ASSESSING THE ROOT CAUSES OF FLOOD AND OPTIONS FOR FUTURE RISK REDUCTION IN RELATION TO THE LAND DEGRADATION OF DECHATU WATERSHED DIRE DAWA ADMINISTRATIVE COUNCIL

BY

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES OF ADDIS ABABA UNIVERSITY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

December, 2008
ADDIS ABABA
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BY

MARIA TADESSE

Table of Content

<table>
<thead>
<tr>
<th>Table of Content</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Tables</td>
<td>V</td>
</tr>
<tr>
<td>List of Figures</td>
<td>VI</td>
</tr>
<tr>
<td>List of Abbreviations</td>
<td>VII</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>IX</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

1.1. Background and Justification

1.2. Statement of the Problem

1.3. Research Objective

1.3.1. General objective

1.3.2. Specific objectives

2. LITERATURE REVIEW

2.1. Occurrence of Flood

2.2. Causes of Floods

2.3. Effects of Flooding

2.4. Factors Affecting Soil Development

2.4.1. Parent Material

2.4.2. Climate, vegetation, and weathering

2.4.3. Topography

2.4.3.1. Effect on soil erosion

2.4.3.2. Effect on deposition and soil texture

2.4.3.3. Microclimatic effects

2.5. Flood in Ethiopia

2.6. Some Causes of Flood in Dire Dawa

2.6.1. Land degradation

2.6.2. Vegetation degradation

2.6.3. Population pressure and settlement pattern

2.6.4. Land tenure and land use system

2.6.5. Poverty

2.6.6. Flooding and sedimentation

2.6.7. Climate change

3. MATERIALS AND METHODS

3.1. Description of Study Area

3.1.1. Location

3.1.2. Topography

3.1.3. Climate

3.1.4. Land use

3.1.5. Soil data of Dechatu watershed

3.1.6. Description of soil profile in the Dechatu watershed

3.1.7. Vegetation type

3.1.8. Population

3.2. Methods of the Study

4. RESULTS AND DISCUSSIONS

4.1. Rural Dire Dawa

4.1.1. Land holding

4.1.2. Land degradation

4.1.3. Soil erosion
4.1.4. Population........................................................................................................44
4.1.5. Consumption of biomass as a source of household energy.................44
4.2. Urban Dire Dawa or low land dwellers.........................................................45
4.3. Soil profile study in the upland area............................................................47
4.4. Land use change of Dechatu watershed.......................................................49

5. CONCLUSIONS.....................................................................................................53

6. RECOMMENDATIONS.......................................................................................55

REFERENCE...............................................................................................................56

ANNEXES.......................................................................................................................61

Annex I........................................................................................................................61
Annex II.......................................................................................................................65
Annex III......................................................................................................................69

List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Soil degradation in different land uses</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>Soil types of the study and calibration area with their aerial coverage (FAO-UNESCO Soil Classification System)</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>Population size in urban Dire Dawa</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>Population size in Rural Dire Dawa</td>
<td>32</td>
</tr>
<tr>
<td>5</td>
<td>Numbers of households Interviewed from each PA’s</td>
<td>35</td>
</tr>
<tr>
<td>6</td>
<td>Numbers of households Interviewed from each Kebele</td>
<td>35</td>
</tr>
</tbody>
</table>
Table 7 Age status of the respondents and family in the rural part of the study area......36
Table 8 Literacy status of the rural part of the study area................................................. 36
Table 9 Respondents perception towards resettlement.........................................................41
Table 10 Age status of the respondents and family members in urban Dire Dawa............45
Table 11 Depth of “A” Horizon.......................................................................................... 48
Table 12 Depth of “B” horizon............................................................................................48
Table 13 1986 and 2000 land use land cover of Dechatu Watershed..............................51

List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fig 1</td>
<td>Hill Slope Position, Runoff and Erosion</td>
<td>11</td>
</tr>
<tr>
<td>Fig 2</td>
<td>Poverty and Environmental Degradation Cause Effect Relation</td>
<td>21</td>
</tr>
<tr>
<td>Fig 3</td>
<td>Dire Dawa Catchments Map</td>
<td>22</td>
</tr>
<tr>
<td>Fig 4</td>
<td>Dechatu Watershed (Location Map)</td>
<td>23</td>
</tr>
<tr>
<td>Fig 5</td>
<td>Dechatu River Crossing Dire Dawa Town</td>
<td>23</td>
</tr>
<tr>
<td>Fig 6</td>
<td>Elevation Map of Dechatu Watershed</td>
<td>24</td>
</tr>
<tr>
<td>Fig 7</td>
<td>Drainage Map of Dechatu Watershed</td>
<td>24</td>
</tr>
</tbody>
</table>
List of Abbreviations

DA  Development Agent
DDAC  Dire Dawa Administrative Council
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDACWMEO</td>
<td>Dire Dawa Administrative Council Water Mines and Energy Office</td>
</tr>
<tr>
<td>DDDIPO</td>
<td>Dire Dawa Development and Improvement Project Office</td>
</tr>
<tr>
<td>ECS-SIDCOH</td>
<td>Ethiopia Catholic Secretariat Social and Development Coordinating Office of Harrar</td>
</tr>
<tr>
<td>FA</td>
<td>Farmers Association</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agricultural Organization</td>
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<tr>
<td>GIS</td>
<td>Geographic Information System</td>
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<tr>
<td>ha</td>
<td>hectare</td>
</tr>
<tr>
<td>m.a.s.l</td>
<td>meters above sea level</td>
</tr>
<tr>
<td>MoWR</td>
<td>Ministry of Water Resources</td>
</tr>
<tr>
<td>NGO</td>
<td>Non Governmental Organization</td>
</tr>
<tr>
<td>NMSA</td>
<td>National Meteorological Services Agency</td>
</tr>
<tr>
<td>PA</td>
<td>Peasant Association</td>
</tr>
<tr>
<td>UTM</td>
<td>Universal Transverse Mercator</td>
</tr>
<tr>
<td>WBISPP</td>
<td>Woody Biomass Inventory and Strategic Planning Project</td>
</tr>
<tr>
<td>WWDSE</td>
<td>Water Works Design &amp; Supervision Enterprise</td>
</tr>
</tbody>
</table>
DEDICATION

I dedicate this thesis to my precious and special Brother ESKINDIR TADESSE who always fills the gap in all my weaknesses, who shared all my pains and persuaded me not to give up; he is a special gift from God. Words are found inadequate to express bottomless gratitude because he lived his life for me and is a source of strength in every aspect of my life, his kind-hearted treatment love and his endless support up to now, brought me to this day.

Acknowledgements

First and foremost, thanks to the gracious merciful and Almighty GOD for granting me His limitless care, love, blessings, assistance, and support all along the way.

My appreciation and sincere heartfelt gratitude goes to my advisor Dr Teshome Soromessa for his skillful assistance, constructive criticism, continuing encouragement and all-round support through out the research; without his help my endeavors would have been fruitless. I feel deeply indebted and express my
sincere gratitude to Prof. Shoeb Quraishi (PhD) for all the wealth of knowledge passed on to me during my studies, the continual advice, for his material support and constructive comments that have helped me to improve the quality and compilation of my thesis work and for his critical review of the thesis manuscript.

I couldn’t get even a single word to express how I’m thankful and grateful for my Father, Tadesse Tamrat, who is source of strength in every aspect my life, his kind-hearted treatment, understanding, and love and his endless support up to now, brought me to this day, I thank and love you Abat. Largest thanks to my caring Brother, Eksindir Tadesse, your strength, patience, and understanding especially your role in my academic success is surely beyond my comprehension, and who always fills the gap in all my weaknesses, who shared all my pains and persuaded me not to give up. Thank you very much Eskiew. My sincere gratitude also goes to my sisters Netsi, Misr and Emuti for their tireless inspiration and encouragement. I always thank God for giving me such precious family and to be part of you.

My deepest thanks goes to Leul Tadesse who is always there for me, caring, advising, and encouraging me with out any hesitation and who is always ready to help me, Leule thank you for everything. My friends and colleagues in and outside the University are all acknowledged for their friendship and support. My friend Hela Getachew I’m really thankful and grateful for you. Special thanks also go to my dorm mates and friends Ginbulanchi Agegnehu and Tawetu Abreha for their heart felt support and encouragement.

This work would have not been completed without the contribution of various institutions, organizations and individuals. In particular, Aderajew Mola, Daniel Tilahun Yohannes G/sillassie, Birhan and my classmate Getachew Fetene for all the DA’s in the study area specially Nigusse and Fri who helped me a lot during data collection. I would like to acknowledge the invaluable input of all individuals and organizations, National Meteorological Services Agency; Forum for Environment; Solomon from Messengers of Love, Dawit from Ministry of Water Resources, Wondyifraw, Bekele, Zemede, Belay, Lule, Aster and Girma from Ethiopian Catholic Church Social Development Coordinating Office of Harare were the contributors among others.

Last but not least I offer my special thanks for those involve directly or indirectly in this study and their names are not listed.

ABSTRACT

Flood hazard has long history in Dire Dawa. Surrounded by the highland areas, the town has often been repeatedly devastated by powerful flood disasters in the past.
This work aimed at investigating the root causes of flood and the options for future risk reduction in relation to the land degradation of Dechatu watershed, Dire Dawa with the objectives of describing the link between land use and land management practices with land degradation, runoff occurrence and flash floods, and assessing the impact of deforestation on catchments hydrology and occurrence of floods. To do these different techniques were applied. Such as, questionnaires survey of the study area, soil profile study of the up land and lowland to compare soil erosion rate in the upland and its deposition in the lowland and satellite image analysis of 1986 and 2000 using ERDAS 8.6 software in order to compare the land use land cover change of the study area.

The major findings of the study showed that most of the farmers in the rural area have a land of less than half a hectare which is only suitable for sorghum, corn and Chat so they are forced to farm on sloppy areas on the route of the flood, and on marginal lands. Large-scale destruction of forest resources in the highland areas has been practiced which has aggravated the rate of flooding in Dire Dawa. The most impressive problem in the rural area is land degradation where as flooding in the urban part of the study area. The soil profile study implies that there is high deposition problem in the lowland area and high erosion rate in the upper rural part, which has aggravated the flood problem by increasing the runoff from the high land and decreasing the river water holding capacity of the river in the lowland because of the soil deposition. The satellite image analysis shows that there is a change in land use land cover, where wood land, shrub land and bare land decrease sand deposit, cultivated area and built up area have increased. Conducting integrated soil and water conservation activities including the construction of hill side terraces, check dams, soil and stone bunds, micro basin , area closure with enrichment cultivation of selected tree species, etc. Identifying weak points through which flooding occurs; and constructing protection walls on identified points; construction of retaining wall and dam at the proposed sites are the main recommendations for the study area.
1. INTRODUCTION

1.1. Background and Justification

A flood is an overflow of an expanse of water that submerges land, a deluge. In the sense of "flowing water", the word is applied to the inflow of the tide, as opposed to the outflow. It is usually due to the mass of water within a body of water, such as a river or lake, exceeding the total capacity of the body, and as a result some of the water flows or sits outside of the normal perimeter of the body. It can also occur in rivers, when the strength of the river is so high it flows right out of the river channel, usually at corners or meanders (O'Connor et al., 2004).

In Ethiopia, the issue of flood continues to be of significant concern to people residing in lowlands, near lakes and river areas, as well as towns located at the foot hills and mountains. Flood disasters are happening more frequently, and having an ever more dramatic impact on Ethiopia in terms of both the human and economic costs.

Ethiopia experiences two types of floods, flash floods and river floods. A flood that rises and falls rapidly with little or no advance warning is called a flash flood. Flash floods usually result from intense rainfall over a relatively small area. Flash flood is the one which forms from excess rains falling on upstream watersheds and rushes downstream with massive concentration, speed and force. Often, they are sudden and appear unnoticed. Therefore, such flood often results in a considerable toll, and the damage becomes especially pronounced and devastating when they pass across or along human settlements and infrastructure concentration (Kefyalew Achamyeleh, 2003).

Flash floods, which is defined by WMO (1994) as a flood of short time duration with relatively high peak discharge, mostly results from intense localized thunderstorm activity, particularly stationary or slowly moving thunderstorms or lines of thunderstorms. WMO (1994) classifies flash floods into three categories. These are heavy rainfall generated flash flood, human induced flash flood and flash flood generated by a sudden release of impounded water.
Heavy rainfall generated flash flood is essentially natural which has not been substantially modified by man, where as human induced flash flood is a result in reduction of stability of the runoff, storage or hydraulic characteristics of the catchments and flash flood generated by a sudden release of impounded water is caused by the failure of a dam or other natural or man made barriers (Garg, 1998).

Flash floods are aggravated over steep channel slopes with limited valley storage. They have the potential of causing land or mud slides. The increase in the destruction of flash floods is a result particularly of the unsustainable urban development and partly from rapid growth of population (Tsegaye Ketema, 2006).

River flooding is a natural process and part of the hydrological cycle of rainfall, surface and groundwater flow and storage. A river may get flooded due to excessive rainfall or erosive melting of snow or ice obstruction in the form of jam or because of some other reason. Whenever the water overflows the banks of the river, the river is said to be flooded. The runoff resulting from a rain flows into a river through drains and streams. The river then flows down streams towards the sea, and goes on receiving additional flows through intermediate streams and smaller rivers, joining it in its journey towards the sea. River flood can also occur whenever rainfall is in heavier quantity, the discharge flowing in the river increases and possibly causing the water to spill over and across the banks of the river. Such spills may flood the adjoining areas, causing heavy losses of man, material and other variable properties. Flood in a river is thus caused by excessive precipitation in the catchments area of that river (Garg, 1998).

Since 1970s, the duration and intensity of drought and floods have been increasing particularly in tropics and subtropics. Historical documents suggest that Dire Dawa has been facing flood problems since 1953. There are different paradigms on the causative factors that trigger flooding in this area. Many people have been associating floods and flash floods of Dire Dawa with torrential rainfall occurring in the main rainy season (mid March to April). Others say that it is because of environmental degradation. This group state that, the forests of the highlands had been cleared. As a result, the soil has been washed out and deposited in the river banks of Dechatu. In which the water holding capacity of the river is decreasing (Daniel Kassahun et al., 2006).
According to Daniel Kassahun et al. (2006) flood hazard has long history in Dire Dawa. Surrounded by the highland areas, the town has often been repeatedly devastated by powerful flood disasters in the past. This perennial problem has been deeply rooted, intricately complex, and meagerly understood. Dire Dawa Administration Council falls under “high flood risk zones” of Ethiopia, susceptible to runoff discharging from the severely degraded upper catchments. In the flood prone areas, poor people are the hardest hit because they occupy dangerous locations (such as flood plains, river banks) with their meager resource to guard themselves from disasters and their lack of capacity to revive after events of flood damages. As more and more plots are cleared for agriculture and settlement, soil water infiltration rates are reduced and the runoff rates amplified.

Since the excessive precipitation in the catchments area cannot be controlled by man at present, the only alternative left for this is to somehow manage the excessive water flow of the river. In spite of maximizing his best effort, man has not been able to fully eliminate floods and has been able only to combat them, or to check and keep them away from intensive habitations, or to check and reduce their devastating effects by pre warning the area residents. Floods can thus only be reduced or mitigated but can be eliminated (Garg, 1998).

To be effective, flood disaster management should be implemented as a comprehensive and continuous activity, not as a periodic reaction to individual disaster circumstances (Calder, 1999). More over, 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 factors that trigger flooding are adequately dealt with, there will be little prospect for meaningful changes in disaster management, no mater 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 the flood causes and impacts on society and the environment is important.
1.2. Statement of the Problem

There are lots of environmental problems in Dire Dawa. Out of this, rainy season flooding is the major and the most disastrous problem of the people living in Dire Dawa town. High flood, which is normally due to the intensive rainfall in the up lands of the watershed, sparse vegetation cover, steep slopes and low infiltration capacity of the ground surface, is a major threat to the people living down town (WWDSE, 2003).

In the past, several flood events occurred and caused a lot of distraction on properties and people in Dire Dawa. The heavy rains in the highlands of East Hararghe Zone of Oromia Region caused flash flood from the overflow of Dechatu dry season stream that hit Dire Dawa town in the middle of the night on the sixth of August (2006), while residents were asleep. According to the Dire Dawa Administration (unpublished document), the 2006 flood affected over 10,000 people and killed 256 others. The death toll was largely due to the fact that the flooding took place at a time when people were in deep sleep. It also washed away houses and properties of many people living along the riverbank. Roads, bridges and other public properties were damaged and washed away. The estimate of overall loss or damage of properties of individuals and infrastructure is disclosed by the Administration to be about Birr 27 million.

Among the main intermittent streams in the Dire Dawa region, Dechatu is the major one where most of the precipitation as run-off from the south escarpment zone drains into it. Although this stream is dry for the most part of the year, it carries very large flow in the rainy season which some times causes flash flooding that result in some damage in the town, mainly because it passes through the middle of the town. Most of the runoff from Dechatu and the other streams spread in the low lying and flat topographic areas north of the town (WWDSE, 2004).

Currently with the existing situation like the one mentioned above, it is important to consider major factors that contributed most in the past flood hazard calamities. It has paramount importance to take notice of these factors to arrive at wise and comprehensive solution towards mitigating the challenge of flooding which is erratic and unpredictable.
1.3. Research Objective

1.3.1. General objective

The overall purpose of the study is to examine the factors contributing to watershed degradation and flooding in the Dechatu watershed at the same time to evaluate perception of the community in the upper and lower zones of the watershed.

1.3.2. Specific objectives

1. To analyze the land use and land cover change and its relation with flash floods,
2. To assess the perception of farmers and residents of urban Dire Dawa factors related to land degradation and flash floods,
3. To assess sediment depositions in the upper and lower zones of the watershed.
2. LITERATURE REVIEW

2.1. Occurrence of Flood

A flood occurs when an area of land, usually low-lying, is covered with water. The worst floods usually occur when a river overflows its banks. Floods happen when soil and vegetation cannot absorb all the water. The water then runs off the land in quantities that cannot be carried in stream channels or kept in natural ponds or man-made reservoirs. Periodic floods occur naturally on many rivers, forming an area known as the flood plain. These river floods usually result from heavy rain, sometimes combined with melting snow, which causes the rivers to overflow their banks. Under sea earthquakes, eruptions of island volcanoes that form a caldera, and marine landslips on continental shelves may all engender a tidal wave called a tsunami that causes destruction to coastal areas (O'Connor et al., 2004).

Flood is one of the most dramatic interactions between man and his environment, emphasizing both the force of natural events and man’s inadequate efforts to control them (Mohammed Ummer et al., 2003). Excess water that overflows stream banks and covers adjacent land is considered a flood. The severity of floods can be described by the depth of water above the normal stream banks or by how frequently a similar event normally occurs (Cunningham and Cunningham, 2004).

Floods are the most frequent type of disaster worldwide. Thus, it is often difficult or impossible to obtain insurance policies which cover destruction of property due to flooding, since floods are a relatively predictable risk. A flood can also be caused by blocked sewage pipes and waterways (O'Connor et al., 2004).

2.2. Causes of Floods

Both natural phenomena and human activity can cause or facilitate flooding and increase flood potential, such as changes in land use practices, over population, deforestation, poor farming practices and cultivation of grass lands (Mohammed Ummer et al., 2003). A flood is caused by a combination of heavy rainfall causing river or oceans to over flow their banks, and can happen at any time of the year, not just in
the winter. Floods generally develop over a period of days, when there is too much rainwater to fit in the rivers and water spreads over the land next to it in other words the floodplain. However, they can happen very quickly when lots of heavy rain falls over a short period of time. These flash floods occur with little or no warning and cause the biggest loss of human life than any other type of flooding. The worst cases of flooding may occur if there is a combination of storms, spring tides and low atmospheric pressure (Thompson, 1964).

As depicted in Sokolovskii (1991), WMO (2005), Dingman (1994), and Wisler and Brater (1959), causes of flooding are meteorological; mostly rainfall and underlying surface conditions 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.

The removal of forest and other natural cover influences infiltration rates and increase sheet erosion. These in turn increase the concentration of sediments in stream beds and contribute to the river morphological changes such as river bank 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 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).

2.3. Effects of Flooding

Flood water can seriously disrupt public and personal transport by cutting off roads and railway lines, as well as communication links when telephone lines are damaged. Floods disrupt normal drainage systems in cities, and sewage spills are common, which represents a serious health hazard, along with standing water and wet materials in the home. Bacteria mould and viruses, cause disease, trigger allergic reactions, and continue to damage materials long after a flood. Floods can distribute large amounts of water and suspended sediment over vast areas, restocking valuable soil nutrients to agricultural lands. In contrast, soil can be eroded by large amounts of fast flowing water,
ruining crops, destroying agricultural land or buildings and drowning farm animals. Severe floods not only ruin homes or businesses and destroy personal property, but the water left behind cause further damage to property and contents. The environment and wildlife is also at risk when damage to businesses causes the accidental release of toxic materials like paints, pesticides, gasoline etc. Floodwater can severely disrupt public and personal transport by cutting off roads and railway lines, as well as communication links when telephone lines are damaged. Unfortunately, flooding not only disrupts many people’s lives each year, but it frequently creates personal tragedies when people are swept away and drowned. Generally the effects of floods can be classified as primary, secondary and tertiary effects (Thompson, 1964).

**Primary effects**

Physical damage: Structures such as buildings get damaged due to flood water. Landslides can also take place.

Casualties: People and livestock die due to drowning. It can also lead to epidemics and diseases.

**Secondary effects**

Water supplies: Contamination of water takes place. Clean drinking water becomes scarce.

Diseases: Unhygienic conditions prevalent due to Spread of water-borne diseases

Crops and food supplies: Shortage of food crops can be caused due to loss of entire harvest.

**Tertiary/long-term effects**

Economic: Economic hardship, due to temporary decline in tourism, rebuilding costs, food shortage leading to price increase etc, especially to the poor.

Psychological: Loss of loved ones etc.
2.4. Factors Affecting Soil Development

Soil research has shown that soil profiles are influenced by five separate, yet interacting, factors: parent material, climate, topography, organisms, and time. These factors give soil profiles their distinctive character.

2.4.1. Parent Material

Soil parent material is the material that soil develops from, and may be rock that has decomposed in place, or material that has been deposited by wind, water, or ice. The character and chemical composition of the parent material plays an important role in determining soil properties, especially during the early stages of development. Soils developed on parent material that is coarse grained and composed of minerals resistant to weathering are likely to exhibit coarse grain texture. Fine grain soil develops where the parent material is composed of unstable minerals that readily weather (McDonald et al., 1990).

Parent material composition has a direct impact on soil chemistry and fertility. Parent materials rich in soluble ions—calcium, magnesium, potassium, and sodium, are easily dissolved in water and made available to plants. Limestone and basaltic lava both have a high content of soluble bases and produce fertile soil in humid climates. If parent materials are low in soluble ions, water moving through the soil removes the bases and substitutes them with hydrogen ions making the soil acidic and unsuitable for agriculture. Soils developed over sandstone are low in soluble bases and coarse in texture which facilitates leaching. Parent material influence on soil properties tends to decrease with time as it is altered and climate becomes more important (Ritter and Michael, 2006).

2.4.2. Climate, vegetation, and weathering

Soils tend to show a strong geographical correlation with climate, especially at the global scale. Energy and precipitation strongly influence physical and chemical reactions on parent material. Climate also determines vegetation cover which in turn influences soil development. Precipitation also affects horizon development factors like the translocation of dissolved ions through the soil. As time passes, climate tends to be a
prime influence on soil properties while the influence of parent material is less (Pidwirny, 2006).

Climate affects both vegetative production and the activity of organisms. Hot, dry desert regions have sparse vegetation and hence limited organic material available for the soil. The lack of precipitation inhibits chemical weathering leading to coarse textured soil in arid regions. Bacterial activity is limited by the cold temperatures in the tundra causing organic matter to build up. In the warm and wet tropics, bacterial activity proceeds at a rapid rate, thoroughly decomposing leaf litter. Under the lush tropical forest vegetation, available nutrients are rapidly taken back up by the trees. The high annual precipitation also flushes some organic material from the soil. These factors combine to create soils lacking much organic matter in their upper horizons (Pidwirny, 2006).

Climate, interacting with vegetation, also affects soil chemistry. Pine forests tend to dominate cool, humid climates. Decomposing pine needles in the presence of water creates a weak acid that strips soluble bases from the soil leaving it in an acidic state. Additionally, pine trees have low nutrient demands so few soil nutrients are taken back up by the trees to be later recycled by decaying needle litter. Broadleaf deciduous trees like oak and maple have higher nutrient demand and thus continually recycle soil nutrients keeping soils high in soluble bases (McDonald et al., 1990).

### 2.4.3. Topography

Topography has a significant impact on soil formation as it determines runoff of water, and its orientation affects microclimate which in turn affects vegetation. For soil to form, the parent material needs to lie relatively undisturbed so soil horizon processes can proceed. Water moving across the surface strips parent material away impeding soil development. Water erosion is more effective on steeper, unvegetated slopes (Ritter and Michael, 2006).

#### 2.4.3.1. Effect on soil erosion

Slope angle and length affects runoff generated when rain falls to the surface. Examine the diagram below showing the relationship between hill slope position, runoff, and erosion.
The amount of water on a particular hill slope segment is dependent on what falls from precipitation and what runs into it from an upslope hill slope segment. The hill slope in Fig 1 has been divided into several segments and the amount of precipitation falling on each segment is the same. As water runs down slope, the water that has accumulated in segment A runs off adding to what falls into segment B by precipitation. The water in B runs into C, and C into D, and so on. The amount of water increases in the down slope direction as water is contributed of water from upslope segments. The velocity of the water increases as well as it moves towards the base of the slope. As a result, the amount and velocity of water, and hence rate of erosion increases as you near the base of the slope. Rather than infiltrating into the soil to promote weathering and soil development, water runs off. Erosion causes stripping of the soil thus preventing parent material to stay in place to develop into a soil. So we should expect to find weakly developed soil at the mid- and near the bottom of the slope (Pidwirny, 2006).

**2.4.3.2. Effect on deposition and soil texture**

Water velocity not only determines the rate of erosion but the deposition of soil material in suspension too. As water empties from a mountain stream, its velocity starts to decrease. The largest size particles, like sand, are the first to drop out of suspension (Site A). Fine, clay size particles can be carried further away from the base of the slope before they are deposited. As a result, coarse textured soils tend to be found near the
base of the mountain and fine textured soils are located further away (McDonald et al.,
1990).

2.4.3.3. Microclimatic effects

Hill slope orientation affects the microclimate of a place. As the slope of the surface
increases, so does the local sun angle, up to a point. As the local sun angle increases, the
intensity of heating increases, causing warmer surface temperatures and, likely,
increased evaporation. Orientation of the hill slope is certainly important too. Those
slopes which face into the sun receive more insolation than those facing away. Thus
inclined surfaces facing into the sun tend to be warmer and drier, than flatter surfaces
facing way from the sun. The microclimate also impact vegetation type (Thompson,
1964).

2.5. Flood in Ethiopia

The rainy season in the country is concentrated in the three months between June and
September, when about 80% of the rains are received. Torrential downpours are
common in most parts of the country. Large scale flooding is rare and limited to the
lowland areas where major rivers cross to neighboring countries. However, intense
rainfall in the highlands causes flooding of settlements close to any stretch of river
courses. The most serious flood problems are found in the Awash River basin. Irrigation
development in this basin is quite advanced and is located in the flood plains on either
side of the river, with close to 70% of the country’s large-scale irrigated agriculture;
thus, high economic damage occurs during flooding. It is estimated that in the Awash
valley almost all of the area delineated for irrigation development is subject to floods.
This amounts to an inundated surface of some 200,000-250,000 ha during high flows.
The other rivers where significant floods occur are the Wabi-Shebelle River in
southeastern Ethiopia near the Somali border and Baro-Akobo/Sobat River in western
Ethiopia, near the Sudanese border. In the Baro-Akobo plain an area of about 300,000-
350,000 ha is prone to annual flooding and in the Wabi-Shebelle Basin some 100,000
ha may be inundated. Several small streams originating in the mountain range at the
foot of which the city lies traverse metropolitan Addis Ababa. Torrential rains, common
during the rainy season, cause sudden rise in the flow of these streams, which bring
about flood damages to settlements along their banks. A similar situation affects the town of Dire Dawa (Kefyalew Achamyelah, 2003).

In Ethiopia the socio economic and ecological impact of the flood is growing each year and its duration of appearance is getting faster and faster. Nonetheless, since its appearance in Dire Dawa from 1953 up to now there is no measure taken by the different stakeholders of the country. This condition plus the poor watershed management in the upper catchments area makes the condition suitable for the flood to aggravate and the problem it causing is also aggravating (Daniel Kassahun et al., 2006).

2.6. Some Causes of Flood in Dire Dawa

2.6.1. Land degradation

The major sources for household energy are biomass such as wood, charcoal, dung and crop residues. These constitute about 81 percent of the total percent of the total household energy consumption of the region (WWDSE, 2001).

The report of Regional Conservation Strategy of DDAC (2001), also show that, the high rate of biomass consumption for household energy has direct implications on the environment. The high consumption of fuel wood and charcoal for cooking encouraged falling of trees in ultimately so that deforestation of the woodland. This in turn results in soil erosion. On the other hand, the use of crop residues and dung for household energy result in the deterioration of soil fertility by interfering in the natural nutrient cycle. Both soil erosion and loss of soil fertility lead to land degradation, which in turn result in low crop production. The absolute harvesting of woody biomass for fuel, including charcoal, in the region was estimated at 94,283 tones per annum, which is set against an annual sustainable supply of only 34,550 tones.

As to a study made by MoWR, some 21 out of 28 farmer associations are consuming more fuel wood than the sustainable supply. Taking together with the town of Dire Dawa, the total consumption in the region is more than twice its annual sustainable supply for wood. Thus it calls for prompt solution to reverse the current trend of fuel wood production and consumption of the region (Halcrow, 2008).
Table 1 Soil degradation in different land uses

<table>
<thead>
<tr>
<th>Land use type</th>
<th>Soil loss (ton/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop land</td>
<td>42</td>
</tr>
<tr>
<td>Perennial crop</td>
<td>8</td>
</tr>
<tr>
<td>Grazing and browsing</td>
<td>5</td>
</tr>
<tr>
<td>Currently unproductive</td>
<td>70</td>
</tr>
<tr>
<td>Currently uncultivated</td>
<td>5</td>
</tr>
<tr>
<td>Forest</td>
<td>1</td>
</tr>
<tr>
<td>Woodlands</td>
<td>5</td>
</tr>
</tbody>
</table>

**Source:** Hurni, (1993)

Being described by Hurni (1993), on the above table, different land use types have different type of soil losses and the most devastating type of erosion occurs in currently unproductive lands where as the least is in the land unit of forest.

The same result is shown in the Soil Conservation Research Project report that has been carried out at national level estimated an average soil loss of 42t/ha/yr on cultivated fields and the maximum of 300-400 t/ha/yr in highly erodable and intensively cereal-cultivated fields (EPA, 2003). The soil loss rate of 0.4 – 21.8tons/ha/yr is by far higher than the annual soil formation rate of 0.4 – 0.5 ton/ha/yr resulting in continuous soil erosion and thus about 75% of the region is severely degraded by soil erosion. Maximum soil loss rate of 21.8 t/ha/yr is a relatively low rate of soil erosion, but reflects the extensive coverage of bench terracing (25%) and land with little remaining soil cover and bare rock (17%) in the catchments (Halcrow, 2008).

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 leads to sheet erosion (WMO and GWP, 2005).
The total consumption of wood as fuel including charcoal, in DDAC, is estimated at 71,257 tones per annum, which is set against an annual sustainable supply of only 35,000 tones (DDAC-WMEO, 2003).

### 2.6.2. Vegetation degradation

Vegetation loss worldwide continues at an alarming rate, posing a serious threat to human communities and natural ecosystems at the outset of the 21st century. Deforestation and related vegetation degradation can have harmful and even deadly consequences for both people and the environment (WWDSE, 2001).

More than 90% of the total destruction of trees is for fuel wood consumption. Fuel wood availability is linked to food security. Thus addressing fuel wood problem is a priority in forestry research and development (Dechassa Jirru, 2006).

As trees that normally induce precipitation in an area are removed, the areas climate becomes increasingly arid, often leading to desertification. Ironically, loss of vegetation can also lead to increased flooding, even if rainfall is reduced. Trees regulate run off from precipitation, buffering against widespread flooding and land slides. Vegetation also serves as important and dependable source of food, shelter, medicine, and fuel for surrounding communities (WWDSE, 2001).

Trees serve as barriers to soil erosion and ensure that vital nutrients are naturally returned to the soil. In many areas valuable soil eroded and crop yields quickly declined when trees are cleared to make ways for agriculture. Eroded soils often end up in streams and rivers, leading to siltation, contamination, and stagnation. These processes in turn, disrupt aquatic ecosystems and silt up reservoirs and dams at down streams (WWDSE, 2004).

Trees are efficient in intercepting rain and allow undergrowth and enhance the rate of infiltration. On the contrary, treeless land suffers from flooding. If the area is
deforested soils would be eroded and therefore the volume of flood water would increase (Dechassa Jirru, 2006). As trees grow, they absorb carbon from the atmosphere and store it in their tissues. When trees or forests are cleared or burned, this carbon is released back into the atmosphere as carbon dioxide which traps the sun’s energy and raises global temperature. Forest contains 40 % of all stored carbon, more than any other terrestrial ecosystem, and thus help buffer against global warming. Further more, deforestation causes loss of aesthetic value and natural beauty embodied in the forest (WWDSE, 2002).

The major source for household energy is biomass such as wood, charcoal, dung and crop residues. These constitute about 81 percent of the total percent of the total household energy consumption of the region (WWDSE, 2001).

2.6.3. Population pressure and settlement pattern

Population is increasing from time to time. Moreover, People want to settle together for security purposes. Government is also encourages people to settle, because it is more economic and efficient to provide services to people if they are in concentrated area. Moreover, as people get service such as schools and health, it is highly likely that the number and size of settlement will expand. There is also voluntary settlement due to secondary effects of other infrastructural development such as industries, roads and market places. In DDAC, most of the settlements are on the mountains and foot slopes which are naturally fragile. Population pressure has forced farmers to cultivate more lands and substantial area has been cleared of its natural vegetation. Very steep and marginal areas are also put under cultivation. Increase in population results in increase in livestock number which in turn creates pressure on land by overgrazing. Thus it needs wise and integrated approach to over come these interacting problems (WWDSE, 2001).

2.6.4. Land tenure and land use system

Farmers feel insecure of their land use right. As a result, little care is taken in the management of land and soil conservation. Land use is practiced conventionally
without effective soil conservation and land management measures. Moreover, though land use and administration systems have been issued, there is no clear-cut implementation strategies on land use, which could restrict the use of land based on capability/suitability classes. There is always professional recommendation not to cultivate areas above 30% slope but has never been practiced for good. Different professionals and institution advocated that until the basis of property ownership is fundamentally changed, the general failure to look after the environment is likely to continue in the country and Dire Dawa Council is not an exception. Such arguments maintain that the ongoing resource destruction in the area is a function of lack of an entrepreneurial system which has its roots in secure land ownership (Halcrow, 2008).

**2.6.5. Poverty**

Of all poverty is the fundamental cause of natural resource degradation. Poverty forces the semi nomadic people in the administrative council to extract as much as they can from the land and it's by products for short term survival without any choice against long term interests (WWDSE, 2001).

Generally, Dire Dawa Administrative Council is food deficit. Production in a normal year covers only two-third of the food requirement of the rural population in the region. The rest is covered by either free food aid or food for work (WWDSE, 2002).

**2.6.6. Flooding and sedimentation**

Sediment transport and sedimentation are removal and deposition of material due to the flood, wind and other carrying agents. Torrential and intensive rain on the highland create surface flooding thereby sediment transportation and deposition on the bottom and depression areas (WWDSE, 2003).

Flooding in the region is a problem mainly along the banks of the river and its tributaries. These floods originate from areas within the region as well as from areas outside the region (Halcrow, 2008).
Flooding and sedimentation have damaged the good land by covering/with water (water logging), burring the good and palatable vegetation, encouraging growth of undesirable species, blocking accesses and trekking routes and force rerouting (WWDSE, 2001).

The plains along the banks of these rivers, which are flooded each year, are also the high potential grazing and cultivation areas for the livestock. The occurrence of flood in these high potential grazing areas imposes grazing pressure in the other low potential grazing fields, which often results in the depletion of the vegetation cover in a short period. This leaves the areas bare and exposed to the eroding forces of wind during the dry season and water during the rainy season. During the rainy season, most of the rain falling in these areas quickly turns into run-off, because infiltration is impeded due to high livestock trampling effect and the resultant soil surface sealing, when raindrops impact finely pulverized bare soil. The high run-off originating from such areas in turn adds to that from the highlands leading to the flooding and sedimentation of the high potential plains along the river banks. The cycle is repeated each year and the net effect is aggravated process of land degradation. Some of the rivers have changed their courses and flooded and deposited sediment on the grazing and flood plain and flood recession farm lands (Halcrow, 2008).

2.6.7. Climate change

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. However the country is not awaked to cope with impacts of climate change. Generally, the central part of Ethiopia is dominated by high lands, with a general elevation exceeding 2000m 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 1000m 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 positive correlation between amount of rainfall and flood magnitude. In Ethiopia, especially in
the high lands, the mean annual rainfall is higher than the lowlands, where it is broadly ranges from >2000mm to<100mm/yr (EPA, 2003). However, the amount itself is not very important. Rather it is the intensity of rainfall which matters most. Again the intensity of the 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 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 manageable scale (Daniel Kassahun et al., 2006).

**Causal nexus: Poverty-Environment Trap**

![Causal nexus: Poverty-Environment Trap diagram](image)

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Fig 2 Poverty and Environmental Degradation Cause Effect Relation
(Source : Lecture note : Mekuria Argaw, 2007)
3. MATERIALS AND METHODS

3.1. Description of Study Area

3.1.1. Location

Dire Dawa Administrative Council lies between 09°28’ and 09°49’N and between 41°38’ and 42°19’E with an area of about 1770km². It is bordered in the north, east and west by the Somali National Regional State and in the south and south west by the Oromia National Regional State. The physiography of Dire Dawa could be classified into mountain ranges, hills, valley bottoms, river terraces and flat plains. The mountain ranges possess slopes exceeding 45%. Hills, scattered all over the region, have slopes ranging between 16 and 30%. In most areas of the hills and mountains, the natural vegetation is already depleted, the bedrocks are exposed, and the soils are washed away. The valley bottoms, river terraces, and flat plains, however, have deep and fertile soils (DDAC-WMEO, 2003). In 2005/6, the total population living in Dire Dawa Administrative Council was 59,692. Traditional crop and livestock production system dominate the livelihood of rural population. As a result, the low productivity per unit of land and livestock are described, “low” (Halcrow, 2007).
Dechatu watershed is one of the watersheds of Dire Dawa Administrative council in eastern Ethiopia. This Watershed is situated in the north - west part of Dire Dawa Administrative Council at the margin of eastern part of Ethiopian Rift Valley in the Awash basin (Fig 4). It is located between 09° 25’ to 09° 40’ North and 41° 42’ to 41° 53’ East in the UTM zone 37 with altitude between 1300 to 2300 m above mean sea level. The study watershed covers an area of 16007ha.

![Fig 4 Dechatu Watershed (Location Map)](image)

Dechatu River is named after the three rivers join together at the gauging station. The three major rivers which come together are Laga Chrichi, Laga Anani, and Laga Gogoityi. The Rivers originates from the highlands of Kersa, Lange, Dengego and Haromaya catchments respectively.

![Fig 5 Dechatu River Crossing Dire Dawa Town](image)

Source: Google Earth
Among the main intermittent streams in the Dire Dawa region, Dechatu is the major one where most of the precipitation as run-off from the south (escarpment zone) drains into it. Although this stream is dry for the most part of the year, it carries very large flow in the rainy season which some times causes flash flooding that result in some damage in the town, mainly because it passes through the middle of the town. Most of the runoff from Dechatu and the other streams spread in the low lying and flat topographic areas north of the town contributing a lot to the ground water (WWDSE, 2004).

3.1.2. Topography

The area is comprised of diversified topographic features: mountains and hills (Mh), alluvial plain (Pa), undulating plain (Pu), town (tw). The elevation ranged from 1300 to 2300 m a.s.l and the average hill slope was about 12.63 % (Fig 6).

3.1.3. Climate

As per Koppen's classification, the study watershed is characterized as Hot Semi-Arid Zone; the mean annual temperature lies between 17°C and 27°C; where as the mean...
annual rainfall is between 410 and 800 mm. The rainfall is highly variable from year to year. (See Fig 8 and Fig 9).

Fig 8 Average Monthly Temperature of Dechatu Watershed

The climate of the study region is dominated by various inter-related factors, but the main factors are the near equatorial location and the altitude. The year is divided into three seasons: a main rainy season (Kiremt) from July to mid - September, a dry season (Bega) from October to February, and finally a "small rainy" season (Belg) in March and April. The small rain originated from the Indian Ocean and is brought by north-west winds; while the heavy rains in the wet season come from the Atlantic Ocean with north-east winds (WWDSE, 2002). (Fig 9).

Fig 9 Average Monthly Rainfall of Dechatu Watershed
3.1.4. Land use

The present land use and land cover of Dire Dawa Administrative Council watershed was studied by water works and design enterprise (WWDSE). Using the Geographic Information Systems (GIS) computer program after making a thorough analysis for ease of identification of the different mapping unit in the Dechatu watershed, it was arrived at the following results.

Out of the total area 42.87% is bare land 34.53% cultivated land 13.33% shrub land 4.97% sand deposit 2.47% open wood land and the rest 1.83% is built up area.

3.1.5. Soil data of Dechatu watershed

Generally the soil of Dechatu watershed comprises six classes Dmpp12, Dmpp13, Dmpp15, Dmpp26, Dmpp28 and Tw. Soil data was obtained from DDAC Integrated Resource Development Master Plan Study Report, 2004 and the classification was made based on the FAO-UNESCO Soil Classification System (Table 2 and Fig 11).
Table 2 Soil types of the study and calibration area with their aerial coverage (FAO-UNESCO Soil Classification System)

<table>
<thead>
<tr>
<th>Pit No.</th>
<th>Map code</th>
<th>Depth (cm)</th>
<th>Sand (%)</th>
<th>Silt (%)</th>
<th>Clay (%)</th>
<th>Class</th>
<th>Organic content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP12 DMPP12</td>
<td>0-10</td>
<td>46.34</td>
<td>16.29</td>
<td>37.37</td>
<td>SC</td>
<td>1.36</td>
<td></td>
</tr>
<tr>
<td>10-55</td>
<td>81.67</td>
<td>4.10</td>
<td>14.23</td>
<td>SL</td>
<td>0.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>55-95</td>
<td>23.14</td>
<td>21.44</td>
<td>55.42</td>
<td>C</td>
<td>0.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MP13 DMPP13</td>
<td>0-16</td>
<td>46.37</td>
<td>30.90</td>
<td>22.73</td>
<td>L</td>
<td>2.68</td>
<td></td>
</tr>
<tr>
<td>MP15 DMPP15</td>
<td>0-15</td>
<td>27.57</td>
<td>34.76</td>
<td>37.67</td>
<td>CL</td>
<td>1.21</td>
<td></td>
</tr>
<tr>
<td>MP26 DMPP26</td>
<td>0-20</td>
<td>43.27</td>
<td>24.99</td>
<td>31.74</td>
<td>CL</td>
<td>1.94</td>
<td></td>
</tr>
<tr>
<td>20-60</td>
<td>47.74</td>
<td>19.72</td>
<td>32.54</td>
<td>SCL</td>
<td>1.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60-200</td>
<td>40.12</td>
<td>22.81</td>
<td>37.07</td>
<td>CL</td>
<td>1.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MP28 DMPP28</td>
<td>0-15</td>
<td>67.88</td>
<td>18.36</td>
<td>13.76</td>
<td>SL</td>
<td>4.00</td>
<td></td>
</tr>
<tr>
<td>15-45</td>
<td>74.70</td>
<td>8.10</td>
<td>17.20</td>
<td>SL</td>
<td>1.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tw Tw</td>
<td>30</td>
<td>33.24</td>
<td>29.52</td>
<td>37.24</td>
<td>CL</td>
<td>1.12</td>
<td></td>
</tr>
</tbody>
</table>


Fig 11 Soil Map of Dechatu Watershed
### 3.1.6. Description of soil profile in the Dechatu watershed

<table>
<thead>
<tr>
<th>I) Typical profile</th>
<th>DMPP 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>Moderately deep to very deep, medium texture soils on undulating plains and valley bottoms</td>
</tr>
<tr>
<td>Current erosion</td>
<td>Severe / rill &amp; gully</td>
</tr>
<tr>
<td>Land use</td>
<td>Dry-land farming</td>
</tr>
</tbody>
</table>

**Description**

These soils occur predominately on valley bottom and foot-slopes of some of the hills and mountains with slopes of 5-8%. They are mostly derived and developed from sedimentary rocks. Surface stone coverage is none to few and the natural vegetation is scattered shrub-land. Land use is dry-land subsistence farming. The soils are moderately to very deep, dark brown over dark brown and very dark brown sandy clays to sandy clay loams over sandy loams. Topsoil structure is weak to moderately developed fine to medium sub-angular blocky over very weak to weak fine to medium sub-angular blocky sub-soils. Moist consistency is very friable on both the top and sub-soils and the whole horizon is moderately to strongly calcareous. Permeability is moderately rapid-to-rapid. The soils are moderately to strongly alkaline in the top and sub-soils with mean PH values of 8.79 and 8.80 respectively and are non-saline throughout. This indicates that the soils are potentially sodic (WWDSE, 2004).

<table>
<thead>
<tr>
<th>II) Typical profile</th>
<th>DMPP 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief description</td>
<td>very shallow, medium textured hilly soils</td>
</tr>
<tr>
<td>Current erosion</td>
<td>sever / rill &amp; gully</td>
</tr>
<tr>
<td>Land use</td>
<td>grazing / wasteland</td>
</tr>
</tbody>
</table>

**Description**

These soils are found at different parts of the project area and are formed on hilly and mountainous topography with slopes of up-to 60%. They are formed from different parent materials especially igneous rocks. They are characterized by their very shallow depth and abundant surface stones (>80%) and weathering. In most areas, even bare
rocks are found. Land use is grazing and the bare rocks are wasteland. The soils are very shallow, somewhat excessively drained, very dark brown over continuous bedrock, loams to sandy clay loams. Soil structure is weak to moderately developed fine to medium sub-angular blocky structure. Moist consistency is very friable and the soils are slightly to moderately calcareous. Permeability is moderately rapid. The soils are moderately to strongly alkaline with mean pH values of 8.52 and are non-saline (WWDSE, 2004).

III) Typical profile - DMPP 15
Brief description - very shallow, medium textured, on rugged steep to very steep, severely dissected hills & mountains
Current erosion - severe/rills & gullies
Land use - grazing & waste land

Description
These soils are located throughout the project area on a steep to very steep, severely dissected hills and mountains with slopes of 30-60% in some cases even on slopes over 60%. They are formed from different parent materials such as igneous rocks like basalts and sedimentary rocks like lime stones. They are characterized by their very shallow depth and abundant surface stones of >80%. In most areas, even base surface rocks are encountered. Land use is grazing and the base rocks are wasteland. The soils are very shallow, excessively drained, brownish yellow over continuous bedrock, clay loams. Soil structure is weak to moderately developed fine to medium sub-angular blocky structure. When moist, consistency is very friable and the soils are strongly calcareous. Permeability is moderately rapid. The soils are moderately to strongly alkaline with pH value of 8.66 and are non-saline (WWDSE, 2004).

IV) Typical profile - DMPP 26
Brief description - deep to very deep, medium textured hilly soils
Current erosion - moderate to severe / rill & gully
Land use - dry land farming
Description

These soils occur on a strongly sloping hilly and mountainous terrain on slopes of 8-16%. They are developed on sedimentary rocks like limestones and sandstones. Surface stone coverage is within the range of 15-40% and the current land cover is shrub land. Land use terrace cultivation. The soils are deep to very deep, very dark brown over very dark brown, clay loams over sandy clay loams. Topsoil structure is weak to moderately developed fine to medium sub-angular blocky over moderately developed fine to medium sub-angular blocky sub-soils. When moist, consistency is very friable throughout. The soils are strongly calcareous. Permeability is moderately rapid-to-rapid. The soils are moderately to strongly alkaline in the top and sub-soils and are non-saline in both horizons. While base saturation is high in both layers with values greater than 90%. Exchangeable Na value is also high in both horizons with values of soils in the top and sub-soils. The ESP value is low in the range of 2.6%. Organic carbon percentage is very low with values of 1.94 on the top and 1.33 in the sub-soils and nitrogen percentage is also low with values of 0.163 and 0.137 in the top and sub-soils respectively. Phosphorous is also very low with value in the range of 2ppm in both layers.

V) Typical profile - DMPP 28
FAO unit - Calcaric Arenesols
Mapping unit - Pu8
Brief description - shallow to moderately deep, coarse textured, undulating to rolling plain soils
Current erosion - severe / rills & gullies
Land use - grazing with some farming on terraces

Description:

These soils occur on the foot-slopes of the hills and undulating to rolling plains where the slopes vary considerably (8-30%) and are mainly developed on sandstones. There is abundant surface stoniness of 40-80% coverage. Land cover is scattered to moderate
shrubs and land use is grazing with some farming on terraces. The soils are well to somewhat excessively drained, shallow to moderately deep, dark brown over dark brown sandy loams through out. Topsoil structure is very weakly developed fine to medium crumb structure over massive and weakly developed fine to medium sub-angular blocky sub-soils. When moist, consistency is very friable and/or loose. Permeability is rapid. The soils are moderately alkaline with PH values of 8.53 and 8.61 on the top and sub-soils respectively. They are non-saline but are potentially sodic (WWDSE, 2004).

### 3.1.7. Vegetation type

Vegetation development in the study area is mainly governed by physiography/altitude, climate, etc besides other factors. Vegetation in the study area is scanty except along the intermittent streams. The natural vegetation is largely scanty acacia trees and cactus. On the patchy rock outcrop areas in the town and its surroundings there is very weak vegetation development since there is no soil development. The dominant vegetation covers of the region’s ecosystem consists of deciduous shrubs mostly *Acacia* species often interspersed with less frequent evergreen shrubs and succulents such as *Euphorbia*, *Aloe*, *Caralluma*, *Opuntia*, and *Dracaena* spp. on rocky out crops (WBISPP, 2000). The low land and flood plains are dominantly covered by species of *Acacia*, *Azadirachta*, *Delonix*, *Ziziphus* and *Prosopis juliflora*. The grass species are widely distributed in patchy and Plateau land escapes. High mountain areas in the southern part are covered by the remnants of dry evergreen montanae forest such as, *Juniperous procera*, *Cordia africana*, *Cupressus lusitanica* and *Olea europea* (WWDSE, 2001).

### 3.1.8. Population

As to CSA, (1994) data during the second census period of 1994, the total population of the Council reckoned to be 251,864 consisting of 173,188 (68.8%) and 78,676 (31.2%) urban and rural population respectively. With regard to sex distribution, 127,286 of the
population is identified to be males and 124,578 females representing 50.5 and 49.5 percent of the total population size respectively.

In addition, the 1994 census result revealed that, there are 52,249 households in DDAC with an average household size of 4.9 persons per household. The average household size identified in the urban area during the second census period was 4.7 persons per household and 6 persons in the rural area.

Out of the above mentioned statistics, the study area covers four kebeles from urban Dire Dawa and five PAs from rural Dire Dawa. The total population of the study area is 35,495. The urban and rural comprises 19504 and 15991 respectively (Table 3 and Table 4).

Generally the study area comprises 14% of the total population of the administrative council.

Table 3 Population size in urban Dire Dawa

<table>
<thead>
<tr>
<th>Kebeles</th>
<th>Area, Km²</th>
<th>Population</th>
<th>% Population of the Council</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kebele 09</td>
<td>0.20</td>
<td>4099</td>
<td>1.63</td>
</tr>
<tr>
<td>Kebele 10</td>
<td>0.13</td>
<td>1736</td>
<td>0.69</td>
</tr>
<tr>
<td>Kebele 11</td>
<td>0.14</td>
<td>5900</td>
<td>2.34</td>
</tr>
<tr>
<td>Kebele 12</td>
<td>0.24</td>
<td>7769</td>
<td>3.08</td>
</tr>
</tbody>
</table>

Table 4 Population size in Rural Dire Dawa

<table>
<thead>
<tr>
<th>Peasant Association</th>
<th>Area, Km²</th>
<th>Population</th>
<th>% Population of the Council</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bishan Behe/Gende ware</td>
<td>22.26</td>
<td>2066</td>
<td>0.82</td>
</tr>
<tr>
<td>Eja Aneni</td>
<td>23.59</td>
<td>1643</td>
<td>0.65</td>
</tr>
<tr>
<td>Jelo Belina</td>
<td>47.73</td>
<td>4272</td>
<td>1.70</td>
</tr>
<tr>
<td>Harela</td>
<td>18.54</td>
<td>3370</td>
<td>1.34</td>
</tr>
<tr>
<td>Adada</td>
<td>26.97</td>
<td>4640</td>
<td>1.84</td>
</tr>
</tbody>
</table>
3.2. **Methods of the Study**

Different approaches and methodologies were applied to access the land degradation and flood problems of the study area.

Prior to fieldwork, review of previous studies and interpretation of available 1: 50 000 National Topographic Maps were made. Moreover, data collection checklists and questionnaires were also prepared.

Data and information about the beneficiary’s perception of land management problems were collected using different methods of data collection; like structured questionnaires, interviews and discussions with beneficiaries and personal observations were employed to generate primary data.

Two types of questionnaires were designed to assess the socio-economic situation of the study area, which were administered to upland and lowland areas.

The survey questionnaires were comprised of both closed and open ended types and covered various issues of land use and flood problems.

Prior to implementing the survey works, the questionnaires were tested after which necessary amendments were incorporated.

High school leavers were recruited and trained to conduct the survey. The facts that the house holds in the area are Afan Oromo speakers, bilingual enumerators from the study area were recruited.

In order to conduct the households survey, total number of house holds within the Woreda were collected from Dire Dawa administrative office; then the households were selected using one-stage clustered sampling. Five peasant associations (PA’s) and four Kebeles were chosen for the house hold survey. Households to be included for the survey
were randomly chosen from the lists of households in the selected PA’s and Kebeles; when the household was unavailable or unwilling to be interviewed a substitute was selected.

For the soil profile study, Three pits were dug randomly for profile studies at each of the land use with grass land, cultivated land and bare land within a view to compare the characterization of A and B horizons, i.e 1 meter depth. 3 pits were dug in one land use type so that the average of the three was taken as a result. An average of 27 pits was dug in each peasant association to study the soil profile.

In order to know the land use/land cover change of the study area, two years of data was downloaded from University of Maryland [www.landcover.org](http://www.landcover.org) (2008) of land sat satellite. The 1986 and 2000 land use land cover of the study area was analyzed using Arc GIS 9.0., ERDAS 8.6; DEM was also used to analyze elevation of the study area. The socio economic data was analyzed using Soft Wares like Microsoft Excel and SPSS.

Flood and land degradation problems (type, extent, causes, symptoms, and impacts), community awareness, attitudes and reaction to the problem were also enlisted with the help of interview. Moreover, non formal interviews and group discussions were made with farmers, women, elders, youth, (on the basis of a checklist) regarding environmental patterns including population pressure (both human and livestock) related issues, patterns in the condition of the vegetation cover, rainfall pattern, etc and impact on natural resources were reviewed from different literatures.

Issues that reflect on the community’s awareness and attitudes towards land degradation and flood (major problems of the area, priority of problems, causes, measures considered appropriate, etc., areas considered to be severely affected by degradation and why so, etc.) were also identified. Data for the study was collected by selecting sample Kebeles from the upland (cause area) and the lowland (affected areas) separately.
Physical data was collected by direct observation and using relevant data to compare the present and past land use land cover and assessing some rehabilitation measures taken after the 2006 flood had appeared.

Sample size for survey, interviewed is given in Table 5 and Table 6 for rural as well as urban areas respectively.

Table 5 Numbers of households Interviewed from each PA’s

<table>
<thead>
<tr>
<th>Name of Peasant Association</th>
<th>Total Number of Population</th>
<th>Total Number of Populations Interviewed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bishan Behe/gende ware</td>
<td>2066</td>
<td>11</td>
</tr>
<tr>
<td>Eja Aneni</td>
<td>1643</td>
<td>8</td>
</tr>
<tr>
<td>Jelo Belina</td>
<td>4272</td>
<td>21</td>
</tr>
<tr>
<td>Harela</td>
<td>3370</td>
<td>13</td>
</tr>
<tr>
<td>Adada</td>
<td>4640</td>
<td>22</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15991</strong></td>
<td><strong>75</strong></td>
</tr>
</tbody>
</table>

Table 6 Numbers of households Interviewed from each Kebele

<table>
<thead>
<tr>
<th>Kebeles</th>
<th>Population</th>
<th>Total Number of Populations Interviewed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kebele 09</td>
<td>4099</td>
<td>21</td>
</tr>
<tr>
<td>Kebele 10</td>
<td>1736</td>
<td>9</td>
</tr>
<tr>
<td>Kebele 11</td>
<td>5900</td>
<td>15</td>
</tr>
<tr>
<td>Kebele 12</td>
<td>7769</td>
<td>35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>19504</strong></td>
<td><strong>80</strong></td>
</tr>
</tbody>
</table>
4. RESULTS AND DISCUSSIONS

Interview and discussion with focus group farmers were held in all the five PAs of the watershed and four Kebeles in urban Dire Dawa to assess the awareness of residents about cause of flood and land degradation. Degree of awareness and perception of the problems varied in different PAs and within the PAs for different groups. It is interesting to note that farmers living on the hills, mountains and steep escarpments are taking serious land degradation problems and the resulting consequences than those in the lower areas; whereas those of the lowland dwellers are facing the problem of flooding.

4.1. Rural Dire Dawa

The study in the rural part of the study area reveals that 72% of the respondents are illiterate out of them 80% are females. Out of the remaining 28%, 18% are above grade 6. The rest 10% can only read and write. Majority of the house holds have family member of more than 8. Almost all of the respondents were living their life time in the place.

Table 7 Age status of the respondents and family in the rural part of the study area

<table>
<thead>
<tr>
<th>Age</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under five</td>
<td>154</td>
<td>26</td>
</tr>
<tr>
<td>Between 6 and 14</td>
<td>96</td>
<td>16</td>
</tr>
<tr>
<td>Between 15 and 19</td>
<td>98</td>
<td>16.5</td>
</tr>
<tr>
<td>Between 20 and 25</td>
<td>87</td>
<td>14.5</td>
</tr>
<tr>
<td>Between 26 and 60</td>
<td>85</td>
<td>14</td>
</tr>
<tr>
<td>Above 60</td>
<td>80</td>
<td>13</td>
</tr>
</tbody>
</table>

Table 8 Literacy status of the rural part of the study area
<table>
<thead>
<tr>
<th>Literacy</th>
<th>sex</th>
<th>Grade</th>
<th>Number of respondents and family members</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>literate</td>
<td>male</td>
<td>Read and write</td>
<td>40</td>
<td>7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Above grade 6</td>
<td>70</td>
<td>11.5%</td>
</tr>
<tr>
<td>Female</td>
<td>Read and write</td>
<td>16</td>
<td>2.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Above grade 6</td>
<td>42</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>Illiterate</td>
<td>Male</td>
<td></td>
<td>86</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>346</td>
<td>58%</td>
<td></td>
</tr>
</tbody>
</table>

### 4.1.1. Land holding

All of the respondents in the rural area are farmers. And they use mixed farming system. As shown on Fig 12, 86% of the respondents have land of 0.25-0.5ha. Where as 12% have land holding of less than 0.25ha. The rest 2% have land of more than 0.5ha. This shows that 98% of the farmers have a land of less than 0.5 ha. This in turn means majority of the residents are forced to farm on unsuitable and marginal lands to sustain their life. Farming on sloppy mountains and marginal lands leads to increased erosion rate and increased runoff.

![land holdings in ha](image.png)

Fig 12 Respondents Land Holdings in ha
4.1.2. Land degradation

As mentioned by Yonas Tadesse and Sinework Danachew, (2006), there is negligible forest coverage (less than 0.03%) in the upland parts of the catchments. On the other hand, about 43% of Kersa and 52.4% of Haromaya fall in between cropland only. The study also reveals that the area is highly degraded. In the field survey, it was observed that large-scale destruction of forest resources in the highland areas has been practiced. This has aggravated the rate of flooding in Dire Dawa; by reducing the rate of soil infiltration and reducing the lag time of surface runoff and facilitates soil erosion. Deforestation also reduces the amount of water that would be intercepted and which would have been later converted into vapor. It also reduces the water holding capacity of soil due to the reduced organic matter in the soil. All of the respondents explained that much of the raindrops changes into run off, which had once been in filtering into the soil. This subsequently resulted in soil erosion and flash flood risk, which were more severe in steeper slope areas where the wood lands have been converted to bare ground and farm land.

Fig 13 Cultivation on Steep Slope and Degraded Lands

The farmers were asked reasons for land degradation and 72% of them reported to be deforestation, steep slope and hilly nature of the terrain, cultivation, overgrazing, aging of land etc. But when they were asked about the cause of the flood 76% of them answered it is the will of God/Allah. Eighty percent of those that answered it is human
induced reasoned out it is because of improper forest management and the rest said it is living standard of the people and land degradation. All the group participants mentioned that the fertility status of their farm is poor to get good yield. The reason for poor yield is poor soil fertility, soil erosion (which felt to reduce depth and washed away the good surface soil), low moisture and change of climate.

The farmers were also asked the most impressive problem in the area and 62% responded land degradation next to it shortage of water supply and flood 30% and 8% respectively.
4.1.3. Soil erosion

In Focused Group Discussion, in order to get the views of farmers on the magnitude of soil erosion and land degradation problems in the respective areas, the question “is there any land abandoned due to erosion?” was raised. Some reported that cultivated lands has become out of use every time due to erosion and gully formation. In the past years, most of the respondent used no soil fertility improvement measure. They did not apply farmyard manure due to lack of moisture. Moreover the majority of farmers do not use chemical fertilizers due to high price.

The researcher also recognized that all the farmers are very much addicted to chat and they pass most of their time chewing it; though it is obvious that the farmers have a good culture of hard working especially terracing. (See Fig 16 a and b)

Farmers were asked whether they practice soil and land management system such as crop rotation, rotational grazing and fallowing. All reported that they use monoculture (especially Chat, corn and sorghum) and no fallowing and rotational grazing as there is shortage of land as most of them posses a land of less than 0.5 ha and the soil is suitable only for these species.
Table 9 Respondents perception towards resettlement

<table>
<thead>
<tr>
<th>Is resettlement an option?</th>
<th>Frequency</th>
<th>Percentage%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>40</td>
<td>53</td>
</tr>
<tr>
<td>No</td>
<td>35</td>
<td>47</td>
</tr>
</tbody>
</table>

As shown in Table 7, majority of the respondents are willing to resettle and the main reason is because of poverty as a result of high land degradation. According to FAO (1988), resettlement must be entirely voluntary; it should not be induced with selective offers of food aid to those who register for it. Those resettled must be fully informed about conditions in the resettlement sites before signing up preferably by community representatives visiting the site. Prospective resettlement areas should be subjected to a thorough environmental assessment prior to being selected as sites including the projection of the current future carrying capacity for the people and livestock. Essential infrastructure and basic social services must be in place before settlers arrive. Clear criteria for occupying land must be established and made known to all.

In focused group discussion and field survey, it is proved that almost all cultivated lands have found to be suffered from erosion. Response to erosion effect on their farm plot was requested and all farmers knows the situation is alarming, but do not have alternative. In addition to this the farmers cultivate marginal lands and on places that are prone to flood on the way of the flood.

Farmers were asked what measure they use to prevent flood disaster not to harm cultivated lands and loss of property they indicated that they use local knowledge of diverting flood and planting bushes that prevent both soil erosion and decrease flood intensity. The elders also informed that they used to have local indigenous cultures that use to prevent soil erosion by constructing structures like stone bunds on the way cattle’s go for grazing. They also informed that this all was at the time the area was covered by open wood land. But now the farmers have little experience of planting trees and no experience of grass planting to prevent soil erosion and have good soil fertility. The other
major problem is lack of community organization and phase out strategy of soil and water conservation measures resulting in failure of concerted efforts.

The farmers also mentioned that the flood is natural in occurrence. According to elders it used to appear every 7 years. But now the intensity increased at short interval. When they were asked what the reason behind is, all of them admitted that it is because of improper forest management as earlier the area was covered by open wood land and now most of the open wood land is converted to cultivated land and the rest to built up area the satellite image analysis also confirm this. (See Table 13 and Fig 19 and 20)

Seventy percent of the respondents reported that when the flood comes it takes away their farm lands and some 27% admitted that it doesn’t have any effect on them except soil erosion. And the rest 3% said it takes all what they have except human life this is because the area is relatively high land than urban Dire Dawa and the flood take away majority of their farm lands, and their fertilized soil because they farm on the path of the flood and on high slope area. Above all their main problem is shortage of land, land degradation and soil erosion. This all is because of land shortage as the population number increase. Since they have to struggle for survival, they live and cultivate on areas that previously have been left as it is the natural path of the flood.

Soil erosion is one of the environmental problems of the watershed. It occurs widely in the region in all its forms i.e. rill, sheet, gully and channel erosion. Soil erosion and related risks in the high lands are different from the lowlands. The removal of nutrient rich top soil through rill and sheet erosion from farms and range lands is producing at an accelerating rate. The combined effect of erosion causes flooding in the lowlands threatening particularly Dire Dawa town, where it entails risk on human lives and their properties.
Fig 17(a) Cultivation on Route of the Flood around Ija Anani

Fig 17(b) Cultivation on Route of the Flood Adada
4.1.4. Population

Due to the rapidly growing population pressure and the subsequent demand for agriculture land, fuel and construction materials, forests and woodlands were cleared indiscriminately. All the farmers reported that they use wood as a source of fuel and they also added that using of wood is not the reason for the high rate of cutting trees since the wood is from their compound and farm land. But the main reason is the woods from the open wood land are used for market purpose to urban Dire Dawa and for charcoal formation. The continuing deforestation resulted in disappearance of the vegetation cover thus aggravating soil erosion. Besides, overgrazing and cultivation in marginal lands further aggravate soil erosion in the region because of high population pressure.

4.1.5. Consumption of biomass as a source of household energy

The high rate of biomass consumption for household energy has a direct implication on the environment. High consumption of fuel wood and charcoal for cooking exacerbates deforestation of woodland. This in turn results in soil erosion. On the other hand, the use of crop residues and dung for household energy result in the deterioration of soil fertility by disrupting the natural nutrient cycle. Both soil erosion and loss of soil fertility lead to land degradation, which in turn result in low crop production.

The recurrent drought and the associated absence of alternative source of income have also forced the rural population to clear more vegetation to generate income through the sale of fuel wood and charcoal. This practice resulted not only in the disappearance of important indigenous tree species but also caused a high rate of soil erosion. Similarly a study was made by World Bank (as cited by Dechassa Jirru, 2006) to study the fuel wood around the major cities and found more than 90% of the total destruction of trees is for fuel wood consumption. Fuel wood availability is linked to food security. Thus addressing fuel wood problem is a priority in forestry research and developments and integrated watershed development. As to the study Dire Dawa was one of them.
4.2. Urban Dire Dawa or low land dwellers

The study in the urban part of the study area reveals that majority of the respondents except the elders are all literate. Majority of the house holds have family member of more than 7. This shows that there is high number of urban dwellers than the rural. Fifty six percent of the respondents in the city have their own business 34% are employed in GO’s and NGO’s. The rest 10% live by remittance from others. Almost all of the respondents were born have pass their life time in the place.

Table 10 Age status of the respondents and family members in urban Dire Dawa

<table>
<thead>
<tr>
<th>Age</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under five</td>
<td>143</td>
<td>23</td>
</tr>
<tr>
<td>Between 6 and 14</td>
<td>89</td>
<td>14</td>
</tr>
<tr>
<td>Between 15 and 19</td>
<td>94</td>
<td>15</td>
</tr>
<tr>
<td>Between 20 and 25</td>
<td>99</td>
<td>15</td>
</tr>
<tr>
<td>Between 26 and 60</td>
<td>135</td>
<td>21.5</td>
</tr>
<tr>
<td>Above 60</td>
<td>72</td>
<td>11.5</td>
</tr>
</tbody>
</table>

Most of the responders have explained that there is deviations in their income (up to 55%) since most of them have their own business as the flood took all their materials and they had no capital to run their business. And after Government and different NGO’s have helped them for the initial capital to sustain their previous activity, the people couldn’t attain as much income as before the flood. The reason for this is they have resettled in a new place and they don’t have customers to buy their goods.

Like the rural pat of the study area there is no community based organization to prevent the flood except ‘Guza’ which help for saving and protection of their materials as the flood appear. The respondents also are not happy by the rehabilitation measures taken so far and they are not confidential with the retaining wall under construction, and there is
no much effort done even the high way (the road connecting Dire Dawa to Addis Ababa and Harar) broken by the 2006 flood is not yet constructed.

The flood is very dangerous and aggravate when it reaches the urban part of Dire Dawa, because of many reasons. As the town is found at the foot hill and the upland area is very degraded and there is small cover of open wood land and shrub land as compared to previous time the runoff from the upland area reaches to urban Dire Dawa with high speed because of altitude difference and there is nothing to decrease its speed as it is bare land and no wood land to infiltrate and decrease the runoff. Above all this, the shape of the watershed is more of circular which speed up the time and acceleration of the runoff to reach to Dire Dawa.

According to Halcrow, (2008) currently the Administrative council is doing some retaining protection work on Dechatu River. The total length of Dechatu River which crosses the town is estimated around 6800m. But there is a retaining wall for about 2000m length on both sides of the river. The remaining 4800m length of the river requires retaining wall protection work on both sides. The retaining wall constructed currently has 3.9 m maximum height. (See Fig 18) But still the residents are settling in the area and it’s a high market place; where the poor people with low standard of living are living.

Fig 18 Retaining Wall around Kefira Coca Kebele (Urban Dire Dawa)
People are still living in the flood prone area, what is most surprising is they still don’t want to resettle to other place. What they fear of is settling in places out of the city without any infrastructure. The people also afraid of future flood risk and the cause for the flood according to them is God’s will. But most of the residents who lost their families and home have been able to resettle to other residences where the ECS-SIDCOH has constructed. When they were asked about the retaining wall under construction, all of the respondents are not confidential on it. They fear that if a flood like the 2006 comes again it will be easy for it to take it away and turn it just to pieces of stone and sand. Then they were asked then what is the best solution to mitigate the flood and they answered there should be community participation in every aspect of the rehabilitation process. They suggest that the prevention is much more preferable than rehabilitation so the government and NGO’s should focus on prevention of the flood not on the rehabilitation activity.

4.3. Soil profile study in the upland area

Soil profile was studied to prove that whether erosion and sedimentation is taking place or not. So that it would be responsible for the flood by decreasing the infiltration and increasing the runoff in the uplands and the sedimentation in the low land by decreasing the carrying capacity of the river to hold more runoff. A small pit around 1 meter depth was dug, since it is a depth of the deepest soil. It was so hard to differentiate the A and the B horizon because of high sedimentation rate in the lower part of the study area, but since the main concept is to study whether erosion and deposition is taking place or not, it was finally possible. The profile study reveals that areas with no vegetation cover have very shallow soil profile and those relatively low land areas have deeper soil than the upper parts. The result also matches with the data obtained from ministry of water resource. As shown on Table 11 and 12 in Jelo Belina especially around “Assefa Shai” the soil is so deep and fertile; the soil from the upland area deposit because of erosion and it is relatively flat slope. But the problem is the area is highly susceptible to flood. Since the river is dry in dry season, the farmers cultivate lands that are path of the flood (See Fig 17 a, b). Areas around Gende Ware are very steep and still the farmers cultivate these steep slope mountains so the land is highly degraded. Where as Harla is an old city
the former city of Harar and it was a trade center, because of earlier settlement and its geographic nature in addition to the farming practice of the people has contributed to high degradation. The life and working style of the people also contributed to high degradation of the area. Since they cultivate on steep slope and deforestation is aggravated in the area, in addition to poverty plays its great roll in the land degradation, soil erosion and flood of the area.

The soil in the lowland is deposited at the river banks and there is a huge amount of sand deposit in the area which is increasing from time to time. Similarly the satellite image analysis confirms this (See Table 13, Fig. 20 and 21).

Table 11 Depth of “A” Horizon

<table>
<thead>
<tr>
<th>PA’s</th>
<th>Grass Land</th>
<th>Cultivated Land</th>
<th>Bare Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gende Ware</td>
<td>^ 4</td>
<td>^4</td>
<td>^2</td>
</tr>
<tr>
<td>Harla</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Jelo Belina</td>
<td>^9</td>
<td>^8</td>
<td>^6</td>
</tr>
<tr>
<td>Ija Anani</td>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Adada</td>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 12 Depth of “B” horizon

<table>
<thead>
<tr>
<th>PA’s</th>
<th>Grass Land</th>
<th>Cultivated Land</th>
<th>Bare Land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gende Ware</td>
<td>^ 6</td>
<td>^4</td>
<td>^9</td>
</tr>
<tr>
<td>Harla</td>
<td>7</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Jelo Belina</td>
<td>^5</td>
<td>^7</td>
<td>^6</td>
</tr>
<tr>
<td>Ija Anani</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Adada</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

However, by realizing the absence of crop production with out soil and water conservation, Agricultural Office of the DDAC in collaboration with non-governmental organizations is conducting different types of soil and water conservation activities. Most of these activities include construction of hillside terraces, soil and stone bunds, check dams, micro basins, and area closure and tree plantation.
4.4. Land use change of Dechatu watershed

Accordingly, the two land use/land cover maps of the year 1986, Fig 19 and 2000 Fig 21 were generated using ERDAS 8.6. Land use change of Dechatu watershed was studied based on 9th March, 1986 Land sat and 15th June, 2000 land sat images, revealed six land use land cover classes in the watershed: built-up area, bare land, cultivated land, sand deposit, shrub land and open wood land.

![Fig 19 1986 Land Use Land Cover Map of Dechatu Watershed](image)

Source: Extracted from 1986 Landsat Image (www.lancover.org)
Fig 20 2000 Land Use Land Cover Map of Dechatu Watershed

Source: Extracted from 2000 Landsat Image (www.landcover.org)
Table 13 1986 and 2000 land use land cover of Dechatu Watershed

<table>
<thead>
<tr>
<th>LU/LC Unit</th>
<th>1986</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area (Hectare)</td>
<td>Percentage</td>
</tr>
<tr>
<td>Built Up Area</td>
<td>143.44</td>
<td>0.90%</td>
</tr>
<tr>
<td>Cultivated Land</td>
<td>1701.63</td>
<td>10.63%</td>
</tr>
<tr>
<td>Bare Land</td>
<td>7094.47</td>
<td>44.32%</td>
</tr>
<tr>
<td>Open Wood Land</td>
<td>549.73</td>
<td>3.43%</td>
</tr>
<tr>
<td>Sand Deposit</td>
<td>206.47</td>
<td>1.29%</td>
</tr>
<tr>
<td>Shrub Land</td>
<td>6311.34</td>
<td>39.43%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>16007.08</td>
<td>100%</td>
</tr>
</tbody>
</table>

Land use change trends like persistent urbanization, intensification or expansion of agriculture, consolidation of farmland, deforestation/afforestation strongly affect the constitution of the landscape and thus land-cover conditions. Increases of surface sealing, soil degradation, such as densification or soil siltation are only examples of negative consequences caused by human society. The main hydrological processes are affected by the spatial variability of soils, topography, land use and cover, climate, and human-induced changes and management.

Referring to 1986 Land Sat as initial state image and 2000 Land Sat as final state image, the change of each land use/land cover class is listed as follows: 0.93% built-up area, -1.45% bare land, 23.9% cultivated land, 3.68% sand deposit, -26.1% shrub land and -0.96% open wood land.
The cultivated area has shown the highest change in terms of area coverage expansion which is highly correlated with the population growth. In the contrary, shrub land shows the highest clearing rate which is directly correlated with surface runoff generation potential. That means this circumstance has a direct impact on the increment of flood volume and discharge. In addition to this the sand deposit at the river banks has increased which decrease the river water carrying capacity and leads to flooding.

As shown on Fig 19 and 21 and Table11, the land use land cover of the study area shows a great change especially the cultivated land has increased by 25 % which means that there is high population pressure in the area and the area is under urbanization. In addition to this the bare land has decreased, because the farmers are cultivating even the unsuitable land. The reason for all this is high population growth and poverty and the natural geography and topography of the area.
5. CONCLUSIONS

There are bundles of both natural and human induced factors for the flood of Dechatu watershed and there are lots of reasons for the high degradation of the area. The following are the proximate causes of land degradation in the area.

- The major natural causes of flooding are steep slopes, circular shape of the watershed, shallow soils, and the town being at the foot hills of the highlands of Kersa, Dengego, Lange and Haromaya.
- The major human induced causes of flooding are reduced vegetation cover, and inappropriate human activities such as cultivation and construction along river courses which narrows the river route and cause it to over flow to the banks.
- Poverty creates conditions that result in greater damage from this natural disaster. Following the floods, incidence of poverty increases, as marginal groups descend into poverty after flood-related losses occur. When people descend into poverty they may not invest on flood mitigation intervention.
- The soil profile study reveals that the area is there is high deposition rate of sand in the lowland area and high erosion rate in the upland area.
- The sand deposit along the river banks has lead to decrement of the carrying capacity of the river and caused the water to flow to beyond its natural path.
- Cultivation on the river banks also contributes to the flooding by increasing the soil erosion and deposition of silt. The soil profile study also insures this as the soil from the bare high land comes with the runoff and deposits in the low land area so the soil in the lowland is thicker.
- The population of the area is highly increasing, as a result built up and cultivated area is increasing by decreasing the open wood land and shrub land.
- As population increase the utilization of natural resource also increases. As a result much of the area which were covered by open wood land and shrub land in 1986 are now converted to bare land, sand deposit, cultivated area and built up areas.
Community participation in decisions related to development of flood mitigation, and land degradation is weak and there is no community based organization to prevent land degradation before the disaster happen. But after the flood has devastated everything they do save material and human lives by ‘guza’ and ‘idir’ which is cultural way of community organization.
6. RECOMMENDATIONS

As there is no one causal factor for the flood there should be integrated and multidirectional solutions for solving the problem. Various flood mitigation techniques must be implemented in the study area so as to minimize the effect of flooding in the area. Some of these are

- Preventing land degradation, poverty reduction, diversified livelihood (reducing dependence on few and means), land use and resource use policies, tenure security coordination and institutional collaboration.
- Conducting integrated soil and water conservation activities including the construction of hill side terraces, check dams, soil and stone bunds, micro basin, area closure with enrichment cultivation of selected tree species, etc.
- Afforestation which includes planting of indigenous as well as selected exotic trees planting selected tree species in the hill sides and area closure sites must be promoted in the area.
- Provide family planning education for the rural as well as urban communities. Implement the population policy of the country.
- Use other alternative energy sources such as solar, Bio gas etc. Introducing fuel minimizing technologies and use of alternative energy sources such as solar, biogas etc. Promote use of locally made energy saving apparatus.
- Identifying weak points through which flooding occurs; and constricting protection walls on identified points; construction of retaining wall and dam at the proposed sites.
- Creating awareness among the rural community about the importance of forest.
- Integrated watershed management should be implemented. There should be cooperation between the upland, the degraded and the origin of the runoff and the lowland, the affected region.
REFERENCE


**Internet Source**


ANNEXES

Annex I

Questionnaires for the rural area (Jelo Belina, Harla, Adada, Ija Anani, Gende Ware)

Please answer the following questions: your good response to the following questions could contribute positively in the efforts of sustainable development.

Personal Information

1) Woreda------------------Kebele----------------Name of informant------------------------

2) What is the level of education attended by the master of the household?
   a) Informal education ( )
   b) Elementary school ≤ 6th grade ( )
   c) Junior High school ≤ 8th grade ( )
   d) High School 9≤ 12 ( )
   e) Technical Vocational ( )
   f) College/University ( )

3) How many family members do you have? (     )

4) What is the age structure of your family members? Figure out in a group
   a) Under five( )
   b) Between 6 and14( )
   c) Between 15 and 19( )
   d) Between 20 and 25 ( )
   e) Between 26 and 60 ( )
   f) Above 60( )

5) How many member of your family are illiterate? ______

6) Year of residence in the area----------------------
Interview Items

7) What is the source of your Income?
   a. Own business  b. Employment  c. Pension  d. Remittances from others  
   e) Farming

8) If you have your own business, what is the type of business you have engaged in?
   a) -----------------------  b) -----------------------  c) ---------------------  d) ------------

9) If you are a farmer, on what type of farming have you been engaged?
   a) Crop production  b) Fruits and vegetables  c) Livestock husbandry  e) Mixed farming

10) What are the most impressing problems of the area? Write your response in order of priority
    a) Flood  (b) Shortage of water supply  (c) Access to school  (d) Access to health center  
    (e) Other

1----- 2----- 3----- 4---- 5-----

11) What do you think is the cause for the flood in Dire Dawa?
   a) Human induced  b) Natural disaster  c) Both

12) If the answer for Q11 includes human induced what is the reason behind?
    a) Land improper management
    b) Improper forest management
    c) Living standard of the people
    d) All

13) What are the techniques you use to mitigate the flood occurrence?
    a) Afforestation  b) Degraded land rehabilitation  c) Not settling in flood prone area

14) Do you have flood early warning system?
    a) Yes
    b) No
15) What were the earlier flood occurrence regimes in the area?
   a) At 5 yrs interval
   b) At 10 yrs interval
   c) At 20 yrs interval

16) Is there any rehabilitation measure taking in the area to prevent future disaster?
   a) Yes
   b) No

17) If the answer for the above question is yes, what type of rehabilitation measures are taking on?
   a) Gully rehabilitation technique
   b) Water harvesting mechanism
   c) Agro-forestry
   d) Check dam

18) What was the previous forest cover in the area?
   a) Highly covered
   b) Moderately covered
   c) Bare ground

19) What is the type of fuel consumed in the area?
   a) Dug
   b) Wood or charcoal
   c) Kerosene
   d) LPG
   e) Electricity

20) How is the population growth in the area?
   a) Its growing fast
   b) Moderate
   c) Low

21) What measures should be taken for future flood risk mitigations?

22) Is there any community based organization for flood prevention and mitigation?
   a) Yes
23) For what kind of activity is the land very productive?
   a) Crop production
   b) Chat plantation
   c) Agro forestry
   d) Coffee plantation

24) Should the area be protected from any human interference i.e. is the area very degraded?

25) What is the reason for high degradation of the area?

26) What should be done to prevent this?

27) What was the status the before and now type of degradation?

28) Does the life style of the people in the area contributed to the land degradation? How?

29) What kind of plants do you plant in your area? Are they indigenous or exotic?

30) Is there any indigenous knowledge that used to prevent any kind of land degradation and proper use natural resources?

31) What are your Main recommendations regarding land use problems for the case of the flood?
Annex II

Questionnaires in low land area DIRE DAWA

Please answer the following questions: your good response to the following questions could contribute positively in the efforts of sustainable development.

Personal Information

1) Woreda------------------Kebele------------------Name of informant------------------------
2) What is the level of education attended by the master of the household?
   a) Informal education ( )
   b) Elementary school ≤ 6\textsuperscript{th} grade ( )
   c) Junior High school ≤ 8\textsuperscript{th} grade ( )
   d) High School 9≤ 12 ( )
   e) Technical Vocational ( )
   f) College/University ( )
3) How many family members do you have? ( )
4) What is the age structure of your family members? Figure out in a group
   a) Under five( )
   b) Between 6 and 14( )
   c) Between 15 and 19( )
   d) Between 20 and 25 ( )
   e) Between 26 and 60 ( )
   f) Above 60( )
5) How many member of your family are illiterate? _______
6) Year of residence in the area---------------------

Interview Items

7) What is your current means of income?
a) Own business b) Employment c) Pension d) Remittances from others e) Farming

8) What was your average household monthly income before the flood?
   a) < 300 Birr   b) Between 301 and 600 Birr  c) Between 601 and 900 d) Between 901 and 1200 e) Between 1201 and 1500 f) Between 1501 and 1800 g) Above 1801

9) Is there a change in your income as a result of your displacement? Yes ( ) No ( )

10) If yes, what percent of your monthly income is lost?
    a) Up to 10%  b) Up to 25%  c) Up to 40%  d) Up to 55%  e) Above 55%

11) What is the reason for the loss of your income?
    a) Loss of family member who generate income b) Loss of business c) Loss of job d) a & b e) b & c f) a & c

12) Is there any effort made by the community to reconstitute the livelihood? Yes ( ) No ( )

13) If No, what is the reason?
    a) Lack of access to fund  b) Lack of employment  c) Lack of support by public institution  d) Other

14) What do you think is the cause for the flood in Dire Dawa?
    a) Human induced  b) Natural disaster  c) Both

15) If the answer for Q14 includes human induced what is the reason behind?
    a) Land improper mgt  b) Improper forest mgt  c) Living standard of the people  d) All

16) What are the techniques you use to mitigate the flood occurrence?
    a) Afforestation  b) Degraded land rehabilitation  c) Not settling in flood prone area

17) Do you have flood early warning system?
    a) Yes  b) No

18) What were the earlier flood occurrence regimes in the area?
    a) At 5 yrs interval  b) At 10 yrs interval  c) At 20 yrs interval  d) Do not happen
19) Are you happy with the measures taken so far towards rehabilitating the affected people? Yes ( ) No ( )

20) Is there any rehabilitation measure taking in the area to prevent future disaster?
   a) Yes
   b) No

21) If the answer for the above question is yes, what type of rehabilitation measures are taking on?
   a) Dam construction
   b) Safe disposal of the flood through the city
   c) Resettlement

22) What was the previous settlement in the area and the present status?
   a) In flood prone area
   b) Not in flood prone area

23) How is the population growth in the area?
   a) Its growing fast
   b) Moderate
   c) Low

24) Have you ever attacked by flood? Yes ( ) No ( )

25) If yes, what was the magnitude of the effect in terms of life and money? Life lost----
    value of property destroyed in Birr ------.

26) Have you fear of flood in coming years? Yes ( ) No ( )

27) If yes, what do you propose as a remedial?
   a) Dike Building b) Evacuate from flood prone area c) Adopt early warning system
d) Mix of a and b

28) If resettlement is required are you willing to evacuate from your current residence?
   Yes ( ) No ( )

29) If yes, are you ready to evacuate immediately? Yes ( ) No ( )

30) If your response to q 29 is No what is your reason?
   a) Weak physical appearance b) Fear of property loss c) Lack of readiness d) Other reason

31) What measures should be taken for future flood risk mitigations?
32) Is there any community based organization for flood prevention and mitigation?
   a) Yes
   b) No

33) Should the area be protected from any human interference i.e. is the area very degraded?

34) What is the reason for high degradation of the area?

35) What should be done to prevent this?

36) What are your Main recommendations regarding land use problems for the case of the flood?

THANK YOU
Annex III

Soil profile study

Cultivated land
Depth of org- semi decomposed humus-------------
Depth of A horizon-------------
Depth of B-horizon-------------

Bare ground
Depth of org- semi decomposed humus-------------
Depth of A horizon-------------
Depth of B-horizon-------------

In grass land
Depth of org- semi decomposed humus-------------
Depth of A horizon-------------
Depth of B-horizon-------------