

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

**PROCESSES OF SOIL EROSION AND ASPECTS
OF COMMUNITY-BASED SOIL CONSERVATION
IN GRAHUTSA-KORIR WATERSHED IN
EASTERN TIGRAY**

HAILU ARAYA

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**PROCESSES OF SOIL EROSION AND ASPECTS OF
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GRAHUTSA-KORIR WATERSHED IN EASTERN
TIGRAY**

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In Partial Fulfillment of the Requirements for the
Degree of Master of Arts in Geography

By
Hailu Araya
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HAILU ARAYA
COLLEGE OF SOCIAL SCIENCES

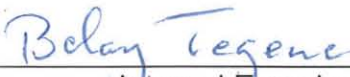
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ABBREVIATIONS

APARD- Andhra Pradesh Academy Of Rural Development

CSE- Conservation Strategy of Ethiopia

EHRS- Ethiopian Highland Reclamation Study

EMA- Ethiopian Mapping Authority

FAO- Food and Agriculture Organization

LUPRD- Land Use Planning and Regulatory Department

MOA- Ministry of Agriculture

NGO- Non-Governmental Organization

SAERT- Sustainable Agriculture and Environmental
Rehabilitation in Tigray

SWC- Soil and Water Conservation

SWCD- Soil and Water Conservation Department

TBANR- Tigray Bureau of Agriculture and Natural Resources

USLE- Universal Soil Loss Equation

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ABSTRACT

Land degradation is a serious problem in Ethiopia in general and the study area in particular. The root causes of environmental degradations are human and animal population pressure and urbanization in the past 40 years. And this means high demand of wood for fuel and construction, and land for farming and grazing. Land in general and vegetation in particular is totally degraded natural vegetation is left towards the churchyards. In addition to these soil types, slope and topography leads to soil erosion. As much as 53.56% of the study area has slope 36.4% or above. There are different gullies with a total length of above 15 kms and average depth of 2.29 m and a width of 10.67 m; indicating these that more than 371,858 m³ of soil is lost in the past years. These and other factors averagely are responsible for the loss of greater than 183,186 tons of soil every year in the study catchment.

Efforts, no doubt, are tried by Governmental and Non- Governmental Organizations to check such degradations, but reports (Pender, 1999) in general point out towards their total or partial failures. This was due to little or no mobilization of the local community, insufficient or lack of maintenance and the lack of appropriate environmental policies, which are still prevalent in the area. Scenario in that formerly constructed dams are almost silted and breached, vegetation are almost weathered, agricultural yield is diminishing, water supply is reduced and the like. Even the conservation measures that were introduced previously lacked follow-up. The ever-increasing demand for vegetation products adversely affects the vegetation cover. In the recent conservation measure the local communities are participating and the preservation of indigenous plants are becoming very effective due to their adaptability to the harsh environment.

Grahutsa-Korir catchment, which is part of Genfel catchment, is highly degraded. One can observe in the catchment large stretches of bare land and dissection with intense gully formations especially in the sandstone part of the catchment, but it is in the limestone formations with their topsoil where the new integrated watershed managements are being practiced mainly to reduce siltation of the new earth dam. Community mobilization today is better, they participate in all the steps from programming to execution, use, maintenance, etc so they are highly concerned with the conservation reasons but for its low financial allotment by the government. The crack of the problem is that the budget allotted is too low to cover greater area.

CHAPTER ONE – INTRODUCTION

1.1 Statement of the Problem

Land degradation is a serious problem in Ethiopia. However, the magnitudes vary with environmental conditions, human activities, and community awareness. Efforts, no doubt, are tried by Governmental and Non- Governmental Organizations to check such degradations, but reports (Pender et al, 1999) in general point out towards their total or partial failures. This could be attributed to the less or no mobilization of the local community, their low-awareness of the problem and usefulness of the methods in practice to mention some.

The root causes of environmental degradations are human and animal population pressure, industrialization and urbanization. And this means high demand of wood for fuel and construction, and land for farming and grazing. The adoption of environmentally unfriendly technologies (Mekete, 1996) and lack of appropriate environmental policies is also evident. The ever-increasing demand for vegetation products adversely affects the vegetation cover.

Grahutsa-Korir catchment, part of Genfel catchment, is a highly degraded. One can observe in the catchment large stretches of bare land and dissection with intense gully formations especially in the sandstone part of the catchment. By the SWCD (MOA, 1995) Genfel-catchment was selected as one of the 35 priority catchment areas for conservation. The scant vegetation cover includes some sparse short bushes and seasonal patches of grasslands that are grazed with little attention to their managements. Cutting of trees and/ or bushes and over-grazing exacerbate the problem. In addition to these soil types, slope and topography leads to soil erosion. These are highly contributing towards soil erosion then leads to the degradation of the area. Conservation practices have been minimal in the catchment. Even the conservation measures that were introduced previously lack follow-up. Hence, the results are not encouraging in rehabilitating the environment.

By the 1984/ 85 Ethiopian drought there were different dams constructed by the Ministry of Agriculture and Relief and Rehabilitation Commission on Food-For-Work basis in the lower plains of the catchment. The Enda Selassie and Grahutsa dams are in the lower catchment of the study area. All of them are out of use i.e., Enda Selassie dam is above the base of the Grahutsa gully, and the Grahutsa dam was filled by siltation only in the second year of its construction. This is because of the untreated upper catchment. Even one can find a number of gullies in the study area but like the Korir gully down stream the treated watershed are either drying or are stagnant with no trace of new formations.

Watershed management programs mainly concerned with soil and water conservation activities and subsequent protection of the process of sedimentation and rehabilitation of the degraded environmental conditions through restoration of ecological balance. The programs should, however, be properly designed and implemented timely as a primary cure in alleviating these serious problems (Elias, 1996).

The problem in the study area invites the assessment of the watershed problems and then deep and wide gully formation down stream, which affect the agricultural productivity. The long time conservation program going on in the study area appears to be fruitless till now, probably, because of the low level of participation of the community in the planning, evaluating and programming. This may have its roots in the negligence of different concerned organizations in increasing community awareness and mobilization.

In the research there will be an assessment of the communities perception towards the integrated conservation programs in the watershed management practices. The present small-scale integrated watershed management practices already started in the Tigray Region as a new phenomena seem as the best approach in the watershed treatment. The researcher wants to look into the outcomes of the soil and water conservation, the recent integrated watershed management practices, community awareness and their sustainability after lots

of financial and labor investments, based on the observation in this sample catchment. Generally, to find the best sustaining methods.

Thus, the whole study is to encompass two major components i.e.,

- i. The examination of the magnitudes, causes and consequences of the degraded attributes of environment in its casual and spatial perspectives, and
- ii. Evaluation of the efforts or measures taken by different segments of Environmental Conservation Bodies, keeping in view the role of local communities. Based on the findings, final recommendations can be forwarded. To achieve this end the Grahutsa-Korir catchment represents the northern highlands of Ethiopia having a long history of human occupancy.

1.2 Objectives

The general objectives of the study area are:

1. To evaluate the causes and consequences of land degradation problem,
2. To assess the level of community awareness, mobilization and participation on land management practices.

Some of the specific objectives of the thesis are the following

- A. To assess the physical land form attribute of the study area,
- B. To identify the causes and consequences of land degradation problems of the study area,
- C. To assess the community awareness of land degradation and their participation in conservation programs;
- D. To assess the system of mobilization in the conservation process;
- E. To assess the visible outcomes of the conservation program;

- F. To suggest appropriate measures of conservation and management based on different type/ cause of degradation.

1.3 Research Questions

In order to accomplish the objectives laid down, the following Research questions emerge which need to be answered through meticulous investigations.

1. First objective, places the question as to what extent the topography of the land is rugged or dissected in absolute or general terms.
2. Objective B needs the answer to the identification of types/ causes of problems and identify the major consequences.
3. Objective C involves the assessment of the awareness of the people towards the processes of land degradation and their consequences and to what extent they are participating in the land management practices.
4. Objective D refers how the system of community mobilization practices in the conservation work
5. Regarding objective E do the community have positive outcomes of the conservation program
6. The last objective F refers to the question of suggesting appropriate conservation and management techniques for different segments of the lands based on the results of the investigations carried out during the period of research, as also the ways the people can be motivated towards participating in the conservation and management programmes initiated by Governmental and Non-Governmental Organizations.

1.4 The Significance of the Research

As mentioned in the objectives, the study concentrated on the assessment of the watershed problems (causes and consequences), the conservation practices through time and their failures, and the community awareness, participation

and mobilization. Though the study is site specific, the results and conclusions obtained can be extrapolated to other regions with similar situations. The results of the micro-level study serve as guideline to organizations and different communities for the identification of the type of problems according to their magnitudes and formulation and implementation of appropriate conservation measures for sustainable development. The results can also be replicated to areas with similar environmental conditions. After its completion, this research will

- i. Be useful for the local community, NGOs, government bodies, and as a model for experience sharing outside etc to assess the local problems in relation to their management
- ii. Be useful to assess local community awareness and participation based on their response
- iii. To know how far local people respond in the watershed management practices
- iv. To know how the professionals and local people are harmoniously working together and mobilized in this aspect
- v. It can also serve as a base line document for future researchers in this field.

1.5 Nature of the data and Methodology used

As the field of research is wide and complex, involving interaction between dynamic earth or environment and innovative man, the data required is sure to be complex and varied in nature. The reconnaissance did reveal the environmental degradation. Hence the study will aim at appraisal of magnitude, causes, and consequences of such degradation and how to combat or restore the conditions, keeping in view the well fare of the present generation and sustainability for the future, side by side the role of the community in such

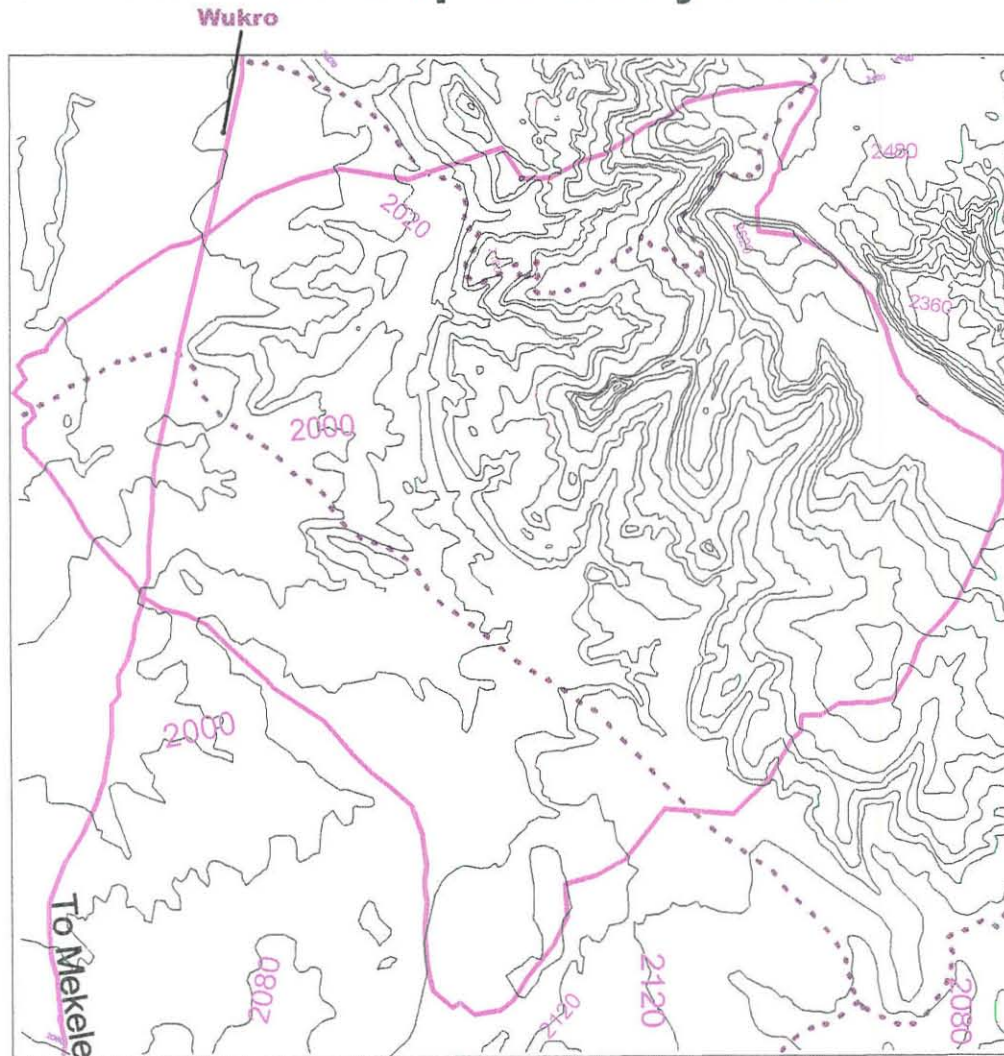
activities is also to be highlighted. Therefore, the study will require primary as well as secondary data.

A. Primary data

From 429 households of the Mahbere Desta (an old name for the three Kushets i.e., Grahutsa, Enda Selassie and Korir), 17% sample households (73 questionnaires) were found to be filled up satisfactorily. Out of that 59 (80.82%) were males and 14 (19.18%) females. Age wise 58 (79.45%) were in the age range between 15 and 64 while 15 (20.55%) above 64 years of age. Elder households were able to narrate the events better due to their longer years of experiences, for this response it taken as a purposive sampling. From the total, 70 (95.89%) were farmers while the rest 3 (4.11%) were labourers and police by occupation from the peasant community.

- i. Field observation including collection of soil samples. The sites of soil sample were taken along suitable transacts aligned based on known places in the field like churches, bridges, peaks, etc, which were also located on 1:50,000-scale map. Two main lines were considered from the lower catchment, which extending from the road reached the top of the hillocks (Map 1) or slopes covering different soil types. Due to the steep and degraded topography the upper catchment has very low depth of soil while the lower catchment contains deep soils. Thus greater varieties of soils exist in limited area of the lower catchment. Due to some problems 23 soil samples were taken in the study area within three main sites i.e., two in the lower and one in the upper catchment.

MAP1 Contour Map of Study Area



— Contours (20m Interval)

□ Limit of Study Area

Road System

— Asphalt

..... Gravel



2 0 2 4 Kilometers

- ii. Group discussions and interviews:- Group discussions with the elders and officials of the community of the study area were arranged concerning the magnitudes of land degradation problems and conservation measures practiced. To understand the level of perception in the whole community, five groups were organized, one group consists of students (grades 7 and 8) with ages between 15 and 25 and coming from the study area. The researcher discussed with the group of 70 – 80 students to understand about land degradation as they perceived it. Each one of the other four groups (one group from each Enda Selassie and Korir Kushets and because of its wider expanse two group from Grahutsa Kushet) were constituted by 4 to 6 persons from each Kushet (village). Two officials (forester and extension agent) and one elder well known were interviewed especially with a view to the vegetation cover change and gully development.
- iii. Administering questionnaires. Questionnaire was formulated to gather primary data (see Annex 8). The majority of the questions were objective type and some open-ended questions. The final copy of the questionnaire was translated into Tigrigna (local language).

Before the questionnaires were administered discussions were held with friends regarding selection of enumerators. It was felt reliable to select students from the communities involved in the discussions about the land degradation problems of study area, presuming that they must have some understanding of the concept of environmental problems and conservation practices, apart from the language of communication with local people. A brief orientation was given to them concerning the content of the questionnaire and how to extract more and reliable answers.

About 21 students (7 from each Kushet) were selected by the group and they have given two questionnaires to administer based on their understanding the way of life and work of conservation activities. But only 25 of the questionnaires were accepted with the information provided. The rest

questionnaires were administered by my-self on house-to-house contact and during discussion. High emphasis was given on elders because of the need of their experience since long.

- iv. Depending on the FAO (1986) method gully measurements were conducted, to know the magnitudes of all the gullies in the study area in terms of their depths, widths and lengths and hence the volumes regardless of their sizes. Depths were measured at the two margins and at the center probably the deepest.
- v. Informal contact with local community to understand their feeling about the conservation practices and payments for the food for work program and the system of community mobilization by officials and local elders were conducted.
- vi. Five sites with a 900 square meter area (30 by 30) were selected to see their vegetation cover and type/s (smaller or bigger), slopes, levels of stoniness, condition of treatment and gullies, etc.
- vii. One linear transect extended for 750 meters in the lower catchment where farming is practiced was surveyed to see how far the farm plots are with old terraces, width of farm boundaries, and the system of ploughing whether they are following the contours.
- viii. Field observations, were taken considering different parameters like soil, geology, vegetation, magnitudes of gullies, cropland damages by soil erosion etc.
- ix. Field sketches were prepared and photographs were taken for specific sites.

B. For secondary data

- i. Reports and records from different offices, mainly from the Wereda agriculture Bureau, Wereda branch office of Sustainable Agriculture and Environment Rehabilitation in Tigray (SAERT), Genfel Tabia Extension

Agent office, etc and Kidist Mariam Wukro Catholic Church Agriculture Department.

- ii. The perusal of published and unpublished documents,
- iii. Topo-sheets of 1:50,000 scale,
- iv. Aerial photographs of different periods i.e., 1965 and the recent one 1994 were scanned to see the land, land use and land cover changes in the time span.

Data Analysis

To analyze the relief of the study area the Miller's and Wentworth's Methods of slope analysis, Prof. R. L. Singh's Relief analysis method, S. W. Wooldrige's hypsometric curve and J. I. Clarke's method of Clinographic curve are used (Singh, 1980) and slope analysis with the FAO (1990). The source of data for analyzing the relief is mainly the topographic map (1:50,000) of the area with contour interval of 20meters.

To produce a three-dimensional topographic map Triangular Irregular Network (TIN) computer is used software ARCVIEW GIS (version 3.2).

In examining the climatic condition of the study area the available monthly temperature and rainfall data are used to assess the magnitude and seasonally of surplus and deficit of moisture with help of Thorn Waite's concept of Potential Evapotranspiration.

The main soil parameters taken can be seen from table 3.5 i.e., soil depth using Auger and tape meter, slope using clinometer, land cover, through observation, pH by using pH meter, soil texture identification by Hydrometer method, soil colour by using the Munsell's Chart.

In the data analysis the researcher used the excel computer software and produced different charts that support the paper. The methodologies employed to analyze the data include both descriptive and inferential statistics. In order to make the data contained in the questionnaire usable and suitable for statistical

analysis like standard deviation, coefficient of variation, mean and median are used, interpretation and hypothesizing, the information is processed and classified and tabulated suitably. Thus, data is organized in the form of tables, charts and graphs and interpreted using descriptive method.

1.6 Limitation of the Study

This work has greatly been challenged by

- i. The lack of related data concerning traditional, and old soil and water conservation measures taken as food-for-work programmes
- ii. Time and financial constraints
- iii. The questionnaires were consist of questions concerning socio-economic, demographic variables as well as questions, used to assess their degree of awareness and participation in the land conservation and management programmes. It is no more to be used in the physical landform parameters.
- iv. Due to less relevance to the objectives of the study questions 5, 6, 10, 13, 20, 21, 24, and 33 are not used in the paper.

1.8 Organization of the paper

This paper has seven chapters preceded by tables of content and followed by references and appendices.

Chapter one- is the introductory part, which deals with the assessment of the problem and description conceptual frameworks, selection of the study area, objectives, research questions, methodology, significance of the study, organization of the paper, limitation of the study etc.

Second chapter is devoted to the literature review, which summarize some of the relevant research works and other publications related to the problems concerning the environmental degradation at global, national or local levels, as land problem soil and water conservation measures and community roles.

Chapter three- provide the general background of the study area including its size and location, geology, geomorphology and surface hydrology, climate, soil, vegetation cover, population, land use, settlement, etc.

Morphometric evaluation of the landform and assessment of environmental problems along with their major causes and consequences in the study area is constitute the subject matter of chapter four.

Chapter five concerns with the assessment/ analysis of the awareness and attitude of the local people towards land problem and level of their participation in the conservation and management practices introduced. In addition it also assess the systems of community mobilization.

Chapter six – deals with the assessment of the visible developments of the community as a result of the community participatory conservation program in the study area

The last chapter is consisting of a brief summary of the study and, as far as possible, feasible/ appropriate recommendations. Towards conservation and management practices, ways of raising the awareness and participation level of the community is forwarded based on the experiences during this research activity.

CHAPTER TWO

LITERATURE REVIEW

2.1 Land Degradation

Current publications in the field indicate that ecological crises are the outcomes of immeasurable assaults and carelessness in use of natural resources (e.g. Pimbert, 1999; Thomas Tolcha, n. d.). They added that the degradation of these basic land resources could have the adverse effects especially in arid and semi-arid regions. As it is stated in the book entitled *Forest and Forestry* (1998), although it is difficult to measure the rate of dilution with any degree of accuracy, there has indisputably been an increase in the areas in which either fewer or no trees are found. These and other evidences clearly show that human mismanagement is the big factor contributing to land degradation.

2.1.1 Global Problem

Many authors/ organizations like ADAB (1986); FAO, Annex II (1988); Bennett (1955); Krauer (1988) identified that the crisis of the human environment has been caused by the interaction of a number of factors, increases in human and animal population as major causes of resource degradation by way of their increasing demand resulting in deforestation and overgrazing. The increase in land under cultivation and the high demand for this resource generally for a better living increased the consumption of natural resources especially following the technological progress and urbanization (*Forest and forestry*, 1998). The same thing is explained by *Britannica* (V. 16; 1997; Wild, 1993) as “the seriousness of environmental degradation started by the recent phenomena due to the development of agriculture (10,000 - 12,000 years), urbanization (6,000 years), industrialization (500 years) and very recent population growth.”

No one denies the abuse of environment by man in general. *Americana* (V. 9, 1995) narrates that the salient factor in human ecology is the increasing take

over of the natural world by human agencies in a state of high technology; Thomas Tolcha (1990) states that continued accelerated erosion always starts when man upsets the natural balance. Some of the consequences of land degradation are land and fertility loss, decline of agricultural output, prevalence of drought and famine, desertification hazards, etc. (Haile-yesus, 1996). As the population continues to expand and the resource base to shrink, consequences are bound to be disastrous (FAO, 1987) because to touch one biotic resource is to touch the other. In less managed regions losses of vegetative cover are followed by soil degradation through various forms of erosion (Katyal, 1995) such as sheet and gully erosion (CSE V. II, 1997). On global level 10 trees is being cut for every one being planted. The figure starts as 20 to 1 in Africa (Mekete, 1996), and 29 to 1 in Sub-Saharan Africa (Salih, 1993). In such a way, many of our traditional agricultural systems that were ecologically stable 40 years ago are breaking down now under increasing population pressure, Zemedede and Endashaw (1996).

African forestry resources have been seriously threatened with deforestation, which would further aggravate drought and famine situations in the continent (Ethiopian Herald, Vol. LVII no. 007, 2000). They give rise to a situation that holds the threat of disaster until the situation is corrected (Dasamann, 1975).

2.1.2 Ethiopian Context

The situation in Ethiopia is also not different from earlier mentioned global trend. Without any effective conservation measure, the problem of environment in Ethiopia may become serious ahead of other countries.

Ethiopia is one of the North East African countries where the natural forests are in danger of complete eradication (Forestry Research Center No. 2: 1980: and No 15:1989; Michelsen & others; 1996). The deforestation process goes on increasing with a remarkable rate, i.e. from the 40% forest coverage and another 26% of savanna woodlands at the beginning of the 20th century reduced to 16% by 1950's, 3.6% by 1980's and to less than 2.7% at present (Bayou, 1996; Fisseha, 1996; Kidane, 1998; CSE, V. 1, 1997).

The forests of Ethiopia has dwindled at an alarming rate in the past few decades, due to the increase of human and animal population pressure (Alemayehu, 1997) followed by overgrazing, clearing of land for agricultural purposes, increased demand for fuel wood (Brown, 1973; Zemedu and Endashaw, 1996; Kidane, 1998) and construction purposes. Which is supported by Addis Tribune (2000) and Seyoum (1996) consequently it becomes a severe ecological disturbance (Belay, 1996) especially the Ethiopian Highlands, where agricultural productions have gone down, drought induced problems and poverty are intensified (Kidane, 1998) as these areas have been settled since long.

As quoted by Belay (1996) from the estimate by NCS (1994), out of the 54 millions hectares of land constituting the highlands, 14 million hectares are seriously degraded, 13 million hectares are moderately degraded, while over 2 million hectares of land's soil depth is so reduced that the land is no more able to support cultivation. Similarly Matthias Reusing (1998) mentioned that the current annual loss of the high forest area has been estimated to be between 150,000 and 200,000 ha; and a much lower estimate by Seyoum (1996) is to be 88,000 ha of deforestation and 13,000 ha of reforestation. From the variability of the estimates of soil loss "the SCRIP has estimated that about 1.5 billion tons of soil are eroded every year in Ethiopia" (Hans and others, 1996). According to the CSE about 74% of the annual runoff of more than 110 billion m³ of soil goes into the rivers that flow into the neighboring countries. This intensified problem brings the estimate of annual loss of soil from cultivated land in the Ethiopian highlands, to be 130 tons/ ha. But Hurni's estimation is much lower erosion rates from cultivated land 42 tons/ ha/ year (Pender, 1999; Lundberg, 1995).

Tigray belongs to the African dry land zone of the Sudan-Sahel or Sub-Sahara Africa. The dry lands are prone to the unpredictability of climate --- traditional methods of cultivation can no longer support the local population (Sadler, 1997). In Tigray, especially in the study area, there are only patches of natural vegetation left mostly confined to churchyards but it is perceived to have high

rate of land degradation (Shah, 1997). The major problems in the study area are fuel wood, wood for house construction, absence of conservation measure and/ or follow up, erosion and sedimentation problems, and shortage of cultivable and grazing lands. These contribute directly to both soil erosion and to the general shortage of biomass in Tigray, which limits the ability of farmers to recycle nutrients from dung and crop residues into the soil.

In Laelai Wukro catchment, which lies side by side to the study area, excessively severe environmental degradation is clearly seen, occurring due to the fact that every point within the catchment is bare and exposed to the direct action of raindrops. The very susceptible nature of the topography of the catchment, which is mainly mountainous, to erosion has a great contribution to the degradation of the area (Elias, 1996).

2.2 Conservation Measures

2.2.1 Global Perspectives

The state of the world's environment is worsening through time (Dilnesaw, 1998) especially most of the third world countries. The land is required for meeting all the needs of human beings but if it is not properly used it may create ecological imbalance and affect the whole system. Environmental problems are experienced throughout the world primarily due to vegetation removal then erosion (APARD, 1994). For more than a century, conservation-minded people have been calling attention to the things that must be done if the story of man on earth is not to be brought to a sudden and sad ending (Dasmann, 1975). Most agency reports and government publications highlight the degradation of soils as a major challenge to development, but soil and water conservation efforts in Africa have had a chequered history --- attempts have been made to introduce SWC measures in a wide range of settings, yet many have failed (Indigenous SWC, 1996) due to lack of community participation.

According to the reporter of Addis Tribune (2000), there had been hot debate in Ethiopia and many agreed that there is a “need to formulate appropriate forestry and forestry related policies and forge strong organizational setup to avert deforestation.” Professionals like Kidane (1998) consider the non-existence of forest policy in Ethiopia as a problem of forest conservation. But results become the contrary like the experience of Kenya the "most of the closed canopy indigenous forests in Kenya are gazzetted as Forest Reserve and managed by the government Forest Department under a system of strict protection. But protection has been an inequitable and ineffective means of forest conservation. It has prohibited access to vital forest resources and generated little local support. Forest planners and managers have by passed local communities and their constraints and priorities in the conservation process" (Emerton and Mogaka, 1996).

Even, during most part of this century, the management of protected areas was essentially a policy task, and local people were seen as a management problem (Yaa Ntiamoa, 1999). Since more than a decade Government has undertaken a massive program of SWC works, particularly the construction of terraces. However, in most parts of the highlands of Ethiopia it has been observed that some of these terraces have been destroyed by the local farmers, while certain indigenous SWC methods such as stone terraces, cut-off drains, etc. continued to be used (Million, 1996). Thus, it can be argued that unless communities accept the conservation programs, it might be fruitless in its sustainability only with the policies issued by governments.

The need, therefore, is to start mobilization towards integrated rural development aimed at the conservation and rehabilitation of natural resources, especially in the mountainous areas where the danger is the greatest. However, communities need the support of plans and programs that provide sufficient incentives for them to take an active and ongoing part in efforts to stabilize agriculture (FAO, 1987). In most parts of the developing countries awareness comes to the mind only after the situation becomes more serious or some times

beyond control. Raising awareness, building confidence, developing group solidarity, using Training for Transformation or development education (Indigenous SWC, 1996) will minimize the problem.

2.2.2 The Ethiopian Context

Conservation has a long history in Ethiopia. The centuries of experience of terracing in Konso are a landmark to sustain locally degraded environment as traditional conservation measure. The recent wasteland conservation system through planting by the Echmare village of Gulomekeda in Tigray is considered as indigenous knowledge (Pender et al, 1999). The traditional measures conducted by man in Ethiopia are not enough unless the government to the conservation processes, especially by way of educating the local community, gives governmental attention.

Emperor Zera Yakob recognized the beneficial effects of forest (Deribe, 1991;). Hills of Yeha (Tigray) were all terraced for cultivation long before. The preservation of areas surrounding churches is a well-known traditional approach (Melaku, 1998). Emperor Menelik II's contribution was appreciable in the conservation history of Ethiopia by declaration of the first forest policy and introduction of fast growing tree species i.e. eucalyptus (Deribe, 1991; Melaku, 1998; Gebre Markos, 1998). Although, there were tremendous trials for conservation activities in the country, his descendents never thought of forest management after his death (Gebre Markos, 1998). Some soil and water conservation practices around the study area were undertaken since long but the results are not encouraging as there was no effective conservation work done in the area. Of course, there are some attempts but they are very limited to small area, and have a great maintenance problem, Elias (1996).

At present, although limited, the importance of treating of catchment areas to reduce siltation of the reservoirs has been realized and consequently there are some economic changes in the life of local communities due to the development of agriculture and related aspects. A study by SAERT has shown that about 1000

m³ of sediment is accumulated annually in the reservoirs in Tigray, which can be averted through encouraging community participation (Pender, 1999).

2.3 The Role of the Community

Human communities worldwide have played a central role in shaping and reshaping of nature and its associates. Community participation in environmental protection is very important but their involvement varies from being just a beneficiary to an active participant. Unless the program envisaged is beneficial to all sections, it is illogic to expect the full cooperation of all and sundry.

2.3.1 The Role of Government Policies

A glimpse of the role of government policies can be obtained from the statement of Njie and Leresche (2000) that, in most parts of Africa resource problems are reaching crisis point and communities have to help themselves in finding solutions. However, they can and will help themselves if the policy framework gives them encouragement. The way to do this, in most instances, is to give the communities tenure rights over local resource, with the state helping to guarantee the security of that tenure. If the problem is to be halted and reversed in a sustainable way, support of local population in planning, management and evaluation, and facilitate local people's analysis, planning, action, monitoring and evaluation is very necessary because it enhance the willingness of stakeholders to implement decisions and improves the effectiveness of the conservation program. Further support comes from Yaa Ntiamoah et al (1999). It is a problem to exclude the community simply by issuing policies, as is evident from experiences of Emerton and Mogaka (1996) in Kenya as the Forest Department are attempting to move away from traditional protection measures preventing human access by policing and legal bans to a system which recognizes the dependencies and needs of local communities and integrates them into forest conservation.

It can be corroborated in the words of Ato Tilaye (1998) in Ethiopian situation as in theory, community and catchment protection plantations belong to local communities, in practice, and the Regional Government controls these. The plantations have largely failed to show the desired results because local people have not been involved in the planning and implementation phase and they have not directly benefited from these forest resources.

Local rules also have important bearing on the management of grazing lands, particularly on common lands. In recent years, many tabias and kushets have established area enclosures, where grazing is restricted to allow natural vegetation grow. Although leadership in establishing these enclosures has been provided by the TBANR, SAERT, and other organizations, decisions about whether to establish such areas and how to manage them according to various officials, are up to the local tabias and their baitos. However, based upon a small number of field interviews, it appears that some local communities may not be very clear about their rights and responsibilities with regard to management of such areas, and are waiting for guidance from the regional authorities (Pender et al, 1999).

2.3.2 Community Mobilization and Participation

According to CSE, V.I, (1997) if a government simply orders people to act, it is not participatory. If a conservation project is to be really participatory, the community has to feel, at least as much as the planning expert, the need for conservation and that it wants to undertake specified conservation measures. If one wants their participation, one must open a dialogue with them to know their minds. Effective people's participation depends on free and open communication among local communities, resource management professionals and government decision-makers (CSE, V.II 1997). Clearly then, the only way the objectives can be achieved is by depending upon systems of participatory democracy and expanding people's participation at the village-level as much as possible --- an

interactive learning environment encourages participatory attitudes, excites interest and commitment (Pretty, 1994).

Such discussions help local people in raising their awareness. Dissemination & cooperation are particularly, important through sharing experience among farmers (Aresawm, 1997). For local communities to overcome common problems, workshops and trainings help through stimulating communication & initiate changes of roles, self-reliant development and participation. This is because incorporating and increasing awareness of the local knowledge into project activities can reduce the risks associated with relying on outside technology and with adopting alternative resource use, techniques and practices. Efforts to involve local people in the conservation will not succeed in the long term unless local people believe that these efforts contribute to their own welfare. Educating, training, and raising awareness are the doorways to effective stakeholder participation and empowerment in biodiversity conservation and management (Yaa Ntiamoa et al 1999).

But when their contribution is considered, local communities may also regulate the use of uncultivated hillsides and wastelands. This approach motivates the community to participate in land management as private holding through their initiatives than non-benefiting community holding by putting some injecting policies. In Eastern Tigray, for example, the leaders of one village (Echmare, in the Gulomekeda Wereda) decided to allow private tree planting on a degraded hillside beginning 1992. Very small plots approximately 20 square meters in size were allocated to each household in the village, and the households were expected to plant trees and provide good management. The penalty for not doing so was to lose access to the plot, and potentially to future plots that may be allocated as well (Pender et al, 1999).

Communities have enclosed degraded hillsides & the natural vegetation is returning. The severe shortage of firewood is being met by communal & individual tree planting, particularly eucalyptus. The cut-and-carry system

allows the farmers to closely control the use of forage (Alemayehu Mengistu, 1998). The village Echmare has continued to allocate parts of the unused hillsides almost every year since 1992. Households are now beginning to harvest the mature eucalyptus trees planted in the first years. Visual observations suggest that each household has about 20 trees surviving per plot allocated, representing a substantial increment in household income and wealth. The success of this experience has led the regional government to adopt a new directive allowing all tabias to allocate unused hillside wastelands for permitted uses, including tree planting, forage production, horticulture, and bee keeping. However, despite the success of the Echmare experience and the new directive, it appears that other tabias are yet to adopt to this approach, in part because the TBANR prefers to implement the approach cautiously, by first testing it in several pilot study communities (Pender, 1999) as barrier on local community knowledge and participation.

Since the 1980's households have been expected to contribute labor to annual voluntary work campaigns, which heavily emphasizes constructions of soil and water conservation structures. Originally households were expected to contribute four months worth of labor during the dry season, but since 1992 the contribution has been reduced to 20 days a year because of their inability to work on personal farm. As a result of these efforts, considerable fraction of Tigray has been treated with various soil and conservation measures (Pender et al, 1999). This is strong evidence that community participation is vital to the success of any program including soil and water conservation projects.

CHAPTER THREE

BACKGROUND OF THE STUDY AREA

After explaining the topic, its aims and objectives and reviewing the related literature preceding chapters, it is worth while to narrate background of the study area so as to acquaint the readers with the base material on which the analysis and conclusion's predictions, generalizations based. The aspects include its location and extent, geology and geomorphology, topography and drainage, climate, vegetation, soil, and land use and descriptions are based on various available sources and field observations.

3.1 Location and Extent

Grahutsa-Korir is the name of the study catchment that includes three villages (locally called Kushets) i.e., Grahutsa to the north, Korir to the south and Enda Selassie at the center. It is located southeast of Wukro town, about 45 kilometers north of Mekelle and about 825 km north of Addis Abeba, between Mekelle and Adigrat. Administratively it forms part of the Genfel Tabia (local name for sub-wereda division) and it is part of the Wukro Wereda within the Eastern Zone of Tigray Region (Map 1).

Geometrically the study area is located between $13^{\circ} 44' 05''$ and $13^{\circ} 47' 15''$ north latitudes and $39^{\circ} 35' 33''$ and $39^{\circ} 40' 00''$ east longitudes (EMA, 1997) covering 37.15 square kms of area, (calculated from the 1:50,000 topographic map). Thus, it constitutes about 3.76% of the area of Wukro Wereda (987.83 km^2). The study area is bounded by Laelai Wukro Kushet in the north; Wukro town in the northwest; Dibab Kushet of the Atsbi-Wenberta Wereda in the east; Mesanu Tabia in the south and Adi-Arba-a and Girda Kushet in the west.

The study area is part of the highland region and its altitude varies from 1960 m (around the channel of Genfel river near its western border) to 2624m (at the top of

Enkot Ridge in the east) above mean sea level. Topographically over half of the study area is rugged.

3.2 Geology

As Northern Plateau, sedimentary rocks of recent formation cover the study area and then exposures are of Cenozoic and Mesozoic eras. The Mesozoic formations, comprising mostly calcareous rocks, are described as the "Mekelle Outlier" (Hunting, 1976), which is formed by exposures of shale and limestone. Adigrat Sandstone is the oldest formation while Trappean lava is the youngest. Except the Trappean lava, as a Cenozoic formation, all formations belong to the Mesozoic era. The shale is found in some parts of the study area at the lower catchment. Wukro as a basin is encircled by Hintalo limestone (Map 4).

In Tigre many small lenses of conglomerate occur in the schist and phyllites of the Basement Complex and show intensively deformed quartzitic pebbles in a matrix of sericite schist (Mohr, 1970). In the study area conglomerate-rocks occur in some parts of the foothills of Grahutsa and Enda Selassie, and along the Korir gully, and are observed more around May Tsiyuk (down around the Mekelle-Adigrat road forming a hill type).

The three main geological formations of Mesozoic era are the

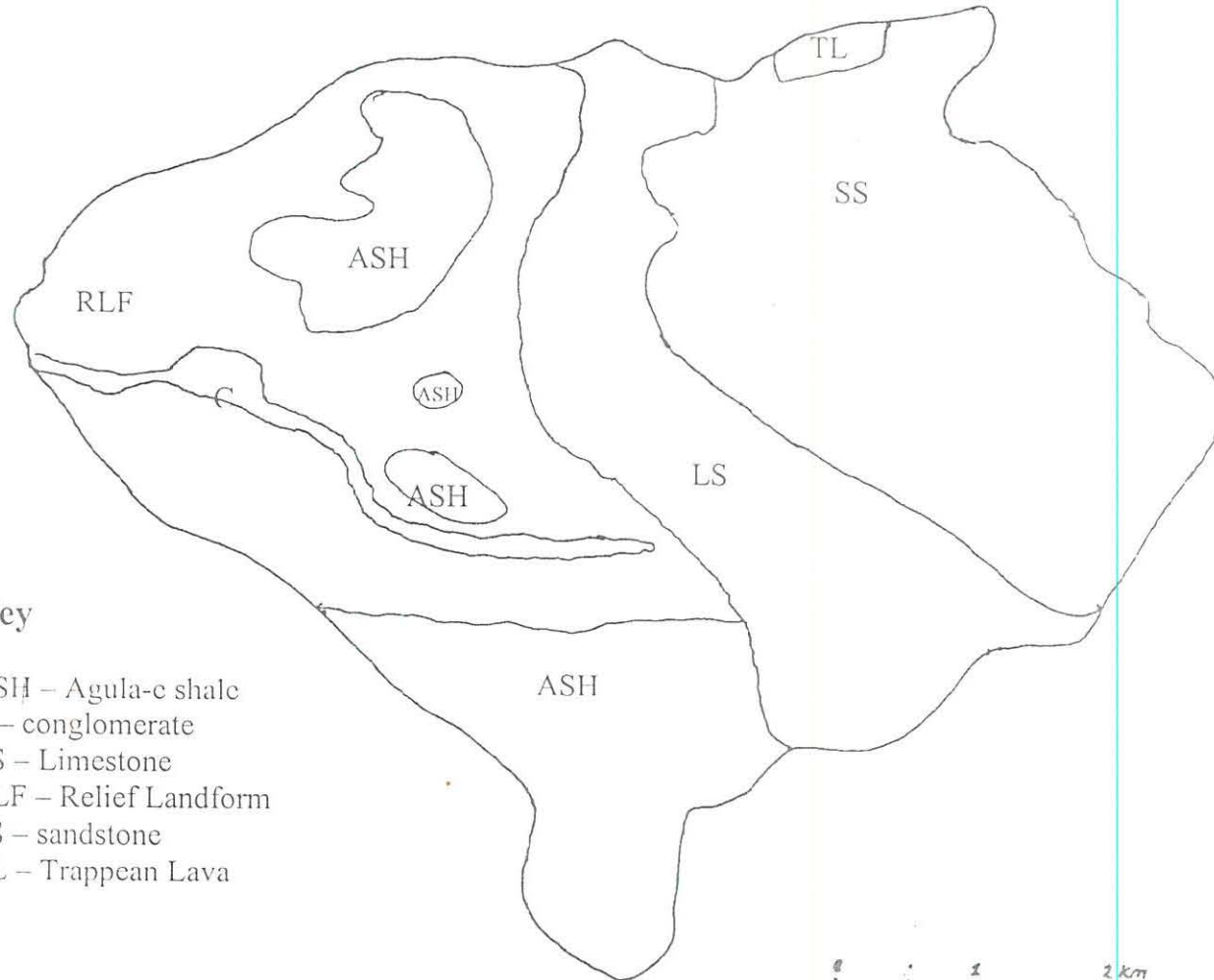
- i. Adigrat sandstone with 350 - 650 m thickness (Hunting, 1976) is the initial deposition of the Mesozoic transgression resting with great unconformity upon the underlying Basement Complex rocks. Fine to medium grained cross-bedded red sandstones lie at the base of the Mesozoic sequence. They outcrop around the margins of the Mekelle outlier where they have been faulted up or where river incision has exposed them below the limestone complex. They also outcrop below the Tertiary basalts in the extreme north of the region (Hunting, 1976). In a given part of Ethiopia the thickness remains fairly constant with local slight variations. However, a general figure for central Ethiopia can be given as 500 m, but variations in the

thickness of the Adigrat sandstone are known to as much as 1000 m and to as little as a few metres. It occupies most part of the upper catchment with a highest altitude.

- ii. Antalo (Hintalo) Limestone with 700 - 750 m thickness (Hunting, 1976), is relatively pure but is interspersed locally with marls. Where the Antalo limestone overlies the Adigrat sandstone in Tigray, thickness of 500 m is found at Wukro (Mohr, 1970). Limestone is well exposed in eastern Tigray where it shows a thicker succession. The fossil fauna are present in the limestone formations (Russo, 1997). To the north the Antalo Limestone thins out and at Wukro it virtually terminates (Mohr, 1970). This northerly limit of the Antalo Limestone coincides with a tectonic line of later faulting and warping. This geologic formation occupies the foothill of the upper catchment of the study area.
- iii. Agula-e shale with 60 - 250 m thickness (Hunting, 1976), comprise alternate layers of calcareous marls. Dominant marl and shale are with minor limestone intercalations. This occupies most of the southwestern part of the study area especially in the lower catchment.

Although it is dominant around the study area, Trappean lava formation found in contact with the sandstone indicates post tilt deposition, which might have been eroded away from about limestone beds. Blanford divided the Trap Series in northern Ethiopia into Magdala and Ashange groups but the distinction between the two groups is difficult to make (Mohr, 1970). The Trappean formation in the study area is generally responsible for the steeper slopes. All-sedimentary formations occupy as an outcrop side by side to each other that might be attributed to severe tectonics like intense tilting.

Map 2 Geology map of the study area

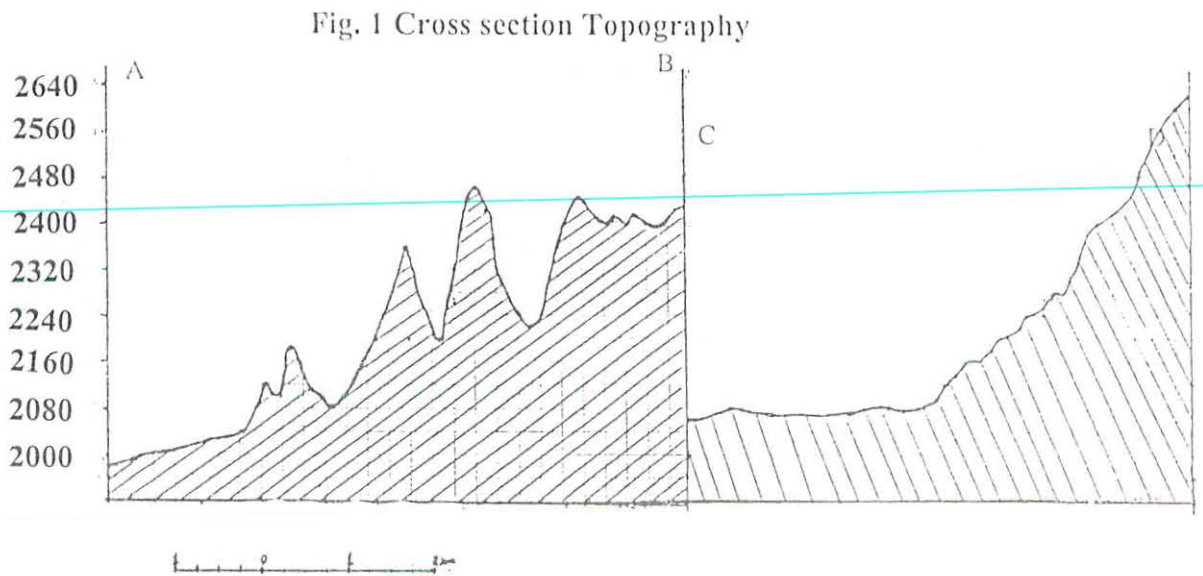


Key

- ASH – Agula-e shale
- C – conglomerate
- LS – Limestone
- RLF – Relief Landform
- SS – sandstone
- TL – Trappean Lava

3.3 Geomorphology and Surface Hydrology

The study area is marked by irregular surface configuration, comprising various topographic features, which include mountain, steep slopes, hillsides and moderately sloping, gently slope and flat plains. It is part of the northern Highlands of Ethiopia in general and Eastern Highlands of Tigray in particular.



As elsewhere the landform have evolved from the alternating work of internal and external geomorphic processes. It is indicated on Map 4 as letters A, B, C, and D and its relief, steep in the east and low in the west taken from the A – B, while C – D shows us that it is rugged, all are indicated on Chart 1 i.e., cross-section relief representation. Particularly, the late-date geologic events have profoundly disrupted and determined the existing surface form of the present day Grahutsa-Korir catchment. According to the (FAO, 1978) the landforms of the study area ranges and hillocks of varied magnitudes and side slopes and flat plains of filled up basins with entrenched stream courses or gullies of varied sizes and shapes. The surface feature of the study area is highly rugged. There

are numerous deeply incised steep to very steep concave and convex valley side slopes and gorges in the upper catchment. Hence, steep sided hills, gullies and valleys dominate the study area as a reflection of a degraded catchment.

Geomorphologically, it is undulating from plain to rolling high with severely dissected rift margins and fault scarps between different sedimentary formations. From the comparison of the aerial photographs 1965 and 1994 it is observed that the recent existing gullies were not there in 1965 except the long and wide gully of Korir from the foothill to the Genfel River.

On a wider scale the surface drainage system is part of the Mediterranean drainage system in general and Tekezze river basin in particular (National Atlas of Ethiopia, 1981). The Genfel River is a local perennial river serving as a tributary of the Tekezze. In the drainage system there are three major seasonal streams forming deep and wide gullies draining the catchment. Since the seasonal streams descend steep slopes of the bare landmass of the upper catchment, they are energetic enough to erode and carry a significant amount of sediments. In their courses, especially the upper and the middle, the rivers have cut deep gorges and narrow valleys making it topographically an area of the intensively dissected slopes. As a result of 1984/85 drought, there were two dams (Grahutsa and Enda Selassie) constructed by the Ministry of Agriculture, and Relief and Rehabilitation Commission on Food-For-Work basis in the lower plains of the study area. But at present all are out of use due to breaching, and siltation resulting from heavy volume of steep and bare rock of the upper catchment.

3.4 Climate

Climate is one of the most important factors that directly affect soil-forming processes and soil properties through weathering, leaching, transportation, etc. It also affects human activity and use and land cover types. The two most important elements of climate involved in most pedogenesis are rainfall and temperature (Belay, 1982). As can be seen from the data collected at Wukro

meteorological station rainfall and temperature vary from year to year and from month to month.

3.4.1 Temperature

Temperature, in general, varies inversely with altitude at the rate of 0.6°C for each 100 meters increase or decrease in altitude (Sadler, 1997). The maximum monthly average temperature in Wukro ranges between 25.8°C (August) and 29.5°C (June). The higher temperatures are observed in the spring season (before summer rains, i.e. in March, April, May, and June) ranging between 28.2°C (April) and 29.5°C (May) while lowest maximum is observed in August (25.8°C). According to the 1.12 standard deviation and 4.08 % coefficient of variation, there is no more variation in the maximum temperature records. This is attributed to the rain and altitude. The minimum monthly average temperature records are very low in the winter (from November to January through December) with temperatures below 8°C and above 6°C . The higher monthly minimum temperature records are in the early and late summer. The annual minimum temperature is 10.4°C greatly dropped about half of the annual average. From the records on the table 1 standard deviation and coefficient of variation are 2.16 and 20.88% respectively. This shows us that there is higher variation than the maximum temperature.

Table 1 Minimum, Maximum and Average Monthly Temperature at Wukro

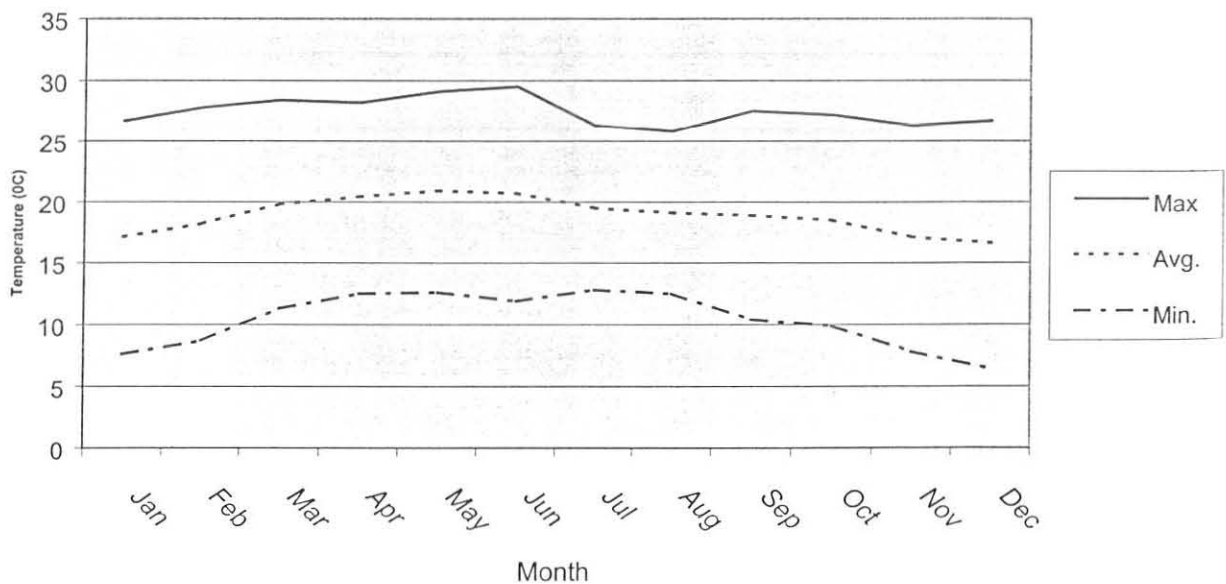
	Jan	Feb	Mar	Apr	Ma	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg	SD	CV
Max	26.7	27.8	28.4	28.2	29.1	29.5	26.3	25.8	27.5	27.2	26.3	26.7	27.5	1.12	4.08
Avg	17.1	18.2	19.8	20.4	20.9	20.7	19.5	19.1	18.9	18.5	17.1	16.6	18.9	1.388	7.34
Min	7.6	8.7	11.3	12.5	12.6	11.9	12.8	12.5	10.4	9.9	7.8	6.4	10.4	2.164	20.88
Rng	19.1	19.1	17.1	15.7	16.5	17.6	13.5	13.3	17.1	17.3	18.5	20.3	17.1	2.046	11.97

Source: Derived from meteorological data

The area under study has mean monthly temperature that varies from 16.6°C in December as a low to 20.9°C as a high in May, generally high before rainy

season and low in winter. The mean annual temperature is about 18.9⁰C. The difference is only 4.3⁰C with standard deviation 1.39 and coefficient of variation 7.34%. The monthly range of temperature is generally high between 13.3⁰C and 20.3⁰C with 2.16 standard deviation and about 12% coefficient of variation. It is relatively lower in summer (July and August) due to cloud cover and rain and higher in winter (November, December, January and February) during sunny months (table 1, chart 1). The highest average monthly maximum temperature is recorded during June, just before the on set of rainy season, which lowers the temperature sharply by >3⁰C (Table 1). As per the temperature records the coldest month at Wukro is the August where average maximum monthly temperature is the lowest (25.8⁰C). A sudden rise is in September by 1.7⁰C.

Chart 1. Monthly minimum, maximum and mean Temperature



Although complete records are not available for longer durations, yet based on the records of 1993 to 1996 it can be inferred that there is gradual increase in over all temperature in the area under study. As is evident from table 3.1 average annual temperature has increased for 18.66⁰C in 1993 to 19.17⁰C in 1996. The absolute increase was 0.21⁰C, 0.12⁰C and 0.18⁰C during 1993 – 1994,

1994 – 1995 and 1995 – 1996 respectively, giving percentage increase 1.13, 0.64, and 0.95. This increase might culminate into or may be the indicative of some environmental upheaval in the world in general and the study area in particular. The monthly range of temperature ascends as high as 20.3⁰C in the month of December. The minimum temperature is observed during the winter (Bega in Ethiopia) season in the months of December, January, and February at which the sun is away to the Southern Hemisphere. The maximum temperature record is mostly in the early summer by the time the sun passes north through Ethiopia, it might be low on its way back due to the high clouds in the Northern highlands.

Table 2 Trends of average monthly and annual temperature of four consecutive years

Year	J	F	M	A	M	J	J	A	S	O	N	D	AV/T
1993	16.6	16.9	18.5	19.8	20.4	21.0	19.6	19.6	19.0	19.0	17.7	15.8	18.66
1994	16.4	17.9	20.4	20.8	21.3	20.3	19.8	18.5	19.1	19.1	16.9	15.9	18.87
1995	16.8	18.6	19.9	20.9	21.4	21.7	19.2	19.8	18.4	17.5	16.2	17.5	18.99
1996	18.7	19.7	20.5	19.9	20.5	19.8	19.6	18.7	19.4	18.6	17.6	17.0	19.17

Source: Meteorological Data

3.4.2 Rainfall

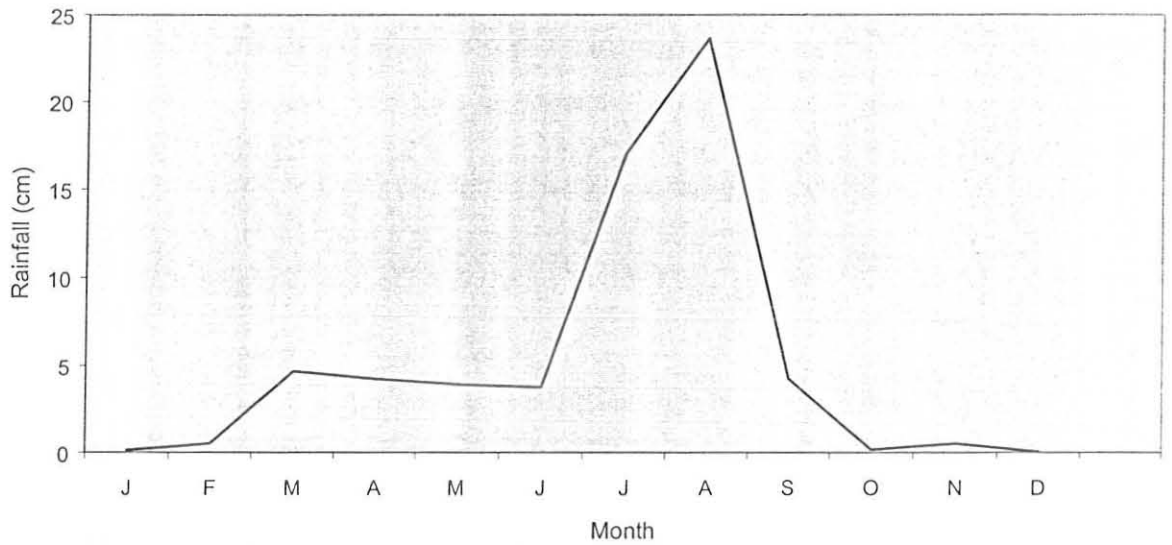
Table 3 Average Monthly Rainfall (1973 – 1999)

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
1973	0	0	0	0	0	0	209.6	62	x	0	0	x	271.6
1974	0	0	15	X	7.7	51	186.5	259.5	70.7	0	0	0	590.4
1975	0	14.5	0.9	31.7	0	59.8	183.8	229.9	104.4	0	0	x	625
1976	0	0	25.9	41.2	144.3	7.3	444.9	361	229.6	x	x	x	1254.
1992	X	X	X	6.5	26.1	6.8	56.6	125.2	18.6	28.5	27.6	9.8	305.7
1993	4.9	9.5	38	79.6	68.9	7.8	144	107.2	28.1	6.5	0	0	494.5
1994	0	0	0	22.1	0	53.3	176.1	261.1	113.1	0	0	0	625.7
1995	0	11.3	33.5	6.5	14.5	0	184.9	198.1	28.6	0	0	0	477.4
1996	0	0	115.4	60.5	73.5	88.8	178	379.1	0	0	20.9	1	917.2
1997	0	0	31.7	72.2	X	19.4	185.3	5.3	23	4.7	x	x	341.6
1998	0	0	3.1	10	49.1	19.3	415.5	X	x	0	0	0	497
1999	X	X	X	X	X	0	167.3	352.6	7.6	0	0	0	527.5

Source: National Meteorological Office, Addis Ababa, X – no data

Although the rainfall records are incomplete for certain years, significant variation in amount is observed from year to year (Table 3). A range of 600 mm and 1000 mm rainfall is given by Daniel (1977). The seasonality of rainfall is too obvious as most of the annual rain (above 50%) comes in the three rainy summer months, i.e. June, July and August and more specifically during July and August (see chart 2). For example, from the table no. 3.6 roughly some one can observe that the three months rain account as high as about 88 percent by 1994 (section 4.2.5). The years of low rainfall in the data provided are 1970-1973, 1992, and the recent one 1997. In some of the rainfall data show us there is spring rain on March, April and May months of the year but mostly rainfall is not reliable as regular seasonal occurrence it also includes the early stop of rain on summer season as a cause of crop failure for the late started summer season crops.

Chart 2. Average Monthly Rainfall of WukroTown



3.5 Soil

Most of the soil forming factors, which include parent material, climate, geology, topography and land use, are involved in the evolution and development of the soil types and process of denudation. The characteristics of the rock materials that provide the parent materials of the soils are in turn influenced by their genetic origins (Belay, 1982).

The soils of the Grahutsa-Korir catchment have developed on the sedimentary formations of shale, limestone, and sandstone and the volcanic Trappean lava, which are exposed in the upper catchment. The Agula-e shale gave rise to stony, calcareous and fine textured parent materials (Hunting, 1976) and they are usually devoid of soil cover or possess only a very shallow mantle of fine textured and highly calcareous material and occupies in most of the southern part of the study area. The Adigrat sandstones weathered to produce non-calcareous, reddish colored parent materials with a high fine sand content covering the eastern part and some pockets of areas of the study area. The flat lands consisting of alluvial nature in the lower catchment.

3.6 Vegetation

The study area lies in the sub-humid bioclimatic zone of the country (National Atlas, 1981). Altitudinally it embraces the two-agroclimatic zones i.e., Weina Dega (1500 – 2300) and Dega (2300 – 3000) (Daniel, 1977; FAO, 1986). The negligible vegetation cover existing in the catchment, comprise sparsely and insignificantly distributed bushes and small coverage of grassland all of which are the remnants of the deforestation in the area under study. As sub-humid highland it lies in the mountain savanna (mainly land of plough cultivators).

There are bushes of Acacia, Egam, Kle-aw, Atame, Kabkeb, and Kulkual (local names). The vegetation type and density has varied from time to time and now limited only to churchyard and enclosed natural vegetation on the watershed. But smaller remnants of vegetation covers can be observed outside the cultivated lands from different types of land and treatment. On the air photo of the 1965, in addition to the churchyard-closed forests, these exist slightly disturbed forests but in the 1994 air photo the former churchyard forest have shrunk and the others totally disappeared.

3.7 Agriculture and Land Use

As can be seen on the land use and land cover map of Ethiopia (FAO, 1978) the study area lies on intensively cultivated part. It is with a rain fed peasant cultivation and sedentary peasant livestock grazing on unimproved pasture and fallow.

Land holding is very different among the sample households, it is measured in Timads, four Timad being equivalent to one hectare. From table 4 above one can see the land holding system in house hold level 1 Timad, 2 Timads, 3 Timads, 4 Timads and over 4 Timads. 26.03% of the sample population have one hectare, 16.44% with three Timads ($\frac{3}{4}$ hectare), 15.07% own two Timads (half hectare), 13.69% owns more than one hectare but the size difference comes from the quality of the plots given.

As to the proportion of the identified land use types out of the total area, uncultivated land constitutes 37.95 percent, which is the largest part of the total area. As the second expanse cultivated land occupies 27.13 percent of the study area and found in the lower catchment. Grassland or grazing land at present is enclosed for rehabilitation comprising of about 15 percent. Watercourse, gully and the dam occupation with 1.24 percent is the least expansion (Table 5).

3.8 Population and settlement

Table 6 Population size, area and density of the study area, zone and the region

	Population Number			Area km ²	Density p/km		
	1994	1998	1999		1994	1998	1999
Tigray Region	3,136,267	3,592,9	3,694,002	50,078.6	62.6	71.7	73.8
Eastern Zone	584,946	669,976	688,759	5,705.3	102.5	117.4	120.7
Wukro Wereda	85,561	99,021	102,024	987.83	86.6	100.2	103.3
Mahbere Desta	2,021	---	2529*	38.37	52.67		65.91**

Source: CSA Abstracts of census 1994 and statistical reports of 1998 and 1999

* Wukro Wereda Agricultural Department by the end of 2000, ** 2000

Population wise, the Wereda in which the area under study is found, has about 2.73% of the region means 14% of the Eastern Zone of Tigray Region, which has about 18% of the Region's total population (Table 6). From time to time population density in the concerned zone Tabia increased from 52.67 to 65.91 p/km² in the years 1994 to 2000.

The study area comprising the three Kushets with 2,021 people (1037 or 51.31 percent female and 984 or 48.69% male) i.e., 429 house holds. It is the population number by 1994 census and became 2529 by the year 2000. In all statistical records the proportion of female are higher in number than the male from Kushet level to the regional level. Generally, female population account about 49.55% as compared to 50.45% male.

Table 7 Age sex composition (2000) of population of the sample House Holds

Age	Male		Female		Total and percent of the total age group
	No.	Percent	No.	Percent	
< 15	106	49.07	110	50.93	216 (48.43%)
15 – 64	107	50.00	107	50.00	214 (47.98%)
> 64	12	75.00	4	25.00	16 (3.59%)
Total	225	50.45	221	49.55	446 (100.00)

Source: Questionnaire

Like any other developing countries under 15 years of age of the study area accounts almost half (48.43%) of the total sample population plus 3.59% over 64 years of age, means the unproductive population became 52.02% of the total while the productive group, regardless of unemployment and disability, is less than half i.e., 47.98 percent of the total population (table 7). The dependency ratio is higher means dependents are higher than the productive group, i.e. 104.04%. This means averagely more than 108 persons are staying at home for the food produced by 96 persons regardless of the disabilities and job-less-ness in the productive age group. From the total population 39.01% are literate and the rest (60.99%) are illiterate (the questionnaire).

From the sample population of the study area, the population increase was 112.28% in the ten year (1963 – 1973), similarly it was 78.51% in (1973 – 1983), 49.07% (1983 – 1993) due to the drought occurrence in 1984/85 and 38.51% between 1985 and 1993.

Settlements are mostly on the foothills, which are not important for cultivation, of the catchment because the low lying land is occupied by agricultural activities and they are under flooding problem that is why it is dissected by wide and deep gullies.

CHAPTER FOUR

ENVIRONMENTAL PROBLEMS AND CONSERVATION PRACTICES

Land, water and land cover are the three major components of environment, which have direct bearing on human beings in any area. Therefore, in this chapter a critical resume of the characteristics of land in terms of its undulations (relative relief), altitude (absolute relief), slope (magnitudes and facets) will be evaluated to the extent they affect the quality of land. The characteristic of drainage will be briefly discussed and so also the distribution and characteristics of grass lands. Along with land evaluation; characteristics and distribution of soils also associated (texture, erodibility, pH, etc) which are already described in section 3.5. Here it may be mentioned with reference to its impacts, degradation, etc. These descriptions will highlight the problems pertaining to their aspects and their causes in the study area. It will be followed by the measures adopted by the people for their conservation.

4.1 Relief and Slope Analysis

4.1.1 Relief Analysis

The word relief refers to the relative vertical inequality of land surfaces, collectively or in individual units (Singh, 1980). There are various methods by which the relief of an area can be analyzed and interpreted in relation to the processes of erosion and deposition. Basically, however, it may be classified in to absolute and relative relief.

4.1.1.1 Absolute Relief

The absolute relief has something yet to infer regarding the operations responsible for its present shape. It is the result of continued internal and external processes prevalent on the earth's surface, provides clues towards

understanding and indicating the intensity of forces at operation. The physical relief features, mainly the detached hillocks, isolated hills, mesas and buttes, etc. account for the possible number of erosional cycles commencing over it, though unable to explain their completion or break explicitly. These remnant surfaces, sometimes part and parcel of a relatively flat block resulting from the normal erosion during base level stability, are termed as erosional surfaces (Singh, 1980).

Table 8 Altitudinal Intervals and Calculated Areal Proportion

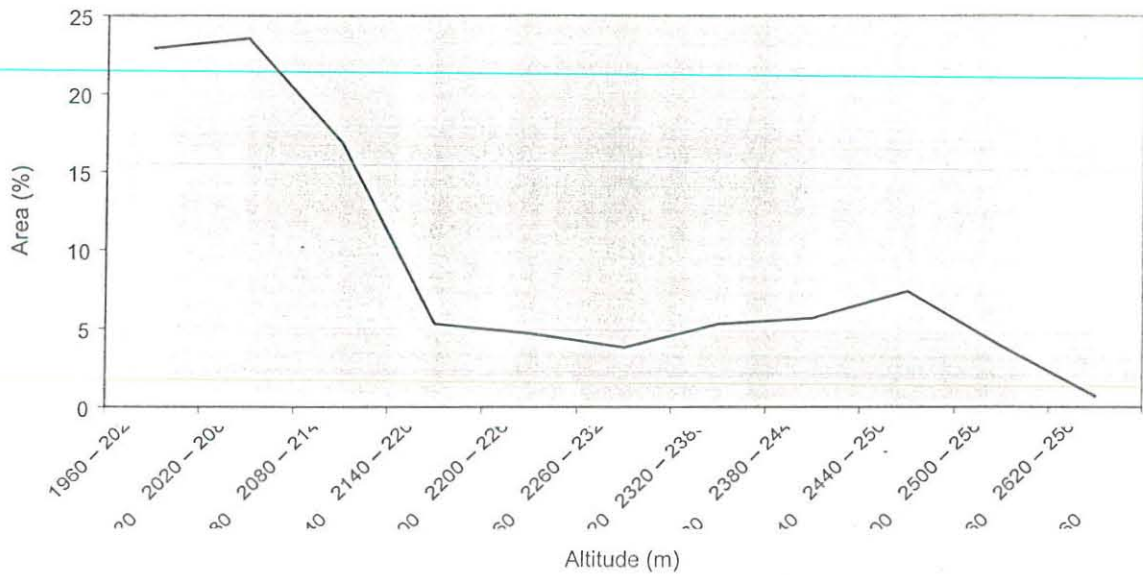
Contour Range (m)	Area (Km)	CA (Km) > LL	Area (%)	CA (%) > LL
1960 – 2020	8.51	37.14	22.90	100.00
2020 – 2080	8.74	28.63	23.54	77.10
2080 – 2140	6.25	19.89	16.83	53.56
2140 – 2200	1.98	13.64	5.32	36.73
2200 – 2260	1.75	11.66	4.70	31.41
2260 – 2320	1.41	9.91	3.80	26.71
2320 – 2380	1.95	8.50	5.29	22.91
2380 – 2440	2.11	6.55	5.67	17.62
2440 – 2500	2.74	4.44	7.38	11.95
2500 – 2560	1.44	1.70	3.87	4.57
2560 – 2620	0.26	0.26	0.70	0.70
Total	37.14	37.14	100.00	100.00

Where CA is cumulative area, >LL is greater than the lower limit.

Its general altitude increases from west to the east. The west is generally flat from less than 1960 meter to the high altitude up to 2624 meter in the east. Mostly this comprises the general Ethiopian altitudinal zonation, which are Dega and Weina Dega (section 3.6). The area-height relations, projected in the form of the altimetric frequency diagram, hypsometric and clinographic curves can explain about the relief aspect. Because, analyzing absolute relief involves altitudinal extents with calculated area (altimetric and hypsographic analysis) and average slope (clinographic analysis).

From the table 8 and chart 1, it can be observed that out of the total area, of the study area large proportion (about 36.73 %) lies within elevation ranging from 2140 to 2620 meters a.s.l. And more than half (about 63.27 %) of the total area is within the altitudinal extents of 1960 and 2140. From this, we may conclude that the study area lies almost above 2000 meters of altitude even above 2020 accounts for 77.10 percent of the total.

Chart 4. Altimetric Frequency Curve of Grahutsa-Korir Catchment

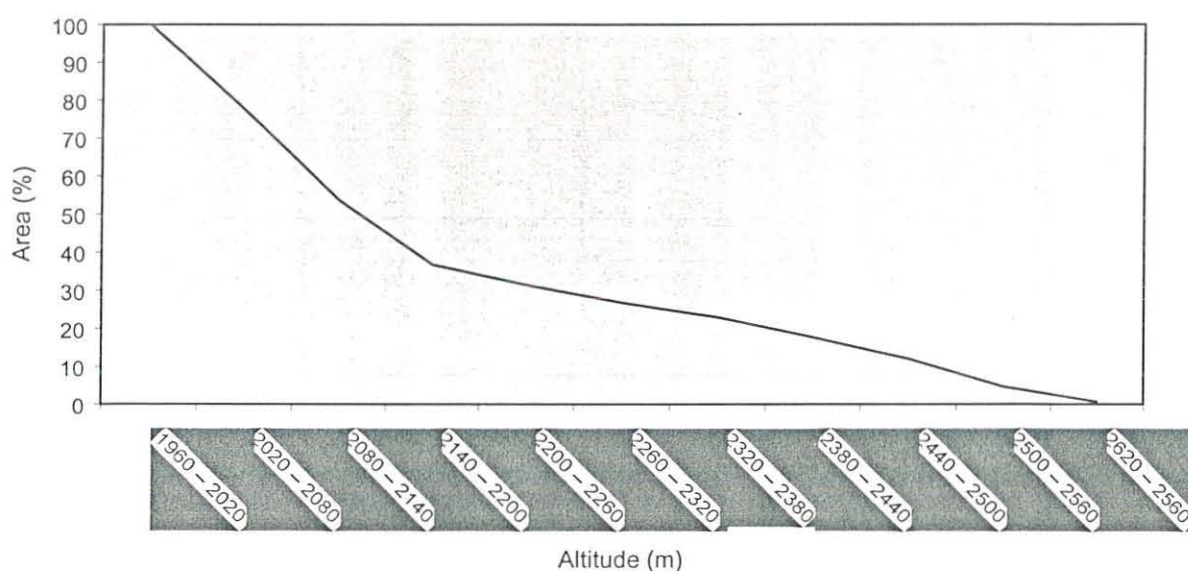


As the altimetric frequency curve shown in Chart 4 and Table 8 above the maximum area of about 23.54%, 22.9% and 16.83% lies within 2020 – 2080, 1960 – 2020 and 2080 – 2140 m altitudes respectively. The next peak is found in the altitudinal range of 2440 – 2500 m with a 7.38% of the total area. The least one with 0.7% is found in the range of 2560 – 2620 m as highest altitude above mean sea level (table 8). It is indicating the effect of geomorphic processes of erosion and deposition on the continuity of the slope in the upper catchment. The breaks (like 2140 – 2200 and 2440 – 2500 m) in the topography not only indicate varied processes of erosion but also rock resistance. Compared to the rest part of the catchment, erosion is especially more intense along the study area (between

2140 and 2620 m elevation considered as a valley while below 2140 m it is a gully) because of the prolonged undercutting by the seasonal streams. However, there is a relative topographic uniformity within elevation ranging below 2140 m. From this it is evident that surface processes have made the relief of the area uneven following the weak zones.

The curve obtained from the hypsographic analysis presents a generalization of the surface character of the study area along with areas incorporated in different height groups (Chart 5). The curve in chart 4 above indicates the proportion of areas above various altitudinal extents. The median elevation in the catchment is 2092.69 meters a.m.s.l. Nevertheless, the distribution is so skewed towards lower altitudes that more than 63 per cent of the total area lays below 2092.69 meters in elevation. Whereas, the remaining 37 per cent predominate the escarpment of the study area.

Chart 5 Hypsometric Curve of Grahutsa-Korir Catchment



Although any considerable point of inflection does not characterize the region, breaks in slope and scarps do exist as indicated in the curve, which result from

the processes of soil removal and mass wasting. Thus, it is shown that areas with altitudes ranging from 1960 to 2140 slope almost uniform.

The clinographic curve is distinct from other methods used to analyze absolute relief for its quality of expressing the ascent of various height groups in a more quantitative way, though it is a laborious task. The method relates altitudinal zones (interval) and calculated average slope. To find the mean intercontour width, the radius of each altitudinal zone is calculated based on the area of equivalent circle and subtracted to get the difference (Table 9).

Table 9 Clinographic data

LL altitude (m)	Frequency (sq. km)	Cum. Freq. > LL	Radius (m)	Difference (m)	Slope (°)
>1960	8.51	37.15	3438.78	419.45	8.1
>2020	8.74	28.64	3019.33	502.51	6.8
>2080	6.25	19.90	2516.82	432.37	7.9
>2140	1.98	13.65	2084.45	157.10	20.9
>2200	1.75	11.67	1927.35	150.38	21.8
>2260	1.41	9.92	1776.97	131.12	24.6
>2320	1.95	8.51	1645.85	201.92	16.5
>2380	2.11	6.55	1443.93	255.11	13.2
>2440	2.74	4.44	1188.82	453.21	7.5
>2500	1.44	1.70	735.61	447.93	7.6
>2560	0.26	0.26	287.68	287.68	11.8

Source: 1:50,000 scale map

The data in the table depict the average slope in degrees within respective altitudinal zones. Therefore, the entire area can be classified into three slope categories based on the observed relative breaks: below 2140 meters with 23.55 sq. km area as a low, 2320 – 2620 meters with 8.5 sq. km is as a moderately steep and between 2140 and 2320 meters with 5.14 sq. km as the steep slope. The same steeper slope between 2140 and 2320m altitude is shown in the clinographic curve (Chart 6).

Steeper slopes characterize areas in 2140 – 2320 m elevation with slopes between 20.9 and 24.6 degrees, which are indicative of the ever-continuing surface processes of erosion. Moreover, lower altitudes are more cultivated and used for grazing thereby accelerating the rate of soil removal and gully development. The interfluves (above 2600 m) on the other hand remain intact mainly because of limited cultivation and grazing and moderate slope. This is better shown in the clinographic curve (chart 6). Steeper gradients observed for altitudes 2140 - 2320 m constitute only 5.14 sq. km (13.84 percent) of the total area. The class between 2320 and 2620 with an area of 8.5 sq. km (22.89 percent) is with in 7.5 and 16.5-degree sloping as moderately steep. But areas below 2140 m elevation constitute 23.55 sq. km (63.27 percent) and an average slope of about 7.6 degree while those between 2440 and 2562 m also resemble.

4.1.1.2. Relative Relief

Relative relief method is based on the difference of the highest and lowest altitude within each cell to the area of the grid cell. It is analyzed by superimposing 1 km by 1km-grid cells. Such a method provides a picture regarding the landform setting a morphological character of the study area. The inability of the absolute relief in expressing, the total morphological character of landform, as it lacks in giving the sharpness of relief, leads to the investigation of still comprehensive devices to express the three dimensional forms with two dimensional medium (Singh, 1980).

The method involves analysis of the relative relief within each cell and grouping them after assessing marked breaks (changes) existing in the calculated data (Table 10).

Table 10 Relative Relief categories and Area in percent.

Relief category	Ranges (m)	Symbol	Area (Sq. km)	Area (%)
Extremely low	<25	Rel	1.925	05.18
Moderately Low	25 - 50	Rml	8.800	23.69
Low	50 – 100	Rl	5.975	16.08
Moderate	100 – 200	Rm	9.450	25.44
Moderately High	200 – 300	Rmh	8.025	21.60
High	>300	Rh	2.975	08.01
Total			37.15	100.00

The Relative Relief of the study area with an area of 37.15 sq. km varies from almost nothing to more than 400 m within each grid. It is evident from table 10, which those areas under the extremely low, moderately low and low relative relief categories are in less than 100 m range in each grid, account for 16.75 sq. km or 44.95 percent of the total area. It is almost flat plain and is found in the western part of the study area where farming is practiced. This area generally comprises below 2040 m of elevation i.e., from the foothills of the study area west of the high relief to the course of Genfel River as alluvial deposited part, which mostly occupies the lower part of Grahutsa and Enda Selassie kushets. The relative relief with more than 100 meter is located along the edges (escarpment) of the eastern part of the study area accounting for 20.45 sq. km or 55.05 percent of the total area. Since this area is marked by sharp changes in elevation for more than half of the study area, it is relatively higher especially along the river gorges of the Grahutsa-Korir catchment as a rugged landform. The entire topography is dominated by the moderate-to-moderate high relief category (100 to 300 m), which accounts about 47.04% of the total. The moderate relief category has the greatest share in study area comprising about 25.44 % occupying 9.45 sq. km followed by moderately low relief category accounting for 23.69% with a total area of 8.80 sq. km of the total area.

Implied to the general topography and processes taking place, relative relief values show that erosion is more prevalent and still accelerated due to various factors among which slope and rainfall are of paramount significance. The low relief category tells us somewhat reduced erosional processes. Nonetheless, towards the gorges of the streams, rejuvenation seems to have taken place as evidenced by the sharp breaks in slope. In all category levels the moderate relief is occupied by valley, gorges, etc. as bad land in all Kushets. In the lower relative relief in the western part of the study area, it is plain occupied with cultivation, dissected by gullies.

4.1.2 Slope Analysis

Topography is one of the major factors controlling the movement of soil materials on the earth's surface. And it is along the hill slopes, where the movement of these materials and water is considered, that geomorphological and pedological processes interact. Therefore, while studying soil-geomorphic relationships and the prevailing surface processes, the main concern is to consider the slope configuration of the area.

Slope is characterized by its gradient, maximum inclination to the horizontal, in degrees or percent, and its effect entails on the processes of erosion and deposition is so profound that there is a need to investigate the characteristics of this important parameter. Ruhe (1975) argued that any analysis of erosion and deposition must include the hill slopes. Thus, the landscape can be divided into three major zones: zones where material is being eroded, zones where material is being deposited and, perhaps, zones that are neither losing nor gaining materials i.e., a zone of continuous soil development (Gerard, 1992). Nevertheless, erosion would normally be expected to increase with increase in slope steepness and length of slope as a result of respective increase in velocity and volume of surface runoff (Morgan, 1994)

Based on the contour map of the study area obtained on the basis of FAO (1990) slope classification, slope is calculated, and from which the slope class map is

constructed and four slope categories are identified. Steeper slopes are more concentrated in the eastern part, particularly along the gorges, of the catchment.

Table 11 Slope classes of the Grahutsa-Korir catchment

Slope Group		Area		Cumulative Area > lower limit	
Percent	Slope Class	Sq. Km	Percent	Sq. Km	Percent
1 – 5	V. Gentle to gentle	7.84	21.1	7.84	21.1
5 – 10	Slopy	9.62	25.9	17.46	47.0
10 – 15	Strongly Slopy	5.76	15.5	23.22	62.5
15 – 30	Moderately Steep	10.25	27.6	33.47	90.1
> 30	Steep	3.68	9.9	37.15	100.0
Total		37.15	100.00	--	--

Source: FAO (1990)

In the distribution of area of the slope groups, affords a marked unevenness. The higher areal frequency occurs in the lower group. As far as the areal distributions of slope categories are concerned, less than 5 percent slope with very gentle to gentle covers about 21.1% (7.84 square km) of the total area, it lies in the western and southwestern parts of the area under study i.e., southeast of Wukro town, occupied by farm plots of the three Kushets between the foot of the upland and the Genfel river.

The slope group between 5 and 10 percent slope as slopy slope account 25.9% of the study area. The strongly slopy slope, moderately steep and steep slopes account 15.5%, 27.6% and 9.9% of the study area. Moderately steep as the highest and steep the smallest land cover of the study area. Generally slopes above 10 percent slope account for about 53% of the total study area (table 11).

Within the slope zone of 15 – 20 degree or strong slope occupies 13.59 percent (5.09 square km) encircling the very strong slope. The slope category above 20 degree constitutes only about 2.25% (0.84 square km) of the study area and is located near to the tip of the study area. It is near the Wukro-Atsbi road

adjacent to Medhane Alem Church and steeper Trappean lava formation called “Sheshahle” found in the northeastern part of the study area.

Varied slope forms characterize the topography of the study area with wide ranging impacts on various activities associated with the utilization of land resources. Generally speaking, it is observed during the author’s field survey that slope configuration and subsequent surface processes of erosion and mass wasting have significantly affected agricultural lands in the lower catchments of the area. The higher slope in the upper catchment is characterized by high erosion giving rise to bad (bare) land, and consequently affected the agriculture and soil in the lower catchments with wide and deep gullies.

As a waxing slope (Singh, 1980) also called interfluvial landscape in the study area is found at the top of the upper catchment, eastern part with sandstone formation as table land; as the steepest part the concave slope is located below the interfluvial near the Medhane Alem Church with two (sandstone and Trappean) formations, it is an area of creeping where accumulation of slope wastes at its base (Doornkamp, 1971); convex slope is mostly located at the middle of the catchment and the constant slope is consisting of the even slope mainly found towards the southern part of the study area.

Much dissection and steeper gradients are observed in the middle catchments as compared to the elevated surfaces. This is partly due to slope configuration of the area along the river gorges within the catchment as running water is more erosive on steeper slopes, thus, causing steeply sloping surfaces. Along the lower elevation zones, there is evidence of rejuvenation in the process of erosion. For this reason the clinographic curve is characterized by steeper slope along such altitudinal extents. Erosion is still active in the area and is especially severe in the middle altitudinal zones along the convergent foot slopes of the catchment.

4.1.3 Climatic and Soil Analysis

4.1.3.1 Climatic Analysis

From the meteorological data (Table 3) we can't tell whether a climate is moist or dry by knowing precipitation alone; we must know whether precipitation is greater or less than the potential evapotranspiration. That is why the ignorance of the magnitude of water need has led to the development of a number of moisture indices, which attempt to evaluate the effectiveness of precipitation. It is recognized that water utilization or water loss evaporation must be related to precipitation somehow (Jensen, E. Marvin, 1973). In this evapotranspiration is computed as a function of temperature alone by the formula $e = 1.6(10t/I)^a$. Where, e = 30 days evapotranspiration (for 12 hour days) in cms, corrected by the sunshine hours or duration, t = mean monthly temperature in $^{\circ}\text{C}$, a = an arbitrary constant varying from place to place (the difference comes on the value of I) by the formula $a = 0.49239 + (1792 \times 10^{-5}) I - (771 \times 10^{-7}) I^2 + (675 \times 10^{-9}) I^3$, and $I = \sum (t/5)^{1.514}$ (summation of 12 months).

As mentioned earlier from table 2 we can see the average temperature is increasing from time to time, i.e. generally high in summer and low in winter. In all the mentioned years adjusted evapotranspiration is higher in all months of the year except in the summer months mainly July and August. It was by the year 1993 spring rain in the month of April was higher than the potential evapotranspiration. When the annual rainfall and potential evapotranspiration are compared only one-year rain became above the potential evapotranspiration. The rest are almost fulfilling about 59.02%, 73.55% and 54.38% of the potential need of the respective years of 1993, 1994 and 1995.

Average annual water surplus and deficit are estimated based on Thornth Waite's empirical formulae for water budget. The relation between mean monthly temperature and potential evapotranspiration adjusted to a standard month of 30 days, each having 12 hours of possible sunshine. For a better comparison the researcher used the adjusted evapotranspiration computed in

relation to the latitudinal sunshine hours. From table 12 one can see the condition of surplus or deficit level at the station.

Moisture index is the status of moisture in the atmosphere at a place.

i. Humidity Index $I_h = 100s/ n$, i.e. surplus as percentage of water need. Where I_h = humidity index, s is surplus, n is sum of the corrected potential evapotranspiration or the annual water need. It is calculated = 12.22

ii. Aridity index of $I_a = 100d/ n$, i.e. deficit as percentage of water need, d is deficit, which is = 38.19

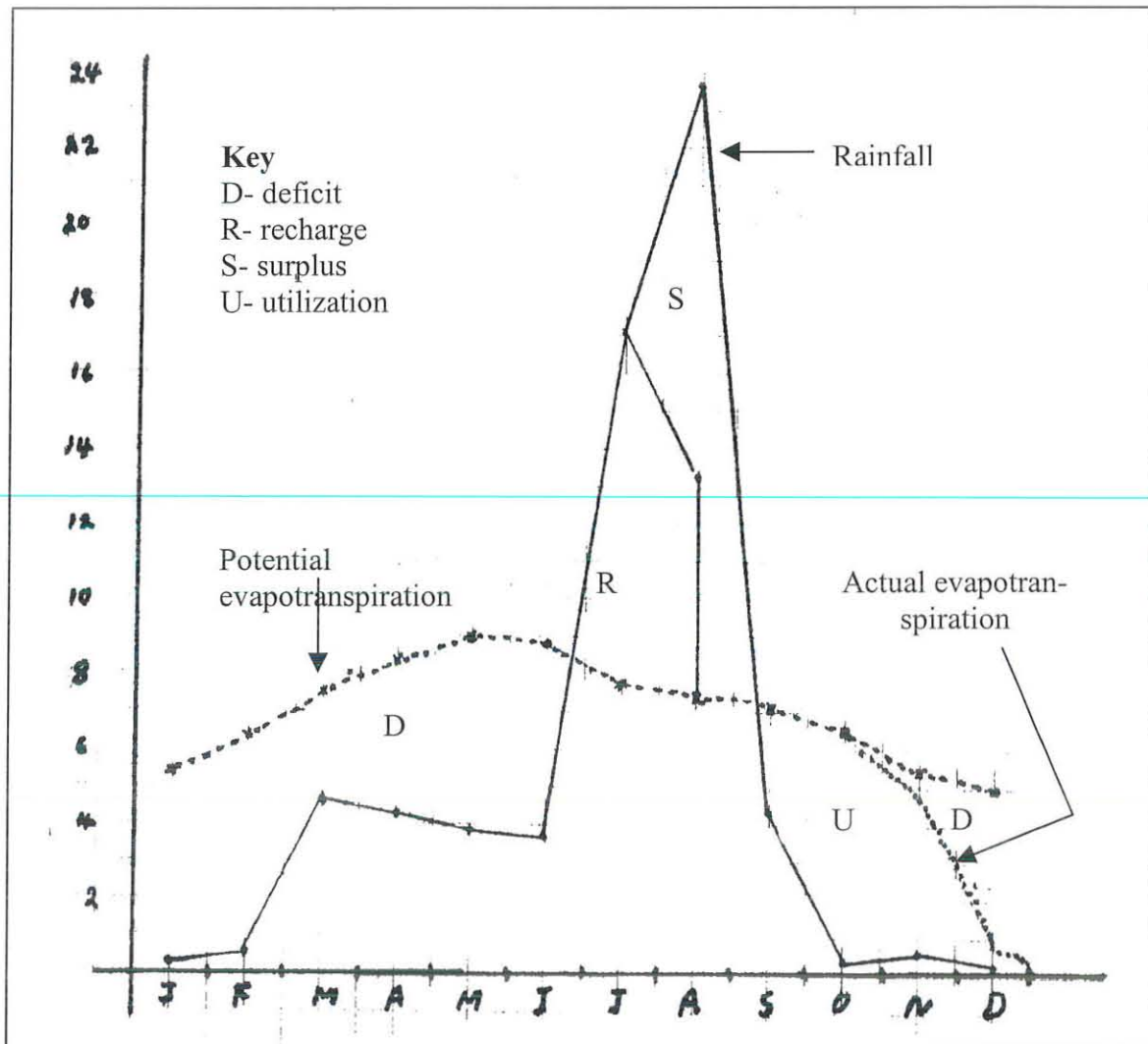
Table 12 Water Balance Table

	J	F	M	A	M	J	J	A	S	O	N	D	
SLH	0.95	0.97	1.00	1.04	1.07	1.08	1.07	1.05	1.02	0.99	0.95	0.94	*
T^0 (C)	17.13	18.28	19.83	20.35	20.90	20.70	19.55	19.15	18.98	18.55	17.10	16.55	18.92
RF (cm)	0.12	0.52	4.67	4.22	3.92	3.75	17.08	23.64	4.25	0.16	0.52	0.03	62.88
RF (%)	0.19	0.83	7.43	6.71	6.23	5.96	27.16	37.60	6.76	0.25	0.83	0.05	100
I	6.45	7.12	8.05	8.37	8.72	8.59	7.88	7.64	7.54	7.28	6.43	6.12	90.19
E=PE cm	5.69	6.47	7.59	7.99	8.42	8.27	7.38	7.09	6.96	6.66	5.67	5.31	83.50
CPET	5.41	6.28	7.59	8.31	9.01	8.93	7.90	7.44	7.10	6.59	5.39	4.99	84.94
RF-CPET	-5.29	-5.77	-2.92	-4.09	-5.09	-5.18	9.18	16.20	-2.85	-6.43	-4.87	-4.96	
SMU	---	---	---	---	---	---	---	---	2.85	6.43	4.87	0.85	15.00
AET	0.12	0.52	4.67	4.22	3.92	3.75	7.90	7.44	7.10	6.59	5.39	0.88	52.50
SMR	---	---	---	---	---	---	9.18	5.82	---	---	---	---	15.00
S	---	---	---	---	---	---	---	10.38	---	---	---	---	10.38
D	5.29	5.77	2.92	4.09	5.09	5.18	---	---	---	---	---	4.11	32.44
RO	0.162	0.081	0.041	0.020	0.010	0.005	0.003	5.190	2.59	1.29	0.65	0.324	10.38

Source: derived from meteorological data

*SLH (sun light hours) calculated in proportion to 12 hours of a day; T is temperature, RF is rainfall, e=PE is potential evapotranspiration, CPET is corrected evapotranspiration, SMU is soil moisture utilization, AET is actual evapotranspiration, SMR is soil moisture recharge, S is available for run off, D is deficit, RO is runoff; the value of a is 1.9766433.

Chart 3 Water Budget of Wukro Town



From the Chart above (3) you can see the zones of deficit, recharge, surplus and utilization indicated by D, R, S and U with their boundaries.

Empirically the Thornthwaite assumed that a surplus of 6 cm in one season may compensate for a deficit of 10 cms in the following season. Hence, the aridity index is weighted by a factor 0.6 and the I_m is defined as $I_m = I_h - 0.6I_a$. We can analyze the actual moisture available by using the Thornthwaite method i.e., moisture index ----> $I_m = I_h - 0.6(I_a)$. Then it (I_m) is calculated as = -10.69

Table 13 Results of soil sample analysis

Code	Depth (cms)	Stoniness (%)	Slope	Land cover	pH	Soil color	
						Dry	Wet
1	50 – 90	10	<3 ⁰	C	8.09	2.5Y 5/1	2.5Y 3/1
2	20 – 50	40	7 ⁰	C	8.23	2.5Y 7/3	2.5Y 5/4
3	> 90	25	10 ⁰	C	8.15	5Y 6/3	5Y 5/3
4	> 90	0	<2 ⁰	C	8.34	7.5Y 4/1	2.5Y 2.5/1
5	50 – 90	10	<2 ⁰	C	7.76	2.5Y 6/3	2.5Y 3/2
6	50 – 90	0	<2 ⁰	C	8.31	2.5Y 4/2	5Y 2.5/1
7	50 – 90	40	9 ⁰	C	8.41	5Y 5/1	5Y 4/1
8	20 – 50	40	15 ⁰	C	8.35	2.5Y 6/3	2.5Y 4/4
9	50 – 90	0	4 ⁰	C	7.48	10YR 4/4	10YR 3/6
10	50 – 90	<5	5 ⁰	C	6.85	7.5YR 5/3	7.5YR 4/4
11	20 – 50	10	8 ⁰	UC	7.70	10YR 4/4	10YR 3/6
12	20 – 50	<5	5 ⁰	UC	7.45	7.5YR 4/6	7.5YR 3/3
13	50 – 90	<5	12 ⁰	UC	7.18	10YR 4/4	10YR 3/3
14	< 20	5 – 10	10 ⁰	UC	6.90	10YR 5/4	10YR 3/6
15	50 – 90	<10	21 ⁰	UC	7.66	2.5Y 6/3	2.5Y 5/4
16	> 90	0	<2 ⁰	C	8.19	2.5Y 5/2	2.5Y 3/1
17	20 – 50	0	2½ ⁰	C	7.95	7.5YR 4/4	7.5YR 5/4
18	50 – 90	0	2 ⁰	F	7.74	10YR 3/2	10YR 2/2
19	> 90	0	<2 ⁰	C	8.04	10YR 3/1	5Y 2.5/1
20	20 – 50	40	4 ⁰	C	8.45	2.5Y 5/2	2.5Y 4/3
21	20 – 50	60 – 70	4 ⁰	C	8.35	10YR 5/2	2.5Y 4/4
22	50 – 90	10	4 ⁰	C	8.46	2.5Y 4/2	2.5Y 3/1
23	> 90	0	<2 ⁰	C	8.02	10YR 5/3	10YR ¾

Source: Field Survey, January 2001. Where C is cultivated, F is fallow and UC is uncultivated land use.

Soils in the study area are of different depths due to the complex interaction between the exogenic and endogenic forces involved in their formation. The depths vary from almost zero (bare rock) on the steep slopes to as deep as more

than 2 meters in the flat plains of the filled up depressions as the materials removed from steep slopes creating bare surfaces are deposited as thick alluvial in the lower catchments (cultivated lands).

The depth of the soil in the upper catchment is a very rare (only two sample pit) to be more than 50 cm the one designated by 14 is very shallow with less than 20 cm and high level gravel while it is rare in the lower catchment to find a thickness with less than 50 cm soil depth. There were only 5 sample pits out of the 18 sites with less than 50 cm depth as shallow soil in the lower catchment. The deep gullies in the lower catchment show the depth of the soil as compared to shallow nature of the gullies the upper catchment. Deeper soils are better for growth and moisture holding.

Table 14 Soil depth groups of the study area based on FAO, 1987 classifications

Depth (cm)	Description	No. of samples included		
		UC	LC	Total
< 20	Very shallow	1 (100.00%)	0	1 (4.34%)
20 – 50	Shallow	2 (28.57%)	5 (71.42%)	7 (30.43%)
50 – 90	Moderately Deep	2 (20.00%)	8 (80.00%)	10 (43.47%)
> 90	Deep	0	5 (100.00%)	5 (21.73%)

Source: Where UC is upper catchment and LC is lower catchment

The pH of a soil would indicate the degree of availability of plant nutrients and lime requirements of a soil. A soil fertility characters can be interpreted from the pH in a 1:2.5 soil: water suspensions, as indicated below. As can be seen on the table 13, the pH analysis shows us that it is generally more than 7.0, and then its possibility of crop growth is very low. 91.30% of the soil sample pits (21 of the 23) have a result of a pH soil analysis above 7.0. This shows us that it may be high in Na, low availability of micronutrients, low availability of p, etc (Table 15).

Table 15 pH classification

PH	Rating	General interpretation
>8.5	Very high	Alkali soils, may be high in Na. Boron toxicity is possible; low availability of micronutrients.
7.0 – 8.5	High	Low availability of p and micronutrients except Molybdenum.
5.5 – 7.0	Medium	Preferred range for most crops.
<5.5	Acidic	Al toxicity, excess Fe and Mn. Low availability of Ca, Mg and Mo. Phosphorus fixation associated with Al and Fe oxides. Nitrification is retarded.

Source: MOA, 1995

Table 16 Comparison of pH with sodium and Exchangeable sodium percentage

Depth	pH	Na	ESP
0 – 18	8.19	1.23	2.3
18 – 85	8.60	3.22	5.7
85 – 140	8.52	9.33	16.5
0 – 14	8.43	0.99	2.4
14 – 52	8.60	2.66	5.9
52 – 124	8.29	4.72	10.9
0 – 12	7.60	1.68	3.2
12 – 84	8.51	1.39	3.1
84 – 146	8.57	3.85	9.1
0 – 14	8.14	1.75	6.1
14 – 57	8.77	3.89	9.0
57 – 130	8.57	5.76	13.1

Source: Belay, 1996

When the pH value rises above 7.5 the presence of calcium, phosphorus and sodium is high. The rise of exchangeable sodium percentage (ESP) is also related to the presence of pH. Exchangeable sodium percentages (ESP) with increase of its value qualify for the sodic phases of a soil. ESP values, which are generally ranged from 5 to 15 % (table 16) were also large enough to affect soil structure

and crops that are very sensitive to sodium ions. The high values in the study area (indicated by 8.23 for 2; 8.41 for 7; 8.45 for 20 8.35 for 6; 8.46 for 22, etc) with much higher at depth below 90 cm. This might agree with Belay (1996) Eutric Vertisols and Vertic Luvisols of Melbe are also prone to degradation resulting from concentration of sodium ions as very well reflected in the significant concentration of these ions in the root zones. Exchangeable sodium also causes dispersion and degradation of soil structure. The widespread tunnel erosion in the Vertic Luvisol landscapes of Melbe area may have been primarily caused by the significant sodium ion concentration. The gully erosion commonly observed at low slope gradients on the Vertisol landscapes may be enhanced by the sodium ions --- also report a widespread occurrence of tunnel and gully erosion in similar landscapes throughout Tigray plateau but attribute the phenomena only to the cracks in the soils. This idea of Melbe has relation with the Adimeskel part of the study area.

The sodicity hazard would be increased many fold especially if the soils were brought under irrigated agriculture. Irrigation can easily bring the water table closer to the surface and lead to capillary rise, evaporation of water and subsequent concentration of sodium in the surface layers (Belay, 1996). It is clearly observed in the irrigated part of Korir below the earth dam. The dark soil below the dam has attained a white color after few years of its irrigation.

A normal soil does not consist of only sand, or only silt, or only clay but is nearly always a mixture of particles of all three-size classes. Then its character differs on the relative proportions of the different size classes (Ahn, 1970). The rate and extent of many physical and chemical reactions is important in plant growth rate governed by texture because it determines the amount of surface on which the reactions can occur. The texture of a soil indicates its rate of infiltration, water holding capacity, etc. All these properties are used to decide on irrigation frequency, fertilizer application and other soil management practices.

Table 17 Soil class and texture analysis (in percent)

	Codes included in similar soil type	Sand	Silt	Clay	Soil type
1	2, 3, 5, 7, 8, 15 and 20	31.5	20	48.5	Clay loam
2	11, 12, 13 and 14	61	17	22	Sandy loam
3	10 and 17	77	3	20	Sandy loam
4	9, 16 and 23	67	11	22	Sandy loam
5	1, 4, 6, 18, 19, 21 and 22	23	18	59	Silty loam

Source: Soil Laboratory Analysis Results

Soils with the greatest capacity to retain water against the pull of gravity are characterized as high in clay. Loam soils have great capacity to hold available water; the amount of clay in the soil has a great influence on its total water holding capacity. Soils dominated by sand and silt are non-plastic, have low water retention capacity, rapid infiltration and low CEC. However, generally these soils have a good drainage and aeration. Soils dominated by clay and fine silt have a high CEC, high degree of aggregation, high water, air and nutrient holding capacity. The infiltration rates are lower than sand. In general loam, sandy clay, sand clay loam and clay are favorable textural classes for agricultural purpose, provided that their structure and consistence are favorable (MOA, 1995). Sandy soil mixed with other soil type dominates in most part of the study area and these soil textures refer to workability and permeability of soils (Russell, 1973). Soils of high percentage of sticky nature (clay) have permeability problem like the group with sample pits 1, 4, 6, 18, 19, 21 and 22 on table 17 and it has about 59 percent clay composition. While clay loam, sandy loam, sandy clay etc. as indicate with 9, 11, 12, 13 14, 16 and 23 on table 17 with about 61 percent and 67 percent sand and more than about 30% silt and clay gave moderate and good permeability. While sandy soil as shown by 10 and 17 is rapid permeability (Hudson, 1981). The samples shown by 2, 3, 5, 7, 8, 15 and 20 are the soil types that are locally known by Bae-kel found in the Agula-e shale nature as white clay soil.

4.2 Causes of Watershed Problems

The most serious land degradation problem associated with the land of the country in general and the study area in particular is the continuous removal of soil and rock material from the surface. A bunch of factors like intensive or torrential rain following the prolonged dry spell which has baked the surface and made it vulnerable to the attacks of rain drops, bareness of surface by removal of vegetation cover for domestic uses (fuel, construction, etc.) in case of forests and by over grazing on the dry lands (in case of grass), etc faulty cultivation method, continuous use of land for agriculture etc. Some of the causes of erosion in Tigray in general and the study area in particular are:

4.2.1 Removal of Vegetation Cover

The highlands of the study area were once covered with luxurious vegetation but centuries of continuous exploitation have turned it into almost barren plateaus of today. Forests and natural woodlands are now virtually confined to pockets of areas i.e., around churches and holly places, leaving the bare land exposed to erosive wind and rain (Sadler, 1997).

In almost all of Tigray, especially the eastern part, all the original forests have been removed for fuel wood, timber and cultivation. Further reduction of the vegetation occurs due to uncontrolled grazing. As a result, the soil is exposed, becoming susceptible to removal (Hunting, 1976). The first phase of erosion is detachment of soil particles by the direct impact of raindrops on to the ground. The rate of erosion is inversely affected by the amount of protective cover on the soil. Different sources and field observation show that the study area is highly degraded because of its inability to retain soil and water at their origin.

The local people realized that vegetation cover is reduced as compared to 40 years back. Their responses to the causes of its reduction vary; 38.35% of the sample population attributed the cause to the use of wood as construction material and for making different instruments; 27.40% ascribe it to the

expansion of farmlands; 23.29% assumed that it was because of the previous civil war. Only 6.85%, 2.74% and 1.37% of the sample population consider the causes of drought, the “Will of God” and charcoal making respectively (Table 18). According to the responses of the society, the land’s capability to feed man has greatly reduced after the drought of 1984/85.

Even the aerial photographs of 1965 and 1994 G.C. reveal wide variation in the vegetation cover the present natural forests seen in the churches and inaccessible areas were wider in expanse and denser in nature but today they have shrunk and/or totally removed. This is witnessed by local elders as they remember a time when the study area and surrounding hillsides contained more trees and vegetation cover, as back as 40 years. It was claimed that the process of deforestation started around 1960s when the land began to be used by a greater numbers and size of people. Trees were removed for clearing the land for cultivation as well as for fuel; their number declined as the population grew. The complete removal of all tree cover could not be precisely dated but its seriousness was felt at least 15 years ago.

Table 18 Personal on the Causes of vegetation removal

Causes	No.	Percent
The Will of God	2	2.74
Civil War	17	23.29
Expansion of farm land	20	27.40
Different purposes	28	38.35
Drought occurrences	5	6.85
Charcoal making	1	1.37

It is true that almost all of the people in the group discussion and 93.15% of the sample population in the study area have experienced the cutting of trees for different purposes, (those not involved are either house wives or church people or priests). The causes of cutting trees are varied as was also revealed by the personal responses of sample households. As much as 33.82% mentioned the

cause as house construction, and household and farm equipments, about 50% indicated used the purposes clearing of land for agriculture etc (as mentioned in the above). Only 8.82% mentioned the primary purposes as firewood. Those, who cut for firewood, it in the nearby town i.e., Wukro in the form of log, root or charcoal for their livelihood. During the Derg Regime, trees were cut during military operations to be used as firewood. The firewood is mostly harvested from Grahutsa and Enda Selassie Kushets because of their proximity to the town. In the rural firewood is not a serious problem because they use animal dung (locally called Akor/ Kubo) for their local consumption.

4.2.2 Human and Animal Pressure

The ever-increasing number of man in this planet especially in developing world is a great problem because it is beyond the natural capacity of the natural resources to fulfill his need. As we now by this time population growth in the world in general and the study area in particular in relation to the resources we have and the methods used is incompatible. The cause of depletion of natural resources is the increase of man and animal population and the consequent increased demand to use the finite natural resources without parallel increase of conservation activities has contributed to the diminishing of natural resources. As is revealed by table 18, in 1963 the average number of domestic animals for each person was 2.60; this means the population number as compared to the number of domestic animals they owned were less. By 1973 (after 10 years) due to the relatively greater increase in population the share of each person was reduced to 2.12. This decline in per individual holding of domestic animals continued declining because of continuous and greater increase in population than erratic pattern in animal population because of climatic vagaries.

The 1973/74 and 1984/85 droughts have greater impact on the number of domestic animals, the people considered the 1984/85 drought as a major catastrophe and described that life had vastly diminished.

Table 19 Human and animal population trends through years

Year	Persons	% Increase	No. of domestic animals	% Increase	Ratio (man: animal)
1963	57	----	148	----	1:2.60
1973	121	112.28	256	72.97	1:2.12
1983	216	78.51	266	3.91	1:1.23
1993	322	49.07	194	-27.07	1:0.60
2000	446	38.51	214	10.31	1:0.48

Due to the increase in human and animal population man has used steep slopes for grazing and/ or for cultivation, neighboring farm plots have even encroached upon the areas enclosed for grazing. The increase of domestic animals in a shrinking grazing land has contributed overgrazing of grazing lands and the upper catchment (Table 19). As a result the soil is exposed, becoming susceptible to erosion.

4.2.3 Topography

As is seen in section 4.1 and photo 1-2, the study area is with a rugged topography and a high proportion is steeply sloping lands. It is evident that erosion is high in the steeper topography because the rate at which soil particles are eroded is mainly affected by the steepness of the slope (Sadler, 1997). In Tigray about 60 percent of the plateau areas are considered unsuitable for cultivation, with slopes averaging over 30 per cent; but 40 per cent of the present cultivated lands are found in this segment (Hunting, 1976). A larger portion of uncultivated steep lands are devoid of vegetation cover. This combination of steep slopes and lack of vegetation cover causes accelerated erosion.

In addition to the bare and steep surfaces, rock types also matter. The rugged upper catchment is dominated by sandstone topography with limestone formation at its foot. Most of the rugged land is highly affected due to the almost soil less topography of the sandstone. It is here that the problems are more acute as about 46.57% of the respondents consider that natural vegetation and natural spring problems occur on sand stone surfaces followed by areas of Trappean lava formations with (39.73%) response of the respondents.

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4.2.4 Roads and Trails/ footpaths

Road construction, and man and animal trails are also creating untold problems. Serious erosion is caused at many places by surface runoff concentrated along trails traced by domestic animals or man made roads, which runs off at high velocity creating gullying (Hunting, 1976). Roads and trails cause almost all of the smaller gullies; examples are observed on the two sides of Mekelle-Wukro and Wukro-Atsbi roads. Because of this problem, Wukro-Atsbi road that is located in the upper catchment of the study area, there is a shift of the road to another side but even the new one is also under such problem. In addition to its being steep slope, the less resistance nature of the Adigrat sandstone is more prone to erosion.

4.2.5 Rainfall intensity

Rainfall in the study area is concentrated in a three months period, often with high intensities of individual storm occurrences. These intensive rainfalls, which follow a longer dry spell, can dangerously aggravate soil erosion (Sadler, 1997). According to the rainfall records obtained from 1973 to 1999 in Wukro town (table 5), high proportion, (mostly between 50 and 85% in different years), of the rainfall comes in the three rainy summer months, i.e. June, July and August or September (with still greater concentration in only two months, July and August). For example, the three summer months recorded 52.4, 70.4, 82.6, 82.9, 86.2, 87.5, and 87.9% of the annual rain of corresponding years of 1993, 1976, 1975, 1995, 1974 and 1994, out of which respective shares of two months were 97%, 86.25%, 77.8%, 79.8%, 93.05%, 86.3% and 79.4%. This shows such a concentration results in high torrential runoff which remove much more loose materials

4.2.6 Improper use of Land and Vegetation

The improper practices of cultivation such as up and down ploughing transverse to the contour, overgrazing, over cultivation and high use of vegetation in the

study area has a long history. In addition to the high human and animal population, steeper slopes are being used for agriculture with poor management. Centuries of continuous exploitation have turned it into the almost barren plateaus of today.

Table 20 Results of ploughing observation

Conditions		Observations	
		Figure	Percent
Plough	Up and down	33	67.35
	Following contour	16	32.65
Terraces	Fully damaged	37	75.51
	Partly damaged	12	24.49
	Undamaged	0	0
Boundaries	Less than 50 cm	49	100.00
	Greater than 50 cm	0	0
Total		49	100.00

Source: Field survey

The direction of ploughing in relation to the slope of the land; the length of slope left unprotected at the beginning of the rains and during fallow periods; the breakdown of the soil structure by repetitive ploughing, etc affect the velocity at which rainfall will runoff and the quantity of soil that will be transported (Hunting, 1976). From the straight line 750 meters walking survey with 4 – 7 degree slope, about 67.35 percent of the farm plots were ploughed with ups and down only 32.65 percent follow contour line. About 75.51 percent of the farm plots with an old terrace structures are damaged while the rest are partially damaged but not maintained, even encroached through the plough of neighboring farm plots; according to the group discussion the reason for the ups and down plough is due to the accustomed plough of a plot almost perpendicular to the pervious plough, this means the 32.65 percent farm plots mentioned earlier will be ploughed transverse to the contour. All (100 percent) of the farm plot boundaries are not enough even for walking, let alone to be wide enough for

growing of grass for protecting sheet and rill erosion, the other way round around each boundary rill and sheet are magnified especially in newly germinated crops (table 20).

4.2.7 Mining and Quarrying

As is already mentioned on section 3.2, limestone formations are enormous with a whitish color. The limestone formation, which is found at the foot of the upper catchment, also gives a way for quarrying of stones and/or lime production for building construction. The local community is engaged in producing lime for house paints since long by using the two most important raw materials limestone and firewood (photo 3). The firewood, which is useful in lime production, requires a special plant species most preferably Seraw that lasts longer. As an indigenous plant it is also important for sustainable environment. There are eight officially licensed production sites that produce lime on an average once in two weeks. For each production process a site needs about 80 donkey loads of wood, (locally estimated as 60 kilos each). It means $8 \text{ (sites)} \times 80 \text{ (donkey carries)} \times 60 \text{ kg (weight each)} = 38,400 \text{ kg}$ of firewood of specific plant species is consumed every two weeks or 76,800 kg a month or 768,000 kg a year (excluding the two summer months). Every mature Seraw plant is assumed to produce 30 kg of wood with good for being used. Thus, as many as 2,560 trees are cut every month or 25,600 trees every year for this operation. Based on table 29, averagely 61 trees are found in one 900 square meter plot means 678 trees are found in one hectare; every year about 37.7 ha of such woodland is cleared without any replacement. The growths are generally natural. Under the deteriorated environment the natural growth may not match with the requirements so the axes are to fall on immature trees as well which will effect their heat efficiency and in time to come the community engaged in this occupation might have to embark up on lesser efficient trees. It is sure to accelerate the rate of deterioration of vegetation/ forest cover. The other raw material i.e., the limestone which being quarried since long, is changing the

surface configuration of the area concerned and making the rock more vulnerable to erosive agents.

Other segments involved with quarrying limestone is the production of blocks and chips of stone for construction of modern structures based on cement and stones/ bricks which is followed by runoff.

4.2.8 Geology and Soil type

Most part of the study area is with a sandstone formation especially in the upper catchment, where it produces a sandy soil that is highly prone to erosion. In this fragile landform with a steep slope and devoid of vegetation the removal of soil is aggravated. Equally this fragile is the landform in the lower catchment where it has developed transported materials mostly from Agula-e shale and limestone (yet to be consolidated) and is dominated by gully formations. It is also characterized by frequent flooding of farm plots.

4.3 Impacts of the Watershed problem

Low vegetative cover especially during erosive rainfall periods, leads to higher rates of erosion. High erosion then very thin layer of top soil and limited recycling of organic matter, limit the moisture holding capacity of the soil, which in turn reduces the ability of plants to utilize the nutrients that are available. Poor soil moisture and nutrient conditions lead to poor plant growth. Reduced availability of crop residues restricts the recycling of organic matter into the soil. Thus the vicious circle of erosion, low organic matter content, low soil moisture, and poor soil and plant nutrition continues, contributing to worsening land degradation, reducing productivity and increasing poverty (Pender et al, 1999). In most part of Tigray the amount of rainfall is not sufficient to sustain even one normal crop growth a year. Under average conditions and presuming the moisture deficit is uniformly distributed over the growing season, yields will be 45% below potential (section 4.1.3). The problem is, of course, much worse in years of poor rainfalls and where soil is thin and degraded. The implications of

all these processes are lower and less reliable crop yields, reduced grazing and browsing for livestock, decrease in availability of fuel wood, decrease in soil water holding capacity, declining dry season water flow and thereby low irrigation possibility, problem of even drinking water for man and animals in dry months and a decrease in the potential for sustained crop production. Crop production in most parts of Tigray does not reach the subsistence level. The situation is worse in the eastern zone, where the study area is found, as the zone is more severely affected by drought and moisture stress.

4.3.1. Gully Development and Soil Erosion

The removal of vegetation and overuse of the land, are realized by the peasant community as causes of land degradation. On many steep hillsides tree cover is scant (photo 4 - 5). Similarly the growth rates of fodder grasses and shrubs are inhibited by lack of moisture, soil depth and fertility. Gullies in the study area are common and they are of two types

- i. Naturally formed gullies, which have developed beyond human time scale i.e., geological time scale since the landform has occurred. It is very wide and deep and mostly they are found in the upper catchments as natural valleys i.e., structural landform. Although there are valleys of massive depth and width, large proportion is formed by natural erosion, largely either on weaker part of the massive sedimentary layers or the junction of two different resistant rocks and become as a point of weakness; as in the Grahutsa gully, where the Adigrat sandstone lies in the southern part and the Trappean Lava on the northern.
- ii. Gullies formed in the human time scale (see photo 6) i.e., those developed by erosion in human history through his interference directly or indirectly with nature.

Concerning the understanding of the sample population for reasons of erosion, about 94.52% of accepted that it is due to deforestation. About 4.11% accepted it as "Will of God". Improper farming method i.e., ploughing transverse to the

contour was given as reason only by 1.37% of the total. As to the major consequences of the land problem in the environment: low soil fertility was accounted for by about 16.44% of the respondents of which was higher amongst from Grahutsa (41.67%) and Enda Selassie (33.33%). Soil erosion was expressed as a major consequence by 45.57% of the respondents, where samples from Korir and Enda Selassie accounted for 44.12% and 32.35% (table 21). In the above two Kushets, it is because of the wider coverage of sandstone landforms. According to the group discussions, insufficient rainfall was expressed as serious problem but the responses to the questionnaires accounted only for 30.14%, a problem next to soil erosion. Further, from the group discussion, it was also gathered that local people considered rainfall problem as normal problem and then soil loss is considered as a serious thing. About 6.85% of the community considers all problems are of equal magnitude.

Table 21 Main causes of depletion of water

Causes	Korir	Enda Selassie	Grahutsa	Total
Soil fertility Depletion	3 (10.72%)	4 (15.38%)	5 (26.32%)	12 (16.44%)
Soil erosion	15 (53.57%)	11 (42.31%)	8 (42.10%)	34 (45.57%)
Low rainfall	8 (28.57%)	9 (34.62%)	5 (26.32%)	22 (30.14%)
Other*	2 (7.14%)	2 (7.69%)	1 (5.26%)	5 (6.85%)

* All and deforestation

By the help of the Universal Soil Loss Equation (USLE) (FAO, 1966; Lundberg et al, 1995) adapted for Ethiopia in relation to the parameters, some rough soil loss of the study area can be calculated. It is clear to see its seriousness in the soil erosion problem by this equation i.e., $A = R.K.L.S.C.P$, the result gives tons/ha/year. A is the average annual soil loss in tons per unit area; R is rainfall factor, which express the capacity of the locally expected rainfall to erode soil from an unprotected field; K is soil erodibility factor; L is length of slope factor; S is steepness of slope factor; C cropping and management factor; P is supporting conservation practice factor (terracing, strip-cropping, contouring).

Table 22 The Universal Soil Loss Equation adapted for Ethiopia

R: Rainfall Erosivity									
Annual rainfall	100	200	400	800	1200	1600	2000	2400	
Annual factor R	48	104	217	441	666	890	1115	1340	
K: Soil Erodibility									
Soil Color	Black		Brown		Red		Yellow		
Factor K	0.15		0.20		0.25		0.30		
L: Slope Length									
Length (m)	5	10	20	40	80	160	240	320	
Factor L	0.5	0.7	1.0	1.4	1.9	2.7	3.2	3.8	
S: Slope Gradient									
Slope (%)	5	10	15	20	30	40	50	60	
Factor S	0.4	1.0	1.6	2.2	3.0	3.8	4.3	4.8	
C: Land Cover									
Dense forest	0.001			Dense grass			0.01		
Other forest	0.01-0.05			Degraded grass			0.05		
Badlands hard	0.05			Fallow hard			0.05		
Badlands soft	0.40			Fallow ploughed			0.06		
Sorghum, maize	0.10			Ethiopian Teff			0.25		
Cereals, pulses	0.15			Continuous fallow			1.00		
P: Management Factor									
Ploughing up and down	1.0			Ploughing on contour			0.9		
Strip cropping	0.8			Intercropping			0.8		
Applying mulch	0.6			Dense Intercropping			0.7		
Stone cover 80%	0.5			Stone cover 40%			0.8		

Source: Lundberg et al, 1995

It is better to take two average sites from the lower and upper catchments i.e., 15 and 20 degrees similarly 26.8 and 36.4 percent slopes with average rain of 600 mm (Table 22). Considering 20 degree or 36.4% slope its soil loss is calculated as 54.88378 tons of soil per hectare per year from the upper catchment, while from the lower catchment with 15 degree or 26.8% slope 42.88186 tons of soil per hectare per year is lost. When we see the total loss of

soil from the study area with a 2092.69 m altitude boundary; 53.56% (19.89 square km equals 1989.75 ha) of the study area is above 2092.69 m altitude 109,205.0 tons/ year from the upper catchment. 46.44% (17.25 square km equals 1725.24 ha) of the study area is below 2092.69 altitude 73,981.5 tons/ year. The total soil loss in the study area is 183,186.5 tons/ year.

Table 23 Aggregate gully parameters in the Study Area

Name of the gully	Length (m)	Av. Width (m)	Av. Depth (m)	Area of Channel (m ²)	Volume (m ³)
Grahutsa	2487.95	10.98	1.66	27,314.66	48,667.9
Wukro-Atsbi Road (1)	185.00	2.35	1.66	433.88	741.24
(2)	275.00	7.17	2.89	1970.63	6817.4
Grahutsa Medhane Alem	420.00	3.98	1.88	1670.50	3175.1
Dombosko	92.50	5.87	3.17	543.0	1697.5
Enda Selassie	1465.0	11.40	2.14	16707.88	39400.4
Korir (below the Dam)	2774.70	13.69	2.02	37985.64	76,731.0
D/t gullies b/n Korir dam and Adimeskel	1705	2.75	0.89	4679.75	4164.7
Below Adimeskel bridge	450	1.05	0.65	472.5	307.1
B/n Enda Selassie and Korir	350	0.95	1.20	332.5	399.00
Korir above the dam (left)	3000	21.03	2.93	63077.75	184503
Korir above the dam (right)	900	3.697	0.76	3327.5	2528.7
Adimeskel *	1076.60	3.28	0.71	3525.73	2724.99
G. Total	15181.7	10.67	2.29	162,041.92	371,858

* *Discontinuous Gully; source: Field Measurement*

Gullies occupy significant proportion of the study area, which means 16.2 hectares (0.44 percentage) of the study area (Table 23). According to the UN classification (FAO, 1986) of gullies based on different characteristics almost all the gullies except Adimeskel are classified under the medium gully class with a depth between 1.38 and 3.17 meters and larger catchment area. As it is seen on table 23, the three longest gullies (Grahutsa, Enda Selassie, and Korir with a lengths of 2488, 1465, and 5774.70 meters respectively) are classified to this type.

Frequent slumping during rain and flooding occurs in Grahutsa, Enda Selassie and Korir (above the dam i.e., in the left side) gullies because of the sandy nature of the soil. From a four-day continuous field observation, it was learnt that frequency of slumping on the gullies after rains are high in the three deep and wide gullies mainly in Grahutsa and Enda Selassie (table 24). In case of Korir Gully which above the earth dam is almost treated, the frequency of slumping and flooding down is very much limited unless the rain is extremely high. The gully below the earth dam is almost stagnant as size and form devoid of flooding because of the earth dam except of the confluence with the Enda Selassie gully.

During rainy season slumping on the sides of gullies are very common in the study area. For instance, as many as 62 slumping (collapse) are observed on four days of observations on the four main continuous gullies (table 24). Out of that 41.94 percent occurred along the Grahutsa, followed by 35.48 percent along the Enda Selassie and 19.35 percent along Korir above the Dam. Down ward from the dam the phenomena was minimum i.e., only 3.22 percent. The difference here is the treatment of the upper catchment (above the earth dam), here is also a difference on the vegetated sides of the gully i.e., higher in the bare land above the dam and low in the grass covered areas below the dam.

Table 24 Landslide and collapse observations in the main gullies of the study area

Name of the Gully	Frequency of slumping per days				Total (percent)
	1 st	2 nd	3 rd	4 th	
GH	6	5	7	8	26 (41.94.)
ES	5	4	7	6	22 (35.48)
KA	3	2	3	4	12 (19.35)
KB	0	0	1	1	2 (3.23)
Total	14 (22.57)	11(17.74)	18 (29.03)	19 (30.65)	62 (100.00)

Where GH is Grahutsa, ES is Enda Selassie, KA Korir above the earth dam and KB Korir below the earth dam. Source: Field Observation (20/11 – 14/12/92 E.C.)

Field experiences also speak of frequent soil erosion in every corner of the study area by the removed vegetation cover, rugged topography, loose soil, high rainfall intensity, etc. From the group discussions and the administered questionnaires, it was found that there is shrinkage of cultivated and grazing land due to development gullies, shortage of surface and underground water due to declining rainfall, removal and reduction in the yields of crops. Thus, all these are presenting a complex problem in the area.

4.3.2. Silt and cut of Earth dams

The serious damage of the study area by the highly degraded upper catchment, which is open and bare land for an observer. It is evident that raindrops start running into the lower catchment with no time to stay there. This situation created fifteen to twenty years Ato Gebre Ezghi from Enda Selassie Kushet said that “the gully, the Grahutsa, started to cut below the Atsbi-Wukro road after 1986 G.C. then over flooded and cut the two earth dams constructed after the 1984/85 Great Ethiopian drought.” The Grahutsa dam, which is located near to the Wukro town is silted and lastly cut by the gully while the Enda Selassie dam is found at the boarder of the two Kushets on the channel of the Grahutsa gully. Then the gully is deep below the base of the earth dam.

4.3.3. Declining yield of crops and food insecurity

The losses of topsoil, soil fertility depletion, reduction in available soil moisture and gullying have their effect on the capability of the land to grow food, fodder and trees. About 93.15% (which comprises 100% of Enda Selassie, 94.74% of Grahutsa and 85.71% of Korir) of the sample population accepted that natural agricultural yield has reduced while 6.85% didn't accept this, i.e., 14.29% of Korir and 5.26% of Grahutsa, by saying that agricultural yield reduction is a problem mainly due to rainfall insufficiency. In the group discussion almost all the participants agreed that natural yield is reduced but it might not be a problem if rain is normal. The presence of the earth dam in Korir, which they

use the whole year for cultivation, might be factor for them to say crop yield is not reduced.

Although there is difference on opinions among the farmers concerning reduction in agricultural production, the insufficiency of annual production was responded by 100% of the sample population. The causes according to the group discussion were expressed as less and insufficient rainfall, low soil fertility, etc. To overcome the insufficiency of food all the family members, etc are engaged as in daily laborers in activities like conservation programs, building construction to get additional income.

4.3.4. Problems of Grazing Land

Previously there were three grazing lands in the lower catchments in the three Kushets of the study area covering sufficient areas. In one way or another they are now reduced significantly especially in Grahutsa and Enda Selassie Kushets, due to shortage of agricultural land. Although community grazing land is a serious matter, by-and-by boundaries are pushed in ward by the farmers of the surrounding farm lands. According to the group discussion “it is the effect of a long process but most of the push is attributed to the frequent famine and drought i.e., by this time land is no more with a green mantle especially the grazing land because this is the time every body gives attention to his green community grazing land” means the nearby farmers push the grazing land during dry season. Gully development is also a problem in all community grazing lands. In Grahutsa and Enda Selassie it is being encroached the sideways and in Korir, there were two gullies which used to cut the grazing lands. At present the community grazing land of Korir is occupied by the reservoir and they are complaining about it. It occupies about 40 hectare of land excluding the farm plots enclosed it.

4.3.5. Farmland Problems

Erosion:- Soil erosion is a serious problem in the study area especially on farm plots, which is expanding in one way and shrinking in the other, a fast frequently observed on farm plots of 97.26% of the sample households (100% in Grahutsa, 96.43% in Korir and 96.15% in Enda Selassie Kushets). Thus, the farm plots only 2.74% of the sample population are not affected by soil erosion. There is no more fallow in the study area because they use crop rotation instead of fallowing; the fallows seen during the field survey were awaiting the sowing of the crops later. The rotations with leguminous crops like chickpeas, peas, etc. are most favored because they are considered as good in regaining soils fertility as the system of fallowing.

In Korir below the earth dam there were 115 farm plots within 100 meters of the gully sides assessed about the type of land use and pattern of erosion. It was observed that 87 (75.65%) farms were not affected by any sort of erosion. Parts of the farms were occupied by barley and wheat, teff and fallow. There were 17 (14.78%) plots showing slight affect of sheet erosion especially on teff farms (up to two weeks from the time it was germinated). The remaining 9.57% appeared to be slightly affected by rills, this is also mainly on teff farms (table 25). In Korir the soil erosion and flooding problem was less because of the earth dam above and the farm boundary development below the dam.

Table 25 Korir Gully below the Dam farm plot assessment of erosion problems 100m on the sides of the gully

	Teff	Millet	B. & W.	Fallow	Vegetable	Flax	M. & S.	Uncultd	Total
Gully	---	---	---	---	---	---	---	---	---
Rill	5	---	2	---	2	---	2	---	11 (9.57)
Sheet	13	1	2	---	---	---	---	1	17 (14.78)
Not affected	22	8	26	15	7	3	3	3	87 (75.65)
Overflooded	---	---	---	---	---	---	---	---	---
Total	40	9	30	15	9	3	5	4	115 (100)

Source: Field Measurement

Where B. & W. is barley and wheat, M. &S. is maize and sorghum and uncultd is uncultivated.

The other site selected was in Adimeskel Gully area lying in the lower catchments in Grahutsa Kushet. The soil of this site is dark clay. The problem is slightly less intensified because of the discontinuous nature of the gully. Here out of the 88 plots selected 53 (60.23%) mostly occupied by wheat and barley (52.8%) and fallow (34%), were not affected, which are more resistance to erosion; farm plots affected by gully account for 18. 18% of the total, which is mainly occupied by barley and wheat crops followed by teff; 15.91% of the farm plots were affected by sheet erosion mainly on teff, and barley and wheat fields; farm plot affected by rill accounts for 4.54% which is mainly on the plots devoted to cultivation of Teff (Table 26).

Table 26 Adimeskel Gully farm plot assessment of erosion problems 100m on the sides of the gully

	Teff	Millet	Barley & wheat	Fallow	Uncultivated	Total
Gully	6 (37.5)	---	9 (56.25)	1 (6.25)	---	16 (18.18)
Rill	3 (75.0)	---	1 (25.0)	---	---	4 (4.54)
Sheet	8 (57.14)	---	5 (35.72)	1 (7.14)	---	14 (15.91)
Not affected	7 (13.2)	---	28 (52.8)	18 (34.0)		53 (60.23)
Overflooded	---	---	---	1 (100.0)	---	1 (1.14)
Total	24 (27.27)	---	43 (48.86)	21 (23.87)	---	88

Source: Field Measurement

The two Kushets (Grahutsa and Enda Selassie) have similar soil and other natural conditions but somewhat different from Korir. The observations were taken 362 plots lying within 100 meters on the two sides of the gullies like Korir about 24.31% of the farm plots were affected by these gullies, mostly covered by barley and wheat followed by teff and millet fields; rill affected farm plots account for about 6.63% all of which were devoted to teff; sheet erosion accounted for 12.71% of the farm plots mainly occupied by crop of teff. Even flooding which has negligible effect in Korir, affected 7.73% of the plots. The unaffected plots accounted for only 48.62%, which were mostly under wheat and barley, millet crops and fallow (table 27).

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Overflooded	---	---	---	1 (100.0)	---	1 (1.14)
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Table 27 Soil erosion problem assessment on farm plots within 100m on the sides of the Grahutsa and Enda Selassie Gully

	Teff	Millet	B. & W.	M. & S.	Abandoned	Fallow	Total
Gully	28 (31.82)	18 (20.45)	34 (38.64)	6 (6.82)	2 (2.27)	---	88 (24.31)
Rill	24 (100.0)	---	---	---	---	---	24 (6.63)
Sheet	34 (73.92)	2 (4.35)	4 (8.69)	2 (4.35)	---	4 (8.69)	46 (12.71)
Not affected	22 (12.5)	40 (22.7)	58 (33.0)	16 (9.1)	6 (3.4)	34 (19.3)	176 (48.62)
Overflooded	2 (7.14)	4 (14.29)	2 (7.14)	---	14 (50.0)	6 (21.43)	28 (7.73)
Total	110 (30.39)	64 (17.68)	98 (27.07)	24 (6.63)	22 (6.08)	44(12.15)	362 (100)

Source: Field Measurement

Where B. & W. is barley and wheat and M. & S. is maize and sorghum.

Increase of gravel: In the farm plots of highlands, the stoniness of soil is invariably expected. To assess the deterioration the responses obtained from sample population were sensitized. Overwhelming proportion (94.52%) replied that the level of stoniness has increased with time on their farm plots, which spatially varied from all the respondents (100%) of Grahutsa and Korir to 84.62% samples of Enda Selassie Kushets. Only 5.48% of the respondents didn't indicate increase of stoniness on their farm plots, all of which belongs to Enda Selassie Kushet. This higher figure in Grahutsa and Korir is attributed to the high coverage of land by limestone, (Agula-e Shale) and/ or greater over flooding of their farm plots by the gullies. In Enda Selassie the exposures of limestones around farm plots are smaller and the deep gully doesn't affect the farm plots sideways through over flooding.

It can be added from Table 13 that mostly observed on rised landform as a hill mainly on the lower catchments and the limestone formation around the foothills of Enda Selassie and Korir. For example, 20 and 21 sample pits are taken around the Korir earth dam where high concentration of boulders is found. The same thing on 2, 3, 7 and 8 are areas of Bae-kel soil formation, where the level of stoniness is higher. Others on the upper catchment there are but lesser amount of stoniness due to the eroded sandstone formation. Where gravelly, stony,

bouldery or rocky conditions in the plough - zone significantly affected the agricultural properties of the soil, that is they are sufficiently severe to hinder or prevent cultivation (Hudson, 1981).

4.3.6. Shortage of Fuel Wood and other Forest products

In the data gathering process all of the sample population agreed the reduction of natural vegetation. According to the group discussion conducted in the field all agreed that vegetation removal is not the priority of rural folks as source of firewood for the rural people unless they are to sell it in the nearby towns. Shortage of firewood was indicated by 30.13% of respondents, invariably involved in selling for making living or those who have no domestic animals at home to get the dung. Vegetation depletion is considered as a cause for soil erosion by 32.88% of the sample population (mainly from Grahutsa); 8.22% accepted it as a cause for the shortage of construction wood; and 2.74% as a cause for the loss of streams and spring water. But 26.03% considered it as a cause for all problems occurring these days.

Wukro town is the driving cause for most of the firewood removals from different parts of the study area because it is the major source of domestic energy as well as the limekilns. The results of a ten days survey of the firewood supply from two main gates Atsbi and Mekele only to Wukro town shows that about 37,018 kgs of parts of trees are supplied for fuel (only excluding wood for construction or other purposes) (table 28). In this occupation both sexes of people, apart from donkey and carts are involved especially as carriers of tree branches, charcoal and cow dung women are the most dominant. As means of transport donkeys are highly used carrying, 66.91% of the total weights of fuel material. The contribution of cow dung (22.26% of the total weight) also is a significant, which is the second to firewood only. Firewood accounts for 68.16% of the energy sources by weight entering into Wukro town. The other sources together account less than 10% of the energy sources by weight.

Table 28 Ten days survey for fuel energy supply to Wukro town in two main gates (Mekelle and Atsbi) from the study area (11— 20/ 06/ 93)

Means	Firewood	Tree branches	Plant root	Charcoal	Cow dung	Total
Men	340 kg	520 kg				860 (1.81)
Women	40 kg	1780 kg		645 kg	10,6000 kg	13,065 (27.44)
Children	216 kg	912 kg		105 kg		1233 (2.59)
Donkey	31,860 kg					31,860 (66.91)
Cart			600 kg			600 (1.26%)
Total (kg)	32,456 (68.16%)	3,212 (6.75%)	600 (1.26%)	750 (1.57%)	10,600 (22.26%)	47,618 (100%)

Source: Field Survey

As can be seen from the table 29 five survey sites (three from uncultivated and two from cultivated areas) each 900 m² (30 m by 30 m) are taken for observation as to what has happened in this environment. Mostly treatment is in the steep slopes (16 – 27 degrees) while in the cultivated land (with low slope i.e., about 2 degrees) treatment is with a trench bund to control moisture and soil run off. Treated sites with follow up have well structured terraces (table 29) but in the untreated sites either they are almost damaged or no terrace, while in the farm plots, the farmers liked it but opposed its construction on the farm they own due to their smaller holding. It can be substantiated by damaging and/or ploughing the margins of the trench bunds in the fields.

There are more vegetation remnants, especially on the uncultivated part with the smaller plant (locally called Siwa Kerni) i.e., 2 – 4 plants in each square meter, that could help in minimizing run off but treatments and follow ups are almost nil. In each sites especially on the uncultivated there are 37 SERAW plants in B site to 76 in C site on the uncultivated while 9 – 12 in the cultivated (table 29). There is acacia in the treated with follow up while Kle-aw is found in the uncultivated with less follow up. This gives a bit of clue in encouraging the enclosure of area for indigenous plant species rather than investing large amount of money and labour in introducing new/ exotic plant species. Further,

the indigenous species are advantageous for their climatic adaptability to the uncertain weather, and faster rehabilitation.

Gullies, rill, sheet and dugouts are highly observed in all untreated parts of the study area especially the steeply uncultivated areas, no gully (on the site indicated by D) formation around the earth dam because of the treated part of its catchment and smaller rills and sheets in the site indicated by E on table 29. Stoniness (tables 13 and 29) is very high at all sites except in the cultivated without any treatment because it is in the lower catchments of the Enda Selassie Kushet. The plant (grass) usage in the treated part is in the form of a cut and carry system.

Table 29 Vegetation cover analysis

Sites	A (Korir)	B (Korir)	C (Ad)	D (sw of the dam)	E (Enda Selassie)
General slope	16°	27°	17°	<2°	2½°
Terraces	4	0	4	2	0
Vegetation Type	Seraw – 69	37	76	12	9
	Kle-aw – 5	2	0	0	0
	Acacia – 0	0	37	0	0
	Siwa kerni 4/ m ²	2/ m ²	3/ m ²	<1/ m ²	<1/ m ²
Gullies	2	3 + many dugouts	2	No *	Smaller rill and sheet
Stoniness	High	High	High	High	Medium

Source: Field Survey

Where A stands for treated but no follow up, B stands for untreated site and C refers for treated site with frequent follow up, Ad is Adimeskel, D and E stands on cultivated land with and without trench bund respectively.

Due to the depletion of plant cover in the study area the time needed to collect firewood went on increasing. For example, in 1963 about 85.71% of the sample population, engaged in collection of fire wood required less than 30 minutes to collect firewood but it reduced to 51.52% by 1973 and only 4.11% by 2000. On the other hand none of the persons engaged in firewood collection required >60 minutes in 1963 but by 1973 some 3.03% of persons required >60 minutes. The

proportion went on increasing reaching to 91.73% by 2000 when the proportion of wood collectors requiring <30 minutes and 30 – 60 minute reduced to 4.11% each (Table 30).

Table 30 Time taken to fetch wood

	Time taken to fetch wood (minutes)			
	Less than 30	30 – 60	More than 60	Total
1963	42 (85.71)	7 (14.29)	-	49 (100.00)
1973	34 (51.52)	30 (45.45)	2 (3.03)	66 (100.00)
1983	7 (9.72)	51 (70.83)	14 (19.44)	72 (100.00)
1993	4 (5.48)	10 (13.70)	59 (80.82)	73 (100.00)
2000	3 (4.11)	3 (4.11)	67 (91.78)	73 (100.00)

Source: Questionnaire

4.3.7. Hydrological problems and Drought Occurrence

As is seen from section 3.5, in addition to the environmental problems, rainfall amount is fluctuating and the reliability of rain is decreasing from time to time. Concerning the status of ground water and nature of rainfall amount in the past 30 years about 86.3% of the total sample population, (84.21% of Grahutsa, 85.71% of Korir and 88.46% of Enda Selassie), answered that it is reduced now. The rest of the community i.e., 13.70% in general didn't agree probably because of the accessibility to spring water and the earth dam. The population of Korir uses the water from the earth dam for their domestic uses and animals as well as for irrigation. Not only the rainwater and ground water but also the surface moisture is very much reduced as was supported by 97.26% of the sample population, (100% of Grahutsa and Enda Selassie, and 92.86% of Korir). Those who derived the reduction of surface moisture are all from Korir reason is reduced this is due to the construction of the Korir earth dam, which allows them to harvest more than once a year. According to their perception of the causes for soil moisture reduction 57.14% attributed it to the reduction of ground

water, 28.57% to the lesser rainfall, 12.70% to deforestation and which causes faster runoff resulting in flooding. Only 1.59% showed their ignorance.

In addition to the reduction of rainfall, its fluctuation from time to time is also a problem (table 14), even the distribution in seasons is also very erratic. All of the sample population accepted that the annual and seasonal distribution in the study area is not enough for even one harvest. There are frequent drought occurrences in the Eastern Tigray, especially in the study area, their perception of the reasons according to the respondents from the local community are: deforestation (64.38%); will of God (21.92%); by man (20.55%) and weather disturbance (1.37%).

Table 31 Trends in time taken to fetch water

Time	Frequency of persons			
	< 30'	30 – 60'	>60'	Total
1963	30 (61.22%)	9 (18.37%)	10 (20.41%)	49
1973	33 (50%)	16 (24.24%)	17 (25.76%)	66
1983	22 (30.99%)	24 (33.80%)	25(34.21%)	71
1993	22 (30.14%)	14 (19.18%)	37 (50.68%)	73
2000	22 (30.14%)	12 (16.44%)	39 (53.42%)	73

Source: Questionnaire

As will be seen in section 6.3.3 there are some developments work on water resources in the study area through the watershed management practices. But magnitude of such hydrological management is very minor because the local communities are still suffering for want of water mainly i.e., Grahutsa and Enda Selassie. Around 1963, 61.22% of the sample population required less than 30 minutes to fetch water from natural water sources. Of which, more than half of the sample population is from Korir where the spring water still exists. The proportion was becoming changed into 50% around 1973 but this number declined into 30.14% afterwards. The proportion of those who required from 30 to 60 minutes to fetch water account 18.37%, 24.24%, 33.33%, 19.18% and 16.44% in 1963, 1973, 1983, 1993 and 2000 respectively, this means after 1973

there was an increase of people who need more time to fetch water as compared to these who need less than 30 minutes. It was only 20.41% by 1963 who required more than 60 minutes to fetch water but the proportion increases from time to time i.e., it become 25.76% after ten years (1973), 34.72% by 1983, 50.68% by 1993 and at present (2000) it is 53.42%. In the water supply it was required less than 30 minutes for most of the population of the study area before 30 years. The greater proportion changed into 30 – 60 minutes, more over after the decline of 1984 rain and 1984/85 drought more than half of the population requires more than an hour to fetch water (refer table 31).

CHAPTER FIVE

COMMUNITY PERCEPTION, ROLE AND MOBILIZATION IN LAND MANAGEMENT

Community involvement in any conservation work is efficient and cheaper than any other measures. The efforts made by the community in constructing conservation structures in Tigray Region using the mass mobilization approach are phenomenal. The Tigray Regional State and particularly, the Tigray Agricultural Bureau has provided critical catalytic and technical support in the process. If one calculates the opportunity cost of this effort in economic terms, this investment in conservation would run in to millions of Birrs. Such investment has continued in spite of general social and economic disruptions of production activities. The latest data show that these conservation efforts are beginning to show results in terms of increasing production and vegetative cover in the Region. However, many reports and papers prepared by the Regional Agricultural Bureau and other agencies indicate that potential for agricultural production is limited due to small land holdings and their fragmentation. These papers also indicate that there would be further degradation of the land resources and deterioration in environment if agricultural production is intensified (Shah, 1997).

5.1 Community Perception on Land Problems

Community awareness on land degradation problem in Ethiopia and elsewhere has been enhanced through the help of various national and international initiatives in the last decades or so. The expansion of activities in conservation indicate the growing awareness of the problem but the limited coverage of such activities and their narrow focus suggest that proper understanding of the problem, processes and solutions of soil degradation, as well as its severity is still lacking in most sections of government. From the study of the EHRS (1986) concerning community awareness of the degradation problem, 89% of the sample

population indicated that land was being degraded, while 79% of them replied that the rate of degradation was already serious and still accelerating. Over 75% of them thought that people needed to be made more aware of the problem. Farmers' present awareness reflects recognition of the symptoms such as declining crop yields, scarcity of livestock feed, fuel wood, water, extension of gullies, etc. Farmers showed little understanding of the underlying causes but expressed their willingness to learn about solutions. In proposing priority actions for further conservation and increased peasant participation, educating the community was considered as most important by 40% of the respondents followed by the provision of food for work (21%), material aid (13%), and demonstrations (17%).

Table 32 Personal judgments about tree cutting

Judgments	Korir	Enda Selassie	Grahutsa	Total
Yes right	4 (14.29%)	4 (15.38%)	3 (15.79%)	11 (15.07%)
Not right	24 (85.71%)	22 (84.62%)	16 (84.21%)	62 (84.93%)

Source: Questionnaire

Table 33 Feelings when some one cuts a tree

Personal Feelings	Korir	Enda Selassie	Grahutsa	Total
Anger but not expressed	8 (28.57%)	6 (23.08%)	1 (5.26%)	15 (20.55%)
Point out ones wrong doing	5 (17.86%)	15 (57.69%)	17 (89.48%)	37 (50.68%)
Report to the officials	8 (28.57%)	3 (11.54%)	1 (5.26%)	12 (16.44%)
Indifferent	4 (14.29%)	2 (7.69%)	0	6 (8.22%)
Taking to the officials	3 (10.71%)	0	0	3 (4.11%)
Total	28 (100.00%)	26 (100.00%)	19 (100.00%)	73 (100.00%)

Source: Questionnaire

It was revealed, 85% (Table 32) of the community understood that cutting of trees was not right and even objected especially in the areas of enclosures. Here more than 50% (refer table 33) responded that they would point out ones wrong doing when they found some one cutting a tree. About 21% of the respondents told that they would be angry but would not tell him to avoid quarrel. About 16.44% opted to inform the local officials, if they found some one cutting a tree

and 8.22% expressed their indifference while 4.11% told that they would take him to the police or proper officials. About 15% of the sample households considered tree cutting as their right to make their living by selling wood and/or charcoal in Wukro town.

Of course, the options and feeling vary significantly between villages. For example in Korir, the feeling of the unexpressed anger was expressed by greater than 28% respondents while only 5.26% shared this feeling in Grahutsa (Table 33). On the other hand in Grahutsa over 89% respondents were of the opinion to point out their wrong doings if one is cutting a tree; this because of their depressed feeling about the seriously degraded environment than other villages (from the group discussion).

In reference to their perception on soil erosion, the researcher tried to judge their perception by making them to peep into past say in 1970s, 1980s and afterwards (Table 36) and by way of expressing about the magnitude like minor, medium and serious. The result was that about 87.67% of the sample population responded that there was minor soil erosion before the 1970s while only 12.33% identified it as medium and no one considered it as serious. By the 1980s only 16.44% of the sample respondents put it in minor category of soil erosion and the remaining all (83.56%) considered it as a medium, they experienced the aggravating situations. Concerning the period after 1980s the soil erosion must have been further aggravated to add to the land problem, resulting in the responses overwhelmingly (78.08%) identifying the soil erosion as serious in the area, while only 1.37% considered the situation as moderate (Table 34).

Table 34 Trends in community perception of soil erosion through time

Periods	Status of Erosion			
	Minor	Medium	Serious	Total
Before 1970s	64 (87.67%)	9 (12.33%)	-	73
The 1980s	12 (16.44%)	61 (83.56%)	-	73
After 1980s	1 (1.37%)	15 (20.55%)	57 (78.08%)	73

Source: Questionnaire

The accelerated soil erosion is a clear evidence of the withering of the vegetation (grasses and trees) and consequently, the seriousness of the land and land use problems. Ato Abera “nature never gave us some thing since the 1984/85 drought that swept everything in front of eyes; no one can believe that plants dried, animals died, lands lost their fertility, rain stopped and when there is rain it erodes what is in the field leaving gullies behind.” About 94.52% of the sample population considers deforestation as the major cause of soil erosion and 4.11% think soil erosion as the “The Will of God” (Table 36). Here about 98.63% of the sample population understands that vegetation can be rehabilitated if protected mainly of the Korir and Grahutsa (100%) and 96.15% of Enda Selassie (Table 5.3.1).

Table 35 Community responses on vegetation rehabilitation

Responses	Korir	Enda Selassie	Grahutsa	Total
Yes	28 (100.0)	25 (96.15%)	19 (100.0%)	72 (98.63%)
No	-	1 (3.85%)	-	1 (1.37%)

Source: Questionnaire

Table 36 Community perceptions on the causes of soil erosion

	Causes	Number	Percent
1	The will of God	3	4.11
2	Deforestation	69	94.52
3	Others	1	1.37
	Total	73	100.00

Source: Questionnaire

Mostly, the local community observe their farm plots; about 78.08% of the sample population follows up their farm plots, if it is affected by rainfall and the remaining (21.92%) don't follow up what happened there (Table 37).

Table 37 Follow up of farm plots after rain by the community

Follow up Response	Korir	Enda Selassie	Grahutsa	Total
Yes	23 (82.14%)	19 (73.08%)	15 (78.95%)	57 (78.08%)
No	5 (17.86%)	7 (26.92%)	4 (21.058%)	16 (21.92%)

Source: Questionnaire

When asked about their actions if they experience the erosion by intense rains, 54.79% of the sample population of the community responded that they would report to the local officials and 34.25% told that they would be unhappy. Only 6.85% opted to take measures to protect their farms. The rest (4.11%) showed their indifference about the problem because of the unreliability of land ownership. Inconsistency in the opinions of the respondents was observed on village level as 73.08% (Table 38) of respondents from Enda Selassie opted to report because of the active response of the Development Agents for their report. Curiously enough all the respondents showing indifference were from Korir, from the group discussion most of the indifferences whom they might have no owning farm land or land below the dam otherwise no erosion problem on their farm plots.

Table 38 Feeling or Action taken when farm plot is affected by rainwater

Personal action taken	Korir	Enda Selassie	Grahutsa	Total
Unhappiness	12 (42.86%)	6 (23.08%)	7 (36.84%)	25 (34.25%)
Indifferent	3 (10.71%)	-	-	3 (4.11%)
Reporting to the officials	12 (42.86%)	19 (73.08%)	9 (47.37%)	40 (54.79%)
Adopt protection measures	1 (3.57%)	1 (3.85%)	3 (15.79%)	5 (6.85%)
Total	28 (100.00%)	26 (100.00%)	19 (100.00%)	73 (100.00%)

Source: Questionnaire

5.2 Role of Community in Land Conservation Practices

Active participation of a community is essential for the success of watershed development programmes. An effective involvement can occur only if the community is driven by the understanding of the problem and the realization that it is being done for the community; as a motivating factor that the community knows the problem very well. Participation as such could be fomented to bear fruits again if the system of governance and popular democracy allows participation at all levels, as it is usually called. It means the participation should begin at the formulation and planning stage of the development programmes and go along to the final level, whereby the

community should decide on the use of the resources it would develop in a watershed management.

Shah (1997) gave his witness on what is happening in Tigray. He stated that the community has contributed millions of workdays as part of mass mobilization approach. Mostly stone and soil bund terraces have been constructed both on arable as well as communal lands in addition to planting of Eucalyptus trees. The author is convinced that efforts in watershed development in which the participation of the community has been limited or non-existent is like building a mansion for a night. Similar lessons have been learnt from the massive soil and water conservation efforts in Eastern Hararghe, Ethiopia, during the Dergue regime. At that time these afforestation and soil and water conservation developments in these highlands of the country were exemplary in nature. But right after the change of government the development of decades was wiped out in few days as if it did not exist at all due to the less community participation in the program (Kebede, 1996). The same thing happened during the fall of the Dergue in the very small area (Adimeskel, Asekoma and Tsira-e Silassie Gara) a long time enclosures on the Mekelle-Adigrat road and on the upper catchment of the study area. It was also frustrating to learn that much of the destruction of the structures and cutting of the trees, which had come up due to the closures and tree planting, were destroyed by the same community which was involved in its making (with food for work arrangements) and was to benefit from the programmes.

One can ask as to what went wrong? Many reasons are possible and their elaborations is beyond the scope of the paper but one is for certain - something was wrong with involvement of the community in the formulation and execution of the development plan. The development was an important step to improve the livelihood of the community, but has ignored the local communities themselves in the whole process. The low level of involvement by the local communities from the inception of the idea to the utilization of the project results, leads to overall failure of the development. The local communities were considered as a threat to the "development" highlighted by many professionals and government officials.

Some experiences from Eastern Tigray also show that the level of participation dictates the level of success in watershed management. Efforts, no doubt, are made by the Governmental and Non- Governmental Organizations to check soil degradations, but reports (Pender, 1999) in general point out towards their total or partial failures. This is attributed to the less or no mobilization of the local community. It is not true that there is low-level of awareness of the problem and the usefulness of the methods in practice by the local community. Almost all of the local community knows it well but it lacks financial and material mobilization for their target activities all members of the five groups in the group discussion conformed that they know the problem but they are not sure what methods are efficient and fast to revert the environment.

Table 39 Reasons of the community for their participation

	Korir	Enda Selassie	Grahutsa	Total
No any other job	1 (3.57%)	0	0	1 (1.37%)
To protect farmland	21 (75.00%)	24 (92.30%)	18 (94.74%)	63 (86.30%)
Forced	2 (7.14%)	1 (3.85%)	1 (5.26%)	4 (5.48%)
Others	4 (14.29%)	1 (3.85%)	0	5 (6.85%)
Total	28 (100.00%)	26 (100.00%)	19 (100.00%)	73 (100.00%)

Source: Questionnaire

About 98.63% of the communities of the study area participate in the conservation program. Of this community, 52.05% (of which 73.68% of Grahutsa, 50% of Korir and 38.46% of Enda Selassie) has been participating since the previous government (before 1991) and 47.95% under the present government (after 1991). The reasons for participating in the conservation programmes, on the whole 86.30% of the sample population gave the reason as to protect their degraded cultivated lands, which on sub-group basis was 94.74% from Grahutsa, 92.30% from Enda Selassie and about 75% from Korir. About 6.85% of the respondents expressed other reasons such as less agricultural yield etc mainly from Korir (14.29%) and Enda Selassie (3.85%). Only 5.48% of the sample population referred to forced reason, and are only involved for the 20 working

days contribution in a year expected from every household. Similarly 1.37% of the total sample population is supposed to have participated because there were no any other alternate jobs to engage (Table 39). More than 98% of the respondents (Table 35) understand that vegetation will rehabilitate if conserved.

One may thus draw the lesson that community participation should begin at the planning stage itself so that due priorities could be given to the relevant programs. Some times, lack of interest in subsequent maintenance of community works is an index of poor participation of farmers at implementation stage. Activities like watershed management and others, which are related with the livelihood of the community, require the mobilization of communities at grassroots level. Although not privately owned, about 80.82% of the sample population does care for the conserved and enclosed areas in the study area; which is mostly true of Grahutsa and Enda Selassie because of their visibly accessible and degraded environment. The 19.18% who don't care for the conserved areas may be because of their priority to making their living, or due to their lesser awareness of the problem or they may not have any concern with the soil and water conservation programs.

People participate in the conservation practices; from different villages located at varied distances. It can be assessed in terms of time taken by the people to reach the conservation sites. Out of the total sample population 35.62% requires 30 – 60 minutes only from Korir (65.4%) and Grahutsa (34.6%); 31.50% requires 1 - 1½ hours mainly from Grahutsa (43.5%) and Enda Selassie (30.4%) and about 20.55% need more than 1½ hours mainly from Enda Selassie (60.0%) and Grahutsa (33.33%) to reach the soil and conservation work site. There are only 12.33% who need less than 30 minutes. Based on the responses of the sample participants, average time taken by them is about 63 minutes, which ranges between the average of 49.3 minutes for the participants from Korir to 72.65 minutes for those from Enda Selassie (Table 40). There is 28.41 of standard deviation and 45.04% coefficient of variation of the time needed to go to the

conservation program sites from their Kushets. This means there is a big variation from Kushet to Kushet.

Table 40 Time needed by the community to travel to the soil and water conservation sites

	Korir	Eenda Selassie	Grahutsa	Total
Less than 30 minutes	4 (14.29%)	1 (3.85%)	4 (21.05%)	9 (12.33%)
30 – 60 minutes	17 (60.71%)	9 (34.62%)	0	26 (35.62%)
1 – 1½ hours	6 (21.43%)	7 (26.92%)	10 (52.63%)	23 (31.50%)
More than 1½ hours	1 (3.57%)	9 (34.62%)	5 (26.32%)	15 (20.55%)
Average Time taken	49.3	72.69	70.26	
Standard Deviation	20.775	27.5	31.18	
Coefficient of Variation	42.15	37.83	44.38	
Mean = 63.08				
S.D. = 28.41				
C.V. = 45.04 %				

5.3 Community Mobilization

Narrow emphasis on physical conservation efforts and structures by concerned officials may lead to discontinuity of group efforts after the enthusiasm and intensive efforts of mass mobilization. Many groups, which are very active at the mass mobilization stage, fizzle out during the post-construction phase. If the initial plan involves discussion on range of production technologies involving experimentation and training, the groups are likely to sustain longer as they would realize many production benefits in the short run (Shah, 1997). Currently, as construction of physical structures is visible and is consistent with mass mobilization approach, it is given high importance. Most of the time the degree of mass mobilization depends on the degree of community perception (awareness) about the problem. The perception about group organization for various activities related with natural resource management oscillates on the interaction of the organizing body and the local community. Success and acceptance of the community mobilization depends on the reality of the

community problem, the acceptance of the methods and technologies used and its importance after accomplishment.

5.3.1 Need and ways of mobilization

For successful execution and continuation of any development program pertaining localities (micro-level), it is necessary that the local people are involved bodily and mentally. This can be achieved by making the people fully aware of the whole scenario i.e., the environmental conditions (in case of land and water conservation projects). It is certain that the people in the locality are fully aware of the deterioration of these resources in their locality. Now the function of the concerned bodies is:

- i. To make them more aware the future consequences,
- ii. To make them aware of the results of controlling the deterioration of these resources,
- iii. To ensure that what ever the gains will be, it will be shared by the people there, so that they can participate in the implementation and keep on protecting in future,
- iv. To acquaint them with the methods of conservation/s and its pros and cons which might involve a short training program as well,
- v. To arrange serious of discussions involving them to invite their ideas and experiences and to know their individual problems if they are involved fully,
- vi. To make them aware of some instant incentives (if possible), and
- vii. To form a committee or team consisting of the local community and local or other officials,

- viii. To chalk out a compromising strategy acceptable to the majority and to get it discussed in the assembly of the people, (it might lead to some improvement in it).

Based on these targets the experience of Gullo Mekeda can be a good lesson. The Eche-marre case is probably a good lesson. Eche-marre is a village (Kushet) found 30 kms North of Adigrat in the wereda of Gullo Mekhada. The community of the village after thorough discussions in their community meetings came to conclusion that the best way for them to manage their watershed was by allowing everybody to take share of the highly degraded hillsides and plant them with trees with all necessary physical structures which then be utilized by the same person. The success of this project influenced the policy for hillside distribution in Tigray (Pender, 1999).

5.3.2 Teams, compositions and responsibilities:-

Any community mobilization in Tigray in general and in the study area in particular has a team work at all levels (Tabia and Kushet), which is locally organized by some members of the concerned community because if there is conservation program somewhere, it will be explained (normally called discussion or locally Miyiyit) to the community by agricultural agent and the local administrative officials. The local community will be grouped as locally known as GUJILE with 7 – 10 persons, by providing with working instruments, electing group leader, writing material, etc (interview with Ato Getachew Desta). This includes the Tabia Administrator, Model Farmers and Agricultural Cadres with their own responsibilities to do in relation to the agricultural Development Agents and others. There is a daily work evaluation by the group submit by the team leader to the agricultural cadre and again the agricultural cadres submit it to the agricultural agent.

The specific responsibilities for each of the member of the team are the following:-

- i. Kushet and/ or Tabia Administrator – he is the leader of the team in leading, mobilizing and follow up the community’s response on the construction work or any other activity. It is assumed that he understands the community’s problems and transmits it to the higher officials and implement punishments on local levels;
- ii. Agricultural Cadres – in each Kushet and Tabia there are two trained agricultural cadres and two contour line drawers. Agricultural cadres are also locally called as HIRSHA CADRES, responsible for technical leaders of the physical construction work; they follow the quality of the work. The contour line drawers are trained in simple surveying, map making and interpretation skills, drawing lines following contours for terracing and/or different types of bunds;
- iii. Model Farmers – they are limited in number and the community selects them in their quick understanding to the newly introduced matters about agriculture. They lead the whole community in generally improved agricultural activities like using fertilizers, handling domestic animals, weeding, etc. in the community as a whole.
- iv. In addition to these group members, higher officials of the Tabia, Wereda or Zonal office that include extension agents working and living near to the local community, experts (this refers to conservationist or so), and supervisors who supervise whether all activities are properly done or not i.e.. for approval.

All activities are to be discussed with the local community, first meet with the prominent members of the community with the help of the team of the concerned location but most of the time points of discussion comes from officials as a top-down, which the community considered it as an order. In the three Kushets

(Grahutsa, Enda Selassie and Korir) of the study area there are four teams one for each Kushet and one for the Tabia, which supervise and guide the Kushets. As shown above, each team consists Tabia or Kushet administrator, Agricultural Cadres and Model farmers responsible to mobilize the conservation or other works in their Kushet or Tabia. Government and NGOs participate in his activity for financial and/ or technical assistance but no NGO is directly participating in the conservation activity except for the release of fund to work in collaboration with the Tigray Regional Bureaus.

As mentioned earlier, the planning and implementation processes of soil and water conservation are done with the active interaction of the people and the Baitos (local administration). Mass mobilization and the involvement of grass-root institutions are the main strategies for implementing the process, which depend very much on farmers' motivation to participate. Thus, the continuation of such motivation will determine the success or failure of any future soil and water conservation program. The organization "Sustainable Agriculture and Environmental Rehabilitation of Tigray" (SAERT) is mandated with building the dams, while the treatment of the catchment and coordination of management of the irrigation is the responsibility of Tigray Bureau of Agriculture and Natural Resources (TBANR). Ensuring adequate coordination between the efforts of these different agencies, thus, is quite important. Although the Korir earth dam was built before the treatment of the upper catchment, now it appears that the problem is well recognized and efforts are being made to treat the catchment before construction of the new dams (Pender et al, 1999).

It doesn't mean that community contributions (paid or free) have no problems. In the group discussion with farmers, they indicated that poorer households are more severely affected by the mass mobilization approach and subsequent contribution expected from them (it operates as a kind of a social and moral levy). Many poor households have raised objections in village meetings to large-scale construction activities on a voluntary basis at a time when their food stock is low and they would have to earn from other resources because the mass

mobilization approach deprives them from seeking work elsewhere and it makes their households more vulnerable. They are also unsure of the benefits from enclosed community lands to their households except the enclosed grazing land where they benefit from the sale of their share of the grasses. The farmers indicated that after some dialogues and negotiations, some poor farmers have been allowed some time off during mass mobilization and labour contribution to work elsewhere (Shah, 1997). However, there are some differences of opinion among the community on the labor contributions in the mass mobilization approach. However, the past tradition and the fear of social sanctions by the community has ensured that majority of the households provide a minimum of 20 days per year for working on the community land on physical conservation measures.

Although the free contribution, mostly construction of 100 meters of terraces or trench bunds a year, is accepted by the community working on convenient days but this interest might be loosened through time if they are not be able to confront their living. Due to the insufficient payment that doesn't satisfy their need, it is no longer to go on as an extended free contribution. About 80.82% of the sample population said that the payment for the work done is not sufficient. It was also observed that, although the payment is not enough, 89.04% of them will not abandon the conservation work because of their interest or concern but about 10.96% opted to completely leave the soil and water conservation work if their living is improved. This is an indication of community initiatives because it is in addition to the 20 working days free of payment decided to contribute annually by the house holds of the local community to work in their degraded environment.

Poor households are still facing critical food shortages. They indicated that there is a need to increase the food component of the program as an incentive to insure higher labor contributions to the watershed management activities of the community. Thus, there is a clear need to think about the nature of incentives to be given to the households. It would be useful to think in terms of production

enhancement incentives (inputs, services, training) as opposed to large-scale introduction of food for work or a combination of both. If productive input incentives are substituted over a period of time for direct “food for work”, it is expected of the households to make critical investments in increasing production in general and food production in particular over a period of time. Otherwise it could lead to constraints in terms of labor availability for both common as well as arable lands.

CHAPTER SIX

APPRAISAL OF THE LAND MANAGEMENT PROGRAM

The information from local informants and elders concerning the conservation works in the catchment in the past reveal that there were some attempts of very localized nature and those too are now out of use because of great maintenance problems. The types of conservation works done in the area under study included soil and/ or stone bunds, terracing, tree planting, and check dams. There is a better conservation system today, regardless of the smaller areal coverage. Besides the smaller areal coverage, there is incorrect alignment of the measures and even improper application as to the type of land use like the Korir and Enda Selassie silted and cut earth dams constructed on the gully way below the untreated upper catchments in order to collect more water. Due to the poor documentation system of the Wereda agricultural office, reliable information on past conservation works is not possible to obtain.

6.1 Indigenous Conservation Trials

In the community's local development trials there are minor activities tried to avert the land problems. Some of them are

1. Planting trees along gullies – At the foothill of the upper catchment of Korir the local people have adapted to planting of thousands of privately owned eucalyptus trees and such people like Ato Woldu G/Meskel, has planted more than 1500 eucalyptus trees along the Korir gully, are considered as community innovators in the Region. There are a number of persons who are sharing their experiences in planting trees and more than 5,000 eucalyptus trees appear along the unoccupied floor of Korir gully around the foothill of the micro-catchment. Some persons of Enda Selassie

and Grahutsa do tree planting along gully sides and floors but it is not a common thing everywhere like that is in Korir.

2. Protecting grazing lands:- seasonal closure of grazing land for oxen locally called Hizaeti Bieray is a long time practice to protect grazing land for oxen which has now changed in to total closure. Also see on section 6.3.2 (i).
3. Keeping farm plot boundaries ungrazed:- it is also a long time used system but is on the decline these days due to reduction in the width of the boundaries due to encroachment by ploughs. It used to serve as protector of sheet and rill erosion.
4. Pilling stones along gullies and diverting flood streams i.e, in most of the areas susceptible to sheet, rill and gully erosions, pilling stones, ploughing or digging diversion canals, etc on the flood ways is common since long. Although not very strong and durable but is very successful method. It is practiced in the wide and deep gullies as group or community work but individually in the overland flooding to protect their farms seasonally.
5. Individually local community uses different systems to increase agricultural yield. About 39.73% of the sample population expressed the use of artificial fertilizer but they consider it as forced upon them by the extension program of the Global 2000, use of animal dung (35.61%) and crop rotation (16.44%) stand next to artificial fertilizer. Only 6.85% use fallowing. In most cases the local community do not use fallowing but instead, traditionally, they apply crop rotation like teff and other leguminous crops (beans, peas, chickpeas, lentils, etc.).

Regardless of importance and modernity of the practices of the community to reduce soil erosion in their farm or environment, pilling stones along the flooding or gully and stone bunds are the common phenomenon in the catchments of all the gullies with slight variation in adoption. Individually about 49.31% of the

sample population use piling of stones to reduce soil erosion, (Enda Selassie 61.54%, Korir 46.43% and Grahutsa 36.84%) while 41.10% use stone bunds around their farm plots, the rest (9.59%) do not adopt any measure (table 41).

Table 41 Individual trials to reduce soil erosion

Measures	Korir	Enda Selassie	Grahutsa	Total
Piling	13 (46.43%)	16 (61.54%)	7 (36.84%)	36 (49.31%)
Stone bund	9 (32.14%)	09 (34.61%)	12 (63.16%)	30 (41.10%)
Nothing	6 (21.43%)	1 (3.85%)		7(9.59%)

Soil and water are the basic resources essential for survival of human kind on earth, but as was discussed in the foregoing, it is highly degraded, then soil and water conservation measures are under exercise on the study area. From the experience of the local community the most frequently observed conservation practices are terracing, which is practiced by 65.75% of the sample population, mainly in Grahutsa (78.95%) and Enda Selassie (73.08%); by 13.70% of the sample population soil, stone and trench bund are practiced mainly in Korir; by 9.59% of the sample population planting trees is highly practiced especially in Korir and Enda Selassie. This means no planting of tree is practiced in Grahutsa (table 42) because of the conservation priority being given to Korir and next to Enda Selassie.

Table 42 Types of soil and water conservation activities practiced

Activities	Korir	Enda Selassie	Grahutsa	Total
Terrace	14 (50.00%)	19 (73.08%)	15 (78.95%)	48 (65.75%)
Planting trees	3 (10.71%)	4 (15.38%)	0	7 (9.59%)
Soil, stone and trench bund	7 (25.00%)	2 (7.69%)	1 (5.26%)	10 (13.70%)
All	4 (14.29%)	1 (3.85%)	3 (15.79%)	8 (10.96%)

Source: Questionnaire

6.2 Integrated Watershed Management

The focus of the previous (before 1991) soil and water conservation program was on controlling soil loss and erosion as major objectives. It would be useful to work on the key principles of watershed management rather than looking only at soil and water conservation because the soil and water conservation practices were used to halt soil and/ or water removal. Watershed management is integration of technologies within the natural boundaries of a drainage area for optimum development of land, water and biomass resources to meet basic needs of the people in a sustained manner. Each watershed has distinct characteristics that define its potential and problems. The size, shape, drainage, geology, rainfall, soil, climate, surface condition, land use, ground water resources, indigenous conservation practices, existing communal management systems, types of livelihoods and the socio-economic status of the population in the watershed determine its runoff, sedimentation, soil, moisture and nutrient conservation measures and its potential for development (Shah, 1997).

The main principles of watershed management that should help in developing appropriate conservation strategies are: utilization of land according to its capacity, introduction of low moisture requiring crops i.e., identification and experimentation with crops which can grow on residual moisture or short rains or runoff harvesting and irrigation; maintaining adequate vegetative cover on the soil for controlling erosion mainly during rainy seasons; conserving maximum possible rainwater and increase moisture infiltration at the place it falls (in situ) on arable land by contour farming and other practices like green manuring and mulching; draining out excess water with a safe velocity to avoid soil erosion and storing it for future use; preventing erosion in watercourses and gullies and increasing ground water recharge by putting check dams and barriers; controlling floods and reducing erosion and sediment production; increasing nutrient flows including productive silt and organic matter through adequate nutrient harvesting techniques; developing and creating high production micro-environments within the watershed; maximizing productivity

per unit area, per unit of rainfall and per unit of water; maximizing the combined income from the interrelated crop-tree-livestock-labor complex over years; stabilizing income even under rainfall conditions, and peasant participatory development in the conservation activities.

Table 43 Conservation preference of the local community to combating devegetaion

Conservation Measures	Korir	Enda Selassie	Grahutsa	Total
Area closure	1 (3.57%)	7 (26.92%)	7 (36.84%)	15 (20.55%)
Privatize	1 (3.57%)	0	2 (10.53%)	3 (4.11%)
Increasing awareness	11 (39.29%)	13 (50.00%)	3 (15.79%)	27 (36.99)
Issuing a policy	15 (53.57%)	4 (15.38%)	7 (36.84%)	26 (35.61%)
Other	0	2 (7.69%)	0	2 (2.74%)

Source: Questionnaire

Communities have their own conservation preference to control vegetation problems. About 37% of the sample population prefer increasing awareness especially from Enda Selassie (50.00%); others, about 35.61% prefer issuing a policy about the use and conservation of community forest and most of them are from Korir and Grahutsa; about 20.55% of the sample population prefer area closures as conservation measure for the vegetation problems in the study area, and 4.11% prefer private ownership (Table 43).

6.3 Some Visible Developments of the Conservation Program

Although practiced since long, there were limited conservation measures taken. As to their preferences of pre and post 1991 conservation measures; about 87.67% (92.86% of Korir, 92.31% of Enda Selassie and 73.68% of Grahutsa) of the local community appreciated the post 1991 conservation measures as encouraging as compared to the pre 1991 which was preferred only by 12.33% as better and productive soil and water conservation practices. This also depends on the effectiveness of the conservation measures under taken around their Kushets, for example majority of the respondents (about 26.32%) preferring the

pre-1991 practices belong to Grahutsa Kushet where there is no conservation work to day being carried out except the development of grazing lands. About 79.45% of the sample population (92.31% of Enda Selassie, 73.68% of Grahutsa and 71.43% of Korir) accepted that there are some improvements in the study area by the soil and water conservation practices. While 20.55% didn't accept this because of the less coverage of land in the soil and water conservation practices.

About 86.21% (table 44) of the sample population (i.e. 92.86% of Grahutsa, 91.67% of Enda Selassie and 75% of Korir) considers the conservation work is productive in protecting soil erosion and increase agricultural yield. The low percentage in the improvements is those who see the impacts of conservation independently i.e., on agricultural yield and soil erosion protection depending on their observation and their past experience on problems.

Table 44 Visible improvements in soil and water situation by conservation program

Improvements	Korir	Enda Selassie	Grahutsa	Total
Agricultural yield	2 (10.00%)	0	0	2 (3.45%)
Soil erosion protection	3 (15.00%)	2 (8.33%)	1 (7.14%)	6 (10.34%)
All Combined	15 (75.00%)	22 (91.67%)	13 (92.86%)	50 (86.21%)

In order to assess the psychological or mental set up of the people the respondents were required to express their opinion whether they will quit participation the conservation programmes. But as they observed improvement in various segments, overwhelming majority (about 89%) working in the soil and water conservation program refuted the quitting of working in the conservation program what so ever their living condition is improved while 11% will leave the conservation work if their living condition is improved. Here, the less percentage in Korir might be the dominant coverage of the Korir subcatchment by the conservation work in addition to the earth dam as compared to the other Kushets.

Due to the land management envisaged in Tigray as a whole and the study area in particular, although not enough, some visible changes: in physical, biological, social and agricultural situation are observed.

6.3.1 Physical changes

Physical structures in soil and water conservation measures were introduced in the study area during the Derg regime. However, the practice continued to be widely exercised to cover more parts of the study area after the downfall of the Derg regime. These measures have been executed by giving top priority to the cultivated lands, especially by applying different types of bunds. During the last 7-8 years, several hectares of land have been treated with different physical structures. Uncultivated lands were treated whenever their impact on cultivated land was found to be more. The physical structure like terracing, trench bund, dams, and the like had been used in soil and water conservation programs since long.

i. Stone and/ or Soil Bunds, and Trench bunds (photo 9 – 10)

These are physical structures constructed to provide physical barrier to runoff by way of introducing slope breaks to reduce the velocity of and hence the erosive power of running water or over land flow. This practice is implemented by group of farmers mobilized at Kushet or Tabia level to construct the structure. The groups of farmers work the structure together on contractual bases and the quality of the work is approved by an agricultural cadre and then by a higher-level supervisor.

All together soil and/ or stone bunds, and trench bunds 572,906 m in length were constructed upstream of the Korir earth dam during the years 1998 and 2000 (table 47). In the formal discussions, it was learnt that farmers liked these bunds very much except for its occupancy of farmlands. But maintenance works are left to be done by individual farmers who own the lands. Active farmers use it in

protecting their land by providing regular maintenance as required. However, some farmers oppose this practice and hence they do not maintain it.

ii. Check dams

It is constructed across gullies and rills to provide physical barriers but this construction is mostly around the upper catchments as a support for area closures and other conservation measures, not in the lower catchments. About 4,559 m (2,120 m in 1999 and 2,439 m in 2000) of check dams were constructed in the study area.

iii. Earth dam Construction (photo 11)

One of the pushes to the upper catchment watershed management practices in the Korir part of the study area is the construction of the Korir earth dam in the lower catchment. The maximum water holding capacity of the reservoir, which covers 10 ha of area, is about 2.8 million m³. It was planned to cultivate about 100 hectares but due to reduced rainfall in the first year it was cultivated only 5% of its potential, the actual cultivation never exceed 56% of the potential in 2000/01. The responses of the sample population revealed that about 96% of them. All of Korir, 96.15% of Enda Selassie and 89.47% of Grahutsa are beneficiaries of this earth dam. The beneficiaries can be classed into 3 categories;

- i. Those who are gaining with water supply for man and animal, and get more than one harvest a year through irrigation. The benefit of collecting more than one harvest is enjoyed only by the farmers who have their farm land in Korir down stream the dam;
- ii. Those who are getting water for their animals and their domestic consumption including land conservation practices such people are from Enda Selassie Kushet; and
- iii. Those who are beneficiary in the food-for-work basis during the construction of the earth dam and/ or the upper catchment. Thus it can be concluded that people from Korir Kushet have got the maximum

benefit while those from Enda Selassie received two types of benefits i.e., water and food for work, while the people from Grahutsa and other Kushets around in the upper catchment enjoyed only the time bound program of food for work.

All gullies below the treated watershed are either being obliterated or have become stagnant. The Korir seasonal river, actually it is gully, became perennial after the construction of the Korir earth dam and watershed management. People told that some years back below the earth dam there were lots of springs and a stream i.e. which are now non-existent.

iv. Hill side Terracing (photo 9)

Hillside terracing is one of the most important physical measures to take place in areas found on steep slopes of Genfel Tabia. Although small in proportion to the size of the area and the magnitude of the problem, the performance of this terracing is good enough to be cited. Seedling plantation is very less so far but terracing is used for soil accumulation and moisture retention and, soil accumulation on these terraces was observed in the field. It was constructed last year and no dense vegetation cover is observed but the total length of the terraces constructed in the three years (1998 – 2000) is 1.1 million meters above the earth dam means in the Korir Kushet. Due to recent construction, it has yet to have good vegetation cover.

6.3.2 Biological changes (photo 8 and 12)

Although, thinking the impacts of these conservation measures in the form of changes in wild life may be a far reaching imagination, but the land cover segment of the bio- has started sending the message of changes in the area under study. As is known, the serious problem in Ethiopia, especially the Northern Highlands, where the study area is located, is the removal of vegetation. The soil and water conservation measures are showing some improvement in terms of harvesting soil and water near the stone bunds. As is

seen from table 47 minor improvement in vegetation cover is accepted by 62.71% and moderate improvement by 35.59% of the sample population. Consequently it has been possible to obtain higher crop yields and biomass. The areas covered show accumulation of soils and development of bench terraces, minimizing rill damage and harvesting water. In addition to programs promoting adoption of soil and water conservation investments, there have been efforts to promote regeneration of degraded grazing areas by establishing area enclosures to promote reforestation. At present time area closure for biological regeneration is given high attention

i. Grazing land management

The area is temporarily enclosed and kept for grazing oxen and is being better managed by the community. It is almost totally covered by selected grass and fodder trees (*Sasbania*) for the purpose of rehabilitation. It is a traditional method of closing grazing land for oxen since long time; locally it is named as Hizaeti Bieray (closed for oxen) and is usually found in flat lands. The enclosure used to be open for oxen after raining season when grass was scanty for oxen but it is not practiced the same way now. At present there are two grazing lands Arato and Embalam spreading over 680 hectares (table 45), which used to be as Hizaeti Bieray but now these are under rehabilitation by modern grazing development program. There are two protected grazing areas in the lower catchment but they are over-grazed with the exception of the new grazing development system adopted under the supervision of the Bureau of Agriculture in collaboration with the local people and authority. According to the opinion in the group discussion, its grass production was decreasing from time to time rapidly since long and mainly since the 1984/85 Ethiopian drought. According to Ato Gebrehans "these grazing lands were used to be grazed the whole year until the 1984/1985 drought." This explains how far the drought has affected the vegetation cover in the study area.

Table 45 Biological conservation on grass development

Name	Located	Size (ha)	Type of conservation
Arato	Grahutsa	300	Grazing land development*
Embalam	Enda Selassie	380	Grazing land Development*
Adi Nebri	Grahutsa	250	Area closure**

* Area protection with soil bund and trench bund

** Protection in the upper catchments without any other conservation structures

The number of oxen to graze here is not limited and no complain comes from the community. Every body, who is a settler in the Kushet, can bring his own oxen but it is completely forbidden to bring oxen not belonging to the dwellers of that locality and other animals. At present there is a different system of using the grazing land, it is not allowed for animal grazing because all are only reserved for cut and carry system; it is with soil and trench bund used for moisture retention. This periodic closure allows the growth of grass to cover the soil, which ultimately has a contributing role to conserve soil and water by providing obstruction and filter out the overland flow of water (Gemad study report, 1998).

ii. Area closure (photo 8)

Mostly it is in the upper catchment, on the steep slopes of the study area. Here natural grass, bush, shrub and tree covers are commonly found. It is found in the flat land of Grahutsa Medhane Alem i.e., in the upper catchment. About 250 hectares (table 45) of land in the upper catchments of Grahutsa Kushet is protected since 1998 for grass and vegetation rehabilitation. Such closures also include unknown areas of Adimeskel, Asekoma and Tsira-e Silassie Gobo. It is a recent phenomenon to close by restricting the grazing of domestic animals but local people can use as cut and carry when necessary by the permission of concerned Kushets. Ato Aseffa said "it is a new life to me to get a better fodder for my cattle at present in the winter season." The process has the full approval of the group of the local community involved in the discussion and they also expressed their happiness in getting grass for their cattle during the dry season;

no hesitation came from the local people in this respect. It is a big advantage in rehabilitation of indigenous plant species in the area closures of the upper catchment. As a result, the soil in this area is now with low pH (Tables 14 and 15) and high nutrient materials. But this enclosure is without any structure constructed side by side for protection.

iii. Widening of Farm boundaries

Due to the land scarcity resulting from ever-increasing population, the boundaries between plots, although very important for water retention, had been narrowed down, (traditionally called Armo-Armo). Armo-Armo is a traditional practice of soil and water conservation by providing narrow physical barrier left unploughed between two plots of land. This structure help to protect the soil from lowering down by holding it tight through the cluster root system of the grasses, which grows on this structure. In the study area where soil and water conservation practices are in operation, its widening is obligatory. Retarding water flow also regulates the movement of run off, which allows extra time to infiltrate the water into the ground. Moreover the sediment and suspended flow of leaf litter and other organic matter get filtered to remain behind the grass hedge.

Table 46 Visible improvements of Soil and Water Conservation practices

Improvements	No	Minor	Medium	Higher
Vegetation	0	37 (62.71%)	21 (35.59%)	1 (1.70%)
Water	7 (11.85%)	25 (42.37%)	25 (42.37%)	2 (3.39%)
Agricultural Yield	2 (3.39%)	40 (67.80%)	17 (28.81%)	0
Social living	4 (6.78%)	19 (32.20%)	25 (42.37%)	11 (18.65%)

iv. Tree planting (photo 7)

Lots of seedlings have been raised and planted so far but the survival rates in communal plantations had generally been low, and there is now an increased interest in promoting reforestation by allocating sloping areas and wastelands to

private individuals for tree planting and other conservation practices (Pender, 1999) but it is simply a plan for the next year (2001/02). In the study area, area closure and indigenous vegetation preservation are given priority over tree planting. As can be seen from table 47 and on other sections only 134,274 trees are planted in the last three years in the upper catchment.

6.3.3 Changes in Hydrological landscape (photo 11)

As mentioned earlier, the study area is with a very limited natural water sources with three water spring points, two in Grahutsa Kushet and one in Korir (in the upper catchment). At present the whole of the hydrological scenario has changed because of the big earth dam with a capacity of 2.8 million meter cube of water and the consequent perennial stream (for a length of 2774.70 meter) down the earth dam. It is highly used by the local community for irrigation (a potential of 100 ha), watering and drinking by people and animals. As to the irrigation, the dam mostly cultivates about half of its potential, (Table 45) it is due to the lesser water supply attributed to the rainfall deficiency and watershed management practices in the upper catchment. It is highly used by communities of the Enda Selassie and Korir Kushets. It is also used for domestic animals coming from the Grahutsa Kushet. By this soil and water conservation practice slight and moderate improvements, in the state of availability of water were expressed 42.37% each of the samples in the area greater improvement were accepted by 3.39% while 11.85% (Table 46) negated the improvement in water supply.

6.3.4 Changes in Agricultural Aspects

Agricultural activities in the study area are practiced on plain land and flat plateau covering less than half of the total area of the catchment, which signifies the great shortage of cultivable land. According to some documents cited by Pender as evidence yield is higher in the treated parts and near the bunds due to availability of soil moisture through seepage than what it is in the untreated parts of the catchment. The moisture retention program practiced by trench bund construction on agricultural farms is a big deal (encouragement) for the

community. 67.80% (table 46) of the sample community responded as minor improvement in yields of the crops and about 28.81% moderate improvement. Only 3.39% did not agree with development in any improvement in yields of the crops in study area. The conservation measures, however, are opposed on two counts, first the problem water logging and farms conquered by long grasses (locally called GESSA) below the dam and second the shrinkage of the farm plot due to coverage of some cultivable land by the structures. The agricultural improvement is not only through trench bund construction but also, as previously mentioned due to the extension of irrigation from the earth dam. There is a big change in the agricultural landscape of the catchment below the earth dam. Here the cropping seasons in one year are normally three with different crops and vegetables. The land, which is found below the earth dam is totally closed, domestic animals are not allowed to graze inside, for its biological conservation program through one meter boundary development with cut and carry system to hold back run-off and enrich organic matter in the farm below the dam.

Table 47 Conservation development and community participation

Year	Terrace (m)	T.P. (no.)	Ssb (m)	Cd (m)	Ac (ha)	Gld (ha)	Pop.	Exp.
Before 1990*	AATSG	AATSG			AATSG			N.A
1998	131,486	50,188	12,569			680	89,537	N.A
1999	131,216			2,120	250		18,888	50,000 Q
2000	893,200	84,083	560,337	2,439			128,956	1.326
Total	1,155,902	134,271	572,906	4,559	250	680	237,381	**

Where T.P is tree planting; Ssb is soil, stone and trench bund; Cd is check dam; Ac is area closure; Gld is grazing land development; Pop is population (population); Exp is expense; N.A is not available; Q is quintals; M.B. is million birr; * refers to the conservation done during the Derg regime and ** refers to 50,000 quintals and 1.326 million birr; AATSG is Adimeskel, Asekoma and Tsira-e Silassie Gobo.

6.3.5 Changes in Socio-economic Dimension

As mentioned earlier more than 98% of the sample population of the study area participate in the conservation program for different reasons and about 86.3% (table 48) of the sample population consider themselves as beneficiaries of the watershed management program, (100% from Grahutsa, 84.62% from Enda Selassie and 78.57% from Korir). This is in relation to the previous time shortage of water supply and the work force employed in the conservation works. The rest don't consider themselves as beneficiaries because (according to the group discussion) either they are not participants or the payments they are getting is very less as compared to their workload. Table 46 shows the responses of sample population concerning whether they perceive any social development, moderate development was responded by 42.37%, while minor or slight development by 32.20%. Appreciable development and no change was expressed by 18.65% and 6.78% respectively.

Such changes are not only through the payment of the food-for work of the conservation program but it includes the improvement of agricultural yield in the conserved farms especially below the earth dam. As the words of Deacon Hagos "the Korir farmers, with a farm plot below the earth dam, are producing three times a year with different fruits and vegetables which is a dynamic change in the life of that community. In the group discussion from one Timad ($\frac{1}{4}$ of a hectare) the market price of one farmer for the tomato produced in one season is about 30, 000 Ethiopian Birr." Although this is taken as highest because of some technical advices for their farming, they are expected to produce better than the earlier years. The problem here is on the fewer beneficiaries below the dam, the small farming plot they have and rendering some of farms landless are with very little farm as the reservoir and the dam have occupied their farms.

Table 48 Condition of beneficiary of the soil and water conservation program

	Korir	Enda Selassie	Grahutsa	Total
Yes	22 (78.57%)	22 (84.62%)	19 (100.00%)	63 (86.30%)
No	6 (21.43%)	4 (15.38%)	-	10 (13.70%)

Generally, it is not easy to say, as there is socio-economic improvement in the study area because the integrated watershed management is a recent activity and expectation visible socio-economic change is like harvesting a crop overnight. Then the only change to be mentioned is the daily labour for payment to feed, considered insufficient for what they work, their families and the gains they get from the Korir earth dam.

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

Land degradation among others, is the consequence of the human and animal pressure on land. Globally the various components of the physical environments especially land and land cover are being changed at an alarming rate lesser in favour of the humidity. It had been more so in Ethiopia. Therefore, the conservation and protection of the remaining forests and land will enable the country not only to maintain the vegetation needed for people to preserve the rare endemic plants and animals, and to protect important watersheds but to maintain the ecological balance in the environment for future generation also. In this rugged and loose surfaced terrain, rendered more vulnerable by removal of vegetation, man and animal increase further upsets the balance in the environment. It is obvious that man himself is also the cause of the problem his activities leading to the emergence of more humanized landscapes like rural and urban settlements, transport arteries, industrialization, etc which culminates into degradation of land and land cover, of course, of varying magnitudes spatially in the world. The situation has reached an alarming stage in countries like Ethiopia, where land occupance dates back to the civil wars during the Dergue regime. The present case study constitutes a part of such land of Northern Ethiopia with heavily degraded environment.

It is known that the cause of environmental degradation mainly deforestation and then soil erosion is man himself. The inappropriate exploitation of natural resource to satisfy his needs is the root cause of such degradations. Added to it had been the rapid increases of human and animal population, which have accelerated the environmental degradation. As in case of Wukro area, population growth, urbanization and the like are the determinants of environmental challenges, through agricultural expansion for more food,

shrinking of forest/ wood lands to cope with increased needs of forest products etc. The erratic nature of rainfall with respect to time and amount is the major natural phenomena. All these together contribute to the accelerated erosion of land and removal of soil, formation of gullies and badlands etc, the components of environmental degradation.

As a consequence of vegetation cover removal, soil is exposed to erosion easily. The natural vegetation is left on enclosures near churchyards. This invitation by man is becoming a serious problem with which the level of degradation mainly soil erosion is changing from sheet to rill and again to gully erosion. Gullies, which are wide and deep, are becoming the most frequently appearing features in most part of the study area. Total lengths of above 15 km of gullies of different lengths are opened and about 120,475 tons of soil is being removed every year. Frequent landslide and collapsing of land are seen along the gullies flaked by sandy soils.

Due to the rugged topography, irregular and insufficient rainfall, soil run off, etc the general elements of environmental degradation, agricultural yield has declined, resulting in food insecurity, low soil fertility, problems of grazing land, increased rills, gullies and stoniness of farm plots, shortage and expensiveness of fuel wood and other forest products, longer time needed to fetch water and fire wood, hydrological problem and frequent drought occurrences etc in Tigray in general and the study area in particular.

Community awareness is not low i.e., they understand the environmental problems better now than at any time. But they want to know how to manage and use the natural resources, which are left at present as also the ways and means to revive them. There is inability of the community in getting financial, material and technical support to control the problem and improve their living.

Conservation in the study area has a long history but it is not effective because of the lesser attention paid by the concerned bodies and lower level of community participation. The negligence of the community participation in environmental conservation programmes may put a question mark to their success because the community is nearest to it and the user or beneficiary. Of course, there is participation of the community in the conservation activities but it lacks full participation from planning to the implementation stage. Community mobilization in the study area is strong enough. The conservation activities today are interrelated to each other. Indigenous conservation measures are also practiced; some of them are tree planting along gullies, seasonal closure of grazing land, developing farm plot boundaries, piling up of stones along flood plains, etc.

The appraisals of modern integrated watershed management practices have their own effects on the natural environment. It is different from the previous soil and water conservation practices; the recent ones are the conservations in totality i.e., from soil and water to different plants etc. Although it is inadequate, the conservation programmes have shown their positive impacts. Some of the developments are the physical changes like soil, stone and trench bunds on cultivated and uncultivated lands, check dams along gullies, earth dam, hillside terracing, etc; biological changes like grazing lands development, area closures, widening of farm plot boundaries, etc.; hydrological developments like the recently developed perennial stream along the gully below the Korir dam and the earth dam by it self; agricultural developments either along the earth dam or on the areas benefiting from the moisture conserved. Consequently there is also a change in the social life of the community especially of those who are the beneficiaries of the earth dam and others who have participated in the watershed management practices.

7.2 Recommendation

It is clear that from the study, the problems realized and conclusion drawn from the study that unless some new conservation measures are taken and existing ones are strengthened the Ethiopian population, and the country as such is likely to face social, economic problems, culminating ultimately into political instability. Hence some, as far as practicable and clearly identified recommendations are forwarded.

1. As has been indicated in this study that ever increasing population pressure is the major cause of the problem of resource/ environmental degradation increasing demand on the finite resources rather depleting resources, there appears to be an urgent need of well-designed natural population policy to control the rapid population growth in the country.
2. People as a major of prestige and social status intend to own more cattle than what they might need for the agricultural activity or some times beyond their means. Hence there is need to arouse awareness amongst them to restrict the population of their domestic animals to the bare minimum needed which they can sustain economically. In this context people must adopt to the modern cattle rearing and grazing traditions with some supportive awareness and incentives.
3. The environment indicated that there is a fast rate of deforestation from time to time and consequently soil erosion and gully development cautioning that there is no time to hesitate for action. To curtail this problem in the whole of the study area following erosional controls in the upper catchments: can be classified
 - i. Construction of physical structures on the steep slopes to control soil removal at its origin,
 - ii. Construction of different types of check dams in the gullies,
 - iii. Construction of trench bunds in cultivated land to retain moisture to overcome the problem of insufficient moisture,
 - iv. Preservation of the indigenous plant species, and

- v. Expanding the church owned forestland.
4. Community participation and community mobilization is strong, no doubt, but it doesn't mean that every participant feels full responsibility in the aspect. More effort is needed to arouse the awareness of each and every member of the community concerning system and its advantages so as to make them involved in the conservation programmes whole heartedly because community is the driving force to the conservation works. This can also solve the local problems by using their traditional and local knowledges gained through their deep life long association with the environment of the area, which can seldom be expected of the professional from the Government or NGOs. The modern conservation techniques should assimilate the local techniques, which might enhance the awareness of the community as well as the sense of responsibility and participation.
 5. To increase and integrate community awareness including the school community, with the professional and academicians, community participatory research and workshops can be advisable.
 6. The field observation, have clearly revealed the effectiveness of the conservation measures although the areal coverage is limited. Closures here are even better rehabilitated than the treated area elsewhere in the history of conservation of the country. It might be due to the selection of indigenous species as they adopted better to their original environment in much shorter time as is true of the regeneration of the indigenous species with remnant deeper roots in their degraded environments. Conservation measures of biological, physical, and others with highly integrated advantages must be encouraged.
 - i. Integrated conservation is useful like planting vegetation in relation to other activities as bee farming
 - ii. Planting of economically useful tree species like fruits as human and animal preference for food in the upper catchments,

- v. Expanding the church owned forestland.
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1. As has been indicated in this study that ever increasing population pressure is the major cause of the problem of resource/ environmental degradation ~~increasing demand on the finite resources rather depleting~~ resources, there appears to be an urgent need of well-designed natural population policy to control the rapid population growth in the country.
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 - ii. Construction of different types of check dams in the gullies,
 - iii. Construction of trench bunds in cultivated land to retain moisture to overcome the problem of insufficient moisture,
 - iv. Preservation of the indigenous plant species, and

- iii. Encourage urban firewood plantations with fast growing selected plant species,
 - iv. Increase of payments of the food-for-work conservation programs to overcome their food shortage,
 - v. Encourage the use of animal dung in the rural and encourage in supplying to the urban community,
 - vi. Supply cheaper fuel resources to the urban people.
 - vii. In addition to community awareness, control firewood traffics at Kuset level
 - viii. Search for more community jobs where the community can work and get food for survival
 - ix. Completely prohibit and follow-up the use of the highly adaptable plant i.e., SERAW in the lime producing enterprises by encouraging to use eucalyptus trees
7. Although what is conserved is very limited in relation to the wider problems in the study area, the recent conservation measures are better than the previous ones. Even the changes observed are below the expectation, still better results and expansion of the area may require;
- i. Promoting with material, financial or moral incentives for individuals to have personal motivation in environmental conservation that could help in solving the problem of fuel wood, construction material, etc and in sustaining soil and its fertility,
 - ii. Practicing widely the integrated watershed conservation program with Governmental, NGO and local communities in harmony.

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APPENDICES

Annex 1- Soil Sample record and result

Code	Depth (cms)	Stoniness (%)	Slope	Land cover	pH (T ⁰)	Soil color	
						Dry	Wet

Annex 2 – Vegetation condition record of sites

Sites	A	B	C	D	E
General slope					
Terraces					
Vegetation					
Gullies					
Stoniness					

Annex 3 - plough observation

Conditions		Observations	
Plough	Up and down		
	Following contour		
Terraces	Fully damaged		
	Partly damaged		
	Undamaged		
Boundaries	Less than 50 cm		
	Greater than 50 cm		

Annex 4 - gully parameters in the Study Area

Name of the gully	Length (m)	Av. Width (m)	Av. Depth (m)	Area of Channel (m ²)	Volume (m ³)

Annex 5 Landslide Field observation

Name of the Gully	Frequency of slumping per days				Total
	1 st	2 nd	3 rd	4 th	

Annex 6 - Farm plot assessment of erosion problems 100m on the sides of the gully

	Teff	Millet	B. & W.	Fallow	Vegetables	Flax	M. & S.	Uncultd	Total
Gull									
Rill									
Shee									
Not									
Over									

Annex 7- Survey on fuel energy supply to Wukro town in two main gates (Mekelle and Atsbi)

Means	Firewood	Tree branches	Plant root	Charcoal	Cow dung
Men					
Women					
Children					
Donkey					
Cart					

Year	< 30 minute	30 – 60 minutes	> 60 minutes
1955			
1965			
1975			
1985			
1993			

8. Trends of gully in your locality in time perspective

Year	No	Minor	Medium	Serious
1955				
1965				
1975				
1985				
1993				

9. Has forest cover declined in your area A. Yes B. No

10. If the answer to question number 9 is yes, what is your opinion can be the reasons in order of importance? A. The Will of God B. Civil war C. For expansion of arable land D. For construction and furnishing E. Any other specify _____

11. What can be the causes of soil erosion? A. The Will of God B. Deforestation C. Any other specify _____

12. Access to fetch water

Year	< 30 minute	30 – 60 minutes	> 60 minutes
1955			
1965			
1975			
1985			
1993			

13. Whether water availability has declined A. Yes B. No

If yes what can be the reasons A. lesser rainfall B. Quick runoff of rainwater C. Drying of the water points by silting, etc D. Any other specify _____

14. What are the main problems of your area concerning environment? A. Loss of soil fertility B. Soil erosion C. Reduced rainfall D. Any other specify _____

15. Impacts of land degradation (according to their importance) A. Loss of arable land B. Loss of surface water C. Loss of underground water D. Loss of rain E. Loss of land productivity F. Loss of pasture land G. Loss of forest land H. All

16. Whether the stoniness of your farm plots has A. Yes B. no

17. At present is soil erosion observed? A. Yes B. No

18. Whether the natural agricultural productivity of your farm plot is A. Reducing B. Increasing

19. What do you do to increase or maintain the fertility of your farmland?
A. Apply animal manure B. Apply chemical fertilizer C. Fallowing
D. Practice crop rotation E. Any other specify _____

20. Is the amount of soil moisture in your farm plots reducing from time to time? A. Yes B. No

21. What type of erosion do you perceive on your farm plots in relation with soil types according to magnitude (1st , 2nd , 3rd)

Magnitude	Sandy	Clay	Loam	Ba-ekel	All
Sheet					
Rill					
Gully					

22. In which type of rocks, vegetation and springs are lost faster? A. Sandstone B. limestone C. Trappean lava D. Any other specify _____
23. Personally what do you do to protect soil erosion? A. Pilling stones B. Construct soil/stone bund C. nothing D. Any other specify _____
24. What are the impacts of soil erosion in your area? A. Soil erosion B. Damage crops C. All D. Any other specify _____
25. What are the impacts of deforestation? A. Shortage of firewood B. Shortage of construction material C. soil erosion D. Loss of surface and spring water E. shortage of grasses F. Any other specify _____
26. Do you participate in the soil and water conservation program? A. Yes B. No
27. If your answer for question number 26 is yes since when A. pre 1991 B. post 1991
28. What are the reasons of your participation in the soil and water conservation? A. For search of work B. For managing our farm plots C. Forced D. Any other specify _____
29. Which conservation measures are found in your locality? A. Terracing B. Tree planting C. trench bund D. Any other specify _____
30. Which type of conservation measure is productive? A. The old B. The new
- If your answer for question number 30 is yes, in what? A. Agricultural yield B. to protected soil erosion C. All D. Any other specify _____
31. Do you care for the conserved areas? A. Yes B. No

32. Do you realize any change in nature from the watershed management program? A. Yes B. No

33. If your answer for question number 32 is yes, what is the change

Change	No	Minor	Medium	High
Vegetation				
Water				
Agricultural Production				
Socio-economic change				

34. In your opinion tree cutting is A. Right B. Wrong

35. In your opinion what must be done to protect deforestation. A. Protecting the planted area B. Privatizing C. Increasing awareness D. Issuing a policy E. Any other specify _____

36. Do you think the vegetation will rehabilitate if conserved? A. Yes B. No

37. How much time do you require to arrive at the soil and water conservation program site? A. < 30 minutes B. 30 – 60 minutes C. One and half hours D. More than one and half hours

38. Do you follow your farm conditions after rain? A. Yes B. No

39. what do you do if your farm plots are affected by soil erosion? A. I feel unhappy B. Nothing C. Report to the local officials D. Any other specify _____

40. Do you consider yourself as a beneficiary of the conservation program? A. Yes B. No, if no why _____

41. Is the payment for the soil and water conservation program enough? A. Yes B. No

42. Do you leave working in the soil and water conservation program if your living is improved? A. Yes B. No, Why _____

43. What do you think the reason of drought occurrence? A. The Will of God
B. Deforestation C. Man D. Any other specify _____
44. Is the summer rainfall in your area sufficient for harvest?
A. yes B. No
45. Do you produce enough to feed your family and meet other expenses like clothing, etc every year? A. Yes B. No
46. If your answer for question number 45 is no, how do you support you living? A. _____ B. _____ C. _____
47. What do you feel or do you do when you see some one cutting a tree?
A. I will be angry but I will no tell him B. I will tell him that is not good
C. I will tell to the local officials D. I don't care E. Any other specify _____
48. Do you consider yourself as a beneficiary of the earth dam A. Yes B. No



Photo 1 - 2. Rugged and steep Topography



Photo 3. Fire wood Consumption in Lime Production



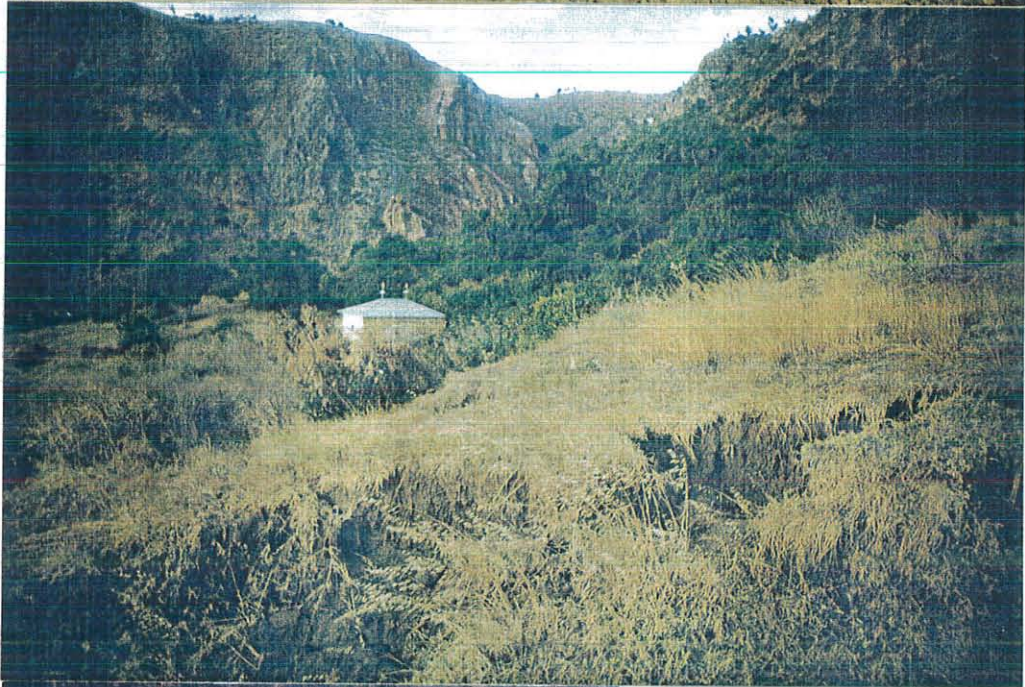
Photo 1 - 2. Rugged and steep Topography



Photo 3. Fire wood Consumption in Lime Production



*Photo 4. Devegetated
Background*



*Photo 5. Natural Forest
Shrunk to the
Churchyard*



*Photo 6. Deep and Wide
Gully with its Collapse*



*Photo 7. Tree Planting
along Gully floors*

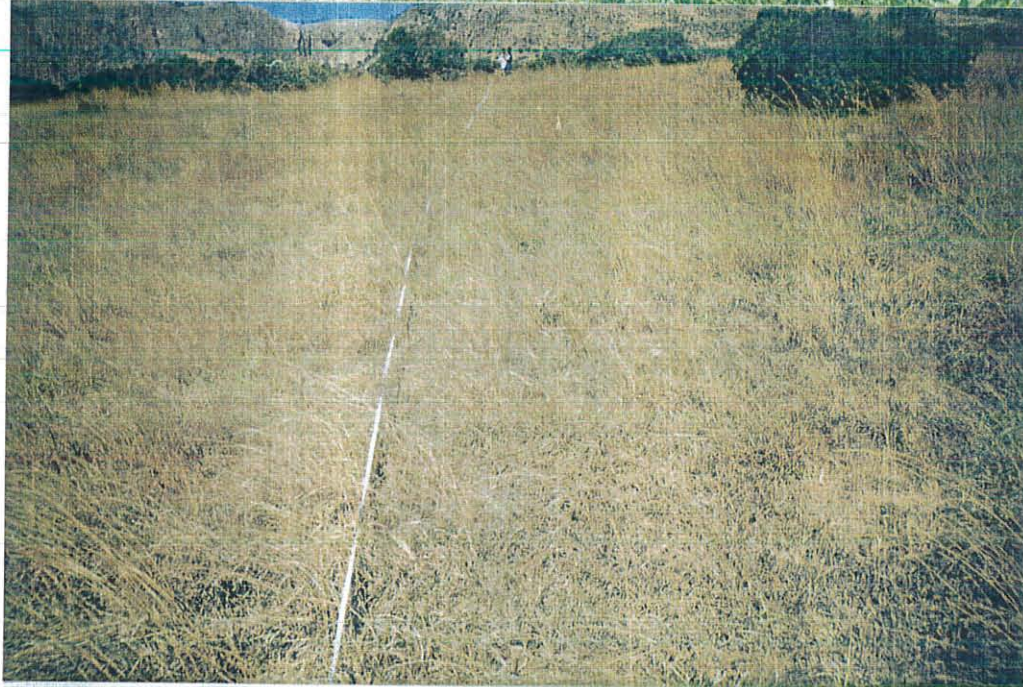


Photo 8. Area enclosures



*Photo 9. Bund constructed
above the Korir earth dam*



Photo 10. Trench bund
above the Korir earth dam



Photo 11. Part of the Korir
earth dam



Photo 12. Rehabilitated
gully part, below the Korir
earth dam