00	138.15	0.00	86.95
22	1661.4	0.00	64.80	1671.35	128.16	226.23	1671.69	50.00	138.15	0.00	70.80
23	1661.7	0.00	48.16	1671.36	128.16	226.58	1671.71	50.00	143.43	0.00	75.44
24	1661.9	0.00	66.86	1671.36	128.16	223.88	1671.71	50.00	121.85	0.00	74.52
25	1662.3	0.00	67.54	1671.28	160.20	269.49	1671.73	50.00	138.75	0.00	75.84
26	1662.5	0.00	74.34	1671.25	160.20	259.18	1671.72	50.00	142.16	0.00	72.65
27	1662.8	0.00	75.38	1671.35	160.20	244.52	1671.70	50.00	118.14	0.00	83.46
28	1663.1	0.00	64.68	1671.40	160.20	248.24	1671.72	50.00	132.49	0.00	78.91
29	1663.4	0.00	69.49	1671.42	160.20	255.55	1671.70	50.00	138.29	0.00	72.84
30	1663.7	0.00	55.42	1671.41	160.20	259.80	1671.66	50.00	139.09	0.00	70.79
31	1664.2	0.00	77.20	1671.39	160.20	254.63	1671.50			0.00	81.09
Av.	**1661.7**	0.00	**57.26**	**1669.15**	**75.68**	**161.14**	**1671.50**	**63.03**	**146.76**	5.34	**87.34**

With regards to the flood management, a number of humanitarian *organizations* and *the Government* were largely involved. From governmental *organizations the National Defense Force, DPPC,* Regional Police Force, etc were involved. From the NGOs, *Action Aid, Farm Africa, Pact Ethiopia* and EPaRDA and other UN family humanitarian institutions, such as ERCS, UNICEF, WFP and

OCHA were participated. According to OCHA (22 Aug. 2006) the coordination efforts were undertaken by OCHA at all levels. According to the *Dasenech Wereda* Administrative office all these institutions had been actively involved in life rescue operation, provision of food, medicine, clothes and other facilities.

4.5.1 Problems faced in rescue efforts and rehabilitation activities

Even though a number of governmental and non-governmental institutions have participated in the reactive flood management, the rescue and rehabilitation operations had suffered from some problems.

For the rescue and relief operations government has played a pivotal role. Three army helicopters and 16 motor boats were involved in the campaign. However, the heavy rain, swirling waters, mud, silt, and bush have hampered efficiency of the effort. According to AFP (Aug. 2006) and OCHA (22 Aug. 2006), four *Kebeles* with more than 3,000 people were in need of urgent relocation. The *Kebeles* had no access to land transportation. These *Kebeles* were also unreachable by boat and helicopters. Thus food and other materials were dropped to them from helicopters.

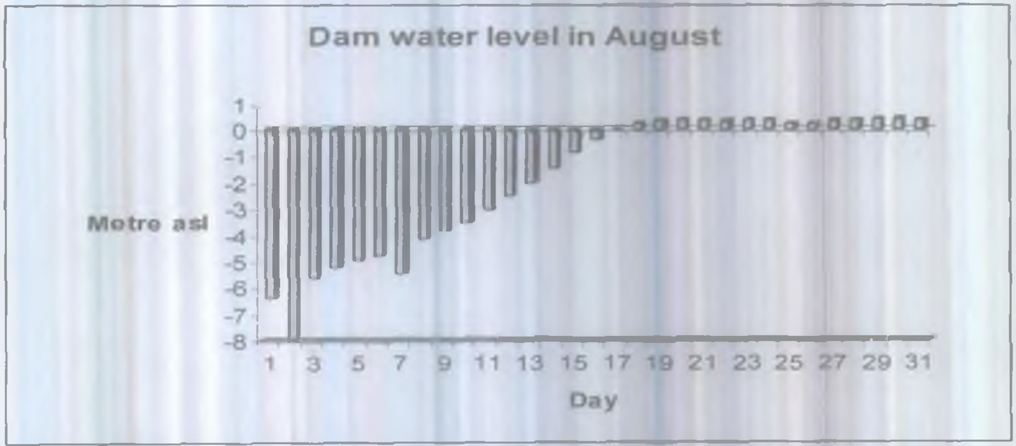


Figure 9. Variability of water level in the dam in August.

It was also reported that some victim were reluctant to leave their cattle. Others were reluctant for cultural reasons, i.e., circumcision processes. In addition, over 4,000 people have refused to leave their cattle in the flooded area. The police officer stated that despite assurances that the government would take care of their livestock in the process of relocation, they refused to leave."

The extreme remoteness of the flooded areas (*Dasenech* and *Nyangatom*) which are > 300 km from the *Zone* Capital Jinka, has aggravated the rescue effort. Besides, the lack of means of communications like telephone, fax and e-mail has worsened the rescue operations.

Although government, NGOs , and the community have participated in the the relief and rehabilitation, the amount of ration handout was not adequate, which was 15 kg per household per month. Health problem, shortage of materials and management problems were also observed during the field survey. As a result, women and children were severely affected. According to the group discussion with community at *Awoga* temporary shelter "children had neither adopted the ration nor obtained alternative food were forced to experience ill health condition and hunger". For example, at *Awoga* temporary shelters the survey team observed 70 women who recently gave births. One women, who had given birth five days before the discussion (on 19 September 20006) told the team that she was not treated according to her culture and traditions. She got no appropriate food for herself. Her case explains the general situation and would be presented below.

> *"I have not gotten any special treatment from the relief operation. If I were at my home, I would get special attention from my husband. He would slaughter fatten goat, buy new clothes to me and the infant. I would also consume animal products such as milk and butter. But here I am forced to eat dry ration like biscuits.*

It was also noted that the victims were new to the cooking utensil they were provided with. They had no knowledge and skill on how to prepare the new food item (wheat powder) into food. To solve the problem, demonstration was carried out to the women by health officers of EPaRDA (Figure 10).

There was also poor medical provision. The informant generally expressed the grievances about lack of proper medical provision. The situation observed during the field survey indicated the health problem was serious. In addition, there was shortage of mosquito nets. According to them "only one mosquito net was given for one household and it could not protect the whole family." They also added that, in times when one of the wives gave birth the net was often given to her and the rest of the family members were exposed to mosquitoes.

Figure 10. Photo showing demonstration given by health officers (of EPARDA) on how to prepare food from wheat flour at *Agolches* sheltering area.

The worst of all, in the reactive flood management activities was the absence of treatment (relief assistance) for certain group of the victims who came to the temporary shelter very late. These people come to the shelters by their own traditional wooden boat and others. These people stated that "we had no access to the rescue operators and were not willing to leave the elders, sick people and cattle behind alone." These people were denied relief assistance. As a result, they were forced to appeal to their neighbors for survival (Figure 11).

Figure 11. Photo of people that did not get any relief assistance at *Agolches* sheltering centre.

Generally, it can be said that efforts of the government and NGOs in relief and rehabilitation operation were handicapped. The relief operation failed to give priority to the most vulnerable groups of society, i.e. infants, children and women (especially those who gave births). Similarly, there was a great discrepancy between material provision and the number of new comers.

5. PROBABILITY AND FREQUENCY OF FLOOD FLOWS

The maximum (peak) flows are usually the higher stage of a river. It is a stage at which the stream channel fills and overflows. Analyses of these events are very important to reduce the damage caused by floods. In this regard, the most important information needed is the "probability" and "frequency" of high flows. Here, to analyze the probability and frequency of occurrences, extreme maximum daily record was considered.

The probability and return period of the annual maximum series was computed. The probability indicates the likelihood for an annual maximum to be equal to or fall below the indicated amount. Thus, the 50% probability approximates to the long-term average of the series. That is 50% chance that an annual maximum in any one year can be equal to or less than the long-term mean of the series. In this regard, there is a probability of about 5% the annual maximum series, will be less than or equal 3.39 m^3/s at the *Amara* and 10.83 m^3/s at *Gilgel-Ghibe* station, hence at a probability level of 95% the annual maximum series are greater than the indicated amounts.

In about 95% the annual maximum discharges at *Amara* and *Gilgel-Ghibe* stations, respectively, are less than or equal to 104.76 m^3/s and 41.32 m^3/s, respectively. There is also a probability of 5% that the annual maximum discharges will exceed the above figure in any year. Importantly the long-term average of the flood discharges exceeds 50% of the total flood events.

On the other hand, frequencies are the average time intervals in years between two events of various magnitudes. Recurrence intervals are the inverse of probabilities. Thus in every 1.01 years, a flood of about 3.39 m^3/s at *Amara* and 10.83 m^3/s at *Gilgel-Ghibe* would exceed, respectively.

However, the recurrence period is not a fixed time interval; the event can occur in any year within the fixed interval. In this regard, the highest maximum flow, i.e. 104.76 m^3/s and 41.32 m^3 /s at *Amara* and *Gilgel-Ghibe* station, have a probability of about 64.09% that these magnitude will be equal or exceed at least once in their return period.

Analyses of the past and present causative factors certainly indicate that there would be higher magnitude of future flood events and damages in any river basin (WMO, 2005). In this regard, the rapid population growth (3% per annum) in the *Omo* basin would exert greater pressure on the natural resources of the basin. In the upper *Ghibe* basin, there is high degree of forest destruction, cultivation of steep slopes, rapid process of urbanization and settlement. These all could increase the peak-flow and soil erosion. Unless urgent interventions measures are undertaken through proper flood management, even a small amount of rainfall will cause peak flow that can cause damaging floods in the basin.

Mismanagements of the developmental project undertaken in the catchment are the other factors for increased flood hazard. Any development projects should give due regard for environmental conservation. Increasing human population has direct relation with the increasing cattle population in the lower *Omo*. This commonly results in overgrazing, destruction of natural vegetation and increased soil erosion.

The future rainfall scenario of Africa as it was analyzed by Hulme *et al.* (2001) and Conway (2000) indicate an increasing and high probability of rainfall in Ethiopia. According to Hulme *et al.* (2001:161), the Global Climate Model (GCM) generates the most extreme wetting scenario in Ethiopia. This is due to the global warming or rising sea surface temperature. Therefore, an increased flood hazard would likely occur in the future.

6. CONCLUSION AND POLICY IMPLICATIONS

6.1 Conclusion

Flood is not new phenomenon in the Lower *Omo* Basin. It is a year to year event. It is also the source of livelihood for people in the area. In recent years, however, its damaging impact outweighed its advantage. The flood area coverage, its frequency and magnitude has increased in recent years. Consequently, its impact on the people, animals and ecosystem has become immense.

The 2006 flood hazard was unique and caused greater damage on human life, animal life and material infrastructures. The flood event killed more than 364 people, it displaced more than 18,000 people (Figure 12), killed more than 3,000 cattle, damaged 760 traditional grain stores and agricultural crops on 240 hectares of land. It also has damaged several schools, clinics, and veterinary services. Moreover, the recent flood hazards has totally disturbed the nomadic lifestyle and caused moral and psychological effect on the victims at *Dasenech Wereda*. Currently, the people are awaiting the charity hands of the government and NGOs for every thing.

The increasing flood event in the recent years is attributed primarily to the environmental degradation such as deforestation and soil erosion, caused by environmentally abusive settlement program, overgrazing and land mismanagements by the development projects in the catchment.

Figure 12. Some of the displaced community at *Dasenech wereda*, Awoga village.

The continued environmental degradation, settlement program, ignorance of watershed management and lack of environmental conservation measures together with the increasing trend of rainfall amount suggests the probability of higher flood to happen in the study area.

6.2 Policy Implications

Although floods are natural, we can manage them. Flood management could help to harness floods for economic developments and to reduce damages on human life, material properties, and on environment. Unlike other countries, floods in Ethiopia have not been used for economic development.

In order to use floods for economic purposes and to reduce their damaging impacts, there must be a clear and feasible water resource policy. To achieve this task, the contribution of flood needs to be recognized at the policy level. In Ethiopia the water policy was enacted in 1999, which is very recent. In this policy, less emphasis is given to flood related issues. In the policy, it is stated "... protecting and controlling flood hazards ...".

In addition, the strategies of the MoWR (2001) emphasizes on the structural measures. Besides, the sustainable means of flood management through watershed management and an integrated socio-economic development approaches are not advocated. The other issues is that there are no flood early warning system known to all the respondents of the study.

Government should lay the legal basis to set rules, regulations, and directives to rehabilitate and protect the degraded environment through the afforestation scheme where people at the grassroots level should take the lead. It is also necessary to set guidance on the population settlement programs provided with alternative source of energy and income for settlers. In this regard, steep slope should be strictly allocated to the afforestation program.

Development projects, mainly at the *Gilgel-Ghibe* HEP project should strictly implement the World Bank's EIA guidelines. Rehabilitation should not be a one time action. This project should involve local farmers especially those who are located at the above the dam site. In this way the *Gilgel-Ghibe* HEP and the other proposed dam sites should revise their implementation of EIA.

Absence of alternative economic activities or job opportunity has its own implication on the severity of the flood hazard in the flood prone areas. It is therefore important to address such issue in the local development plan in the area. In the group discussion at *Awoga* shelter, elders, children and women would be interested, if assisted by the government, to take part in the crop production practices in the flood free areas of the locality.

During the field survey, the team did not see any proactive and integrated work in the control of flood hazard. According to key informants at *Sokoru* and *Bako Weredas*, no efforts were made to integrate socio-economic development tasks and natural ecosystem conservation measures. This gap need to be addressed by the policy

The inadequacy of institutions is another setback identified in this study. Even the mandate of the available institutions is not clearly known. According to the informants in the *Dasenech*, *Bako* and *Sokoru Weredas,*, there is no government body that is responsible to the flood management. According to them, it is only after the flood took place that an ad hoc committee is set up to carry out a reactive flood management measure. Usually, members of the ad hoc committee are representatives of the police, the office of Agricultural and Rural Development, Health office and *Wereda* administration, chaired by the *Wereda* Cabine Head.

The other policy issue is the absence of communication and coordination between the upland and the affected areas. But it is very vital to make fast information communication during the time of heavy rainfall in the upland area.

The conflict management practice which is operated by the NGOs is a very good beginning. However, such practices should be strengthened through government bodies

The other important thing is data acquisition system. The availability of rainfall and runoff data in the basin is very poor due to few recording stations when compared to the large area coverage of the basin. Even the available recording stations are not functioning well, which are handicapped by short period data with enormous degree of errors. It is therefore imperative to strengthen and the existing recording stations and establish new ones with improved the data acquisition techniques.

One of the most important factors that the current policy has totally ignored is the growing threat of global warming. Emphasis must be given to this issue because of its link to the extreme weather and hydrologic events. Some studies have reported the positive correlation between increasing rainfall in Ethiopia and the rising of sea surface temperature over Atlantic and Indian Ocean (Conway, 2000; Hulme *et al.* 2001).

Since the flood problem is very series, there must be a short term, medium and long-term plans in bid to manage the flood hazard. While the short-term plan includes strengthening of early warning system and physical measures such as levees and rehabilitation activities, the medium plan may include delineating flood zone in the flood affected areas. The long-term plan includes biological measures such as afforestation.

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CAUSES, CONSEQUENCES AND MANAGEMENT ASPECTS OF THE 2006 FLOODING HAZARDS IN AWASH RIVER BASIN

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† Wondafrash and Yonas got involved in this study because Tsige couldn't last within the study team due to other commitment.

1. INTRODUCTION

Awash Basin is the heartland of Ethiopia. It is within this basin that Addis Ababa is located. Moreover, five regional states and the Dire Dawa Administrative Council share the water resources in the basin. In economic terms, the basin plays a pivotal role in the economy of the country by virtue of the existence of industries, large plantations, irrigation schemes and hydroelectric power plant. Thus, these unique geopolitical and economic advantages of the basin have attracted very large settlement into the basin.

Among the many river basins of Ethiopia, Awash basin is the one which has been affected by recurrent flood. The basin used to be repeatedly hit by severe floods even when other basins were safe. At the latest flood event of August 2006, however, the extent of the flood in the country was so large that other basins were similarly affected.

Flood is one of water-related extreme events that bring sufferings, death and immense material losses to humans. It occurs most commonly from heavy rainfall when natural water courses or river channels could no longer convey excess runoff. Then, the water spills beyond the channel and causes the afore-mentioned damages. The damages inflicted by floods worldwide are on the rise. According to Kundzewicz et al. (2001), floods in the period between 1971-1995 affected more than 1.5 billion people, killing 318,000 and leaving over 81 million people homeless in the world.

In general, flooding in Ethiopia has been increasing in frequency and magnitude. Consequently, huge causalities have been occurring to humans. In the meantime, its economic effects are so immense on the staggering economy of the country. Especially, the recent floods of August 2006 were the most severe of all floods that occurred in Ethiopia. It killed more than 637 people and affected about 200,000. In addition, 35,000 people were displaced (Addis Zemen, 26 Aug., 2006).

In the Awash Basin, although human deaths were minimal, the flood has inflicted tremendous material and property loss. It ruined a private investment in cut flowers worth millions of Birr, killed a number of domestic animals and other infrastructure (Ethiopian Herald, 28 Aug., 2006; Addis Zemen, 29 Aug., 2006).

The occurrence of flooding in the Awash Basin is attributed to many interwoven factors. However, the underlying causes of the floods can be categorized into natural and human induced factors. The effects of each of these factors upon flooding are quite unproportional. The greater cause arises from human impacts on the river basin than the way floods could occur through natural circumstances (Kundzewicz *et al.*, 2001). Therefore, one of the manifestations of human impacts to the environment is an increase in flood frequency and magnitude (Viessman and Lewis, 2003).

Over the past several decades floods hit Awash Basin and inflicted causalities and material loss. In addition, the incidence took place in all the upper, middle and lower parts of the basin (MoWR, 2006).

In general, these facts discussed above confirm the vulnerability of all societies within the basin to flooding. The adaptation capacity of the societies depends on the extent of range of opinions pursued to mitigate flood hazards. Therefore, in the face of increasing severity of floods in the Awash Basin, it is very important to identify or assess the major flood causing factors and their effects, and evaluate the flood management practices in the basin.

2. LITERATURE REVIEW

2.1 Environmental Degradation in the Awash Basin

There are a number of adverse effects upon the ecosystem that emerge from the reckless or unsustainable land and water uses by man. One such effect is land degradation. The Awash Basin is subjected to serious land degradation due to rapid population pressure, particularly on the upper parts of the basin. According to Girma Tadesse *et al.* (2003) the existing high population pressure in the basin has resulted in accelerated soil erosion. As a result, the average annual soil loss in the catchments is estimated at 200-300 tons/ha (EVDSA, 1994). The main causes of such an accentuated rate of soil erosion are deforestation, over grazing, and mismanaged agricultural activities. These are entirely human induced factors.

The rapid rate of soil erosion in the basin is the most serious thereat to Koka dam. Due to heavy sedimentation, the water holding capacity of the dam has reduced by 30 percent (Girma Tadesse *et al.*, 2002). Therefore, in 2002, the volume of the dam was 1,186 million m^3. Its designed storage capacity was 1,667 million m^3. The dam has special significance other than its use for electric power generation and irrigation. According to WMO/GWP (2003), the construction of the dam has regulated the water flow and therefore reducing the flood incidence in the lower basin.

However, the rising bed of the dam by silt deposit is forcing the frequent spill out of water. This is because the capacity of the reservoir to withhold additional runoff has significantly reduced. This in turn exacerbates flooding in the low-lying plain. In line with the decreasing volume of the dam water, EVDSA (1989) warned that an increase of three meter in water level of the reservoir would flood an additional 50 km^2 of relatively flat lands between Alem Tena and Mojo towns.

Another most pressing environmental concern in the river basin is deforestation. As discussed above, soil erosion and sedimentation are great menace to the local environment of the basin. It is, therefore, possible to infer from the situation that there exists large degree of deforestation and very little land cover in the highlands of the Upper basin.

2.2 The State of Flood in the Awash Basin

Halcrow (2006) identified several areas of extreme to high flood susceptible along Awash River. Thus, areas west of Koka dam and those between the confluences of two streams, *Arba 2* and *Awadi* are found to be extremely flood susceptible. Whereas areas that lie between the towns of *Debel* and *Gewane* in the vicinity of Lake Yaridi are also highly susceptible. And the area between *Dupti* town to Lake Abe is designated as high flood susceptible area. Only few pocket areas in the basin were delineated as safe spots from flood hazard.

In Awash Basin, floods mostly occur in the months of August/September, following rainfalls in the western highland and escarpments, from where most of the tributaries of Awash River emerge. The main flood contributing areas are, therefore, North Shewa Zones of Oromia and Amhara Regions, and South Wollo Zone of Amhara Region (Girma Tadesse *et al.*, 2003; Halcrow, 2006). It is important to note that flood is a resource by its own. As Kundzewicz *et al.* (2001) put it, " ...in arid climates, floods are water resources. If we do not capture the flood flows, then there will be no water available for the rest of the year."

The water resource available in Awash Basin is estimated at 4.9 billion m^3 (MoWR, 2002). This amount of water is sufficient only for irrigating 152,000 ha out of the 206,400 ha of irrigable land in the basin (Zewdie Abate, 1994). The advantage of Awash Basin is that utilization of these resources entirely depend on internal or domestic actors. Unlike other rivers of Ethiopia, which in one way or the other are influenced by the outcome of multinational cooperation, developmental activities in Awash Basin rely on natural and economic opportunities within the basin. The advantage of Awash Basin is that it is not a tranboundary river (Zewdie Abate, 1994).

2.3 Flood Triggering Factors

In many cases the increase in flooding incidences and damage due to floods can be associated with urbanization and intensive economic utilization of flood plains and not necessarily due to increase in flood frequency per se (WMO/GWP, 2003).

The removal of forest and other natural cover influences infiltration rates and increases sheet erosion. These in turn increase the concentration of sediments in the stream beds and contribute to the river morphological changes such as riverbank erosion, rise in river bed levels and reservoir sedimentation. Deforestation is believed to have significant contribution to catastrophic flooding. It also accelerates land slides and mud flows. Storage in reservoirs, wetlands and marshes contribute directly to changes in the timing of runoff, the amount of natural storage in the basin and the vulnerability of river channels to the erosive forces of water (Viessmun and Lewis, 2003; Gregory and Walling, 1973).

However, in the basin most of the water resource, 72 percent is lost through evaporation, 18 percent as run off and 10 percent as ground water (Girma Tadesse *et al.*, 2003). Therefore, the high evaporative loss calls for the effective utilization of the water resources of the basin.

The high pressure on forest resources in particular, has led to the exploitation of fragile watersheds and ecosystems that have resulted in the loss of vegetation and subsequently soil erosion. This uncontrolled deforestation and expansion of farmlands have induced soil erosion and land degradation which is the root cause for constantly increased sediment load over the years in Awash River flows (Girma Tadesse *et al.*, 2003). According to Mitchell (2006), the total annual sediment load from Mojo stream is estimated at 1,750 tons/km². In general, the single overriding factor in the overall degradation of the ecology of Awash Basin is the rapid increase in population and the adverse effect it has on the fragile resources of the basin. As a result, frequent and devastating floods occur in the basin.

3. SURVEY METHODOLOGY

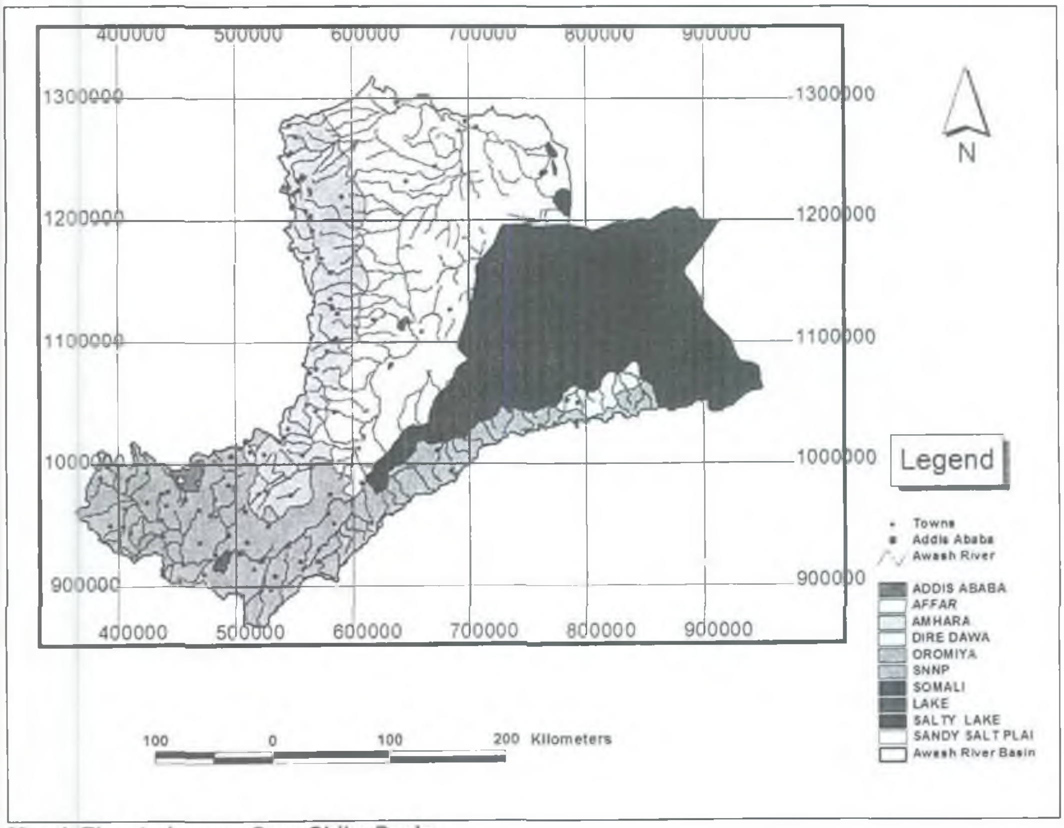
3.1 Study Area Description

3.1.1 Geographical location

The Awash Basin falls within the tropics, specifically lying between 8^0 and 12^0N latitude and 38^0 and 43^0E. The river basin is delimited in the north by Denakil River Basin, in the West Abbay River Basin, in the South west by the Omo-Gibe and Rift valley lakes, in the South east by the Wabi Shebelle River Basin and to the east Aysha dry basin and Djibouti.

The river basin originates from the central highlands, in a place named *Mecha*, which is West of Addis Ababa, near Ginchi. It has a southeast trajectory up to *Melka Gorge* where it starts changing its direction to the east. After Wonji it takes a north-east direction which is generally maintained up to the confluence of Logia River, it ends in lakes Gamarri, *Afambo* and *Abbe* where water is lost due to evaporation.

The area of Awash River Basin, which is rather narrow on the upper part and then widens towards the north, is about 116,179 km² (EVDSA, 1990).



Map 1. The study area: Omo-Ghibe Basin.

3.1.2 Climate

In general, the climate of the Awash Basin is influenced by the Inter-Tropical Convergence Zone (ITCZ) that causes the short or spring rains in March and at its northern most extreme it produces the heavy summer rains in July and August whilst its southern part is influenced by the drier weather caused by the easterly air flows.

The 1,200 km long Awash River with its tributaries experiences the cool, humid highland climate in its upper basin and arid and simi-arid climate in its lower basin. The mean annual rainfall ranges between 1,600 mm in upper basin and 160 mm in its lower basin.

3.1.3 Vegetation

The distribution of flora in the Awash Basin is a direct reflection of climate. It ranges from degraded montane savanna and highland forests in the Upper Awash Basin to woodland and tree savanna in the Middle and desert and semi-desert vegetations in the Lower Awash Basin.

The dominant vegetation in the Upper and Middle part of the Awash River Basin is grassland with some scrubland and riparian forest along the course of the river.

3.1.4 Topography

The topography of Awash Basin is divided into upland (all lands above 1500 m a.s.l.) upper valley, middle (area between 1,500 m and 1,000 m a.s.l.), lower valley (area between 1,000 m and 500 m a.s.l), and Eastern catchments (closed sub-basin are between 2500 m and 1000 m a.s.l.), and the upper, middle and lower valley are part of the Great Rift Valley systems. The Lower Awash valley comprises the deltaic alluvial plains in the Tendaho, Assaita, Det Behri area and the terminal lakes area (Girma Tadesse *et al.*, 2003).

3.1.5 Soil

The parent material of the soils may be grouped as volcanic rocks, general skeletal soils of ancient alluvial and colluviums, recently deposited alluvium at the Rift Valley depressions adjacent to the Awash River. The soils of the study area are predominantly eutric fluvents. Fluvisols and vertisols are the second dominant soils that occupy about 30 percent of the total area (Girma Tadesse *et al.*, 2003).

5.1.6 Demographic profile

The overall population of Awash Basin is estimated to be 28.5 million (CSA, 2003). The main population centers lie in the Upper Awash River Basin and upland areas above 1500 m a.s.l. that normally takes the lower limit of rain-fed agriculture.

Before the irrigation development of the Awash Valley, the population was broadly divided into sedentary cultivators in the highlands and the pastoralists (*Afar and Isa*) in the lowlands. Between the highlands and lowlands, there is a buffer zone, which is mainly inhabited by the *Kareyu Oromos*. However, irrigation development in the basin has attracted huge population into the basin.

3.1.7 Procedures of sample site selection

Awash River Basin is a major basin that faces serious and perennial flood problems. Floods of Awash caused several damages to property and life at different flooding periods. Therefore, taking into account the huge damages inflicted by floods from Awash River Basin, conducting a survey in order to identify the root causes of floods in one of the major flood affected areas (Awash Basin) is found to be timely and a major issue.

The sites selected from Upper and Middle Awash Basin are believed to be representative and could produce the intended information for the purpose of the survey.

Accordingly, in Dugda Bora *Wereda* of East Shewa zone of Oromia, *Waqe Miyo* and *Waqe Tiyo* Peasant Kebele Associations (PKAs) are in Upper Awash Basin that are venerable to flooding. Melka Werer, Amibara and Wonji vicinities are located in the Middle Awash where field observations were made.

3.1.8 Data source and types

In order to attain the set objectives, this survey has employed both primary and secondary data sources. Data collection tools from primary sources were direct observation, discussion with key informants, questionnaire based group discussion and acquisition of pictures.

Focus group discussion (FGD) was conducted with elders drawn from the Upper and Middle Awash areas. Individuals for the FGD were selected in collaboration with the PKA leaders. In Upper Awash, four individuals were selected. All of them were above 45 years. In Middle Awash, FGD was conducted with members of the Melka Ido Peasant Irrigation Association and in Melka Werer and Amibara sites. In Melka Ido, nine individuals were involved. All of the individuals in the group were farmers aged above 40 years of age. Similarly, in Amibara and Melka Werer, five individuals aged above 45 years were selected for the discussion.

The other tool data used to collect the issues of flood causative factors, flooding impact, and flood disaster management was key informant interviewing. Structured interview guide questions were used in order to collect the necessary information from the interviewees.

Field observation on different features that give clear view about the flood and its impacts was also another tool of data collection. Field observation was conducted in the Amibara Irrigation Project and Summit Agro-Industry, which involved a cut-flower industry, to observe the damages inflicted by the flood. Furthermore, the field observation in Middle Awash also included the *Melka Ido* Farmers Irrigation Association, where the other flood damages occurred. The Wonji sugar plantation is another site of observation where flood inflicted serious damages on farm plantation. Field observation also included Koka dam and its surroundings and Mojo area where environmental degradation is severe.

Reviewing of different secondary sources and meteorological data has also been incorporated in the survey.

3.1.9 Data analysis

Qualitative data gathered with the help of observation, FGD and key informant interview were analyzed through descriptive method of analysis. Rainfall data were analyzed through trend analysis. Simple statistical methods such as percentages and averages were also used.

4. RESULTS AND DISCUSSION

4.1 Description of Flood Related Factors

4.1.1 Settlement history

Awash Basin is one of the most important areas of Ethiopia, which is capable of attracting large number of population. The hospitable climate of the highlands and escarpments was the most important natural factor which encouraged permanent settlements for centuries. Therefore, the western escapement of the basin, the land area that stretches from Ginchi (West of Addis Ababa) to Sirinka town (in Wollo) is densely populated. The flat central massif part of Upper Awash is the principal urban center in Ethiopia. Especially after the establishment of the malaria eradication program in the 1950s, the area has become suitable place for human settlement. Apart from climatic suitability, socioeconomic factors have also attracted large number of population. The most important one is the presence of Addis Ababa, which is the political and financial capital within the basin. On the other hand, the concentration of irrigation schemes and factories have encouraged both permanent and temporary settlements (migration) in the basin. For instance, Kloos (1982) revealed that out of 150,000 people living in irrigation schemes, 100,000 were migrants from other parts of the country. According to a key informant, Wonji Sugar Factory workers have settled along Awash Riverbank starting from the time the factory began operating.

Moreover, there is a regular transhumance in the basin. Pastoralists from the Lower Awash move to the Middle in search for pasture. In the Lower Awash population settlement is very sparse due to harsh climatic conditions and the prevalence of malaria.

These settlements took place as a process of regular or historical way of new land occupation or driven by migration to seek better opportunities. Therefore, there was no government sponsored resettlement programme within the basin.

Finally, the age old settled life along the escarpments has resulted in depletion of forest resources and accelerated soil erosion. Moreover, the irrigation schemes have fueled the land use and land cover change, i.e., from riverine forest into plantation agriculture. Demand for firewood, construction material, and settlement have further aggravated the rate of deforestation in the basin.

4.1.2 Rainfall regime

According to the group discussions held in Upper Awash Basin, rainfall is has been decreasing. According to them, during the reign of Emperor Haile Sellassie I (1930 – 1974), heavy rainfall used to fall in the basin. However, the amount has been decreasing since then. Such observation by the FGD is also shared by the works of Yonas Taddese and Mekonnen Adinew (2005), who studied the trend of rainfall at Berga and Holetta stations of the Upper Awash, which demonstrated a decreasing trend over the years between 1975 – 2000. In those years, rainfall was decreasing by 0.5 mm and 0.85 mm per annum at Berga and Holetta stations, respectively.

Rainfall trend in Dugda Bora (Alem Tena) showed a decreasing trend over the years between 1973 – 2005 (Figure 1).

During the recorded years rainfall decreased by 0.11 mm every year. During the group discussion held in Dugda Bora (Alem Tena) *Wereda*, members have claimed that there is variation in rainfall amount, intensity and duration between the past and the present rainfall regimes of the survey area. In light with this, during the reign of Haile Sillassie I, the rainfall amount was to be high and its duration was normal. In explaining this matter, members used the productivity of crops cultivated in the area.

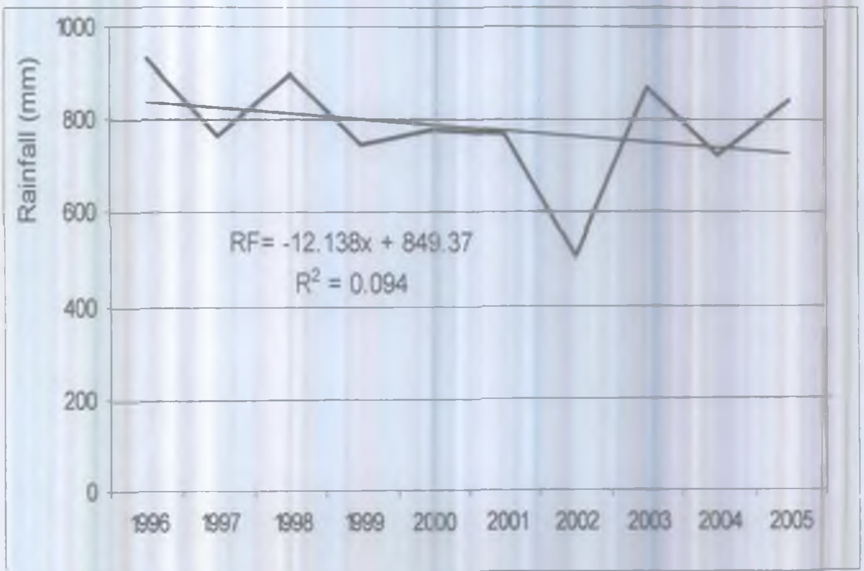
In contrast, according to members in the discussion, the post-imperial regime experienced insufficient amount and seasonal variation in rainfall. Asked what the factors are, they attributed it to the environmental degradations. They have mentioned frequent events of crop failures in post-imperial period in explaining this decreasing trend.

It is said that Middle Awash and Lower Awash Basin of the survey area have been receiving small amount of rainfall as compared to the Upper Awash. Particularly in Lower Awash, the occurrence of such small rainfall are falling in the form of heavy shower. Local informants put the area under arid and semi-arid climatic regions.

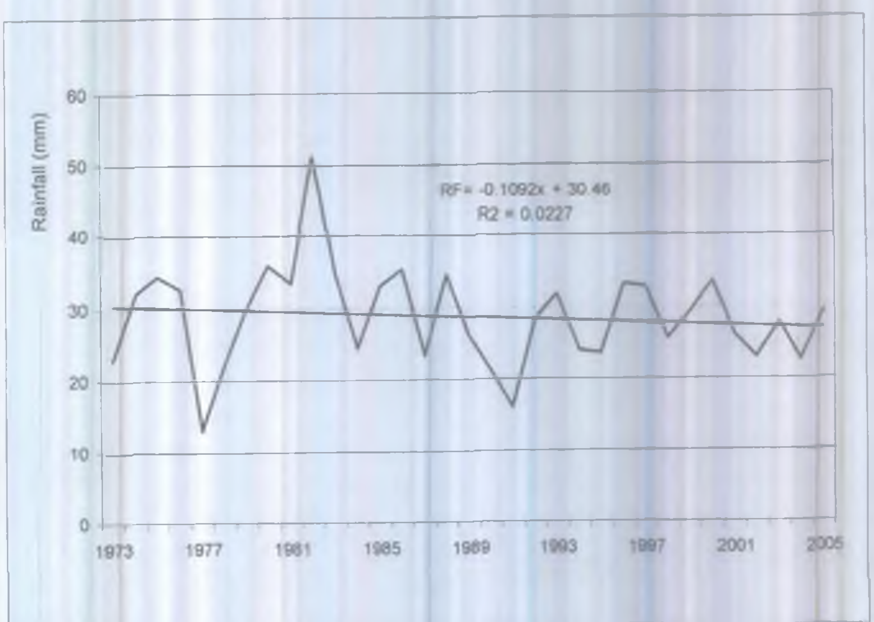
4.1.3 Deforestation regime

The highlands in Western Shewa, in the Upper Awash Basin, were once covered with dense forest. The dominant tree species were *Tid* and *Zigba*. Nowadays however, it has been difficult to find any dense forest in the area at all. Today, there are scattered individual trees of *Tid* and *Zigba* in remote and inaccessible places only.

The key informants, members of group discussion and officials at *Wereda* level were asked to explain the factors for the deforestation. Similar responses were obtained from most of them. Accordingly, they explained that population pressure and the prevailing land use are the major factors. Particularly elders said that during the reign of Haile Sillassie, large proportion of the plateau in Western Showa (Ginchi, Holetta and Addis Alem areas) were covered with dense natural forests. According to elders, it was after 1974 that the area witnessed severe depletion of forest resources. In explaining this further, they have mentioned that there were stiff competition among peasants for the purpose of securing agriculture land, and wood for construction and fuel. This also persisted during the period of the *Derg*.



Wonji Research Station



Dugda Bora (Alem Tena) Station

Figure 1. Rainfall trends in upper Awash.

The informants explained that the *Derg* regime had made attempts to rehabilitate the degraded land, through reforestation program which they described as successful. However, following the downfall of *Derg*, another round of forest destruction was experienced in the area. We realized that there is no considerable attempt to rehabilitate the already degraded environment and to protect the existing few patches of forest resources.

As a result, massive destruction of forests and felling of trees have continued in Middle Awash areas. One key informant explained that the burning of trees for the purpose of producing charcoal has been a long established practice of forest destruction in the Middle Awash Basin. In relation to this, we were informed that there are people who have the legal permission to produce charcoal. These people were allowed to produce the charcoal by burning the exotic tree species called *Prosopis juliflora*. This was made deliberately to reduce the expansion of this unwanted species, believed to have the nature of prohibiting undergrowth. It is said that in areas where this species expanded its distribution, the size of the grass cover shrank. This has a serious repercussion on animal feed shortage of the area.

Plate 1. An example of degraded hills in the Awash Basin.

In fact as we were informed, the charcoal producers are not limited to the exploitation of *Prosopis juliflora* to produce charcoal. Along with it, they also cut down other indigenous trees and riverine forests. As we have assessed the area, charcoal production is seriously threatening the vegetation status of the area.

4.1.4 Flooding regime

Flooding has a long history in the Awash River Basin. In the late 1950s, widespread flooding events occurred in the Awash Basin (WMO, 2003). Koka dam was constructed in 1957 – 1960. In addition to its hydropower generation purpose the dam was also aimed to store the surface runoff that could otherwise cause flood. As a result of the dam construction, it is claimed that at downstream flood conditions in the upper valley of Awash River were controlled. Meanwhile, silts loaded in the river are deposited into the dam and buildup the proportion of dead storage over the live storage. From time to time the continued siltation in the dam, for the dam construction has not integrated silt trap mechanisms such as planting of trees over the bare lands, reduced the amount of water stored in the dam. This has also forced the dam administration to release the dam water every year during the rainy periods. Swelling of the volume of the dam before high flow reaches it forced the spill out of water from the dam causing several flood damages on both the middle and lower basins.

Flooding in the basin has become a year-to-year phenomenon and several damaging high floods were recorded in the Awash Basin. In 1993, a high magnitude of flood destroyed 7,000 ha of farmland. In 1996, higher flood was recorded in Wonji which caused 20,000 people to be displaced.

In the subsequent years of 1997, 1998, 1999 and the following periods floods became higher in magnitude. The floods have caused damages both on state and private farms. Furthermore, flood in late August 2005 inflicted severe damages both on property and human life. The bridge leading to Det Bahir irrigation scheme was washed away. As a result, five human lives were lost. The flood in the year 2006 was also very severe in its magnitude and caused damages on property and lives.

4.1.5 Development trends within the basin

The Awash Basin has been playing a great role for a sustainable economic development of Ethiopia. However, the development activities within the basin caused severe damage to the environment. Yet as a consequence, the human activities suffer from unbearable response of the damages. This cause and effect interplay between human and the environment in the basin is treated below from flooding perspectives.

1. *Rapid Urbanization*: Within the Awash Basin there are large number of urban centers. Addis Ababa and other principal towns like Adama, Dessie and Dire Dawa are found within the basin. The urban centers have large population sizes whose existence highly demands the use of forest resources for construction and fuel wood. This process has exacerbated the rate of deforestation especially around the urban centers. The deforestation in turn resulted in accelerated soil erosion and sedimentation problems in the basin. The urban landscape and industries also accelerate flooding in the basin. Compact surfaces such as asphalts generate quick overland flow within a short time and quickly joins the river channel without being abstracted. Besides, waste materials damped into the river from the industries contaminate and increase the volume of runoff.
2. *Road Construction*: One important recent development in the basin is the maintenance and/or up grading of roads. Over the past ten years the maintenance and upgrading took

place on the road that radiate from Addis Ababa to Harar, Hawassa and Jimma towns. In addition, there were several new roads. These construction activities incurred environmental damages through deforestation and soil excavation. The problem is aggravated because reclamation measures were hardly undertaken ones the road constructions were completed. Therefore, road construction has contributed for further deforestation and soil erosion, which in turn contributed a great deal to the increased sedimentation of the river channel.

3. *Large Scale Faming:* In 2002, the total irrigated area at the Awash Basin was 68,800 ha (Girma Tadesse *et al.*, 2003). The farms have been facing a drainage problem and causing a rise in ground water table. The rise in ground water table in turn resulted in the salinization of soils. Girma Tadesse *et al.* (2003:4) explain the problem in Middle Awash as, "development of large scale irrigation projects without functional drainage system and appropriate water management practices have led to the gradual rise of saline ground water". The salinization has greatly affected the soil pH. According to Girma Tadesse and Fentaw Abegaz (2003), the soil pH in Middle Awash ranged from 7.1 to 8.6. In general, the drainage problem is complicated due to lack of irrigation canals maintenance. Low infiltration rate usually leads to surface storage and thereby to flood.
4. *Location of Development Establishments:* Many developmental establishments within the Awash Basin are located close to the river bank. By virtue of their location, some of the establishments risked themselves to flooding. Thus, during high flows they suffer from damages caused by floods. As observed in the survey area, the most disastrous damage occurred to a development firm by the recent flood (2006). A good example is the damage that occurred to a flower farm located at about five meters away from the riverbank in Wonji area. It seems that the location of the farm did not take into account the flood history and maximum flow of the river. Moreover, the flood threatened Wonji sugar factory. Our informant from the factory explained that the sugar in stock was transported to Adama (Nazereth) warehouse in fear of the floods.

In general, developmental activities within the Awash and along the riverbanks affected the river's morphology especially, when human interventions came close to the riverbanks, the river had no choice other than overflowing its channel. The overflow is further speeded up by spill out from Koka dam.

4.2 Analysis of Flooding Impact

During heavy rainfall in the eastern highlands and escarpments of north Shewa and Wello and at the release of water from Koka dam, surface water quickly turned into floods. In fact, the Middle and Lower Awash Basins are experiencing floods of various magnitudes over several decades. However, the frequencies of occurrences have been increasing from time to time.

In the recent (2006) flooding event, the damages inflicted on property and farmlands were so severe than floods ever experienced in the basin. According to the group discussion, the 2006 flood has caused the death of two people in *Waye Miyo and Waqe Tiyo* PKA, in *Dugda Bora Wereda*. This flood displaced 2,200 people from *Dulecha Wereda* of Zone 3 (OCHA, 2006). The group discussion further revealed that, in *Dugda Bora Wereda* floods displaced 937 households, in *Hasuba* (*Melka Werer – Amibara*) 30-50 households were displaced.

Regarding the damages inflicted on livestock, in the zone 337 animals were taken away by the floods. In *Gewane Wereda* alone 80 goats and cattle were taken away. In *Bure Mudaytu Wereda* 140 goats and sheep; in *Dereb Tona*, *Dengleta* peasant kebeles, 10 donkeys and 69 calves and one vehicle were wiped out by the flood (Addis Zemen, 2006).

The Awash River Basin accounts for huge proportion of the country's investment. However, floods are nowadays threatening the expansion of investments within the basin. The 2006 floods that inundated several areas in the basin incurred huge property damages. The over flow of Awash River caused property damage valued at 6.8 million U.S. dollars on Summit Agro-Industry, a private company based in *Wonji* area (ENA, 2006). The flash flood that occurred in August 2006 completely damaged a flower farm on 24 hectares of land. In the flower farm, over one million rose cuts have also been damaged while over 1,200 workers on the farm became idle (ENA, 2006).

According to the group discussion, in *Amibara* area, *Hasuba* kebele, Awash River broke down dykes and flooded about 2,000 ha of rangeland and farmland. In *Gerafita*, the river diverted its course and flooded 800 ha of irrigation plantations. Similarly, in *Melka Ido* farmers' irrigation association, a farmland of about 674 ha of Teff, wheat and vegetable were damaged by the floods. In *Dugda Bora Wereda*, about 1,800 ha of pepper, maize, wheat and tomato farms were flooded by Awash River.

Plate 2. Flooding has substantially damaged the Summit Agro-Industry.

4.3 Analysis of Flood Causative Factors

The Awash River Basin is one of the most flood susceptible areas in Ethiopia. As a result, flooding occurs in most parts of the basin during wet season (June to August). Although the flood is the result of a combination of meteorological and hydrological factors, its magnitude and severity is accelerated by the following factors.

- *Sedimentation:* The Awash Basin, as discussed in the preceding sections, is one of the most degraded catchments in Ethiopia. The major forms of land degradation in the basin are deforestation and soil erosion. The effects of these phenomena are highly reflected through the siltation of the river channel and reservoirs within the basin. Different sources indicate that sedimentation of the river channel, particularly along *Melka Sadi* and *Amibara* irrigation schemes is the major cause of high flooding. The bulk of the sediment comes from three main streams; these are *Arba*, *Kesem* and *Kebena*. These streams transport huge sediment load from almost barren escarpments of the basin. For instance, at *Awash Arba* annual sediment yield was about 30 million tons from 21,160 m^2 subcatchment (EVDSA, 1989). According to the information obtained from *Amibara* irrigation project at *Melka Werer*, there is a *significant amount of reduction in the* depth of the river and an increase in water level. Therefore, measurement of water level at Melka Sadi, Melka Werer and head works indicates that between 1981 and 2006 the water level increased on average nearly by 7cm (Figure 2). In the mean time, the highest water level at the spot, 755.7cm was recorded on 31 August 2006. The increase in water level is attributed more to sediment load of the river than an increase in surface runoff. The irrigation project at the main intake was designed to discharge water into the primary canal through gravity flow. The maximum water level at the intake was assumed to be 753 cm. This limit was exceeded in late July 2006. Then, the main weir was blocked to protect the farm. The blockage has its own impact on the flooding of the left bank of Awash River. This is because the blockage gives further impetus to the river so that it can break the dykes easily. Furthermore, the primary drain outfall through which excess water should leave at the outlet of the irrigation canal is not functioning well because of low maintenance of the canals. There is disagreement over who should maintain the canals. According to a key informant at the Amibara state farm, private investors, who are using the canals refused to cover the 30 percent maintenance cost demanded by the state farms.

Plate 3. Most soils of the Awash Basin are very sensitive to erosion.

- *Spill out of Water from Koka Dam:* The construction of Koka dam in 1960 played an important role in flood protection of the Lower Awash Basin. It served as the main flood storage. However, due to siltation the water holding capacity of the dam has significantly reduced. As a result, the volume of the dam has decreased from the designed storage capacity of 1,667 million m^3 to 1,186 million m^3 in 2002, which has resulted in a 30 % loss (EEPC, 2003; see also Figure 3). Therefore, the rise in water level of the dam has forced the spill out of water every rainy season since 1997. The water release is causing flooding of areas below the dam. This shows that the flood regulating role of the dam is decreasing.
- *Weak Flood Protection Structures:* Awash Basin has good reputation of flood protection

through structural measures. One such measure is the building of dykes in low-lying areas where the river could breach its channel. From field observation, it was understood that the dykes are all earth dykes. The dykes around Amibara at the left bank in Hasuba Peasant Kebele Association was broken and 2,000 ha land was inundated in 2006.

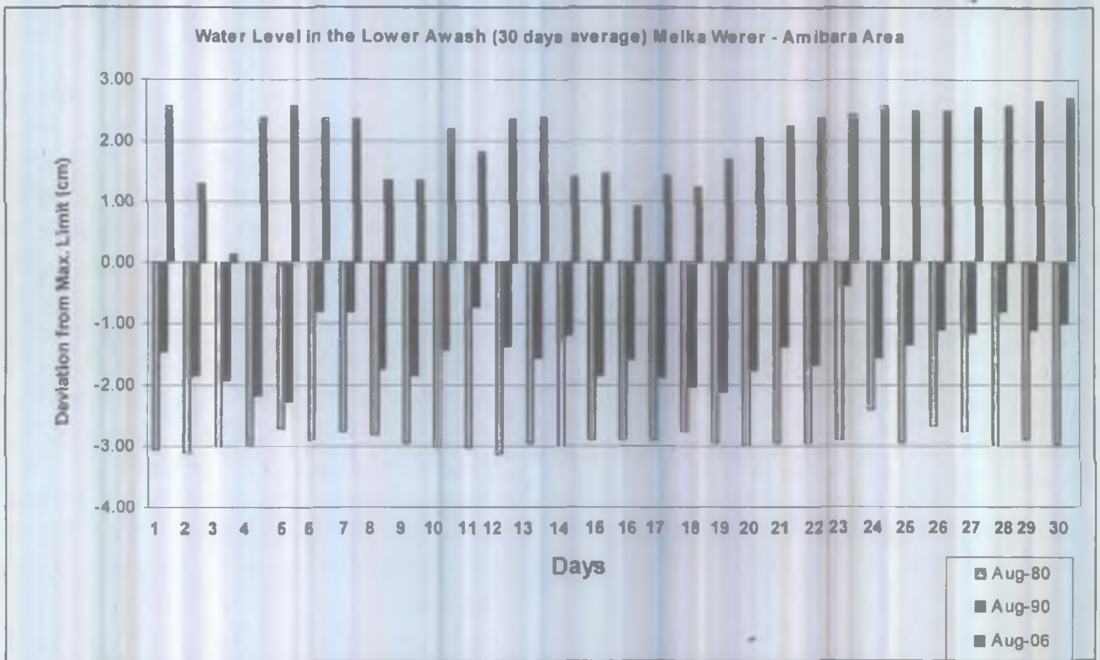


Figure 2. Water level in the lower Awash River.

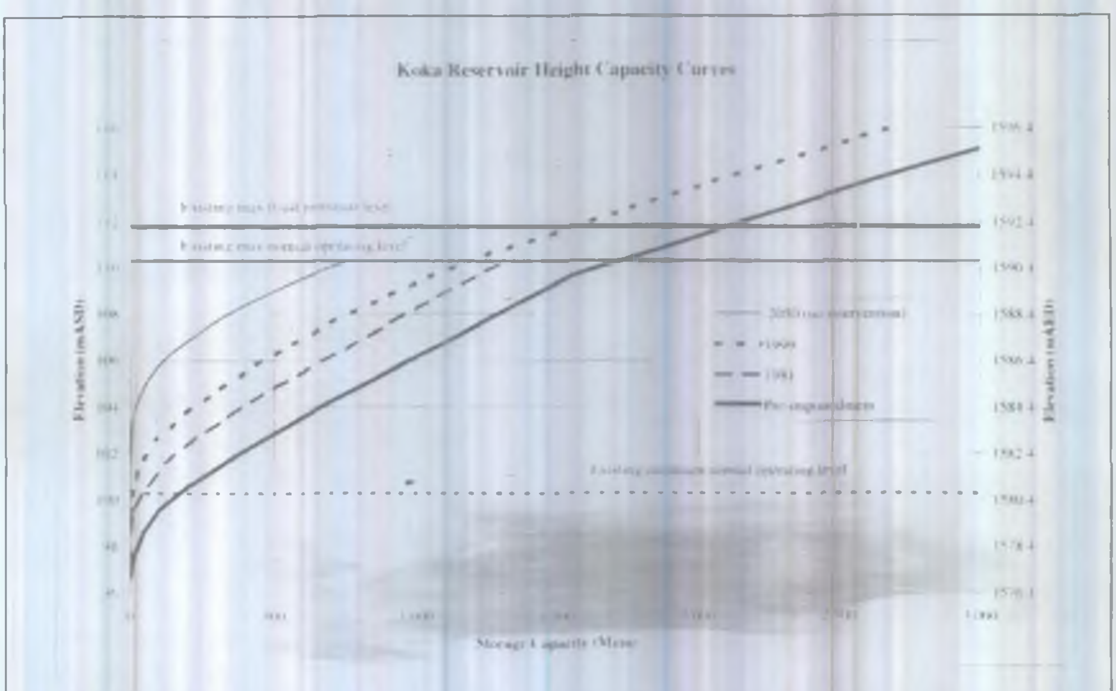


Figure 3. Water level of the Koka dam; Source: EEPC (2003).

4.4 Survey of Good Practices

In the Lower, Middle and Upper Awash Basins some appreciable practices have been carried out to safeguard farms and settlements from damage. In this regard several dykes have been constructed along its banks and nearby irrigation schemes. These dykes are important to curb the annual flooding and reduce the deposition of silt on the rich farmlands. For example, in the Middle Awash along the Amibara irrigation project area, dykes have protected around 10,000 hectares of farmland from the 2006 flood effect. It was also noted that this project center was equipped with adequate maintenance services.

The other important good practice that has been observed in the Lower Awash plain area is the river training. In its lower course, the Awash River frequently changes the course of its channel, which causes greater flood damage. The river training allowed removing silts from the river. As a result, the river in that area has attained appreciable depth and width, which relatively reduced the hazards of flooding. The government also built a control weir at the junction of *Kesem* and *Kebena* to maintain a balanced flow for adequate water supplies to development branches.

Since its construction, the Koka dam has been serving as a flood control mechanism by storing water at times of high flows. However, in recent years, the initial reservoir capacity of Koka has been reduced substantially due to large amount of sediment deposition.

The establishment of two flood management units in the Middle irrigation projects and Lower Awash area set up by the government are among the good practices. These flood management units are responsible for maintaining dykes and insuring continued water supply to farms. However, according to WMO (2003), these units have not been obtaining proper support in recent years to execute their duties effectively.

Some preparedness practices have also been carried out in the flood affected areas. According ENA (2006), around 3,000 people were relocated to safe areas. ENA (2006), also added that members of the defense force, the Disaster Prevention and Preparedness Agency and employees of Wonji Sugar Factory were working closely to prevent flood in the factory. In addition, DPPA had dispatched some 8,000 sand bags to the areas.

4.5 Appraisal of Flood Management Practices

4.5.1 Flood management institution

The Ethiopian Electric Power Corporation (EEPCO) is one of the largest institutions, that have been involved in flood management in the Awash Basin. The Koka dam was constructed with an initial water holding capacity of 1.8 billion cubic meters with the purpose of serving for irrigation, production of electricity and flood protection to the Middle and Lower Awash areas by retaining incoming floods. However, this structure has now been unable to fulfill its purpose. This is mainly due to the reduced capacity of the Koka Reservoir. According to WMO/GWP (2003), the reservoir has lost 40% of its water holding capacity. This is due to increasing silt deposition in the dam. That is, the inflow into the reservoir from the upper catchment of the Awash Basin is heavily loaded with silt. The upper catchment areas of Awash, mainly its western side, is highly degraded, densely populated, and deforested. Hence it has become a major source of sediments. This situation has created the problem of increased flooding risk down stream rather than protecting it from flood hazard.

On the other hand, two flood management units were established by the government in the Awash Basin: one for Middle Awash Irrigation Projects and the other for the Lower Awash area. Their responsibilities are to maintain and protect dykes and water courses so as to avoid the flooding of irrigation areas. However, these units have not been fully executing their responsibilities due to material and financial constraints.

Furthermore, a semi-autonomous institution known as the "Awash Valley Agency" had played an important role in flood hazard mitigation. The institution is responsible to collect water resource data, plan, design implementation and oversee operation of all water projects within the basin. In the context of Ethiopian Water Policy, flood management is viewed as an integral part of an integrated water Resources management. Therefore, the Awash Valley Agency is responsible in flood management. But this Agency has heavily committed itself in the development of water resources infrastructure, building of dams, irrigation and encouraging private business participation in irrigation development rather than protecting the flood hazard. However, flood management in the river basin has improved substantially with the intervention of the Awash Valley Agency with the strengthening of the previous, existing flood management units stated above, i.e. the project control center in the Middle Awash valley and river training unit in Lower Awash.

4.5.2 Disaster preparedness

Before the release of water from Koka dam, the reservoir operational committee advices people located at the downstream. This helps residents and firms to take action before the released water reaches them. However, apart from the releasing of water information there is no information whether the amount to be realized would incur flood.

4.5.3 Post-flooding disaster management

The post disaster management employed in the study area includes the distribution of food, blanket, mosquito net and other important materials for the survival of their lives. In some areas, where the farmlands have been flooded, they were drained by water pumps, which were provided by the government.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Generally speaking, Awash River Basin has been one of the hot spots of flooding hazard. However, the causality of the flood has become more frequent and more devastating especially in the recent years. As the number of economic establishments and immigrants are expanding by the years, the damage inflicted at a unit piece of land would likely to escalate exponentially.

From the analysis of various data input, it was concluded that there were no significant change in the amount of rainfall to trigger the 2006 flood in the Awash Basin. Rather, it was due to the combined effects of the negative influence impacted on the river morphology due to heavy investment and settlement very close to the river bank. Moreover, it was also due to high dam siltation caused by massive degradation taking place in the upland area coupled with the higher erodibility of the soils in the rift valley.

5.2 Recommendations

1. Large-scale land rehabilitation activity should be implemented particularly in the upper catchments in order to reduce the amount of sediment transported into the river channel and Koka dam. On steep slopes reforestation and other soil conservation techniques should be encouraged.
2. In order to sustain the flood regulatory role of Koka dam and the irrigation schemes, appropriate rehabilitation measures should be employed on the establishments. This may involve dredging out of sediments or expansion of the dam and maintaining the irrigation canals so that water can drain up to the drain outfall. In addition the recommendations forwarded by EEPC (2003) should be implemented to solve the sedimentation problem of Koka dam.
3. Flood control structures, especially dykes should be made strong enough in order to resist high flows.
4. Proper flood zoning should be made where adequate buffer zone along the river banks should be restricted for farming, settlement and the establishment of other firms.
5. Environmental impact assessment has to be done before any development activity is allowed in the basin.
6. Illegal human interventions through river channel diversion are common signs of water scarcity in the area. Therefore, adequate rural water supply projects including animal watering schemes should be widely promoted.

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FLOODING AT DIRE DAWA: A CASE STUDY OF THE 2006

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1. INTRODUCTION

1.1 Background

During recent years, records of loss of life and damage caused by floods worldwide show a steadily rising trend. While being beneficial to the flood plains and their productivity, floods do have great damage potential and affect ever-increasing number of people. On a global scale, there is evidence that the number of people affected and economic damages resulting from flooding are on the rise. Flood losses reduce the asset base of households, communities and societies by destroying standing crops, dwellings and infrastructure. Flood disaster events of the last decade have shown that impacts of flooding due to extreme events is not limited to the least developed nations, but can also devastate and ravage the most economically advanced and industrialized nations (WMO & GWP, 2003).

Factors such as, low income, poor housing and public services, lack of social security and insurance coverage force the poor in many countries to behave in ways that expose them to greater risk. Migrants to cities from poor rural areas frequently find themselves settling in flood prone areas where they cluster in large numbers of informal settlements within many urban areas and mega-cities (WMO & GWP, 2005).

The issue of flood has now become increasingly an issue of management and planning of water resources. According to WMO & GWP (2003), integrated water resource management in Ethiopia is not in an advanced stage. Flood management being an integral part of integrated water resources management, has not been treated separately on a sustainable manner in the country. The only flood control and management activity being carried out in the country is in the Awash River Basin.

The increase in flood damages in many parts of Ethiopia over years in general and the recently occurred serious damages in Dire Dawa and other parts of Ethiopia in particular should remind us the urgent need to make a paradigm shift. This helps to reduce the human vulnerability and to guarantee sustainable development owing to the recently witnessed unprecedented damage caused. On the other hand, if things are left unchanged, other developmental efforts would bear no fruits. This is because floods could destroy them all. Therefore, appropriate management approach to water related extreme events, is a primary issue for the benefit of developmental activities.

In most parts of the country, the major rain season is concentrated in the three months: between June and September when about 80% of the rains are received. Torrential down pours are common in those moments. Intense rainfall in the highlands could cause flooding of settlements close to river courses (WMO & GWP, 2003).

In August 2006, Ethiopia has been struggling to deal with flash flooding across the country. According to the latest figures, around 118,000 people had been affected, 620 people have been confirmed dead, 244 are missed in Dire Dawa and about 50,000 have been displaced (Action Aid, 2006).

On 5 August 2006, torrential rains caused the *Dechatu* River to outburst, causing serious flash floods in Dire Dawa (International Federation of Red Cross and Red Crescent Societies, 23 August 2006).

Floods are not new to the Dire Dawa town. Surrounded by highland areas within five kilometers of radius, Dire Dawa is often hit by floods, and the last casualty was registered two years ago, with the death of 45 people. The devastating impact of the latest flood, on the night of August 6 2006 was unprecedented (Fortune, 13 August 2006) where about 254 people died and many more missed.

1.2 Rationale of the Study

Although Dire Dawa is a flood prone town, the August 2006 one was an extremely unique. In fact, over the years, floods have increased in frequency and damages. While the frequency has become higher the interval has shortened. Despite the changing characteristics of the flood dynamics in the study area, the studies on the issue were negligible. Unless the issue is analyzed through in-depth studies, Dire Dawa would likely suffer from the ever growing consequences of upcoming floods.

To this end, this study has planned to contribute through assessing major causes of the flooding hazard and providing valuable flood-related facts to the policy makers and implementing institutions and organizations.

1.3 Objectives of the Survey

The specific objectives of the survey are:

- To identify and assess the major triggering factors of flooding in Dire Dawa town;
- To analyze the impacts of flood disaster in Dire Dawa;
- To appraise the employed flood disaster management practices; and
- To generate policy relevant recommendations.

1.4 Limitation of the study

This survey was undertaken through rapid assessment, which is aimed at identifying the major flood causing factors. In the course of the survey, several problems were encountered. Satellite imageries could have captured the dynamics of land cover changes, particularly in the upland sites, but it was not possible to get them during the short period of the survey. There was also lack of the hydrological data for the *Dechatu* River, and therefore the hydrological analysis was not undertaken. In addition, the available rainfall data was not adequate enough to undertake the analysis at the required level of precision. Finally, the survey was conducted in a very short span of time and therefore focused more on the empirical evidences.

2. LITERATURE REVIEW

2.1 Watershed Degradation in the Dire Dawa Watershed

Soil erosion is a serious ecological and economic problem. It is widespread and severe in Ethiopia. In Dire Dawa watershed, soil erosion is a well-known problem and responsible for rapid land degradation. Most erosion occurs on the cultivated lands in the form of sheet, rill and gully erosion. Consequently, rapid losses of soil fertility and yield decline are noted.

The soil conservation research project that has been carried out at national level estimated an average soil loss of 42 t/ha/yr on cultivated fields and the maximum of 300-400 t/ha/yr in highly erodable and intensively cereal-cultivated fields (EPA, 2003). However, Woody Biomass Inventory and Strategic Planning Project (WBISPP) calculated maximum soil erosion rate to be 21.8 t/ha/yr in DDAC (MoWR, 2006).

In Dire Dawa area, significant amount of fertile soil is eroded due to massive deforestation and cultivation of steep slopes. Much of the land has suffered erosion damage and some places have even reached irreversible stage. Steep slopes and unsustainable farming practices have contributed to such severe erosion hazards (DDAC Water, Mines and Energy Office, 2003). The current annual loss of forest areas at country level ranges from 150,000 to 200,000 hectares (MNRDEP, 1994). The total consumption of wood as fuel including charcoal, in DDAC, is estimated at 71,257 tons per annum, which is set against an annual sustainable supply of only 35,000 tons (DDAC-WMEO, 2003).

2.2 Flooding at Dire Dawa

There is no perennial river in the administrative region, but there are four major watercourses, which either pass through or skirt the boundary of the town, which include *Lege-Hare, Goro Dechatu* and Butugi Rivers. The eastern escarpment of the watershed is highly eroded due to the dominance of steep slopes. As a result, flash floods are not uncommon, incurring considerable damage to property and infrastructure (MoWR, 2006).

Dire Dawa lies at the foothills of a mountain range. There is a big dry waterway, which divides the town into two parts. During the rain season, this dry waterway suddenly turns to a large river. The town is subjected to annual flooding by runoff from the surrounding uplands during the torrential rains. The administration of the town in collaboration with neighboring regions has plans to implement watershed management programs. This intervention is expected to reduce flood risks in the town (WMO and GWP, 2003). Presently there are initiatives of catchments treatment at *Oda Gunufeta – Cherecha – Dechatu* in the Dire Dawa Administrative Council (MoWR, 2006).

3. SURVEY METHODOLOGY

3.1 Study Area Description

Dire Dawa Administrative Council (DDAC) is located some 515 km east of Addis Ababa. It lies between 09^{0}28' and 09^{0}49'N latitude, and between 41^{0}38' and 42^{0}19'E longitude. It is bounded in the north, east and west by the Somali National Regional State and in the south and southwest by the Oromia National Regional State (Figure 1).

The administrative region is interconnected by main roads and railway. The physiography could be classified into mountain ranges, hills, valley bottoms, river terraces and flat plains. The mountain ranges are found mainly in the southern part. These mountain ranges possess slopes above 45%. The hills are found scattered allover the region, with slopes ranging between 16 and 30%. The soil depth is so shallow, which is dominated by pebbles and rock out crops that are devoid of vegetation cover.

There are also deep and fertile soils at the valley bottoms, river terraces and flat plains (DDAC-WMEO, 2003). The flat plains are found mostly in the northeastern and northwestern parts of the Administrative Council.

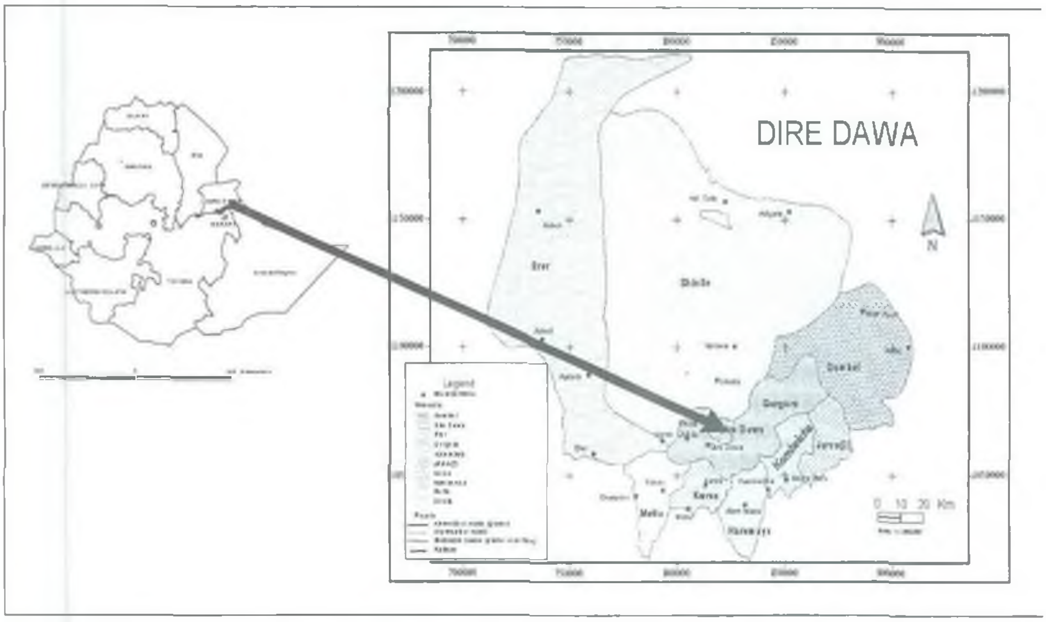


Figure 1. Map of the study area (Dire Dawa).

The rainfall pattern in the DDAC is a bi-modal type of rainfall with the first peak in April and the main peak in July (Figure 2). June is a month of dry spell between, the rainy seasons of February to May and July to September. The long dry season is between October and January. The annual mean rainfall varies between 580 mm in the northern part and 880 mm in the southern mountain range (DDAC-WMEO, 2003).

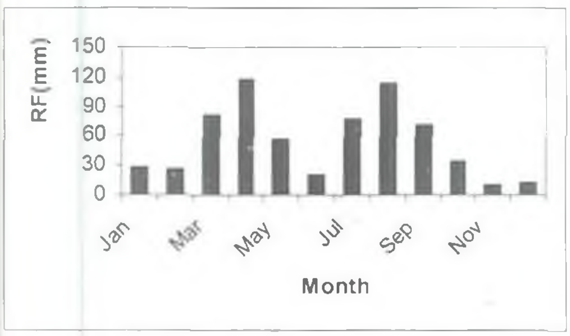


Figure 2. The rainfall regime of Dire Dawa station (Source, NMSA, 2006).

The mean annual temperature varies from 20-30⁰C in the lowland part and 14-20⁰C in the upper part. The hottest months are May and June. Due to its high temperature, the potential evapo-transpiration of the Administrative Council is also high, particularly in March to June.

Vegetation cover in the Dire Dawa Administrative Council belongs to the arid and semi arid (which include cactus, scrub, thorn scrub and many woody and sparse grass formation). The vegetation in the region does not continuously cover large area; rather it is fragmented patches of bushland, shrubland and scattered trees in agricultural land and hillsides (DDAC-WMEO, 2003).

In 1998 E.C. the total population living in the study area was 59,692 (30,186 males and 29,506 females) and 12,325 households. The average household size is about 4.86 (CSA, 1995).

Crop and livestock production predominate the livelihood of rural population. Most of the agricultural activities are practiced in the traditional way. As a result, productivity per unit of cropping land and livestock production unit are low (DDAC-WMEO, 2003).

3.2 Sample Site Selection

The upland parts of the region, the *Dechatu* sub-watershed, which consists of streams of *Lege Butugi* from *Alemaya Wereda* and *Lege Dechatu* from *Karsa* and *Dengego* area are sites selected for this survey based on the following important points (Figure 3). The sites are the sources high amount of runoff that joins *Dechatu* River, which ultimately floods Dire- Dawa. Besides, the sites have experienced relatively serious vegetation degradation. Consequently, this survey has selected four representative samples both from the upland and the affected areas (Figure 4).

3.3 Data Sources and Types

This survey has employed both primary and secondary data sources through Focused Group Discussion (FGD), interviewing key informants and direct observation in the field.

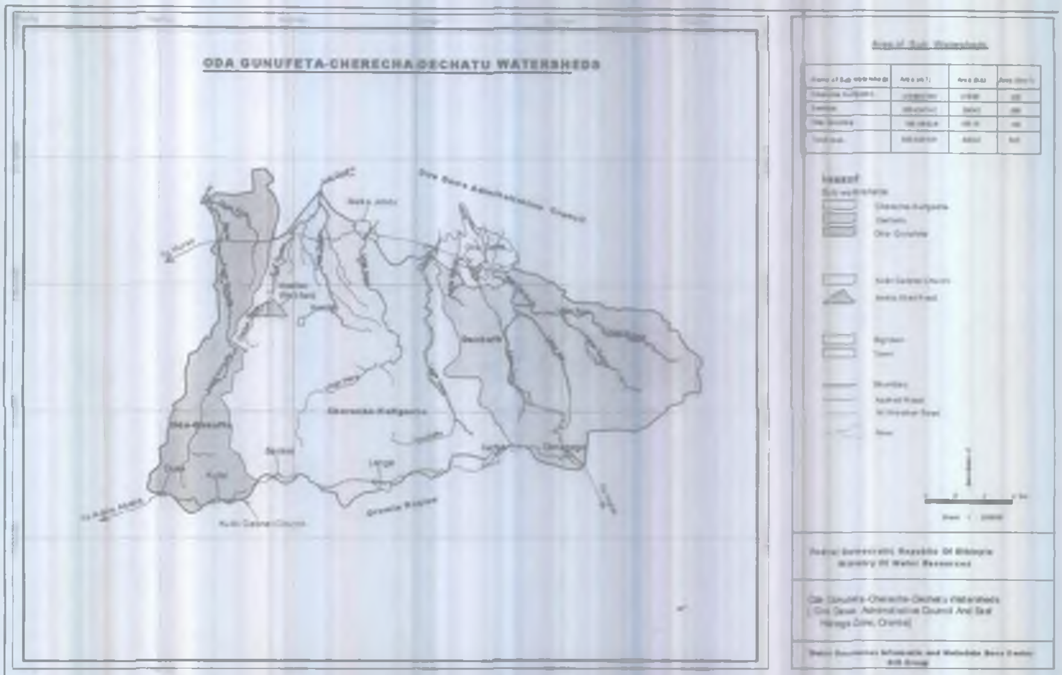


Figure 3. Map of Dire Dawa and East Hararge watershed (MoWR 2006).

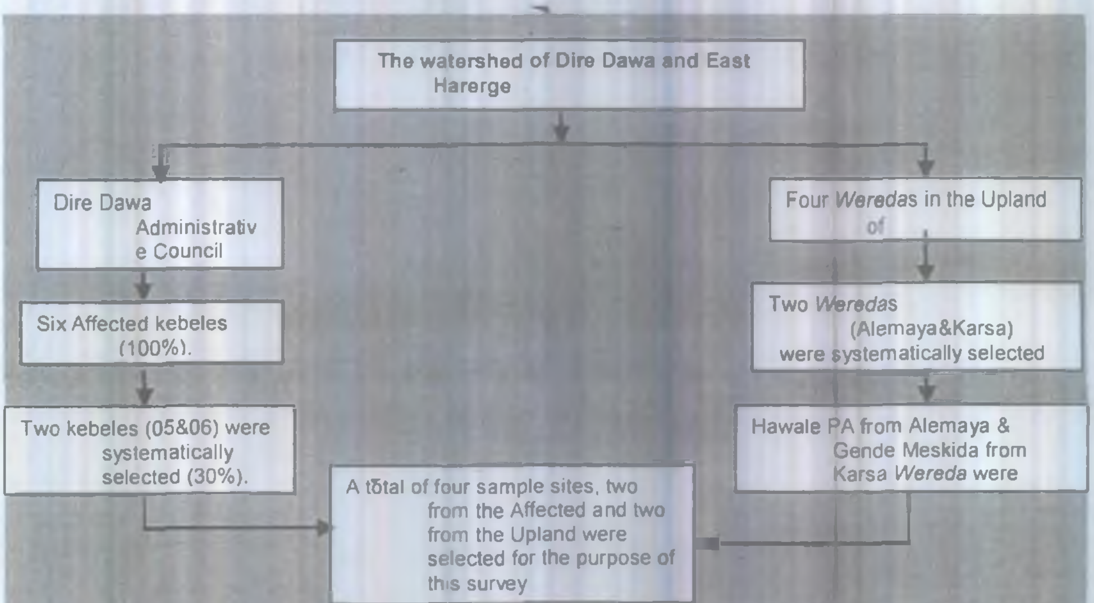


Figure 4. Procedure of sample site selection.

A. Focused group discussion

FGD was conducted with involvement of elders both in the 'impact' and 'upland' area. Elders were involved in the FGD because they have a wealth of information about the environmental phenomenon in the survey area. The FGD was undertaken in collaboration with 05 and 06 *Kebele* administration where the flood disaster of August 2006 took place. Each FGD consisted of five individuals. In the 'upland' sites, the *Gende Meskida* village (*Karsa Wereda*) and *Hawale* PA in Alemaya *Wereda* were involved.

B. Interview with key Informants

In-depth interviews were conducted with the aim of obtaining information on the issues of catchment management, degradation and rehabilitation, trends of flooding, etc. The interview consisted semi-structured questions. The interviewees were drawn from Dire Dawa Administrative Council Natural Resource Protection and Development Office, Kebele development committee, Disaster Preparedness and Prevention Bureau, Jerusalem Children and Community Organization (a local NGO), and farmers.

During the field observation, direct experiences were obtained from the vegetation cover, river course modification, flood disasters and other silent features. Field observation had been conducted in *Gende Hada* JeCCDO development site; *Dengego* mountain range; *Dechatu* River course; Harla Belina PA, Natural Resource Development and Protection Office's rehabilitation site.

The secondary data were obtained from the government institutions such as National Meteorological Service Agency, Ministry of water Resources and published and unpublished documents have been used as background information and they were incorporated in the analysis. In addition, the rainfall records of the 2006 Summer season from *Karsa Wereda* Natural Resource Development and Protection Office were also used.

This survey has mainly relied on the qualitative data analysis with little undertaking of quantitative data analysis. While the qualitative data, gathered with the help of direct observation and group discussion and key informant interviews were analyzed through descriptive method of analysis; quantitative data analysis was employed to undertake trend analysis of rainfall at different stations in the survey area.

4. RESULTS AND DISCUSSION

4.1 Description of Flood Related Factors

In the analysis of flood, it is important to look at the factors that have direct relation with floods. The survey focuses on the description of the phenomenon within the catchments and the changes brought about in different times. It also examines how the recent flood disaster in the study area would be related to the phenomenon. Therefore, this part looks at the history of some of the events in the survey catchments.

4.1.1 Settlement history

Since its inception, Dire Dawa has been experiencing high population growth. This is due to high immigration mainly due to trade and in search of job in the industries. The population growth rate is 2.23% (CSA, 1995).

According to a key informant, over the last 20 years the number of people residing around the banks of *Dechatu* River has been increasing. Many residential houses were constructed across the flooding zone delineated by the Italians (during their occupation of Ethiopia in 1936–1941).

On the other hand, the town administration has been granting house construction license in areas which were identified as flooding zone. This granted the expansion of house construction in the area, including the illegal ones. The shanty villages, such as *Bihre-Tsige*, are the case in point.

Similarly, in the upland part of the catchment, there has been growing pressure of population settlement. According to the results of the group discussion, population in the eastern escarpment has been increasing since late 1980s and early 1990s. People settled and secured farmlands in the hill slopes. Especially during the late years of *Derge* regime, less attention was given to the conservation of soil and forest in the area. The attention was rather on the political affairs. This resource control lacuna has resulted in the massive settlement of population on fragile parts of the catchment.

4.1.2 Deforestation and soil degradation

The highlands of eastern Harerge were once covered with dense forests. However, due to the rapid increase in population pressure and the subsequent demand for agricultural land, firewood, and wood, forests and woodlands were cleared indiscriminately. According to the group discussion in the upland, during the reign of Emperor Haile Silassie I (1930-1974), the forest cover of the highland part was very dense.

Since forests were owned by landlords, no one was allowed to enter the forest zone let alone to cause damage. In fact, the collapse of the imperial rule gave way to massive forest destruction. It is said that peasants have done this in retaliation to the landlords. Consequently, the mountain remained devoid of vegetation and this in turn aggravated soil erosion.

According to a key informant, in the 1980s the *Derge* effected large-scale mass campaign of undertaking soil conservation and reforestation works supported by food-for-work in *Dengego* highland. This had brought significant improvement in maintaining the soil and forest status of the upland. The government was widely appreciated for its protection and rehabilitation of the forest resources in the 1980s. However, the late years of the regime the settlers turned the forests into farmlands. In the area, large-scale deforestation and human settlement took place in the forest especially in the transitional period (i.e., 1991 – 1995).

According to ONRS (2001), the accessible forest in the East Harerge zone was heavily depleted by time of government transition, i.e., 1991. Consequently, the area is now devoid of its forest resources.

Lack of awareness on the part of the population was the major problem. Another serious problem was that the local population lacked sense of ownership on the development process. In addition, the fall of *Derge* gave impetus for further degradation on the remnant forests until recently. To complicate the matter further, the current Ethiopian government has made fewer attempts to rehabilitate the forest resources. These attempts are found insignificant and limited to pocket areas.

4.1.3 Rainfall regimes

With regard to the rainfall intensity and duration in the study area, mixed information were obtained from the upland sites. FGD held in *Hawale* PA unanimously disclosed that rainfall intensity and duration are almost similar to the past and no changes have been noted. Meanwhile, FGD in *Gende Meskida* village witnessed a heavier rainfall in the 2006 summer.

According to FGD in *Karsa Wereda* (*Gende Meskida*), during the reign of Haile Silassie, the rainfall was heavy and evenly distributed, which satisfactorily drench the ground with moisture. As time went on, it started to fluctuate both in amount and distribution. Some times, the rain falls with low intensity for long time. At another time, the amount of rainfall within a rainy season became too small and unreliable. A key informant explains this further. The rainfall during the last several years has showed a decreasing trend in both duration and intensity. The rainfalls interrupt several times within the cropping seasons. As a result, farmers have faced frequent crop failures especially in the recent past.

Unlike the previous years, however the rainy season of the year 2006 (July and August) was described as 'unusual' and extremely heavy in amount and strong in its intensity. It was said that, during the 2006 rainy period, the rain was raining day and night, and it has restricted even the movement of people from place to place and from doing other activities. All the months of the rainy season in 2006 experienced intensive rainfall as compared to the past five rainy seasons.

Unlike the opinion shared by group members of *Dengego* (*Gende Meskida*), the discussion held with elderly group of *Hawale* revealed that rainfall in the area has not showed considerable change in the amount and intensity. According to them, the rainfall of 2006 rainy season was not exceptionally high from the rainfall of the rainy periods in the past. It was said that, there were cases when the rain used to fall heavily during the time of Haile Silassie and during the *Derge's* regime.

The empirical rainfall data obtianed from the meteorological agency for the past 15 & 20 years for *Karsa* and Alemaya stations, respectively, has supported the opinion of the group in *Gende Meskida* village, which showed a decreasing trend of rainfall through time in both stations. Rainfall in *Alemaya* and *Karsa* showed an annual decrease by about 3 mm (0.3%) and 32 mm (0.32%) respectively during the period of records (Figure 5).

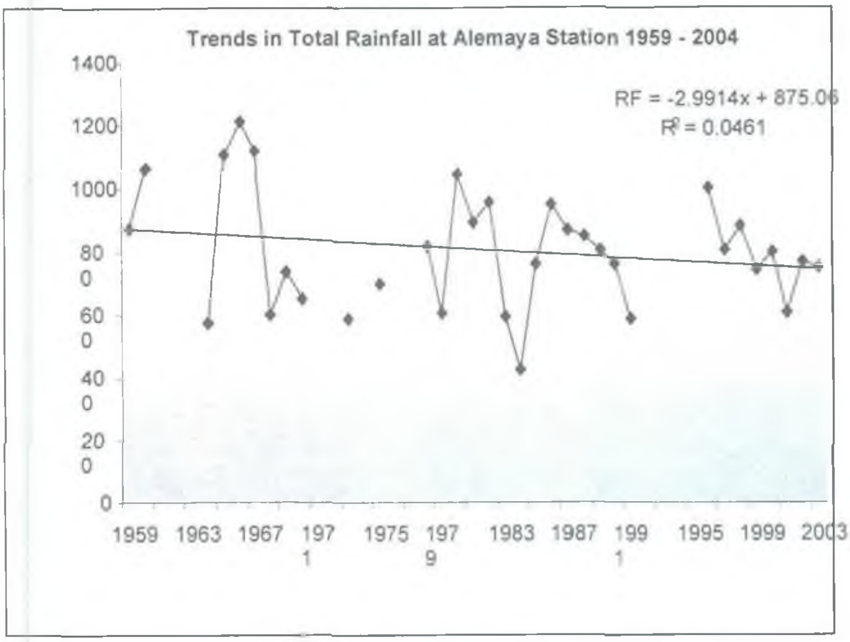
4.1.4 Flooding regime

Flooding is not new to Dire Dawa. The town has experienced various flooding events over the past three decades or so. However, this year's event was the worst in the last 25 years. According to the discussion with elderly group in the town, the first well-recognized flash flood occurred in the area in 1945. This was not as strong as floods occurred during the following periods. After a gap of 32 years, it occurred for the second time in 1977. This latter incidence of the flood was also less in its magnitude and caused negligible causality. The recent flooding, to most of the residents, was a surprise because for most of them this was their first flooding event. According to A key informant, the 2006 flooding resembles the flooding event which took place during the Ethio-Somalia war of 1977. At that time, some militia men, who were guarding Dire Dawa town from Somalia invaders were shooting their gun at the flood, with the conviction that the horrific flood was the works of the devil's spirit (Figure 6).

Latter, after four years, in 1981, another flood event occurred. The flood during this time was very severe and the damage it caused was so great. As said the Key informant stated, the volume of the flood very large, which overflowed the biggest bridge of the town. The next flooding periods were in 1997 and 2001, which occurred after 16 years and 5 years respectively. Conway (2000) reported that the October to February of 1997/98 as the wettest records owing to unseasonably high rainfall. Particularly October was responsible for widespread flooding across Ethiopia and parts of Somalia and Kenya. In 2004, another disastrous flooding inundated Dire Dawa and caused huge damage on life and property. Since then, the frequency of occurrence of flooding shortened to one year.

4.2 Analysis of Flooding Impacts

The nature of the topography surrounding and its location make Dire Dawa more vulnerable to flooding hazards. Whenever heavy rains fall in the highlands of *Alemaya*, *Lange*, and *Karsa*, it instantly turns into floods. In fact, the town had been experiencing floods of varied magnitude. The memory of our key informants in flood regimes and impacts are fresh. According to them, in 1981 and 2004, eighty and forty-five people respectively were killed. Similarly, a key informant stated unknown number of street dwellers were taken up by the 2006 flood.



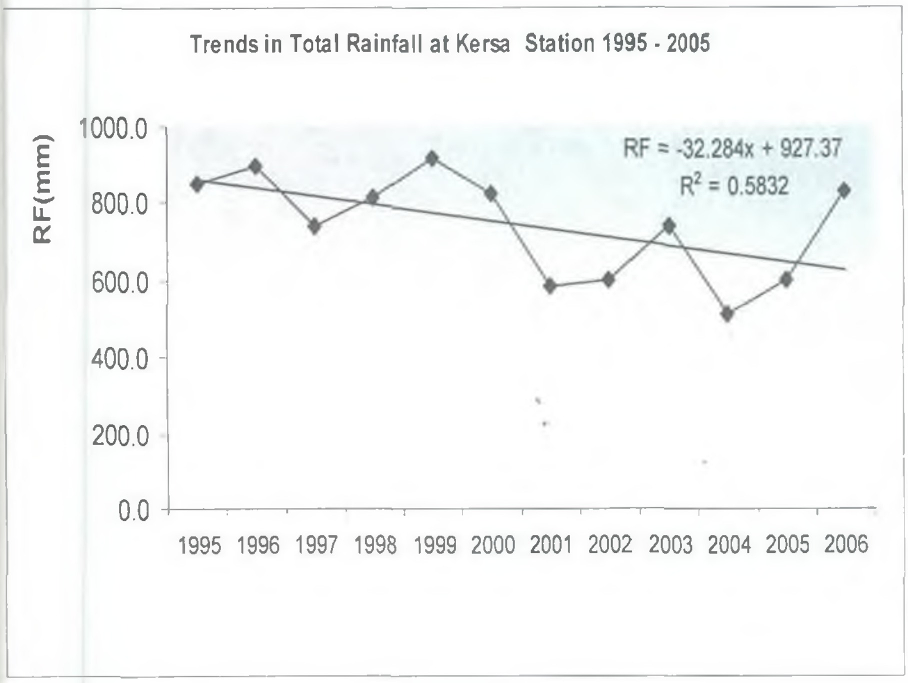


Figure 5. Rainfall trends in the upland catchments.

The 2006 flood has caused the death of 256 people among which 39 were children (Associated Press, 2006). It also left 9,027 people displaced and 244 were missing. Furthermore, the flood has destroyed properties, infrastructures like soil bund, stone bund, stone check dam, water-harvesting ponds and cut off drain and several houses. The damage on cultivated farm plots amounted to 230.6 ha. These were covered with sorghum, maize, haricot bean and sesame. The damage on fruits and vegetables amounted to 17.2 ha. On cash crops, it damaged 6 ha. In addition, 1,036 livestock died (DDAC-RDB, 2006) (Table 1).

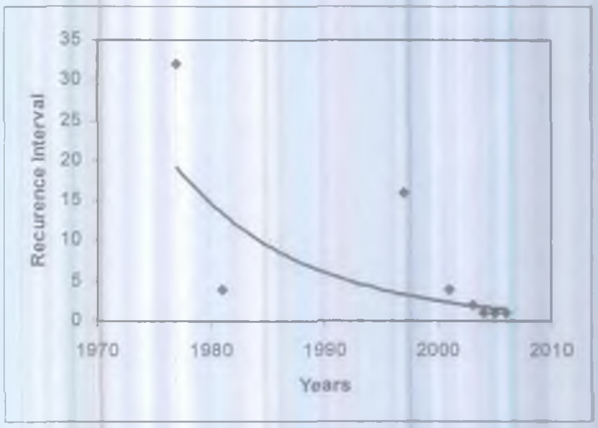


Figure 6. Declining trend of flooding intervals at Dire Dawa.

Table 1. Damages incurred by flood accident of 2006 in rural areas.

	Type of damage	Unit	Total damage
1	**Infrastructure**		
	Soil bund	km	209.2
	Stone hund	km	54.3
	Stone check dam	M^3	7200
	Water harvesting ponds	No	2
	Cut off drains	km	37.85
	Different types of houses	No	28
2	**Damage on farm plots**	Ha	230.635
	Sorghum	Ha	204.36
	Maize	Ha	24.9
	Haricot bean	Ha	0.75
	Sea same	Ha	0.625
3	**Fruits and vegetables**	Ha	17.21
	Fruit	Ha	15
	Vegetables	Ha	2.21
4	**Cash crops**	Ha	5.6
5	**Different farm tools**	No	292
6	**Livestock death**	No	1036

Source: DDAC Rural Development Bureau, 2006.

Concerning the damage of flood on the farmlands, about 1,827 rural households and 1,600 urban households were made homeless. The 2006 flash flood caused damages on different institutions such as Ethio-Djibouti railway enterprise, the Ethiopian Electricity Power Corporation, the Ethiopian Telecommunication Corporation, the Dire Dawa Transport Authority, etc. The floods were also discouraging to the growing private investment sector in the Administrative Council by wiping out their investment capital. For instance, one businessmen, has lost a coffee processing machinery as well as vehicles worth of approximately 15 million Birr, while the Hmdeyel Milk Processing Company completely wiped out (Fortune, 2006).

In general, the overall extent of damage occurred in the urban and rural communities have been estimated worth over 50 million Birr (MoWR, 2006). Contrary to the official report on the number of death tolls by the flood, the field assessment revealed an exceeding number of death tolls. This is mainly because of the large number of homeless people who used to live along the flooding zone who were unaccounted for. This group of the society includes daily laborers, beggars, street children and other marginalized group like mentally disordered peoples. Some analysts push the figure up to 1,000 people. Although unquantifiable and intangible, the field survey has assessed the flood impacts on victim's psychology. Many people were totally unhappy, depressed and frustrated. Sense of insecurity and interruptions of socio-economic activities were among the flood impacts.

Table 2. Damages incurred by flood accident in urban area in 2006.

No.	Type of damage	Unit	Total damage
1	Road	Birr	5,121,734.84
2	Ford	Birr	1,219,749.00
3	Bridge	Birr	1,200,000.00
4	Retaining wall	Birr	2,284,916.00
5	Residence	No.	1,600

Source: Dire Dawa Flash Flood Appeal (2006).

Plate 1. Road cut by the 2006 flood.

4.3 Analysis of Flood Causative Factors

In the catchment, the runoff is generated from many intermittent streams, which flow down over steep slopes at greater velocity. Numerous streams confluence at "Genet Recreation Center" to form *Dechatu* River.

When the river reaches Dire Dawa, it gradually loses its speed and energy. This is because of the wider flooding plain, which spreads the river into large surface. In normal circumstances, floods resulted from the swell of the river are friendly to the environment and human settlement. However, gradually the river experiences outburst on to properties and human settlements.

The following are the identified major factors of flooding in Dire Dawa:

4.3.1 Land degradation in the catchment:

In the field survey, it was observed by the survey team that large-scale destruction of forest resources in the highland areas has been practiced. This has aggravated the rate of flooding in Dire Dawa. The practices of indiscriminate forest resource clearance over the uplands of the catchments have significantly decreased the infiltration rate of the rainwater into the soil which lead to sheet erosion (WMO and GWP, 2005). Informants explained that 'much' of the raindrops changes into run off, which had once been infiltering into the soil. This subsequently resulted in soil erosion and flash flood risk, which were more severe in a steeper slope of *Dengego* area where the forestlands have been converted to farmlands.

According to ONRS (2001), in *Dengego-Hawale*, natural forest cover is 0% while cultivated land covers 47% and the remaining 39% and 14% of the land areas were under the cover of shrubland and grassland respectively. Similarly, it is estimated that East Harerge has lost about 6% (180 ha.) of its high forest resources between 1990 and 2000 due to agricultural expansion.

Plate 2. Degraded lands of *Dengego*.

Table 3. Land use and land cover types in *Karsa* and Alemaya *Weredas*.

Wereda	Area (ha.)	Cultivation	Forest	Plantation	Shrubland	Grassland	Rock
Karsa	45832	19831	137	266	3180	18584	3834
Alemaya	63132	33108	0	0	1998	25778	2248

Source: ORS (2001).

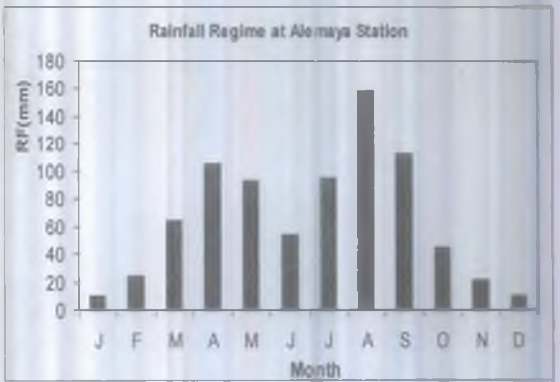
According to a key informant, occurrences of higher rate of runoff were common in steeper parts of the *Dengego* highland, where forest cover has been converted to barren land or farmlands. The higher runoff in turn was causing flash floods at different times in Dire Dawa. Daniel (1977) stated that even low intensity of rainfall in the highlands does not guarantee the occurrence of fast rate of runoff and accelerated soil erosion due to the steeper slopes. Subtler changes, which might have worsen flood risk, are produced by land use changes e.g. de-vegetation (WMO & GWP, 2005).

In Dire Dawa, flash floods used to occur in times of heavy and long duration rain fall, however, nowadays they started to occur even in times of short duration of rain and at any degree of rainfall intensity. As revealed by one of the field assessments of the survey team, the cause for this is to be associated with the massive degradation of vegetation cover in the catchment.

According to one of the informant's explanation, due to the on going indiscriminate clearance of forests in the upland catchment, the rate of runoff and soil erosion in the catchment have become extremely high. This is true given the area's bi-modal rainfall regime (Figure 7), in which soil transportation process through runoff takes place twice a year. As a result extremely large amount of sediments have been transporting annually. Currently, the upland catchment is 'largely' covered by rock outcrops. It is this gradual sedimentation process that has raised the channel bed almost to the level of the riverbank, and which became one of the causes for the risk of flash floods in the vulnerable *kebeles* of Dire Dawa.

4.3.2 Meteorological factor.

Based on obtained rainfall data, rainfall in the catchment has showed a decreasing trend through time. Similarly, one key informant explained congruent with the result of the trend analysis. He described the subsequent decreasing trend of rainfall since the downfall of the Imperial Regime. In explaining this, he often mentioned crop failure and decrease in production at different cropping periods in the past due to lack of enough amount of rainfall. He further explained that in the 2006 *kiremt*, rainfall intensity was extremely high. According to him, *Karsa*, located in the upper part of Dire Dawa got flooded for the first time. The meteorological records revealed that the rainfall in the year 2006 *kiremt* significantly increased as compared to the past five rain seasons. However, this was not the only extreme event in the catchment.



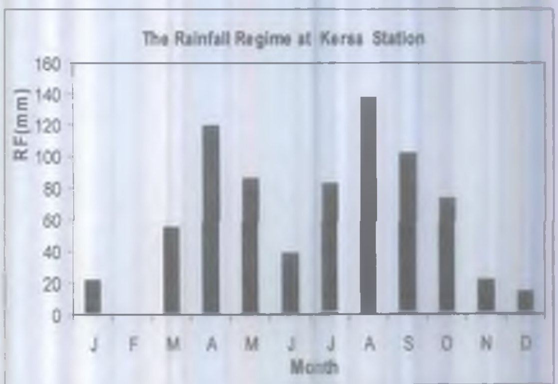


Figure 7. Rainfall regimes at upland area (NMSA, 2006).

Although the empirical data on rainfall shows decreasing trend, the 2006 rainfall data, obtained at *Karsa* and Alemaya stations has increased by about 68.3% and 19.6%, and 48% and 3.8% when compared to the rainfall in the years 2004 and 2005 respectively (Table 3). However, the lesser rainfall observed in 2005, 2004, etc., has caused comparable flood with the year 2006 at Dire Dawa. On the other hand, the higher summer rainfall obtained in the years 1961, 1966, 1967, etc., than the 2006 rainfall did not caused comparable flooding at Dire Dawa.

4.3.3 Human interventions within the flooding zone

The multitude of human interventions in the river zone for various purposes could trigger the river to overflow its banks. JeCCDO, a local NGO based in Dire Dawa, has effected several development activities in the areas of the town Administrative Council. One of which was the planting of different fruit and seedlings of trees in the flooding zone by approaching from the right bank by about 50 meters. It was done by lifting up the ground from one side by digging it with bulldozers. According to the informants, it was this activity, which ultimately has resulted in narrowing the river channel. Asked what it looked like before, they said that, the river channel existed intact for a long period and allowed wider space to floods. However, since this intervention, the river has been forced to flow in the narrower channel. It was this narrow channel, which pressurized the large volume of the river water and forced it to out burst its bank and consequently flooded one of the *kebeles* called *Gende Gurage*, located near *Dechatu* river.

One of the informants concluded that development intervention should have been supported by proper surveys by professionals. He added that, otherwise it would potentially obstruct the normal and natural systems and inflicts undesired outcomes. In all his explanations, he mentioned JeCCDO's intervention in the course of *Dechatu* River. Another informant, on her part confirmed that the JeCCDO intervention within the river buffer zone has lacked a detailed assessment on the impacts of such intervention in the river course.

Expansion of continued self-initiated human settlement, the establishment of Coca Cola Bottling Factory, a big shopping center, and a bus station by the government within the flooding zone have compromised the width of the riverbed, elevating its flow and leading to the current overflow. These were the frequently mentioned human interventions that have contributed a lot in triggering floods.

According to informants, the community has put forth complaints. For instance, during the construction of Coca Cola Factory on the flooding zone, people opposed to the location of the factory, which they said, narrows the flooding channel and would eventually trigger flooding. However, the complaints was unheard by the concerned body. Pursuant of the factory, several other constructions were legalized within the flooding channel. Consequently, what is happening at present is what the community was complaining about in the past. On the other hand, the group discussion held at Dire Dawa demanded that the frequently occurred administration changes in the Administrative council has contributed to the unwise management of the dry river plain.

Poor people find it easy to settle the most vulnerable part of the flooding zones. According to one informant, flood risk areas have not yet been allocated to prevent people from settling in such vulnerable areas. As a result, there is an increasing trend of dwelling by people within the river channel.

It was said that Italians, during their occupation of Ethiopia (1935-1941), had delineated flooding zone at Dire Dawa. This was meant to allow the river to flow without causing damages. However, as time went on people settled and practiced various economic and social activities by getting legal construction license within the delineated zone in the last few decades. Since then, the houses and buildings obstructed the normal flow and diverted the floods into the residential areas.

Table 4. Maximum rainfall occurrences at the upland stations.

Maximum Rainfall Occurrence at Alemaya Station							
Year	Total summer (Rf)	Max. Rf	Months	Year	Total summer (Rf)	Max. Rf	Months
1959	109.0	65.5	Aug	1985	208.2	90.2	Aug
1960	382.7	197.2	Jul	1986	308.2	161.4	Aug
1961	382.4	153.0	Jul	i987	216.1	123.2	Aug
1966	740.0	500.2	Aug	1988	336.3	180.7	Aug
1967	426.9	228.2	Aug	1989	302.6	146.0	Aug
1968	338.4	128.0	Jun	1990	289.7	154.7	Aug
1969	324.0	.168.0	Aug	1991	241.8	109.1	July
1970	282.8	160.7	Aug	1992	243.4	97.6	Aug
1971	307.1	127.3	Jul	1997	295.7	148.7	July
1974	282.0	111.5	Jun	1998	263.7	128.5	July
1976	231.0	134.7	Aug	1999	363.8	238.6	Aug
1979	296.9	160.7	Aug	2000	243.1	141.5	Aug
1980	218.9	95.9	Aug	2001	384.2	217.7	Aug
1981	343.6	204.7	Aug	2002	273.4	165.3	Aug
1982	238.7	122.1	Aug	2003	441.5	272.4	Aug
1983	496.6	305.2	Aug	2004	215.9	116.4	Aug
1984	271.6	101.6	Aug	2005	307.9	158.8	Aug
				2006	319.7	119.8	July

Maximum Rainfall Occurrence at Kersa Station							
Year	Total summer (Rf)	Max. Rf	Months	Year	Total summer (Rf)	Max. Rf	Months
1995	75.5	57.1	June	2001	248.5	148.4	Aug
1996	336.7	221.0	Aug	2002	196.3	125.0	Aug
1997	178.3	104.6	Aug	2003	346.5	149.1	July
1998	406.7	231.0	JuLY	2004	166.8	81.9	July
1999	393.8	189.5	Aug	2005	234.7	167.2	Aug
2000	274.7	191.7	Aug	2006	280.8	158.0	Aug

According to an informant, extraction of sand from the river channel, particularly from the place a bit outside of the town, has deepened the channel in that particular area. This too has narrowed the channel width and increased the speed of the river flow. Similarly, the practice of quarrying of rocks from the riverbank made the river not to loose its energy/velocity. Rocks, particularly bigger ones, in the river could greatly reduce the speed of a river. However, due to the massive extraction of sands and rocks the river water reaches the town with full speed.

4.3.4 Lack of adequate flood protection measures

There are few flood protection structures, such as retaining wall and levees. These were constructed in order to protect the outburst of *Dechatu* River. The field assessment and the view of informants revealed that the existing flood protection structures are inadequate. The channel bed, which is almost at the level of its bank due to deposition of silt, easily allows the river water to flow over the banks and turn into flood. The existing retaining walls also need renewal and require reinforcement. This is because large portion of the existing retaining wall has already been taken away by the flood for its strength could not resist the force of the flood.

Similarly, in the uplands there is lack of runoff/flood protection structures such as check dams, terraces, and the like. As informants reiterated it, unless the streams/ rivers are checked within the upland, the river water would get great velocity when it reaches the town and would cause damage. One of the informants described when the flood reaches the town it is like a lion, therefore, it is better to tame it while it is at upland areas.

Therefore, the cumulative effects of rainfall intensity, environmental degradation within the catchment, human intervention within the flooding zone and lack of adequate flood protection structures, all together could have caused and triggered flooding processes and flood disaster in Dire Dawa in the year 2006 rainy season.

4.4 Survey of Good Practices

The attempt of rehabilitating the degraded hill in *Hadda* village is one of a promising activities in the Administrative Council. According to a key informant, the rehabilitation activity started in 2004. Awareness creation on the part of the community about the causes and consequences of environmental degradation, the importance of rehabilitating the environment, have been undertaken. Agreements was made among the community members on rehabilitating efforts of the environment and on the benefits, and thus the community agreed to take the responsibility of keeping the rehabilitated zone. *It was stated that this* has created a sense of resource ownership among the community.

An informant explained that before the introduction of the rehabilitation activity sediments used to be transported through runoff. After the implementation the amount of runoff has decreased significantly Similarly, rehabilitation in the degraded highland have been undertaken by the town Administrative Council Natural Resources Development and Protection Bureau. Rehabilitation was also undertaken in the *Harlla Belina* PA. and *Alolla* model sites in the southwest part of Dire Dawa.

It was reported that in the last two years the rehabilitation project was successfully implemented. The terraces constructed and seedlings planted have brought tangible progress. As the result of the implemented physical and biological measures, the volume of soil and water transportation has been *significantly reduced*.

The Natural Resource Development and Protection Bureau has constructed several area closures on the steep slope at the *Allola* model site. It was observed that there is a tendency of the expansion of less palatable and alien invasive plants like *Partineum hysterophorus*.

In addition, in order to minimize the loss of sediments and water, a physical structure was constructed along the gullies, called sediment storage dam (SSD) . It was constructed from mass of earth and stone with a height of 8-10 meters. It is said that the highest SSD could conserve 30,000-40,000 m^3 of water. The water conserved in the SSD gradually infiltrates into the ground while some of it is lost through evaporation. SSD increases the ground water capacity and reduces sediment losses. Since the introduction of SSD, substantial volumes of the water and sediments have been harnessed. *Therefore, SSDs have proved successful in* increasing the ground water storage in the area. Moreover, they have protected the *Sabian kebele* of Dire Dawa from floods.

4.5 Appraisal of Flood Disaster Management

In light of the adopted flood management measures applied in the catchment, particularly in the affected areas, there are good practices conducted by different parties. The prime one is the biological measure. It was implemented in the sub-catchments of the *Genda Hada* , *Harlla Balina* and *Alolla*. Respondents of the survey acknowledge its significant contribution to the reduction of runoff. Respondents added that those runoffs that were previously contributing to the floods affecting Dire Dawa which are now significantly reduced. The survey team also observed physical structures such *as terracing on the hill slopes. It was reported that* the biological measure and terraces are the most important practices in reducing the risks of flash floods. However, these efforts are limited to smaller catchments and it could not totally protect Dire Dawa from flood risk.

With regards to whether there exists the practice of information exchange among the people, or not, the informants stated that usually during heavy rainfall in the upland such as, such as Alemaya and *Karsa*, people from uplands used to inform and warn their relatives in Dire Dawa. This was done by using telephone and by sending oral messages. In fact, informants have unveiled the inadequacy of the circulation and dissemination of the messages. Based on this, the survey team has realized that people have good understanding on the importance of information exchange and the need to modernize it in order to reduce flood risks.

Asked what if other important practices have been practiced with regard to responding to flood hazards, the informants reiterated that there is a good deal of resilience in the part of the affected people of Dire Dawa. According to them, immediately after the flood disaster, most people were seen engaging themselves in the post-flood recovery activity in order to bring the situation back to its normal condition. They did not waste much time in mourning.

In connection to the above underlined theme, the survey also assessed the post-disaster management activities. In here, the disaster management activities are assessed at the community and government categories. With respect to the role of local community, the approach has been post disaster activities. Evacuation of the affected people into safer villages, to homes of relatives, are the primary measures taken by the community. This activity allows the rescuing of valuable assets. The community also helps victims to protect their properties from robbery. Assistance, in the form of food, cloths and money is also made through *Idir*, Churches and Mosques.

With regard to the role of government bodies at all levels, informants unanimously disclosed the inadequacy of the action. According to the informants, the role of government in post-disaster management activities has become pronounced especially after the 2006 flood disaster. The police force is said to have played greater role in the rescue operation. The police and defense force fired in the air in order to awake people and to enable them evacuate from the flood affected area. The government has also provided food, cloths, medical care and shelters assistance to the flood victims. Following the disaster, the government resettled the victims in temporary shelters followed by post management activities. An overall coordination mechanism was established with a leadership of the mayor of the town. DPPB served as a bridge between donors and the task force. Several respondents have confirmed that the works of the taskforce was very effective, especially in the area of managing diseases. Clinics were setup and medical provisions were made.

Although several humanitarian activities were done in the post disaster management, lack of preparedness has influenced the efficiency of evacuating victims. The preparedness to forecast floods and conduct early warning was constrained by the existing weak linkages with National Meteorological Service Agency.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Currently, there is lack of coordinated effort between societies in the upland (flood contributing) and the impact area (Dire Dawa) to reduce any further flood hazards. For instance, there are no significant efforts to protect the forest resources and rehabilitate the degraded uplands. Rather, an increasing population pressure undertaking on the remaining sparse vegetation cover. Furthermore, the problem is further aggravated by the absence of clearly articulated local level land use planning.

There are also external threats to the area where scenarios of future climate in East Africa show the likely phenomena of extreme weather events, such as floods. Such treats would likely inflict enormous impact in a situation where there is no adequate preparedness to protect the likely damages of floods. Therefore unless some remedies, such as effective early warning and preparedness are taken, it is more likely that Dire Dawa would suffer similar damaging consequences of floods in the future.

5.2 Recommendations

Based on the findings of the survey, the following recommendations are forwarded:

- The implementation of an integrated watershed management approach with due emphasis on community based catchment rehabilitation projects should be promoted in order to bring about a sustainable SWC and flood management practices within the watershed;.
- It is the absence of a clearly stated local level land use planning which impaired local forest officers to restrict people not to destroy the forest land. Therefore, there is an urgent needs to enact rules and regulations, which will give the legal basis for forest management practitioners in the area.
- The Dire Dawa Council Urban Planning Bureau and other concerned institutions should be geared towards mitigating the ongoing intensification of land uses over the flood plain. To achieve this, the flooding zone need to be delineated through strict urban land use rules and regulations.
- If development intervention is a must in the flood plain, there should be effective environmental impact assessment, followed by sound environmental auditing measures.
- In a bid to mitigate the flood disaster causalities, the practice of flood forecast and early warning system should be strengthened and modernized. In this regard, reliable and up-to-date meteorological information are important. Besides, the flood warning information system should be integrated with the Frequency Modulation (FM) radio Parallelly, non-structural flood management practices should be encouraged to thrive. .
- The existing DPPC structure to tackle natural hazards is drought-based and meant for rural areas. It gives little attention to the protection of flood hazards in towns. Therefore, the mandate should incorporate the preparedness for urban flooding.
- The high turn over of the administrative personnel in the council has seriously influenced the sustainability of flood management efforts. Therefore, it is important to enable stable administrative officials with respect to the flood and flood related activities.
- The understanding of flood in the Water Management Policy is viewed as a disastrous and damaging phenomena, which is expressed through "combating and regulating

floods through sustainable mitigation, prevention, rehabilitation and other practical measures" (MoWR, 1999). It seems for this reason that the policy focused on the protection than the utilization of floods for economic developments. Therefore, it is imperative to appreciate the role and management of floods for its best services to the people. In this regard, it is wise to think of enacting floodwater management policy.

- Finally, it is vital to make use of the wisdom of the local community on flood management. In this regard, the Administrative Council has to create a close relationship with the community and give attention to there demands.

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Participants of the Workshop

GLOBAL CLIMATE CHANGE AND ETHIOPIA'S VULNERABILITY TO THE ENVIRONMENTAL HAZARDS

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1. INTRODUCTION

Our world is in a state of dynamism. Both the biophysical and socioeconomic attributes are subject to different forms of changes, which include climatic, land cover, demographic, and socio economic change. Especially, climate change has been very common throughout the geologic history of our Earth. Scientists are, however, much concerned about climate change when it is happening too quickly. King (2004), UK's Government Chief Scientific adviser, stated that "climate change is the most severe problem, even more serious than the threat of terrorism".

Global warming is mainly caused by anthropogenic factors, which alter the atmospheric circulation and change the weather patterns. The growing concentration of CO_2 in the atmosphere is rising the mean global temperature. As a result, higher evapo-transpiration, changed amount and distribution of rainfall, and several other impacts may follow.

Nowadays, natural disasters are happening more often and having an even more dramatic impact in terms of their human and economic costs. In the last ten years, the number of people affected by natural disasters in the world is close to two billion, which has tripled when compared to the preceding decade. According to the International Federation of the Red Cross and Red Crescent Societies, from 1994 to 1998, the number of disasters averaged 428 per year. From 1999 to 1998, this figure shot up by two-thirds to an average of 707 natural disasters each year. The biggest rise occurred in developing countries, which suffered an increase of 142%. The factors most often blamed for the increase in natural disasters are population growth, environmental degradation, climate change and negative results of economic globalization.

Various research outputs have demonstrated that global climate change is responsible for the growing frequency and magnitude of environmental hazards. It is believed that environmental hazards would not only be enhanced but also become powerful in the causalities.

In Ethiopia, the occurrence of environmental hazards is gaining momentum. According to EPA (2003), factors that contributed to the occurrence and severity of environmental disasters include:- rapid population growth, accelerated depletion of forest resources, disruption in the amount and distribution of rainfall, the spread of drought-induced animal diseases, low production and productivity of the rain-fed agricultural sector, and the consequent grinding poverty endured by the population.

Despite the availability of a wide body of literature on the various impacts of global climate change, the issue in Ethiopia has hardly been tabled for a wider public understanding and debate. Since Ethiopia is a country with rapid population growth, widespread poverty, massive environmental degradation, and an economy that heavily rely on rainfed agriculture, the likely impact of GCC would be enormous. However, the likely impact of climate change on the Ethiopian economy, and specifically on the agriculture, has not been presented at the annual conferences of the Ethiopian Economic Association (EEA)[†]. It is, therefore, safe to consider that many people, including government and scholars, have overlooked the likely linkages between global climate change and the natural disasters in Ethiopia.

This article attempts to scan the likely impact of the changing global climate on the rainfed-agriculture dependent Ethiopian economy, in the light of the rapidly growing population, and the massive resource degradation taking place in the country. The assessment would base itself on the available but fragmented climate change related information on Ethiopia, coupled with the implication drawn from the pool of literature dealing mainly on the climate changes in east Africa. The paper is organized into five Sections. Section two provides an overview of climate change at global, continental and national levels. Section three provides analyses of important disasters affected by global climate change. Section four describes factors which could complicate the likely impacts of climate change in Ethiopia. Finally, a concluding discussion is presented in Section five.

2. OVERVIEW OF CLIMATE CHANGE

In this Section, an attempt is made to highlight the general features of climate change as specifically

[†] In the last four years, close to 300 papers were presented at the International Conference on the Ethiopian Economy.

tuned to different geographical scales, viz., global, continental, and national levels.

2.1 Global Overview

Throughout the history of the world, there have been various forms of climate changes. However, the change in the remote past was essentially natural, with little or no human influence. Since recently, the human element has been added to the climate change equation, which is mainly due to the anthropogenic gases, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and halocarbon compounds (IPCC, 2001). Over the last 140 years, the earth's atmosphere has warmed by about 0.6ºC (Figure 1), and the see level rose by 10 to 20 cm. It is predicted that by the year 2100, the rise in temperature could be as much as 5ºC. NASA researchers say that temperature has increased at a "remarkably rapid" rate.

Rapid rise of temperature is responsible for the frequent and severe weather events, involving heavy rainfall, high winds, and storm surges. Derived impacts include catastrophic droughts, vigorous hydrological cycle, increased frequency of extreme weather events, such as floods and droughts. Moreover, there would be increased incidence of forest fire, increased outbreaks of diseases and pests, increased emergence of noxious weeds, etc (Rosenzweig and Hillel, 2000). According to Oxfam (2000), between 1990 and 1998, about 94% of the world's major natural disasters occurred in the developing countries.

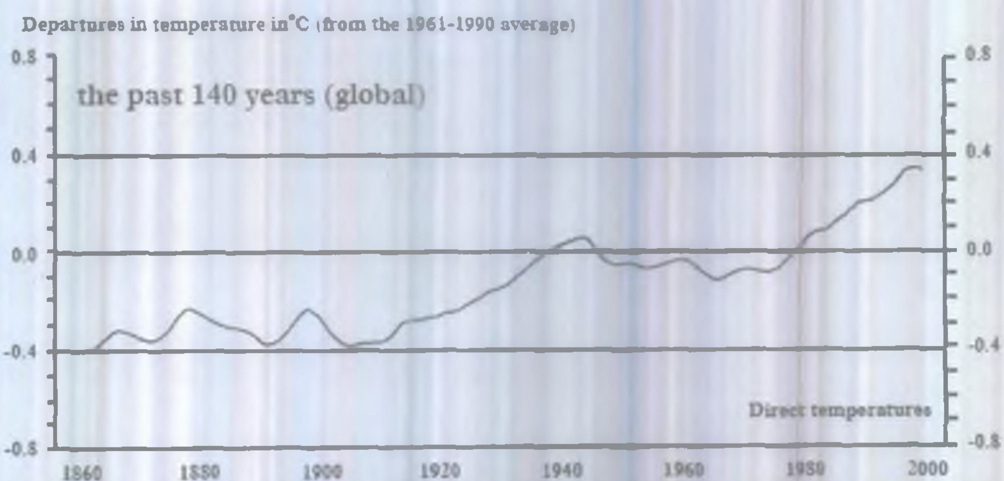

Figure 1. Patterns of temperature in the past 140 years.

Under the Kyoto Protocol, 25 developed countries, not including the U.S. and Australia, promised to reduce their emissions by 5% below the 1990 levels by 2012. However, emissions in some Kyoto countries like Spain and Canada have soared instead of declining. Canada has already declared that it will not meet its target. Paradoxically, scientists estimate that global greenhouse gas reductions of 80% are needed before 2050 to avoid the worst and irreversible impacts.

Contrary to the widely circulated view, climate change has also some positive outcomes. It could make higher altitudes and latitudinal areas suitable for agriculture- through increased length of growing season and increased CO_2 level, which would lead to increased photosynthesis rates, increased water use efficiency, improved soil fertility and boosted crop yields from flood generated silts.

2.2 African Overview

Africa has a highly variable and unpredictable climate. Baseline data on African climate is sketchy and not fully understood, and El Niño poses a dominant influence. As a result, the African climate is difficult to model due to the complex topography, feedbacks from surface cover, and influence of the oceans. In Sahel, which includes northern Ethiopia, it is predicted that the global warming will heat the land more than the sea, leading to changes in air pressure and weather (Royal Meteorological Institute, 2005). On the other hand, the Sahel rainfall (July to September) will rise by 1-2 mm a day.

According to IPPC (2001b), Africa is the most vulnerable region to climate change, due to the extreme poverty of many Africans, frequent natural disasters such as droughts and floods, and agricultural systems that heavily depend on rainfall. Issues of concern in Africa include water resources, food security and agriculture, natural resource management, biodiversity and human health (Figure 2).

(Source: UNEP/GRID Arendal/Anna Balance, 2002)

Figure 2. Climate change vulnerability in Africa.

The extent to which East African countries are vulnerable to climate change depends on the exposure and sensitivity to climate changes as well as the ability to adapt to new conditions (Kelly and Adger, 2000). When sudden shocks, caused by climate change, are coupled with vulnerabilities and institutional weaknesses, it would lead to much larger and longer poverty traps than the local livelihood systems, national governments and the international humanitarian systems seem capable of coping with (Devereux and Edward, 2004). According to reports of Christian Aid, 185 million people in Sub-Saharan Africa could die of disease directly attributable to climate change by the end of the century.

Countries in East Africa are the most food insecure, and climate change is reported to aggravate falling harvests (Devereux and Edward, 2004). If Africa's weather gets any more fickle, then they are in very deep trouble. This is because agriculture is highly vulnerable to climate variability and long-term climate change, which could result in higher food prices, lower domestic revenues, etc. Such changes would compound the challenges of East Africa, where agricultural yields and per capita food production have been declining and where population growth will escalate the demand for food, water and livestock forage in the next 30 years (Davidson *et al.*, 2003).

In 1997/8, El Nino caused extensive floods in Somalia and Kenya. The phenomena led to disease, damage to property and crops. With the projected global warming and the associated intense precipitation and more extended dry periods, the frequency and severity of droughts, floods, and storm surges are expected to increase. Moreover, crop yields will fall, planting dates of annual crops would change, fungal outbreaks and insect infestations would increase, risk of food would increase, the ecosystem integrity and resilience would be reduced, and the biodiversity would decline. Such chain of processes would increase the vulnerability of developing countries. Food and water supply are just two of a plethora of worries. By 2025, some 480 million people in Africa could be living in water-stressed areas.

According to reports of the 12th Conference of the Parties (COP 12) on UN Climate Change, which was conducted in Kenya, poverty and climate changes are inextricably linked. It is the poor who would disproportionately be suffering from the effects of global warming. It is also stated that climate change will devastate Africa unless substantial help is obtained from the developed world. For instance, in Tanzania and Sudan, maize and sorghum yields could drop up to 33% and 82%, respectively (URT, 2003). Similarly, Gum Arabic production may decline by 25-35% in Sudan (RoS, 2003).

2.3 Ethiopian Overview

One of the results of global climate change is the sea level rise. Many countries of Africa are endowed with coastlines. Such coastal areas are densely populated and therefore are susceptible to displacement and loss of economic activities. However, this threat is not an immediate concern for Ethiopia.

Rainfall is an important climatic element, which plays a vital role in Ethiopia. As agriculture is the mainstay of over 85% of the population, the amount, variability and intensity of rainfall is very important. Farmers in central and north-central Ethiopia have the opinion that (Daniel Kassahun, 2006; 2007) in the old days (about three or four decades ago), the rainfall used to be suitable for agriculture and health. Since then, they witnessed not only a decline in amount, but also in intensity and distribution. Consequently, most farmers are pessimistic of their future wellbeing. This assertion conforms to the scientific evidences that rainfall in sub-Saharan countries has recently been lower in amount and erratic in the distribution.

According to UNFCCC (2001), for over five decades, rainfall in Ethiopia remained constant when averaged over the whole country. However, a declining trend was observed over the northern (Figure 3) and southwestern (Figure 4) parts. Contrarily, increasing trend was observed in the central (Figure 5) part of Ethiopia. With respect to the temperature, there has been an overall trend of warming. The average annual minimum temperature has been increasing by 0.25^{0}C per decade (Figure 6), while average annual maximum temperature has increased by 0.1^{0}C per decade (Figure 7).

Given the predicted increase of temperature, substantial parts of Ethiopia (mainly the *bereha* and *kola* agro-ecological zones) would likely be turned into an inhospitable environment. Currently, the highland parts of Ethiopia are densely populated and massively degraded. In the past, lowlands have been considered as a potential "shock absorber" for the out migrants from the densely populated highlands. However, such function would no more be there given the ongoing climate changes taking place in the country.

The climate change in Ethiopia is also linked to increased risk of food shortage and famine. Ethiopia is already faced with recurring cycles of flood, drought and crop failures. This would also lead to decreased area under cultivation. However, the country is not awakened to cope with impacts of climate change.

It is repeatedly stated that the poor are at risk from climate change and in Ethiopia, the proportion of the poor is among the highest in the world. Ethiopia's vulnerability is explained in part by the fact that 85% of its population work and live in agriculture, more than 98% of which is dependent on increasingly erratic rainfalls.

The UN estimates that in Ethiopia, Eritrea, the Gambia, Ghana, Sudan and Zambia, cereal crop yields will decline by up to five percent by the 2080s mainly due to climate-linked factors. Besides, as climate change forces people to switch from long maturing to short maturing crops, there would be significant impact on the volume of obtainable yield. Agricultural research has demonstrated that the longer the length of growing period, the higher would be the obtainable yield, and vise versa.

3. GLOBAL CLIMATE CHANGE AND NATURAL HAZARDS IN ETHIOPIA

Among the African countries the intensity of natural hazards are exceedingly higher in Ethiopia (Figure 8). These hazards are likely to intensify in the years to come, due mainly, to global climate change. In this Section, the discussion will revolve around the linkages between climate change and different forms of environmental hazards, which include desertification, drought and famine, flooding, health problems, forest fire, extinction of biodiversity, and conflict/clashes which are specifically tuned to the Ethiopian condition.

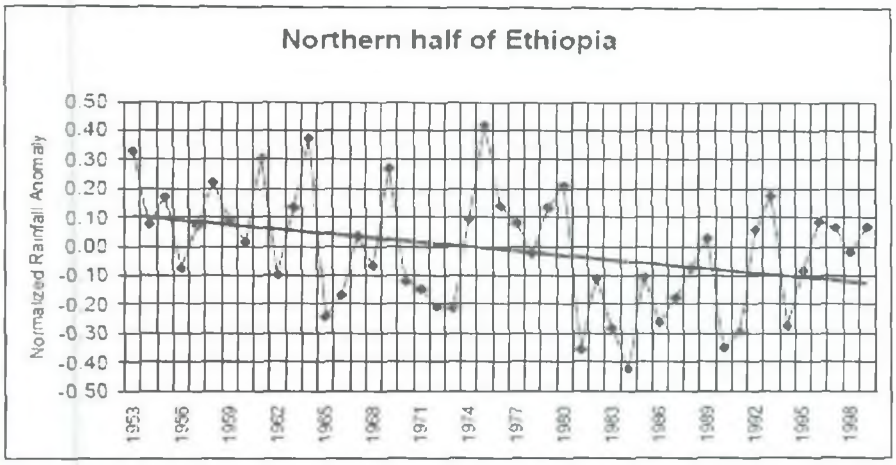

Figure 3. Variability and trends of rainfall in the northern part of Ethiopia.

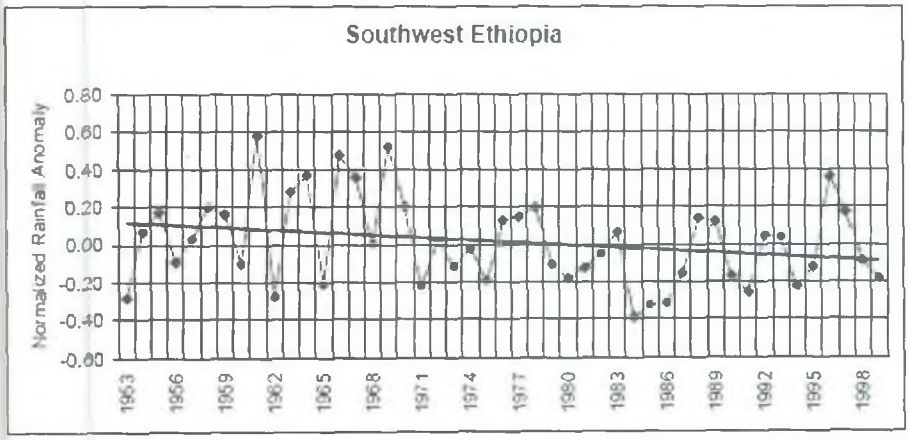

Figure 4. Variability and trends of rainfall in southwestern parts of Ethiopia.

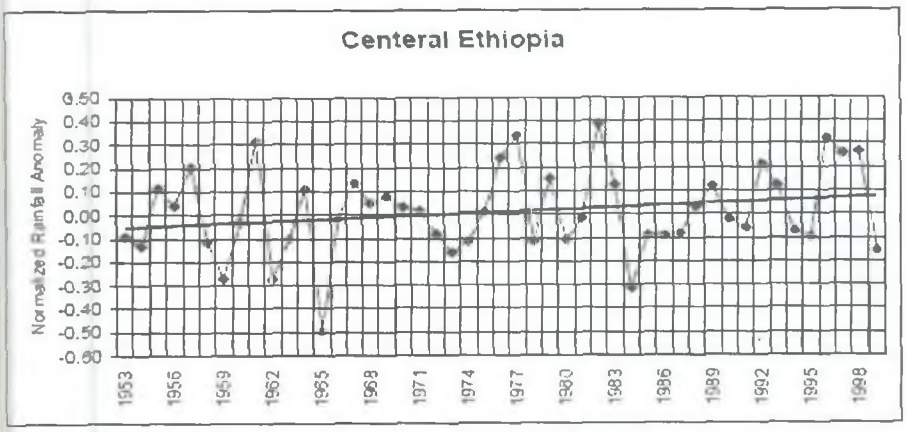

Figure 5. Trends and variability of rainfall in the central part of Ethiopia.

3.1 Desertification, Drought and Famine Hazard

Dryland climate occur throughout the world in areas where the ratio of precipitation to potential evapotranspiration on annual basis falls between 0.05 and 0.65. Many scientists believe that the end result of human activity is the degradation of the landscape, including changes in climate that exacerbate desertification processes. A number of scientists and policy makers are concerned about the desertification issue. By mid 90s, the United Nations was able to hammer out a convention to combat desertification. Ethiopia has ratified this convention through its Proclamation No. 80/1997.

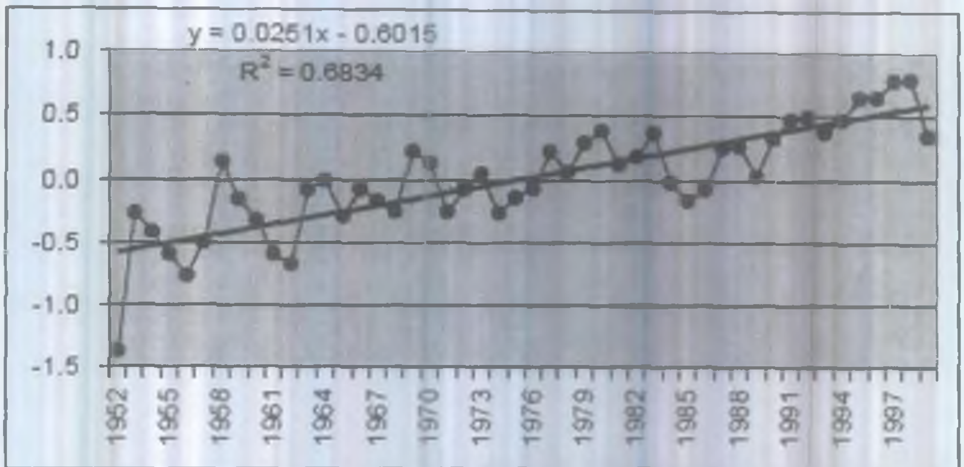

Figure 6. Trends and variability of the minimum temperature in Ethiopia.

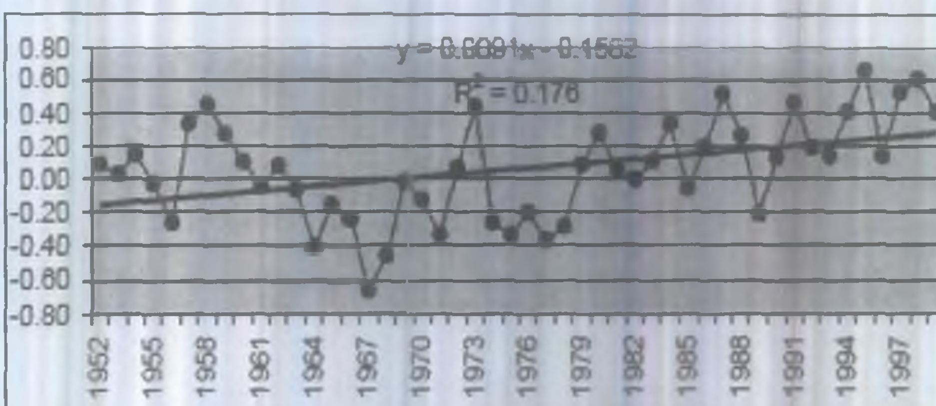

Figure 7. Trends and variability of the maximum temperature in Ethiopia.

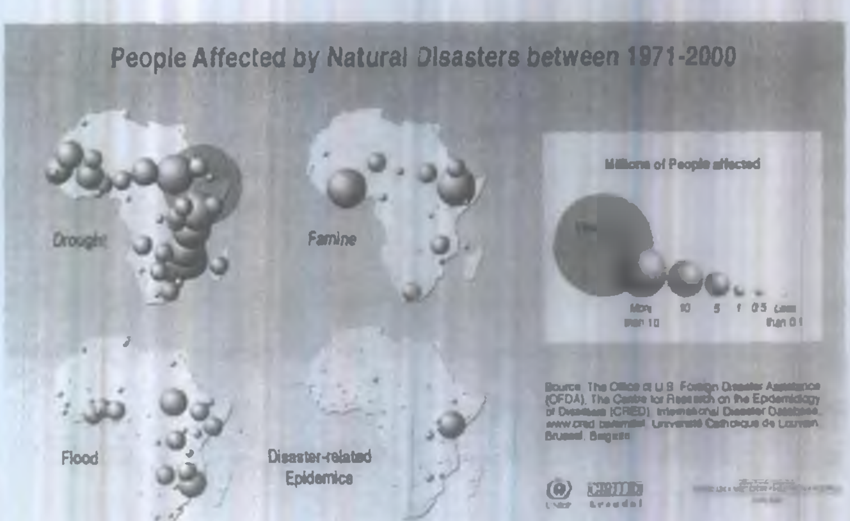

Figure 8. Distribution of natural disasters in Africa.

Ethiopia has been severely threatened by droughts every 7-8 years. Once drought occurs, it affects the region for 2, 3 or more years. Main drought areas are found in the north, east, south and a part of the central. The unprotected upper catchment areas are major causes of the flood. Down streams of Awash and Wabi-Shabele Rivers are attacked by floods in every rainy season.

Sophisticated general circulation models have revealed that in the Sahel land degradation would cause both an increase in local temperatures and a decrease in rainfall levels (Xue, 1997). Crop simulation models of future climate scenarios (IPCC, 2001a) suggest that there would be reduction in agricultural production and it would be more severe in tropical regions. Episodes of heat stress are detrimental to crops, especially during critical growth stages, and such episodes are likely to be more frequent and prolonged in the future. The same would be true in Ethiopia.

In Ethiopia, despite the great potential of irrigable water sources, which is 3.5 million ha of irrigable land, not more than 5% of the potential is currently irrigated (EPA, 2003). Especially in the semi-arid parts of Ethiopia, the non-irrigated agriculture is already near their maximum temperature tolerance. Therefore, even small changes in rainfall or temperature could devastate the agricultural output, with attendant consequences for food security.

The north eastern, southeastern, eastern, southern and extreme southwestern parts of the country are mostly lowlands below 1500 m a.s.l., and are estimated to cover from 55 to 60% of the total land area. In most cases, these low-lying areas are affected by drought and shortage of grazing lands. These areas are also susceptible to desertification. According to Obasi (2005), ENSO has effects on the Ethiopian livestock through making them low in energy levels due to sparse pastures. As water shortage is already the major challenge of pastoral areas, further lowering of the rainfall amount would exacerbate the problem.

Simonett (1999) reported that a 2^{0}C increase in the average temperature could drastically reduce the area suitable for growing Robusta coffee in Uganda. Coffee is the major export item of Ethiopia. In 2003/04, about 156.4 million kg was exported. However, the prediction made for Uganda would likely reflect the reality in Ethiopia. This implies that areas which used to be suitable for coffee production would be substantially reduced. As coffee is number one export item, its impact in Ethiopia would have far reaching and multi-pronged effect.

3.2 Flooding Hazard

Ethiopia is composed of three major physiographic regions, viz., the western, the south-eastern, and the rift valley. While the first two are characterized by an outward orientation of slopes, the third is mainly of inward slopping pattern. Within each physiographic region, there are of course several minor slope patterns without defined direction or orientation. Of the three patterns, the outward orientation of slopes accounts for the bigger portion of the country, which put the country to be a looser of flood water.

Generally, the central part of Ethiopia is dominated by highlands, with a general elevation exceeding 2000 m a.s.l. Almost all the rivers originate from this part of the country. By the time they reach the peripheral parts in all directions, the elevation drops to as low as 500 to 1000 m a.s.l. This makes the topographic factors more powerful in making the magnitude of floods to be potentially higher.

There are several factors for the severity of a given flood. The first is the amount of rainfall. This amount could be either higher or lower, and broadly speaking, there is a positive correlation between amount of rainfall and flood magnitude. In Ethiopia, especially in the highlands, the mean annual rainfall is higher than the lowlands, where it broadly ranges from >2000 mm to <100 mm/year (EPA, 2003). However, the amount itself is not very important. Rather it is the intensity of the rainfall which matters most. Again the intensity of rainfall gives limited information as long as the land cover condition is considered. The presence or absence of vegetation cover could play an important factor either to magnify or suppress a given flood. However, in Ethiopia the natural cover condition is much depleted, where the current natural vegetation cover doesn't exceed 10%. This is because about 150,000 - 200,000 ha of natural vegetation are lost annually. Especially most highland parts of the country are depleted and when coupled with the topographic characteristics, the situation is conducive for the enhanced flood magnitude. Whatever the amount and intensity of rainfall and whatever the land cover condition is, if there are good management systems on the ground, the flood would be within the manageable scale.

At last, whatever the magnitude of flood is generated, the magnitude of the inflicted causality could either be higher or lower depending on the resilience of the affected people. While poor people have little preparedness and the capability to cope with the problem of flood, the well-to-do have a better opportunity to withstand the threat of floods. However, about 44% of the Ethiopian population lives below the bread line and their susceptibility for flood hazard would be much higher.

One of the impacts of climate change is the tendency of the rainfall to behave very erratically in its distribution. The amount which used to fall over long span of time would be concentrated in a very short period. Such pattern gives little time for the rainwater to percolate or infiltrate into the soil and therefore the great percentage of the amount would end up in flash flood. Such enhanced volume of flood would have greater inertia to detach soil particles and therefore, the erosiveness of the rainfall would increase.

3.3 Health Hazard

Habitat modification, road and dam construction, irrigation, increased proximity of people and livestock, and the concentration or expansion urban environments, all modify the transmission of infectious disease and can lead to outbreaks and emergence episodes (Patz *et al.* 2004). The health condition in Ethiopia is at a precarious state. Poverty, coupled with the poor sanitation, lack of clean water, absence of waste disposal adds up to the poor health condition in Ethiopia. To add more fuel to the problem, the health service in the country is very poor. Recently, HIV is added to the health problem matrix of the country.

However, several scholars disclosed that as a result of climate change, diseases such as malaria, dengue fever, cholera, dysentery and respiratory diseases are expected to increase. For example, malaria is already a serious health problem in East Africa (Figure 9), and climate change is likely to only worsen this situation. According to Githeko *et al.* (2000), an increase of between 1 and 3^{0}C in global annual temperature would enable mosquitoes to extend their range. Similarly, the increased rainfall would attract vectors and increase their survival rate. The outbreak of rift valley disease has also led to livestock deaths and malaria outbreak. As a result, hundreds of deaths were inflicted in the previously unexposed populations.

Malaria climbs up high altitude areas where it has not previously been a serious threat. In recent years, it has become clear that climate change will have direct and indirect impacts on diseases that are endemic in Africa. Following the 1997-1998 El Niño event, malaria, Rift Valley fever, and cholera outbreaks were recorded in many countries of East Africa. Furthermore, flooding could facilitate breeding of malaria vectors and consequently malaria transmission in lowland areas. The meningitis belt, which is commonly found in the drier parts of West and Central Africa, has started to expand towards the eastern part of the continent.

A decline in human health could happen as people's resistance to disease is weakened by water shortages, heat stress, and malnutrition which in turn are exacerbated by climatic change. Increases in infectious diseases and waterborne illness, and higher levels of pollution leading to a rise in respiratory illness will be widespread due to climate change (IPCC, 2001b).

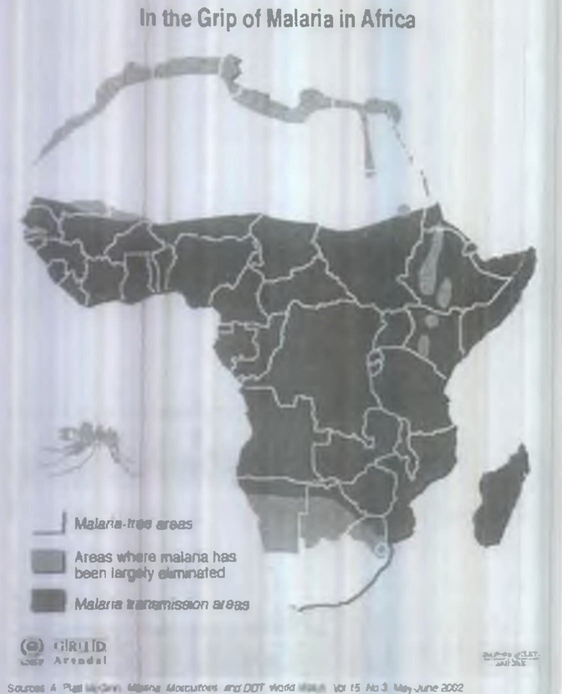

Figure 9. Distribution of malaria in Africa.

3.4 Forest Fire Hazard

One of the growing threats of global climate change is the loss of forest and biodiversity due to forest fire. Forest fire could be caused by natural as well as human factors. However, compared to the human factors, the natural causes are negligible. Forest fire is commonly employed especially in the lowland parts of Ethiopia for the purpose of evading livestock pests, clearing new agricultural lands, and boosting the fertility of soil for grass and herbal growth, etc. However, due to global climate change there would be an increased temperature coupled with prolonged period of moisture stress. Such phenomena would exacerbate forest fire and make the damage very severe. In a country where the stock of natural vegetations is negligible in size, the impact of forest fire would be unbearably costly.

3.5 Biodiversity Hazard

Climate change could impact biodiversity through changes such as habitat and its biomass productivity, physiological responses of individual organisms, species distribution from one type to another, disappearance of some species, etc.

As a result of its topography and diverse climatic conditions, Ethiopia is part of two of the 34 biodiversity hotspots of the world. According to JICA (1999), there are more than 5,770 species of animals in Ethiopia, of which 10% is endemic. For flora, about 600 taxa are estimated to be endemic, though more research for further identification is still needed. The fauna and flora has been affected by industrial and agricultural developments. The major constraints with regard to the biodiversity conservation are lack of coordination of conservation activities, lack of fund, inadequate database poor forest management, low level of citizen's awareness to conservation and so on. It goes without saying that any change in the levels of these temperature and moisture, which is induced from climate changes, would lead to the rapid extinction of some the species.

3.6 Hazards of Conflict Among People

Conflict among households and communities could emerge in two ways. The first is due to the impact of the arid and semi arid environment, where water table would be lowered, water points would dryout, grazing areas would deplete and shrink in area, etc. Under such circumstances, there would be an enhanced competition for scarce resources. There is also added population growth, which would lead to the elements of explosion. Therefore, the already existing conflict would further be aggravated. Secondly, areas which already are in the food scarce and degraded environment would be the worst hit by the global climate change. Therefore, human and livestock survival would be barely possible in those areas. Under such circumstances, people would be obliged to migrate towards better-off areas, where there are possibilities of harnessing the natural resource for the benefit of survival. Recent experiences of population movement in the highland-lowland interface demonstrate this fact.

In Ethiopia, the demographic shift could take place in two directions: vertically or laterally. The vertical pattern is the movement of population towards the highland areas. This movement is in search of better climatic condition for undertaking agriculture. Paradoxically, highland areas of the country are densely populated. While 50% of the country's population lives above 2,200 m a.s.l., 11% live below 1,400 m a.s.l. (EPA, 2003). Therefore, there is little room to accommodate the growing number of environmental refugees in the future.

This horizontal pattern of population shift has been undertaking from the environmentally degraded areas of the north, northeast, central and southeast parts of the country towards the western and southwestern parts. The westward movement of people was undertaken both during the *Derge* and the EPRDF governments. Tesfaye Teklu (2004) reviewed some instances of large influx of migrants from different highlands to some areas like northeast Welega and Metekel. This wave of migration has caused resentment and grievances from endogenous peoples residing mostly in the lowlands. Similarly, Tesfaye Tafesse (2004) characterized the migrants from various zones of Amhara Region, who settled in various places of Oromia Region, and witnessed the consequences of violent conflict and displacement. Such types of conflicts are also observed in other parts of Africa. The conflict between herders and farmers in Sudan's Darfur region, and the fighting in Chad are the same. The problem is scarcity of resources, especially water. On one side there are herders and on the other side there are farmers.

These days, it is common to note that some lowland pastoralists are facing chronic water and fodder shortages. During dry seasons, they are forced to migrate to upland areas. Such seasonal movement is not without problems. As upland areas are already densely populated, there are frequent clashes happening here and there. The case in point is the frequent clashes that flare-up at *Boset Wereda* of East Showa Zone, Oromia and the Bati/Kalu *weredas* of South Wollo Zone, Amhara.

4. COMPLICATING FACTORS OF CLIMATE CHANGE IN ETHIOPIA

There are several factors which could add fuel to the impact of climate change in Ethiopia. The rapidly growing population, widespread poverty, massive land degradation, heavy reliance of the economy on the rainfed agriculture, and absence of coping mechanisms to climate change. The following are brief explanations of each.

4.1 Demographic Pressure

The fact that about 50% of Ethiopia's population reside above 2,200 m a.s.l. demonstrates that in the elevation between 2,200 and 2,600 m a.s.l., there is the highest population density, i.e., 170/km^2. Currently, it is growing at a rate of 3% per annum, which would likely double in 22 years time.

Taking the huge number of population at hand, whatever increased productivity attained through intensification of the rainfed agriculture would be bound to fall short of the ever-increasing population.

Food production rate has failed to keep pace with fast population growth, and the nation could not produce ample food to feed the population. Amazingly, the total crop yields in the private sector had fallen from about 12.5 quintals per ha (1979/80 – 1985/86) to 1.7 quintal per hectare in 1995/96 (CSA 1987, 1996). Rather food imports grew from 3% of the total imports in 1975 to 12% in 1990 (CSA 1990).

4.2 Poverty

Disasters are closely linked to poverty; they can wipe out decades of development in a matter of hours, in a manner that rarely happens in richer countries. The poor are more likely to occupy dangerous locations, such as flood plains, river banks, steep slopes, reclaimed land and highly populated settlements of shanty home.

Ethiopia is one of the least developed countries in the world. According to MoFED (2002), rural and urban poverty is 45.4 and 36.9 percent, respectively. The annual per capita consumption of cereals and pulses in Ethiopia is 163 kg compared to the UNICEF standard of 240 kg and that of the average for developing countries of 230 kg. Impacts of climate change are not simply of environmental concern, but also of national development. According to The Guardian (Oct 13, 2006), failure to take action to combat climate change will cause environmental catastrophe and cost the global economy $ 20 trillion a year by the end of the century. In other words, the damage is forecast to cost 8% of global GDP by 2100.

4.3 Massive Land Degradation

Official documents (EPA, 2003) estimate that the country loses forest at a rate of 100,000 - 200,000 ha annually. Currently, it covers less than 2.7%. Some three decades ago the Ethiopian Highlands Reclamation Study (EHRS) estimated annual average net soil loss of 130 tons/ha; a mean loss of 1,900 million tons of soil; an annual soil depth loss of 8 mm (FAO, 1986). Since then the population of the country has doubled, and one can easily estimate how these figures might have aggravated at the present time. The annual loss in grain production due to soil degradation was estimated at 40,000 tons in 1997, which reached 170,000 tons in 2000 (Shibru Tedla and Kifle Lemma, 1998). This translates into an annual income loss of US $ 150 million (Barbier, 1998), which is a loss of approximately 17 percent of the total agricultural GDP (EPA, 1997).

4.4 Heavy Reliance on Rainfed Agriculture

Agriculture is the mainstay of the Ethiopian economy and therefore is it is very volatile. It is a livelihood for more than 85% of the population. This is mainly due to its dependence on rain and the seasonal shocks that are frequently observed. According to EEA (2005), rainfall, agricultural output, and the performance of Ethiopian economy are casually intertwined. The Ethiopian agriculture is dominantly of rainfed type. On the other hand, the global climate change makes the rainfall to be erratic in its distribution and variable in its amount. These variations, coupled with changes in temperature, pose series challenge on the performance of crop production in the country.

4.5 Absence of Climate Change Coping Mechanisms

It is always stated that for every one dollar of prevention, about seven dollars of hazards would be saved. Ethiopia is located in one of the most vulnerable regions to climate change. This is a result of low adaptive capacity of the poor population. The low capacity is due to the extreme poverty of many Ethiopians, frequent natural disasters such as droughts and floods and agriculture heavily dependent on rainfall. Most of the sectoral plans of the country have neglected the likely impact of climate change, and therefore, coping mechanisms are neither developed nor known.

Based on an understanding of vulnerabilities, capacities and risks, support can build on people's local means of coping with risk. This might include income-generating activities to allow for cash purchases, or supporting migration as a form of coping with climate variation or market fluctuations. Seasonal migration to towns may also present an attractive option in areas with opportunities to gain income or skills. Focused policies that enhance the benefits and reduce the risks of migration can therefore help reduce vulnerability to climate change. However, let alone the practical action, even the issue itself is not adequately taken up by policy makers.

4.6 Inadequate Policy Framework

Ethiopia has ratified the conventions on Framework Convention on Climate Change (FCCC) (Proclamation No. 97/1994) and United Nations Convention to Combat Desertification (CCD) (Proclamation No. 80/1997) which have direct relationship with the issue under discussion. There are also several policies on various aspects of the environment, most of which were proclaimed over a decade ago. The Forestry Proclamation (No. 94/02), Environmental Health Proclamation (No. 200/2000), Water Resources Management and Administration Proclamation (No. 197/2000), Ethiopian Environmental Policy (1997), etc. There are also sectoral and cross-sectoral policies, such as disaster preparedness and prevention management, environmental conservation, population, food security, rural development, etc. However, several studies have confirmed that those policies are not translated into laws and directives. As a result, the forests, endangered species, sensitive ecosystems, etc. are not strictly protected. Similarly the rapid pace of population growth is far from being slow i.e., the total fertility rate has remained high and the family planning measures are not adequately stretched out. Most importantly, there are no policies pertaining to the threat of climate change in the country, and efforts to combat the emerging problem of climate change lack the policy ground.

5. CONCLUSION

Climate change is a dynamic phenomenon and the threats to the frequency and severity of natural hazards would be mounting from time to time and as a result more devastating havocs would likely to surface. It is time to wake up and look for ways to mitigate the problems and develop the adaptation to the changed conditions. While Ethiopia has contributed very little to the global warming, it would be one of the countries most affected by its impact. Ethiopia is predicted to face the worst hits of climate change due to its heavy dependence on the rainfed agriculture, which in turn is very susceptible to the climate change. To put matters worse, the poor economic condition of the country debilitates peoples' capability to cope with the growing frequency of natural hazards in the country. Further, implication of the climate change is predicted in the years to come as future climate is expected to worsen its impact. When such problems are superimposed on other emerging problems, such as HIV/AIDS, attempts to realize the MDG would be questionable.

The above-stated entwined problems stipulate extraordinary effort in the part of government, non-government, donors and the public at large at least to mitigate the looming catastrophe. In the mean time, it would be wise to make the population and economic activities readied to adapt to the changing patterns of the climate. In this regard, it is very important to increase irrigation practices to boost crop production and reduce crop failure; increase capital investment in reservoirs and infrastructure; institute policy mechanisms to control unsustainable forest clearing; promote techniques for tackling emergency food shortage; adjust farming areas and reduce animal population; and the like. In this regard, mainstreaming climate change adaptation into the development agenda, across all sectors and all levels of government would be very crucial.

On the other extreme, the global climate change could bring about some positive outcome. Corollary to the theories of Boserup, which argues that population growth could enhance, instead of being a hurdle, the economic and technological development (Boserup 1981), global climate, too, could trigger technological and economical breakthrough. In view of Boserup's theory, population growth is a source of increased efficiency, economies of scale and technological innovation that is proved in several developing countries. In the case of climate change, the phenomena could lead to transformation from rainfed to irrigated agriculture, increased harnessing of rainwater, modernization of agriculture through intensification, and declining share of agriculture in the economy.

Of all the suggested measures, however, an enhanced care of the degraded environment through sustainable natural and watershed management practices would play pivotal role not only to breaking the degradation-cum-natural hazards, but also capacitate peoples' copping mechanisms of upcoming environmental hazards. In this regard, awareness creation across the board should be given the priority.

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