

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

GIS AND REMOTE SENSING INTEGRATED ENVIRONMENTAL IMPACT ASSESSMENT OF IRRIGATION PROJECT IN FINCHAA VALLEY AREA

BY
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Abstract

This research was conducted in order to assess the environmental impacts of Finchaa irrigation project using GIS and remote sensing techniques. Because of the limited resources only some environmental parameters were selected. These parameters are natural vegetation, soil/land, water quality, climate and health conditions.

The normalized vegetation index (NDVI) analysis was used to detect the spatial and temporal change of vegetation biomass in the study area. The result indicated that the natural vegetation biomass is declining. This is mainly due to the expansion of agricultural land and escalating human made structures in the area.

The water physico-chemical analysis demonstrated that the down stream water has more chemical substances and degraded physical properties than the up stream counterparts. The direct leakage of industrial liquid waste and the agro-chemicals from irrigation fields are supposed to contribute for this result. The GIS analysis of a 100 meter buffer around Major rivers and tributary streams is found to be a necessary action to mitigate the problem of pollution.

The soil chemical and physical property analysis in the irrigated and non irrigated fields reveals that the soil samples taken from irrigated fields contain higher phosphorous, Nitrogen and organic carbon compared to its counter parts. The use of agro-chemicals in the irrigation fields contribute for the result.

From the twenty two years rain fall, temperature and humidity data no abrupt inclining or declining trend is observed that could tell the possible impacts of the project.

The post irrigation development years witness that some water born diseases and malaria case records have increased. It is also found out that expansion of irrigation fields and the respective Malaria case records are positively correlated.

Generally, despite the significance of the Finchaa irrigation project, it has negative environmental repercussions. This is evident from vegetation cover distraction, water quality deterioration in the down stream area, alteration of soil physical and chemical components and increasing health threats. If the current condition continues the problems may out weight the benefits of the irrigation project. Thus in the project site and adjoining areas urgent environmental conservation is necessary. This helps to sustain the existing and revitalize the fading resources.

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Dedicated to

My Departed Mother

Fatuma Hassen

ACRONYMS

DEM	Digital Elevation Model
EIA	Environmental Impact Assessment
FSF	Finchaa Sugar Factory
GIS	Geographic Information System
ILRI	International livestock research institute
IWMI	International Water Management Institute
NDVI	Normalized Vegetation Index
RGB	Red, Green, Blue
RS	Remote Sensing

CHAPTER ONE

1. INTRODUCTION

1.1 Background Information

The expansion of irrigation scheme in Ethiopia lend a hand to achieve food self sufficiency and poverty reduction. Irrigation agriculture makes production more unwavering than the rain fed agriculture. Proper planning and management aided irrigation projects contribute for the growth of national GDP and GNP. It also creates job opportunities for several thousands of people directly or indirectly.

Despite their significances, however, irrigation practices have sometimes adverse impact on environmental conditions. It is known that Human activities have a profound effect up on the natural environment and are becoming the main agent of environmental degradation.

Finchaa valley was one of the few areas in Ethiopia to preserve its natural conditions for years. The topographic set up made the area to be inaccessible. In 1975 the valley was selected as a suitable site by the state farm to produce food and commercial crops. After few years the area was again chosen to establish a sugar factory. Following these there were many activities carried out in the area. Some of these activities have an enormous positive contribution while some others have negative effect on the environment.

In Finchaa valley, following the establishment of the sugar factory more pronounced land degradation is observed. There is large scale land clearance (deforestation) by the factory for new irrigation field.

In addition there are many people in and outside the valley that earn their livelihood from forest and forest products.
The factory uses agrochemicals like fertilizers, pesticides and herbicides in irrigation fields and the wash away collected in ditches and then join the nearby tributary stream. On the other hand some Part of the liquid waste from the factory spillover the treatment plant and joins Finchaa River. The problems emanate from the little attention given for environmental conservation as the main objective is to maximize production and productivity. The cumulative effects of these all problems can result in environmental degradation.

Land clearing for agriculture, agricultural malpractices, lack of awareness in policy makers and activities of the public are some of the major causes of environmental degradation. Girma A. (2005)

In Finchaa valley there exists a continuous disturbance on vegetation cover, soil, and water. If the trend goes on, there will be an extreme effect on the environment. Thus, it is indispensable to carry out environmental impact assessment (EIA) of the irrigation project in the area.

Environmental Impact Assessment has been recognized as an integral part of the early planning studies of irrigation projects in order to identify any expected negative impacts and to suggest the necessary actions to curb the problem. In addition, EIA can consider different designed alternatives for the project as an essential step for better decision making. The application of Geographic information system and remote sensing can facilitate the study of environmental impact assessment of irrigation projects for a better outcome.

1.2. Statement of the problem

The developments of irrigation projects have many advantages for a country. But some times irrigation schemes can have an adverse effect on the environment. It can be said that poorly planned irrigation projects usually result in socio-economic and environmental damages. Even some times in an effort to address some environmental impacts of the project some other disadvantages may arise.

Basically the question of sustainable development depends on how well the environmental conditions remain relatively unaffected. In the study area, the environmental conditions are influenced by the sugar factory and its irrigation scheme. As an agro-industrial processing plant the factory demands the clearance of vegetation from large areas, Plough of this land, diverting rivers to cane fields, producing smokes, emitting solid and liquid by-products and a wide range of construction works. These and other activities of the factory are the leading agents for some social and environmental problems in the study area. The extent and severity of the environmental impacts of the project in the area should be assessed to mitigate the negative impacts of the project and even to secure better and long lasting advantages.

One field in which impact assessment is likely of particular value is the formulation of sustainable development strategies. It has the potential to introduce foreword looking and objective assessment and valuable for mediation and conflict management. Borrow C.J. (2000)

The natural environment in Finchaa valley is under continuous threat due to negligent actions. The cause, course and result of these problems need to be assessed and addressed in a scientific way. In this regard some GIS and remote sensing techniques make the task of impact assessment easier and objective.

The main concern of this research work is, thus, to assess the environmental impact of irrigation scheme in the valley by analyzing the existing interaction and interrelation ships among the environmental elements and there by reach at weighting conclusions and suggest feasible recommendations useful for sustainable development.

1.3. OBJECTIVES OF THE STUDY

1.3.1. General Objectives

- To Asses the impact of the irrigation project on the natural environment of Finchaa valley Area.

1.3.2. Specific Objectives

- To see the impacts of Finchaa irrigation scheme on vegetation cover using satellite images of different years.
- To explore the extent of soil quality degradation as a result of the irrigation scheme.
- To asses the impact of the irrigation on water quality in the upstream and down steam water of Finchaa River.
- To see the climatic change (temperature and rain fall) over the past 22 years and interpret the results on sustainability of the irrigation project.
- To investigate some health threats following the irrigation project spatially and temporally.
- To propose some valuable measures to be taken to mitigate the negative impacts of the irrigation project on the environment in such away that assures sustainable development.

. Significance Of The Study

Geographic information system and remote sensing integrated environmental impact assessment allows seeing the past-present pace of changes and fore tell their future trends and styles of change. In so doing it is possible to relinquish the existing signs of environmental disasters and its forthcoming consequences.

In light of this the final out come of the research is believed to help national and international organizations working in irrigation and related projects in scrutinizing the possible negative impacts of this sector. It can also serve as a reference for policy and decision makers, investors and investment plans for analyzing their projects before hand and forward informed decisions.

The thesis is believed to have a special contribution in identifying the pick problems of the irrigation and addresses them in more scientific ways. Finchaa sugar factory in particular, is the main beneficiary in using the findings of the paper as an input meeting its development goals and expansion plans. On the other hand the paper can give a yellow light for the factory to take justifiable action towards the degrading environment.

The concerned bodies can use the result in their efforts to identify, monitor and prevent the negative environmental impacts of the irrigation schemes. Further more it helps see the future possibilities of occurrence and trend of the negative consequences of irrigation projects so as to take pro-active measures and avoid the occurrence of similar problems.

Finally, the findings of the research can serve as an input for further investigations on the impacts of the irrigation scheme in the study area and similar ecosystems at large.

1.5. Scope of the study

To have the broad picture of the environmental components related to land escape, land use and land cover of the study area relatively wider area is delineated with special attention to the irrigation project area. This is believed to show the direct and indirect impacts not only on the project site but also on the flanking areas.

The term “environment” is defined in a different way by different researchers. For the sake of simplicity only some components of the environment are inculcated and accordingly the vegetation cover, the soil/land, the water (drainage system), the climate (rain fall and temperature) and health conditions helpful for the impact assessment are considered. Some of these elements are integrated with Geographic information systems and remote sensing techniques to have a better look at both positive and negative impacts of the irrigation scheme over time.

Taking the available time and resource in to consideration it is reasonable and convincing to scope the research topic on the above mentioned parameters.

1.6. Research Methodology

In order to make out the positive and negative impacts of the irrigation project on the environment of Finchaa valley area more of primary and some secondary data are collected. Some of these data are integrated with GIS and remote sensing techniques in a way that manifests the impacts of the irrigation project on the environment.

To best investigate the positive as well as negative impacts some components of the environment are preferred for investigation. These are vegetation cover, soil/land, water, climate and health cases records.

The first line consideration is given to the direct environmental impacts of the irrigation scheme. In light of this the indirect impacts are also inspected to the best of the researchers' knowledge and available resources.

Different years of satellite images are used for the vegetation cover change with the expansion of the irrigation in Finchaa valley. Under this the scope and extent of variation in land cover, land use, reflectance properties, Image differencing, erosion estimation and the NDVI analysis are explored and quantified.

To investigate the impacts of the irrigation on the soil the physical and chemical soil analysis has been made. The soil samples in different sites were collected. These sites are the irrigated fields, ploughed but not yet planted and non irrigated (vegetated) areas. The samples were taken in three layers and totally nine samples were analyzed. The result is believed to show the soil component anomalies in the irrigated and non irrigated areas and the possible causes. Visual presentation of the land with and without irrigation also gives some idea about the level of land degradation. Some GIS integrated slope analysis also provides slope differences and the intensity of erosion.

In order to investigate water quality problems water samples from upstream and down stream areas were taken and these samples are supposed to show the spatial water quality changes. This intern helps to examine the impacts of the project on water quality. Quantity wise the irrigation water use will be incorporated to asses the problems emanating from under and/or over utilization of water.

Long year's meteorological data are used in order to evaluate the micro climate of Finchaa valley area for temporal anomalies. In light of this panorama other environmental components are examined and possible solutions recommended. This again helps to foretell the sustainability of the irrigation scheme in relation to climatic favorability.

The unstructured interview to the concerned bodies and past research works furnish with valuable information with respect to the past-present natural and socio-economic setup of the area. These data are integrated with impact assessment and GIS/RS techniques in such a way that shows the kind and extent of changes that have been taking place.

1.7. Limitation of the study

The main constraint of this research work are time and lack of related specific research works in the study area. The research costs obtained from Addis Ababa University and IWMI are not sufficient enough to carry out more detailed works.

These problems bound the scope and coverage of the thesis and obstruct not to investigate many soil and water samples that could help for a better environmental impact assessment.

Lack of successive and high resolution satellite images also hinders short term and detailed land use land cover change detection and further analysis.

Unwillingness of some offices to provide some reference information for fear of embezzlement can be sited as the other limiting factor in obtaining valuable information.

1.8. Organization of the Research paper

The paper is composed of six chapters. The first chapter introduces the background information of Finchaa valley area, problem definition and general and specific objectives of the thesis. In addition it deals with the significance, scope and methodology of the research work with encountered inadequacies.

The second chapter mainly deals with review of related literatures on environmental impact assessment, irrigation impacts (positive and negative) and role of GIS and remote sensing in environmental impact assessment.

The description of the study area will be presented in the third chapter. This chapter gives the general information about the physical geographic setup of Finchaa valley and the adjacent areas.

Under Chapter four the vegetation cover changes in the pre and post project years and the possible aftermaths are discussed. In addition the effects of the project on the physical and chemical properties of the soil are presented and analyzed with respect to the present and future outcomes.

The water quality analysis and drainage system anomalies are presented under chapter five. In this chapter the climatic and health data are also presented and interpreted.

The final chapter summaries the point by point discussions on the impacts of the irrigation project and forward feasible recommendations help full for environmental conservation and sustainable development.

1.9. Operational Definition of terms

"Belg": is Amharic word which describes the semi rainy months of Spring.

Environmental Conservation: any action taken to protect the existing Natural resources and rejuvenate the degraded environment.

Environmental Degradation: the deterioration of the physical, chemical and biological quality of environmental components.

Environmental Impact assessment: the system used to identify any positive or negative impact of a project.

Finchaa valley area: these include the valley to the Abay River and flanking highlands, Finchaa Lake and town and the Amerti-Nashe basin.

GIS: is the tool that mange the spatially represented data and further analyze raw data in meaning full ways for a better understanding.

Irrigation project: irrigation project in this research is contextually defined as the agricultural and industrial development activities.

"Kiremt": Amharic word which describes the rainy season starting In June and ends by the beginning of September.

Negative Impact: indicates the unexpected and unwanted out comes due to development activities which could result in environmental quality degradation.

Remote sensing: the system of capturing, interpreting and analyzing data obtained by using satellites.

Soil pollution: refers to the change in soil constituents as a result of addition of agro-chemicals and other toxic wastes.

Water quality problem: any decline in the physical, chemical and biological composition of water.

CHAPTER TWO

2. Review of Related Literatures

2.1. Environmental Impact Assessment (EIA)

Environmental Impact Assessment is a planning tool that facilitate the decision making process by evaluating the environmental consequences of a proposed activity before action is taken. The concept has ramifications in the long run for almost all development activity because sustainable development depends on protecting the natural resources which is the foundation for further development. Alan Gilpin (1995)

Some writers argued that Environmental impact assessment is an activity to be carried out before a project. But EIA is a very help full procedure to be followed at all stages of development projects even after the establishment of a project as the goal is to mitigate the negative impacts of a proposed activity on the environment. This involves fostering environmentally sound projects and bargaining with projects that are not environmentally sound.

Agrawal M.L. and A.K. Dikshit (2002) described the role and scope of EIA as:

> *"a systematic, well documented and multidisciplinary procedure, where we identify, describe and assess the direct and indirect effects of a project or an activity on different environmental factors such as soil, water, air, climate, landscape, cultural heritage, flora, fauna, human beings; and also interactions among the factors. EIA helps to develop environmental friendly projects and seeks to reduce environmental degradation caused by developmental activities. EIA*

is a pre decision tool with many different purposes useful for different actors, planners, designers, project proponents, and public and decision makers. It also provides a plan to reduce the negative environmental effects of development project through alternative approaches, design modifications and remedial measures....Environmental Impact Assessment (EIA) consists of a systematic investigation of both positive and negative impacts on the physical, biological, socioeconomic environment, which would be caused or induced due to a proposed developmental project. Its primary objective is to encourage the inclusion of environmental considerations in planning and decision making and to ultimately arrive at actions that are more environmentally compatible."

However, it is irrefutable that Environmental impact assessment is more effective to be conducted before launching a project. This helps to provide decision makers with reliable information about the likely impacts of irrigation on the environment. This intern helps to stop projects that are not sound and costly (environmental, social, economic and political costs).The better the EIA the lesser would be the negative impacts of irrigation projects on the environment and vice versa.

Morgan.M.K. (1998) argued that EIA is a process for identifying, predicting, evaluating and mitigating environmental impacts and communicating the information to decision maker and the public. Thus, EIA should be carried out before a project. It helps to protect sensitive ecosystems, enhancing quality of life, promoting sustainable resource uses.

Still group of people consider environmental impact assessments as anti development plans and simple resource wastage. They even consider EIA to be unfitting to developing countries who are giving priority to rural development projects and food self sufficiency. But development and

environment should not be seen as separate and conflicting issues rather one is complementary to the other. Environmental considerations guarantee the sustainability of developments and intern well designed developments help protect the environment.

> *"While promoting rural development projects the environmental dimensions have to be integrated in the planning process as to achieve sustainable growth. Environmental impact assessment can be used as a power full tool to resolve this conflict between environmental concepts and development pursuits. EIA helps to support environmentally sound and sustainable development. Several projects could be better developed (fruit full) if environmental impact assessment was carried out."* Painnly J.P. (1994)

The final destiny of environmental impact assessment should be to assure the sustainable use of resources with out damaging environmental components. It is only then that we can appreciate development and development plans. Environmental considerations should not be understood as something against development rather it fosters and guarantee the continuity of our development.

Glen Paoletto (2003) presents this concern by saying

> *"The issue to be addressed here is how environmental damage can be avoided or reduced so as to ensure that development initiatives and their benefits are sustainable. The directive of environmental management should be to achieve the greatest benefit presently possible for the use of natural resources without reducing their potential to meet future needs and the carrying capacity of the environment. Taking environmental considerations into account in development planning does not imply that the pace of socio-economic*

progress will be slowed down, and taking environmental considerations into account in the various phases of the project cycle must not be seen as placing undue constraints on a country's development options. If projects are to be suspended on environmental grounds, alternative opinions that are environmentally sound must be provided to meet the country's developmental needs for most projects, particularly those involving large public investments in areas such as infrastructure, an Environmental Impact Assessment (EIA) should be carried out and linked to the cost-benefit analysis. The objective of the EIA is to ensure that environmental aspects are addressed and potential problems are foreseen at the appropriate stage of project design. EIA should be envisaged as an integral part of the planning process and initiated at the project level from the start."

Mainly EIA help to see the current environmental conditions in light of the initial conditions. In so doing we can compare and contrast the existing trends and there by analyze the type, extent and pace of changes. In addition EIA should be carried out thought out the life time of a project.

An environmental impact assessment should contain three sub-sections relating to environmental effects, a determination of the initial reference state, an estimate of the future state 'without action, an estimate of the future state 'with action. Haklay M. et.al (2001)

2.2. Irrigation Impact Assessment

It has been long time that human beings identified irrigation as an important agricultural phenomenon that help to get more and reliable production compared to rain fed agriculture.
Referring EVDSA, Darout Gum'a (2004) defined irrigation development as an agricultural development in which technology intervenes to provide control for the soil moisture regimes in the crop zone in order to achieve a high standard of continuous cropping.

Irrigation development in a certain area can be resulted in positive as well as negative impacts on the environment. Absence of well designed and well managed irrigation projects result in negative environmental impacts. The source of this impact arises in different stages of the irrigation project.

Mintesinot et.al (2004) reviewed the issue in the preliminary report on Tekeze basin and concluded that:

> *"Irrigation scheme development is on of the most commonly practiced strategy to secure food self-sufficiency in most of the developing countries. However, the development of this irrigation schemes result in a very huge loss on the environment and human health besides their benefit to the community...The intervention of irrigation schemes highly benefited the farmers in improving their livelihood. But the management systems are very poor so that a lot of negative environmental impacts have been observed.*"

For third world countries like Ethiopia the question of food self sufficiency has been given priority, to this end using irrigation agriculture is given first line attention. But for the better use and sustainability of irrigation projects special care should be given on each steps of the project development.

The federal democratic republic of Ethiopia under African Development Fund in its agricultural sector review (2002) stated the positive contribution of irrigation for the country as; there is a big potential to produce food, exportable crops and industrial raw materials using irrigation. Thus development of irrigation is imperative for the county's poverty reduction efforts Support for irrigation development and water harvesting, with emphasis on small-scale irrigation, towards ensuring enhanced food security and income generation.

It is undeniable that irrigated agriculture has many advantages over the rain fed agriculture. In addition well planned irrigation projects contribute for the economic and social well being of a society in various ways. Some of the many advantages of irrigation schemes includes large job opportunities(as irrigation farming is a labor intensive activity),increase production, maintain surface and ground water balance (if applied properly),contribute for economic developments and the national GDP and GNP.

Claudio O. Stockle (2002) stated that irrigation have resulted in lower food prices, higher employment and more rapid Agricultural and economic development. The spread of irrigation has been a key factor behind the near tripling of global grain production since 1950.

On the other hand irrigation can also have immense negative impacts if not used properly. In addition, the negative repercussion of irrigation

projects affects not only the environment but also the sustainability of the irrigation project itself and there by many other wakes of life.
Negative or unwanted impacts can arise at different stages and from different sources.
The FAO Environmental impact assessment report (2001) mentioned the multi faceted negative impacts of irrigation project as follows:

> *"The most common problems of(ill designed) irrigation schemes are Soil acidification, Alkalization, Water logging, Salinization, Drying of drinking & irrigation wells, Increased incidence of water related disease, Increased inequity, Weaker community infrastructure, Poor water quality, Reduction in irrigation water quality, Water quality problems for downstream users caused by irrigation return flow, Reduced big-diversity in project area, Ecological degradation, Damage to downstream ecosystems due to reduced water quantity and quality."*

Poorly scheduled and ill designed irrigation projects create problem on the environment as there is land clearance, land plaughing, use of pesticides and fertilizers, road construction etc in irrigation fields. Negative or unwanted impacts can arise at different stages and from different sources.

> *"Irrigation and water resource development can cause social and environmental problems. Irrigation represents an alteration of the natural conditions of the landscape by extracting water from an available source, adding water to fields where there was none or little before, and introducing man-made structures and features to extract, transfer and dispose of water. Irrigation projects and irrigated agriculture practices can impact the environment in a variety of way. Construction of irrigation projects, water supply and*

operation of irrigation projects and irrigated agriculture management Practices. One reason is that irrigation often exacerbates the effects of salinity, which may occurs naturally. Estimates indicate that roughly one-third of the irrigated land in the major irrigation countries is already badly affected by salinity or is expected to become so in the near future." Stockle C.O. (2002)

The alteration of natural environment, at a lesser or greater extent, creates problems to the natural as well as human made environment. The scope and severity of these impacts mainly depends on how well the projects emphasize the environmental considerations.

Smol J.P. (2002) explained the negative impacts of water diversion by giving example of Aral Sea. He stated that Aral sea found bordering Kazakhstan, Uzbekistan and Turkmenistan and due to ill (planned) diversion of the sea water it decrease in size (40%) with in 30 years, increase salinity, lose its esthetic value, fish species disappeared and leaves behind fishermen unemployed…A large number of ecological, health and social problems have been linked to this near total distraction of an entire ecosystem.

"Without appropriate management measures, irrigated agriculture has the potential to create serious ecological imbalances both at the project site and in adjacent areas. Excessive clearance of natural vegetation cover in the command area, for example, can affect the microclimate and expose the soil to erosion, leading to a loss of top soil and nutrient leaching. The removal of roots and vegetation disrupts the water cycle, increasing the rate at which water enters rivers and streams, thereby changing flow regimes and increasing siltation in the downstream zone. This is often to the detriment of fisheries and aquaculture activities. The destruction of natural habitats in this manner and the creation of agricultural monocultures

also impacts on the local flora and fauna reducing biodiversity. The introduction of exotic species of plant or animal may oust indigenous species or introduce disease agents which may affect plants, animals and/or man. Fertilizers and pesticides are widely applied to correct imbalances. These can percolate through the soil and/or be carried away in the drainage water polluting both groundwater and surface waters especially in the downstream zone. The nutrients in fertilizers may give rise to eutrophication of surface water bodies and promote the growth of aquatic weeds. Pesticide residues are hazardous to the health of both man and animals." FAO Corporate document (2001)

Dereje A. (2005) from different sources reviewed that it is to be known that irrigation agriculture is not always with positive out comes. past experience in different parts of the world indicated that many areas that were once productive are currently put out of production mainly due to salinity problems resulting from use of poor quality water for irrigation and/or application of excess irrigation water (even of good quality) in the absence of effective drainage system.

When ever there comes development, there exists alteration of natural environments especially natural vegetation cover. Irrigation projects mainly require large scale land clearance. This can be compensated if due attention is given to the environment but paying little or no attention to the natural environment may claim even the sustainability of the project.

Sophie N. et.al (2003) said that irrigated agriculture is the largest user of water globally and its development can have significant impacts on inland …these impacts can be varied and complex, and range from biodiversity Concerns to economic impacts and changes in the livelihood opportunities of rural households. There is a need to improve the knowledge of these impacts and integrate their assessment into project planning and implementation. To date; most impact assessments for inland fisheries have focused on the ecological impacts of modified river flows and habitats without taking full account of production and livelihood impacts and interactions between these. The approach developed is focused on production and livelihoods, and intends to support improved management and sustainability of land, water and fish resources. It builds upon commonly used frameworks for Environmental Impact Assessment but places particular emphasis on a holistic assessment that is integrated across disciplinary perspectives and sectoral interests.

Natural resource degradation mainly emanates from or aggravated by human activities. In making life easier the current advancement in technology requires huge amount of resource exploitation. Over-exploitation and misuse of resource is mainly leading to resource depletion and negative repercussion on our planet earth. This puts life and lives in problem. For instance, Soil/land is the main means of production and determines production and productivity. But due attention is not given for this resource as most of the soil/land degradation emanates from malpractices on agricultural, industrial, construction or other related developments. Vegetation also plays a key role in maintaining the natural balance, hosting the wild life, manipulating the micro climate, minimizing soil erosion, balances the ecosystem, maintains the amount of surface and ground water, provides

aesthetic value and many others. However, currently natural vegetation cover is the first victim of “developments” including irrigation venture.

The major factor behind wide spread land degradation in Ethiopia is ill planed and poorly deigned land use. This continuous and ever increasing problem is mainly exacerbated by large scale land clearance for developmental purposes.

Group of researchers from International Livestock Research Institute found out that land resource degradation is the major threat that affects the existence and livelihood of the community. The degradation of land resource due to overexploitation and misuse and Consequent economic, social and environmental impacts has intensified the pressure on the land resources of the country. Therefore, it is of paramount importance to identify suitable land for various uses in optimum utilization while causing minimum impact to the environment. In order to utilize the land resources in sustainable way, a land-use plan that incorporates the different land characteristics has a paramount importance. Atesmachew B. et.al (2004)

> *“There are many possible consequences of the improper design of irrigation systems. These were classified and discussed as factors relating to (1) public health if backflow prevention systems are not properly designed or installed, (2) waste of natural resources including water, chemicals, and the energy required for pumping if systems are not properly designed and thus water cannot be applied uniformly, (3) pollution of water supplies if poor system design results in non uniform water and chemical applications and leaching of chemicals to the water supplies, (4) operator safety if components are not properly selected and installed, (5) cost of irrigation if total annual fixed and operating costs are not*

considered, (6) economic return from irrigation if a poorly designed irrigation system cannot provide the crop's water requirements, (7) and system life expectancy if components are not properly selected and installed for the operating conditions expected for each individual system. To avoid problems with poorly-designed systems, all of these factors must be considered when irrigation systems are designed." Smajstrla A.G. et.al (2003)

The pre project survey and environmental impact assessment determines the cost or the benefit to weight more, well designed and scientific research based irrigation projects usually creates lesser negative impacts to the environment than randomly established one. Basically there should be some environmental impact considerations before and on the process of irrigation projects.

Bandaragoda D. J. (1998) quoting from Perry (1995) stated that there are three basic elements essential to developing functional irrigation projects: water rights, infrastructure capable of delivering the service implied in the water right, and assigned Operational responsibilities.

2.3. GIS and Remote Sensing in Irrigation Impact Assessment

"Geographic information System (GIS), is a tool for collecting, storing, retrieving at will, transforming and displaying spatial data for a particular set of purposes, can provide all desirable requirements…as most of the environmental attributes are spatial in nature and to understand and manipulate these attributes, suitable spatial database management system is require this can be well handled by integrating GIS as a tool… GIS acts as an Integrating framework for generation, storage and display of the thematic information relative to the sensitivity of the affected resources; GIS is unique in its ability to capture, store and manage spatially referenced data; GIS supplies a framework. Using GIS various types of visual impacts can be evaluated like, how a road will look like? How much portion of the road will be visible from a particular point? We can calculate and visualize the impact on ground levels either in filling or cutting and area of quarries etc. As a system: GIS can serve as a basis for scoping of environmental effects … The GIS based EIA is having the final output in pictorial form, which is very helpful and easy to understand by non technical decision makers." Agrawal M.L. and A.K. Dikshit (2002)

Geographic information system is a powerful tool to handle spatial data and analyze in a more meaning full ways.

The paper by Haklay M. et.al (2001) affirmed that:

"GIS can serve as a basis for scoping of environmental effects, despite the economies of scale of GIS systems, the inaccuracy of some layers of digitized data, and the severe time and budget constraints under which scoping is carried out. From a technical

perspective, once the basic data bases are available, regardless of accuracy, a GIS based system can probably provide better targeted guidelines for EIS, and reduce the probability of either unnecessary data being collected or important effects being overlooked…Geographical Information System (GIS) are computer systems that can store, integrate, analyze and display spatial data. GIS offers a special environment for dealing with the spatial properties of a project. Those special attributes of the GIS are very important for the analysis of environmental issues, since most of them are spatial by nature, and no other computerized system can handle them properly (Schaller, 1990). In recent years important developments have helped in reducing the complexity of spatial analysis."

Chris Parker (1997) explained the role of GIS as since a GIS collects and manages environmental data in a standardized manner. Its use is likely to result in more efficient data collection and analysis. For instance flood risk maps captured on a GIS, can be available to planning, housing, communications and insurance organizations. The common use of environmental data sets minimizes duplication of effort and helps engender the team approach required to tackle multi disciplinary environmental problems.

Preventing or mitigating environmental impacts often requires the consideration of a number of environmental attributes, whose relationships may be dynamic in that they change over time and in their spatial relationships.

GIS functionality provides the environmental manager with a powerful set of tools for modeling spatial problems where several layers of graphical and tabular data may be involved. For example, well field protection involves taking account of potential hazards to the well field

from flooding risk, septic tanks, storage tanks and industrial areas, and delineating buffer zones to protect well fields from such hazards. GIS can resolve these spatial problems accurately and rapidly.

Because of its spatial modeling capabilities GIS can provide useful support to management decision making. *'What* if type models can be run in GIS to simulate the effects of adopting different environmental policy options. A more informed choice can then be made by using GIS as a decision support tool. It can also be used to display the results of other environmental models such as air and water pollution dispersion models together with other layers of information held in the GIS to 'add value' to analytical results and their implications…GIS can be particularly valuable in an environmental monitoring role to identify and delineate spatial changes in environmental conditions over time…GIS provides a measure of flexibility and timeliness when responding to environmental questions. Since the GIS data set can be readily updated in the light of new information or changes in environmental conditions it maintains a far greater currency than a paper map which may be several years old and represents only a snapshot of environmental conditions at a point in time. When the environmental GIS is updated the result of the query is also updated, as are the results of the environmental model to which that new data element was added. Hence the environmental GIS can be more responsive to dealing with environmental issues such as environmental contingency planning or disaster management.

> *"The living things and non-living things should be strand together as symbiosis in the ecological system. Therefore, the planning for the integrated on natural and environmental management for the proper use is the very important tool for natural conservation and environmental rehabilitation. The most the important factor effect to the ecology, environment, social and economic is human being. A*

planning and decision-making approach that is founded on ecological principles and recognizes that human intervention in the environment has significant effects across the whole connected natural system…the provision of opportunity for general public during a planning process and to influence decisions resulting from a planning process. The public is all inclusive and includes individual citizens, all levels of government, non-government organizations, and the private sector. The stakeholders will be making decision on their benefit in the future. The problems in each area will be solved in different levels and situations by stakeholders. Equal and participation created the vision for the future 20 years…the application using by GIS and other database are the important tool for planning and decision making …GIS data base contained natural resources, infrastructure, economic and social map layers. Those maps were overlaid for spatial analysis the potential ability of the land to support renewable natural resources such as forestry, agriculture, wildlife, recreation and water production. In the other hand, spatial data could be used for problems and opportunities analysis. Spatial data could show the situation and size of problems and development opportunities. GIS is a tool for analysis target area, criteria, objectives, management guideline, zoning, resolution of conflicts and options in each area." Vicharn.A. and Sirirat S. (2001).

CHAPTER THREE

3. Description of the study Area

3.1. Location

Finchaa valley area is found in western part of Ethiopia, in Oromiya region, eastern wallega zone. The area is enclosed with in three Woredas; Abay Chomen, Jimma Horro and Guduru. Astronomically the study area is situated with in 9° 30' to 9° 60'N and 37° 10' to 37°30'E.

Finchaa Valley area is reached through the main high way west of the capital, Addis Ababa. The Asphalted road runs west of Addis Ababa to Gedo for 194km and the all weather gravel road (about 138km) ends up in Finchaa valley.

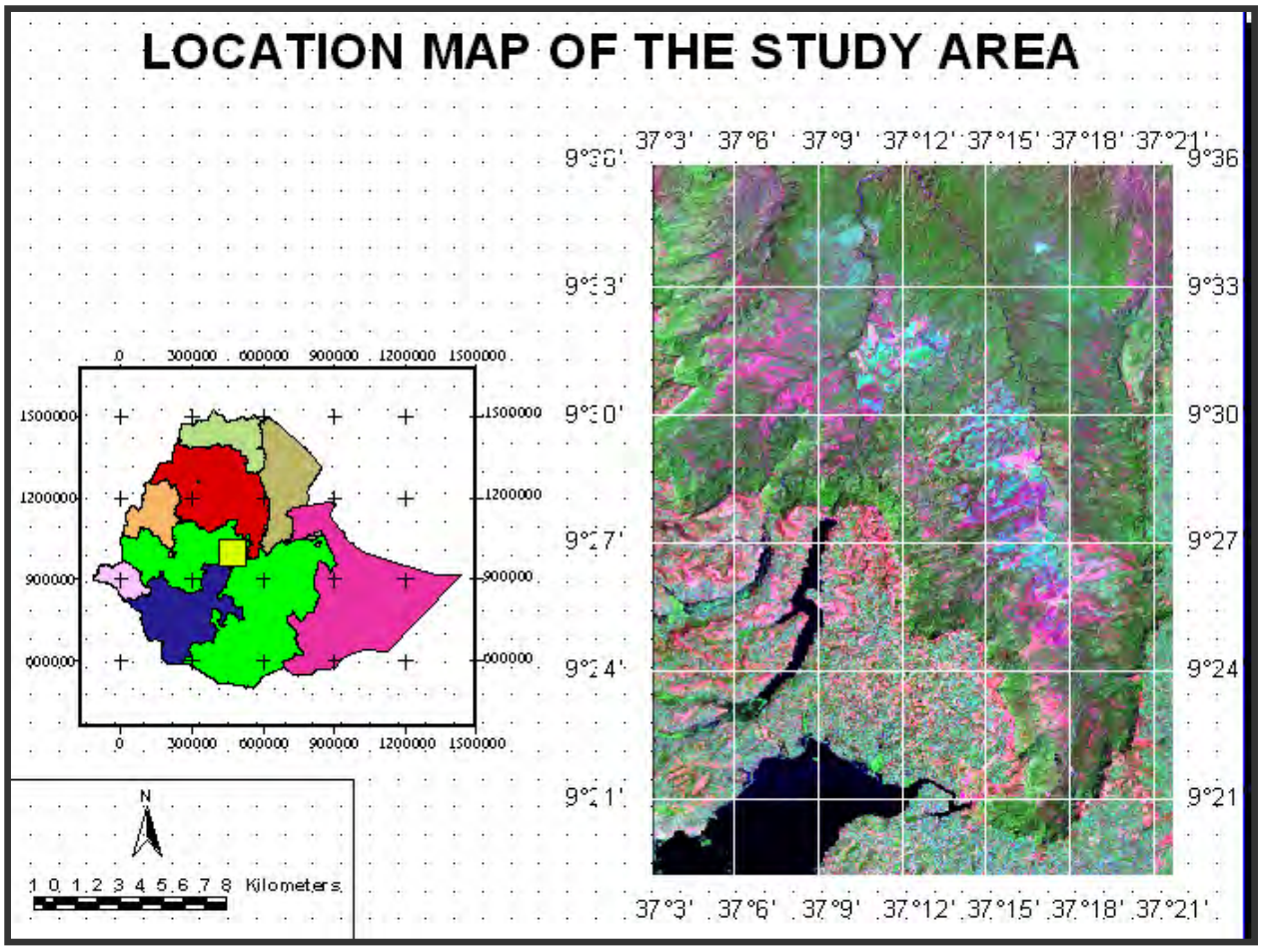

Figure 3.1. Location map of Finchaa valley area

3.2. Topography

One of the prominent aspects of Finchaa valley area is the landscape. The topography greatly varies from low land (<1000m) to high land (>2000m).The lowest area in the study area is about 902 meter above sea level and the highest being 2448.5 meters. This big elevation difference with in short distance contributes a lot for soil erosion and micro climate anomalies. It has again an enormous role in controlling factor on the surface and sub surface hydrological conditions.

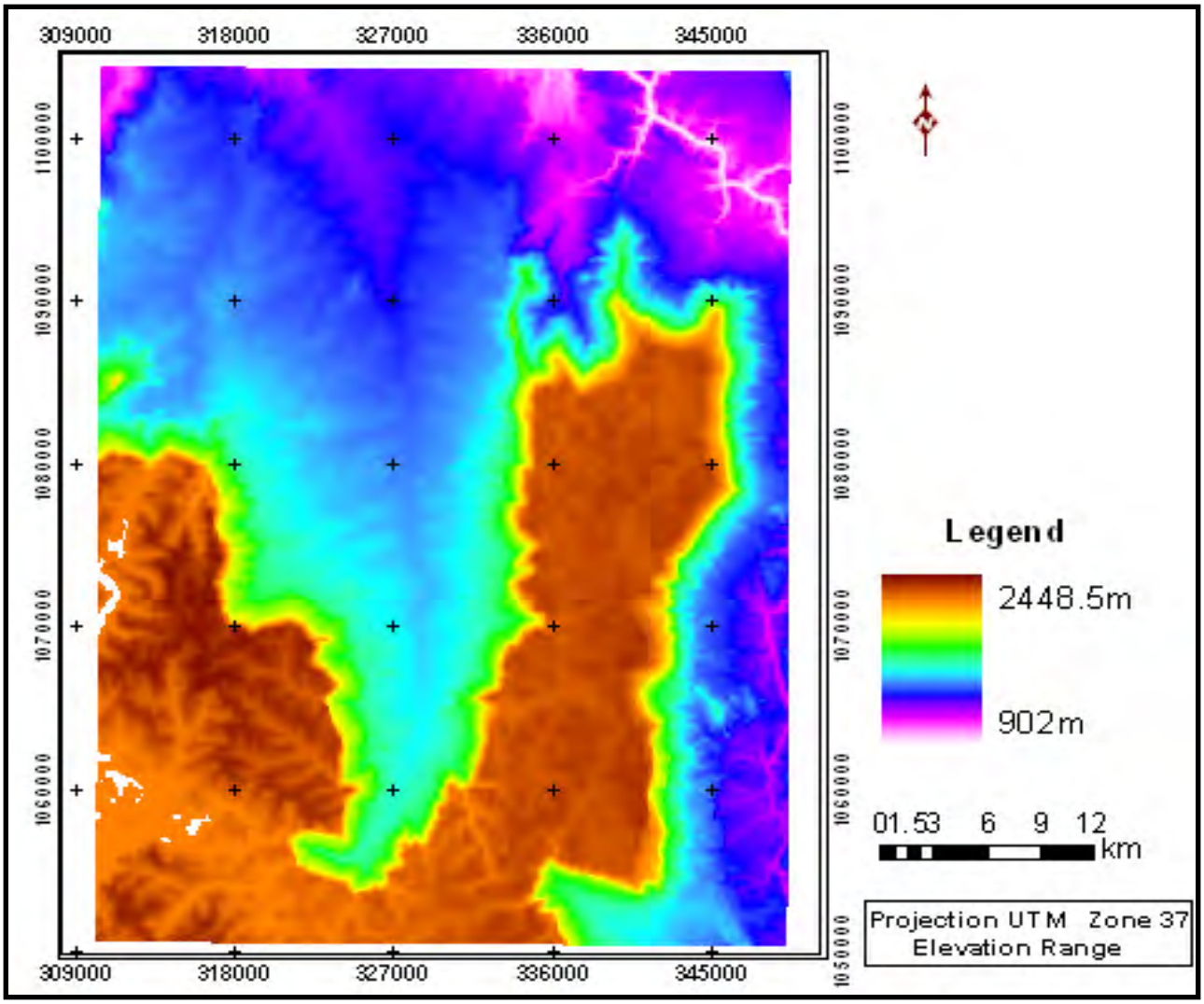

Figure 3.2. Elevation range in Finchaa valley Area

Finchaa valley is low lying area surrounded by elevated and precipitous escarpments. The valley is surrounded by these escarpments in the eastern, southern and western sides. These features have their own role to play in slope change and some other related analysis.

The average elevation in the valley floor is about 1,550 meter. In the surrounding elevated areas the average elevation is about1800 meter. The valley in the project site is about 12 kilometer wide and extends for about 37 kilometers. It has a “u” shaped profile. This mainly creates fertile ground for soil erosion and makes road construction a problem.

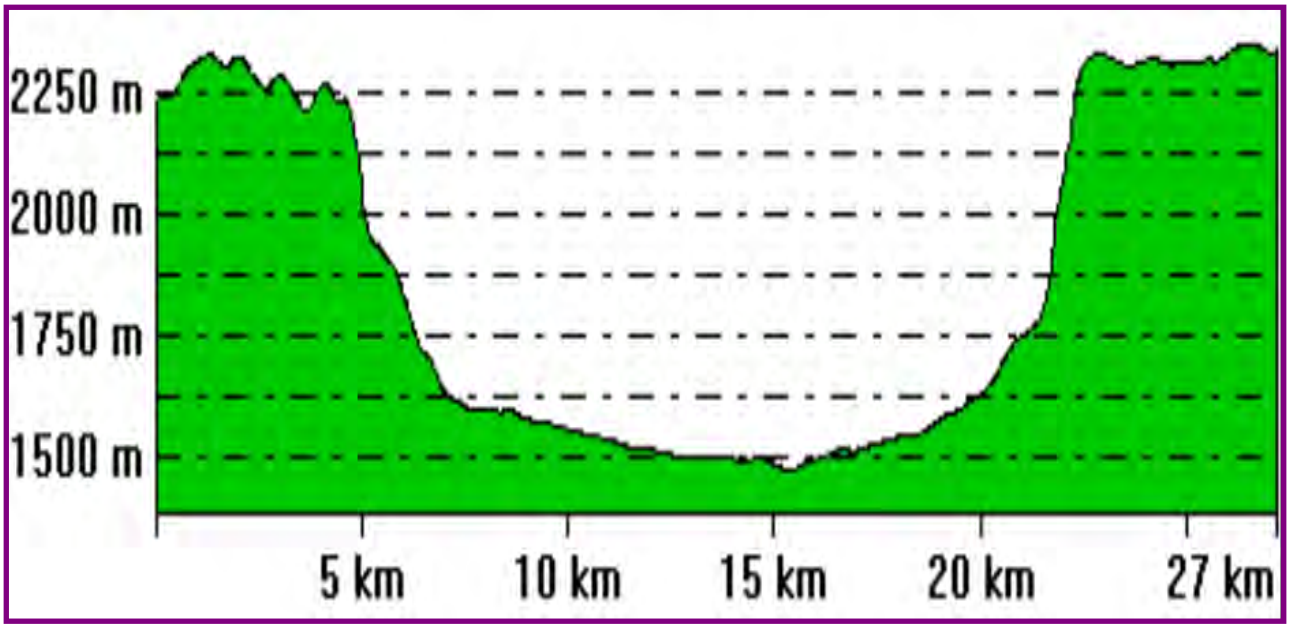

Figure 3.3.The vertical cross-section of Finchaa valley.

The east and west escapements constitute the steepest slopes in the area. The valley floor has the elevation less than 1600 meter. Where as the surrounding high lands have altitude greater than 2250 meter. This abrupt elevation difference brought variation in weather conditions in the high lands and the valley floor.

In the study area the steepest slope is situated in the elevation range of 1600 to 2300 meter and from 950 to 1050 meter. Spatially these areas refer to the adjoining escarpments and the far down stream areas respectively. By implication high run off and lateral erosion is high in these areas compared to the gentler slope locations. The valley floor is marked by a general slope less than 25 percent.

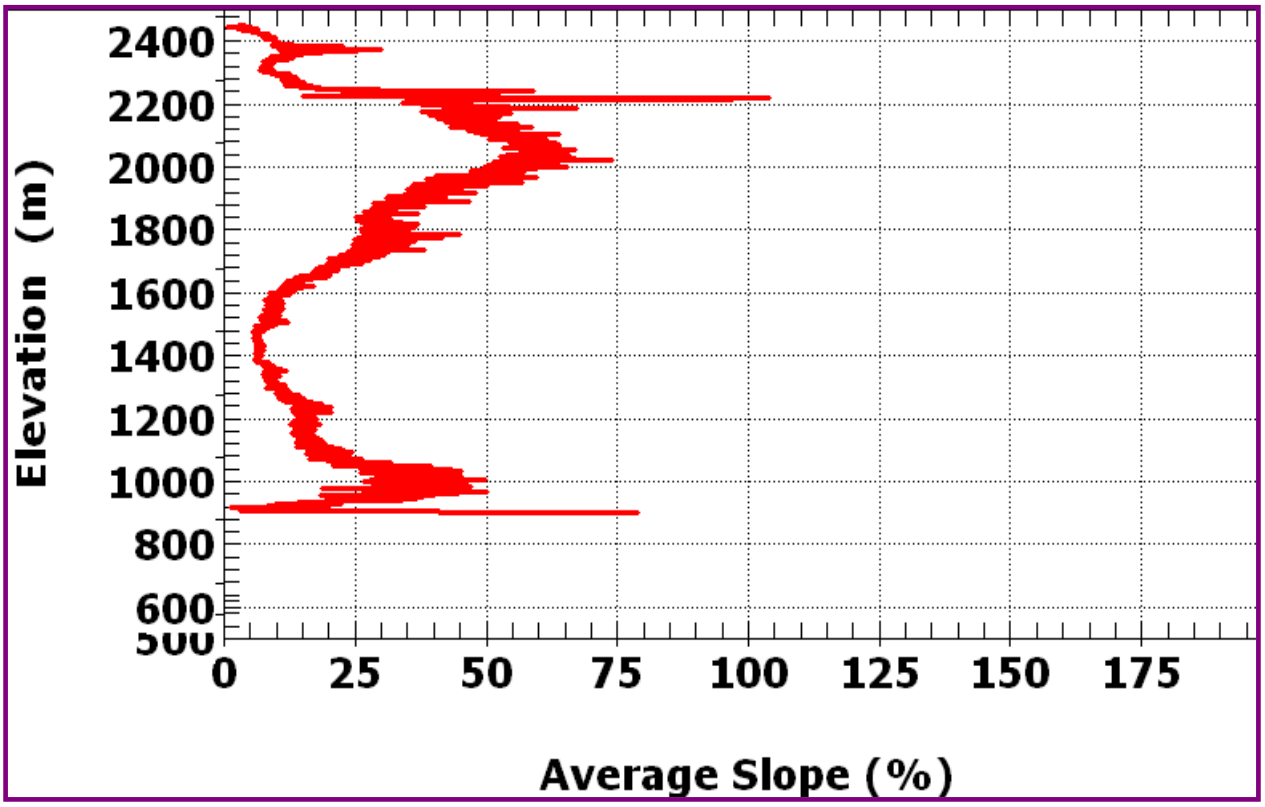

Figure 3.4. Elevation against average slope in Finchaa valley Area.

3.3. Vegetation Cover and Wild life

3.3.1. Vegetation Cover

Finchaa valley has been home for variety of flora and fauna. There are different kinds of trees and grass species which totally covered the top escarpments to the valley floor.

The feasibility study carried out by Shawinigan Company (1981) witnessed this. It stated that vegetation is more dense and varied and growth is more vigorous, canopy is up to 80 percent during the wet season. The major species are *comburtum*, *isoberlinia* and *acacia*. The ground flora is completely dominated by the tall grass species, *hyparrahenia Rufa*, which grows to the height of 2.5 m. Bamboo, is found in patches through out the area.

The landsat MSS image of 1972 shows that most of the area was under natural environment. There were few artificial structures observed. The 1986 image reveals that parts of the east and west banks are cultivated under the state farm. But still the majority of the area was under natural vegetation cover. As the 2000 ETM image shows much of the western bank is under irrigation and human made features like Agricultural fields, roads and buildings are discernible. The abandoned east bank which was under the state farm is also distinguished as degraded area.

There have been many problems facing the vegetation cover in the study area, mainly in the valley. Large scale vegetation clearance has been taking place for the last thirty years with different justifications.

Those diverse types of trees witnessed by Shawinigan Company have been exposed to extensive and sever burning for long years. The company sited two major stake holders for the forest fire by the year 1981, these are natural factors and natural wild honey collectors. But currently this number is augmented by three; natural factors, Natural honey collectors, sugar cane burning, charcoal and timber making and fire wood and wood products. Fire is the most pressing problem in Finchaa valley. Now days the frequent sugar cane burning for ease of harvesting gives good opportunities for the fire to escape from the cane fields and expand to the forest boundary. The factory assigns few numbers of guards during cane

burning to control the fire. But some times there are incidents where the fire escapes to the forest. Even after burning there is little or some times no attention given to extinguish the fire. This mainly aggravates the problem of forest fire.

Figure 3.5 Forest Fire in Finchaa Valley.

The factory cleared vegetation to construct infrastructures and



irrigation. The factory lit fire to cane fields (hoping) to increase sucrose content and to accelerate harvesting process. But some times such fire escaped from cane field and fire vegetation. This is one obstacle to the forestry program in the valley. For instance in 1995/96 a total of 13.5 hectares of eucalyptus plantation was burnt due to such fire." Zeleke kebebew (2005)

The second top problem of vegetation resource in Finchaa Valley area is deforestation. Deforestation has long history in the area. Especially the coming of the state farm in 1975 brought about a paradigm shift in the history of the valley. The State farm was aimed at producing food and

commercial crops. The project comes with mechanized farming equipments which were used to carry out large scale land (vegetation) clearing and preparation. Large scale vegetation clearing has takes place and in the mean time farm lands, roads, settlement camps and other construction activities chiefly in the east bank of Finchaa River were carried out.

In 1991 the State farm devolves the project to Finchaa sugar factory. This incident opened up the second history of vegetation clearance in Finchaa Valley.

Finchaa sugar factory consider the west bank as more suitable and currently 8,064.88 hector of land is irrigated. The factory abandoned the eastern bank until the recent years. Currently, however, vegetation clearing and land preparation is going on. This decision was mainly based on land suitability.

As per the recommendation of the companies that handled the feasibility studies the forestry department of Finchaa Sugar Factory was established. The first line objective is to reclaim the vegetation that has been removed for cane plantation and construction purposes.

The department is currently taking actions to carry out the aforestation and reforestation. But the amount planted and the vegetation removed is incomparable.

Ato Nigatu Assefa, head of forestry department, explained that about 600 hector of land is currently under forest cover. In the future the unit has the plan to cover 2,200 hector of land with Eucalyptus tree. According to Ato Nigatu eucalyptus is preferred because of its availability and fast growth. Critics stated that domination of a single species do have its own negative repercussion on the existing ecosystem.

The conservation of natural vegetation helps to balance the natural systems. This in turn avoids the distraction of environmental

components on one hand and promises sustainable use of resources on the other.

3.3.2 Wild life

Finchaa valley was a Sanctuary for varied wild animals. There were large number of wild animals like carnivores, browsers, grazers and other small animals. The natural vegetation in the area was dense and with full canopy during the wet season. As eye witnesses confirmed there were large number of wild animals residing in the area. The tall savanna grass mixed with trees which has occupied most of the valley floor creates favorable conditions for grazers, brothers and carnivores. Reptiles are also found in the river courses.

In the earlier years of the farm a variety of animals were seen on the road to Finchaa town. Regrettably Monkeys and some other few animals are the only animals that can be seen on the road now a days.
Three reasons were given for the devastation of this resource. These are the large scale deforestation, expansion of irrigation project and increased number of population in the area. The animals were believed to migrate down to the Abay River.
Still the far down stream area and with in 100 meter of the gallery forests of Finchaa and Neshe Rivers together with their tributaries can serve as home for the remaining wild animals. if proper value is given for wild life conservation the present condition is not that much discouraging to rehabilitate this resource.

3.4. Drainage system

There exists a well developed drainage system in Finchaa valley area. There are two major drainage basins. These are Finchaa and Amerti-Nashe river basins.

The Finchaa River basin starts from chomen swamps and is joined by several tributaries and collected in the dam. Water from the lake drains down to the valley after it produces 133 Mega watt of electrical power at Finchaa hydro-electrical power station. In addition Finchaa Lake is rich in fish resource, preeminent for recreation purpose and is home for a variety of birds' life. In the in the valley floor the river is used for drinking, irrigation and industrial purposes. The river is diverted near the power house at mouth of the valley. The canal extends for about 44 kilometers in the west bank. Water is taken through the pipe to water the cane using sprinklers. Finally Finchaa River drains to Abay River.

On the other hand the Amerti-Neshe River system in the western side drains the North Western part of the valley. The Neshe River descends down to the valley and joins Finchaa River in the far down stream area and joins the Abay River. Currently dam construction is being carried out which is anticipated to produce 97 mega watt of hydro electrical power. The Nashe River system is relatively unexploited and has a potential for future development.

These two major basins in the study forms well developed and networked drainage system. This makes the area to have strategic importance and very little is exploited to the present. Especially they have great potential for hydro-electrical power generation and irrigation development. However the current and future developments in the basins should be environmentally sound for better competence and sustainability.

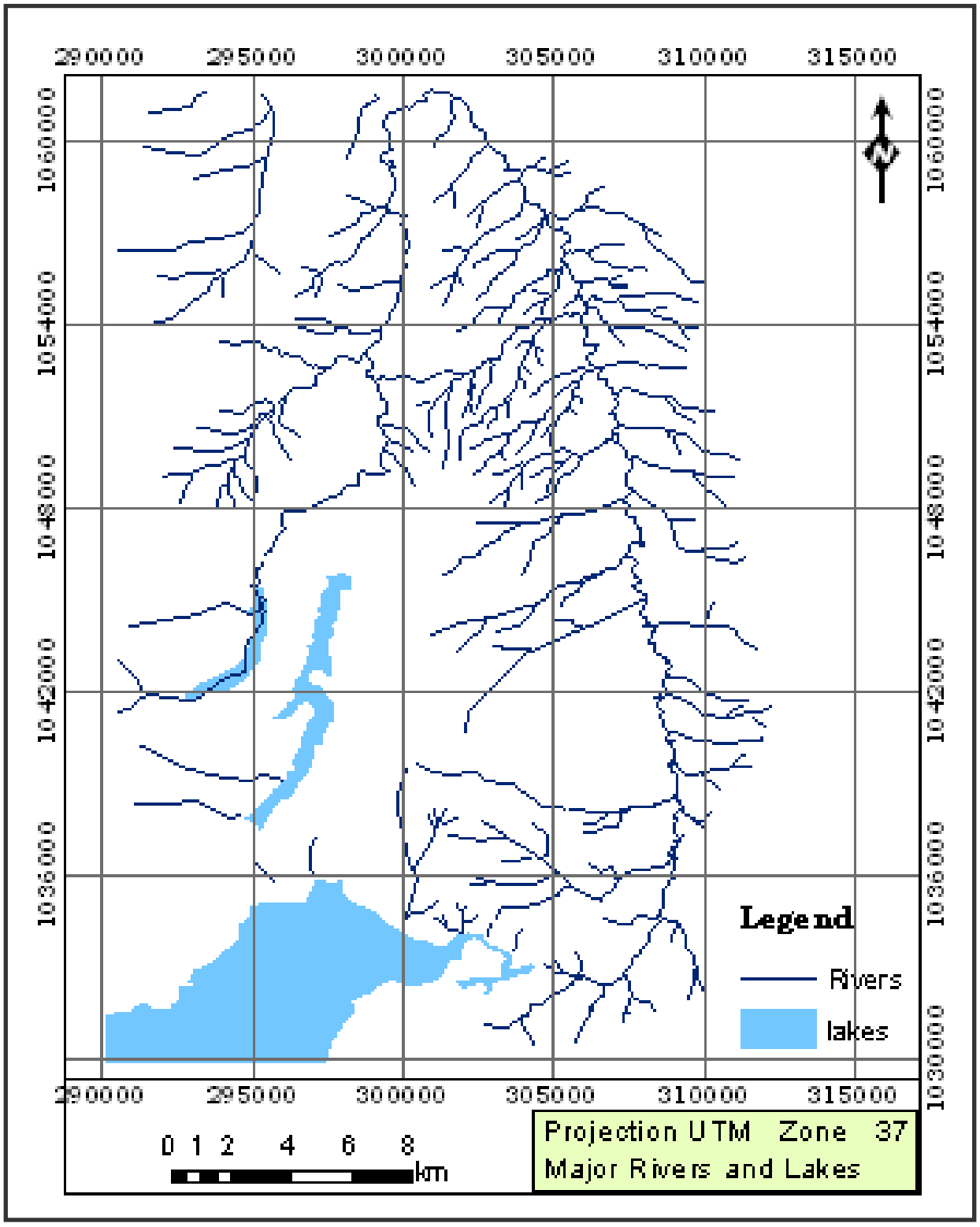

Figure3.6.The major Drainage system in Finchaa Valley Area.

3.5. Geology and Soil

3.5.1. Geology

In a geological time frame the plateau fencing the Finchaa valley is volcanic capped massive beds of Mesozoic sediments overlaid by Adigrat sand stone. In the valley floor the Mesozoic sand stone overlies the basement complex in the south, progressing to the north this sand become thinner and thinner. Colluvial and alluvial materials form the major parts of the surfacial deposits of the area. The Adigrat sand stone to some extent contributes for the soil formation as a parent material and this is discernible in the dominant soil type of the area.

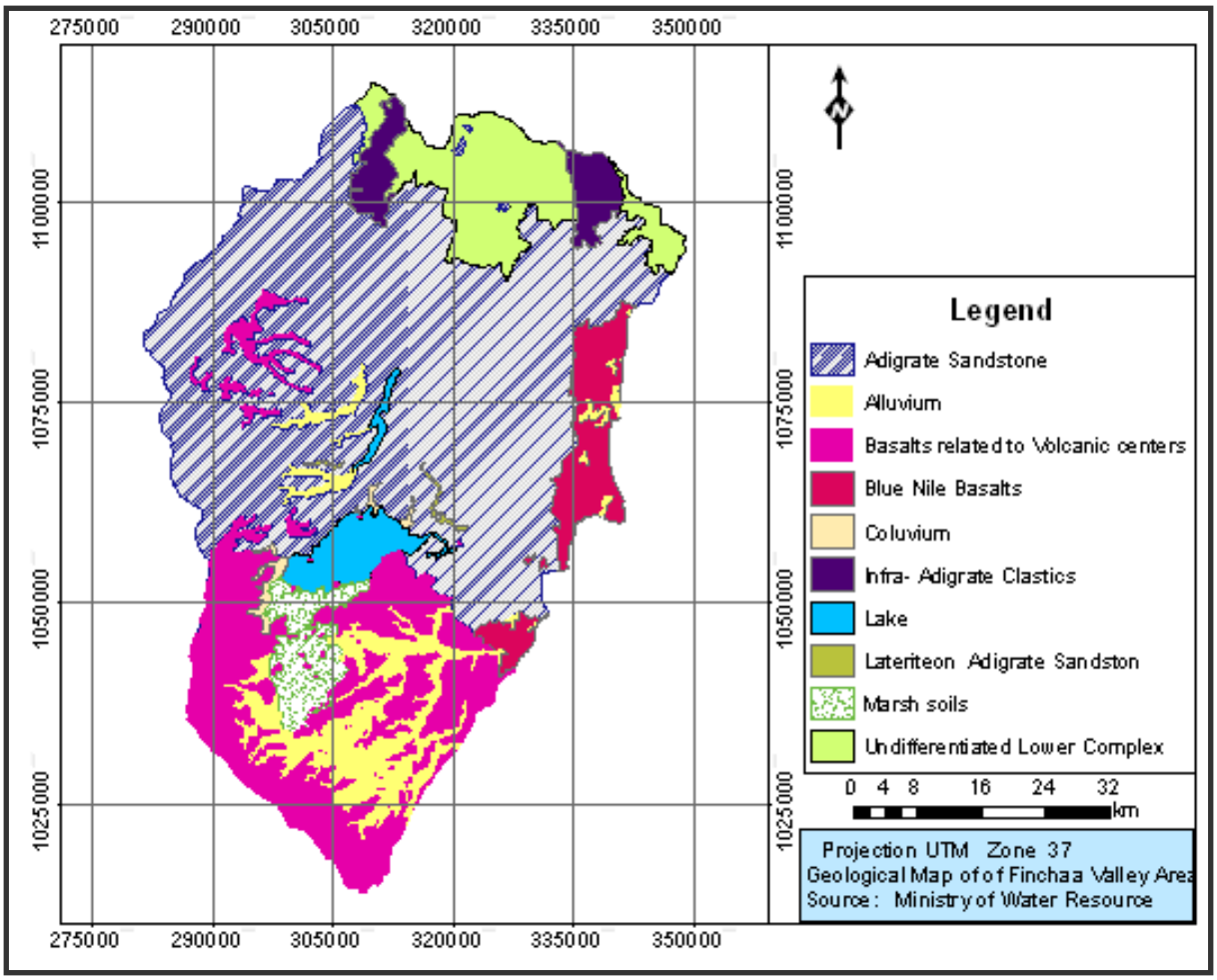

Figure 3.7. Geological map of Finchaa valley area

(Modified from Ministry of Water resource)

3.5.2. Soil

The soil in Finchaa valley is made of alluvial and colluvial materials from the surrounding escarpments. The partially rocky steep escarpments aided with active erosion contribute for the formation of the soil components. There are about five soil types in Finchaa valley area of which Luvisols and vertisols are the two dominant classes. These soils accounts for more than 95 percent of the cultivated land. Luvisols are found in the extensive area of the valley and usually have red to reddish brown color. There are three sub families of the Luvisols .These are the chromic Luvisols, Haplic Luvisols and glayic/hydromorphic/ Luvisols.

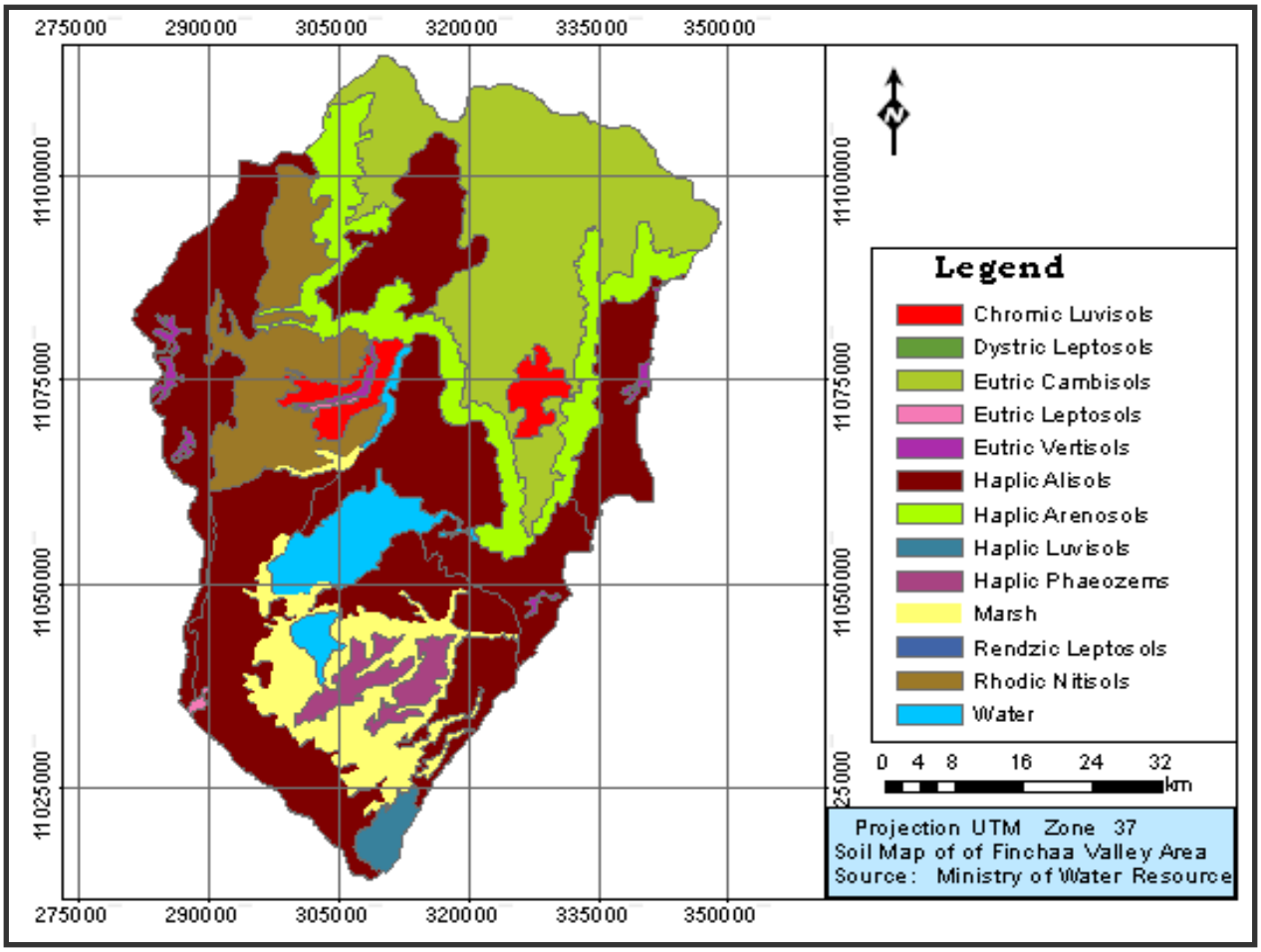

Figure 3.8. Soil map of Finchaa valley area.

(Modified from Ministry of Water resource)

One of the worst enemies of soil in and around Finchaa valley area is erosion. The sever soil erosion is instigated mainly by human activity and followed by natural land escape of the area. Land clearance for agriculture, frequent forest fire, road and building constructions, application of chemicals and others are some of the human induced problems. The steep escarpments together with relatively high rain fall forms the natural causes of erosion and exacerbate the problem. These problems affect the quality and quantity of the soil resource in the project area.

All forms of soil erosion are actively operating in the area; splash, sheet, rill and gully. In Many areas around the main road to Finchaa town and major river course the gully are rapidly expanding.



Figure 3.9. Human activity Induced Gully along the Road.

In the feasibility study of Finchaa sugar project it was underlined that Luvisols have limited fertility and are exposed to extreme erosion. In order to mitigate the problem of erosion many Soil conservation methods were recommended including planting trees (afforestation and reforestation), leaving water courses undisturbed and many others.

Beyond taking the most fertile top soils and minerals one of the grave drawbacks of erosion is that it rapidly turns many usable lands to bad land. In so doing it minimize productivity and efficiency of the irrigated and potentially irrigable lands.

> *"The soils in Finchaa valley are erodable. Thus, sheet, rill and gully erosion has been noted both on the previously cleared state farm and the relatively virgin bush land…the gullies have expanded both linearly and laterally. The results of this sever and continuing soil erosion cause greater dissection of the potential usable land, the loss of the more fertile top soils which in turn results in shallow soils and exposure of rocks and stones. The exposed stones and rocks make mechanical cultivation difficult if not impossible. All this reduces the sustained viability of the project…methods of controlling soil erosion should include social, economic, physical and biological techniques.*" Girma Teferi (2001)

In the irrigated fields different types of fertilizers, pesticides and herbicides are being used. Since 1994/5 to the present (May, 2006) about 161,348 quintals of fertilizers, 151,553 litters of herbicides and 12,604 litters of pesticides were applied. Their possible impacts and detailed soil chemical analysis will be presented in chapter four.

The proper use of sprinkler irrigation is by far better than furrow irrigation in soothing erosion. With this regard Finchaa sugar Factory is benefited a lot as it is using sprinkler irrigation because of undulations.

Generally there are different types of soils in Finchaa valley. Luvisols and vertisols are the most dominant soil types. These two soils have their own limitations. Especially the dominantly cultivated Luvisols are Limited in their fertility and needs a proper management. It has course textured and weak structure. The improper utilization of this scarce resource will jeopardize productivity and the sustainability of production on these soils.

3.6. Climate

The climate of the study area ranges from hot to temperate climate. There are distinct wet and dry seasons. The climate of the area is mainly controlled by elevation, latitude and wind movement. The micro climate of the area is mainly influenced by the abrupt topographic variations.

The project area can be categorized as one of the wet areas in the country. The area receives an average annual rain fall of 1300mm. The rainy season comprises the months of June, July, August and September.

The valley is hot in relation to the surrounding high lands and the months of December, January and February constitutes the dry season. The maximum temperature is 36°c and the minimum is 14°c. On the average the area experienced the temperature of 23°c.

Broadly speaking the project area can be grouped as one of the wet areas in Ethiopia .climatic conditions slightly varies from year to year.

3.1.6. Demographic characteristics

The demographic history of Finchaa valley can be seen in three major courses. The pre 1975 (before any economic development in the area), from 1975 to 1991 where the state farm stayed in the valley and after 1991, after the imminent of Finchaa Sugar factory.

In the pre 1975 years Finchaa valley was not permanently inhibited .Only few natural Honey collectors and Hunters used to visit the area. This was so for three major reasons. The First is the presence of epidemics like Tsetse fly and Malaria. This made settlement in the pre 1975 momentary and seasonal. Secondly, the topographic setup with the dense natural vegetation made the area to be inaccessible. Finally the absence of infrastructure and services hampered permanent settlement. Thus; there was no considerable permanent settlement in these years.

The second demographic stage started with the coming of the state farm by the mid 1975.The commencement of the state farm attracted people and made permanent settlement easy. The state farm carried out large scale vegetation clearance for preparation of agricultural land, construction of roads, houses and other infrastructures. Following this incident People migrated to the valley to work for the State farm, to give services for workers or for other reasons. But even in those days there were only few people in the area.

By the 1991 when the valley was selected as the most suitable site for cane plantation the State farm handed over the area to Finchaa Sugar project. This incident can be considered as the opening for the third stage and can be regarded as a bench mark in the demographic history of Finchaa valley.

Finchaa sugar project opened up large job opportunities and many people were attracted from almost all parts of the country. Population number radically increased. For instance, in fifteen years period (1991-2005) the population of Finchaa valley grows by more than ten folds.

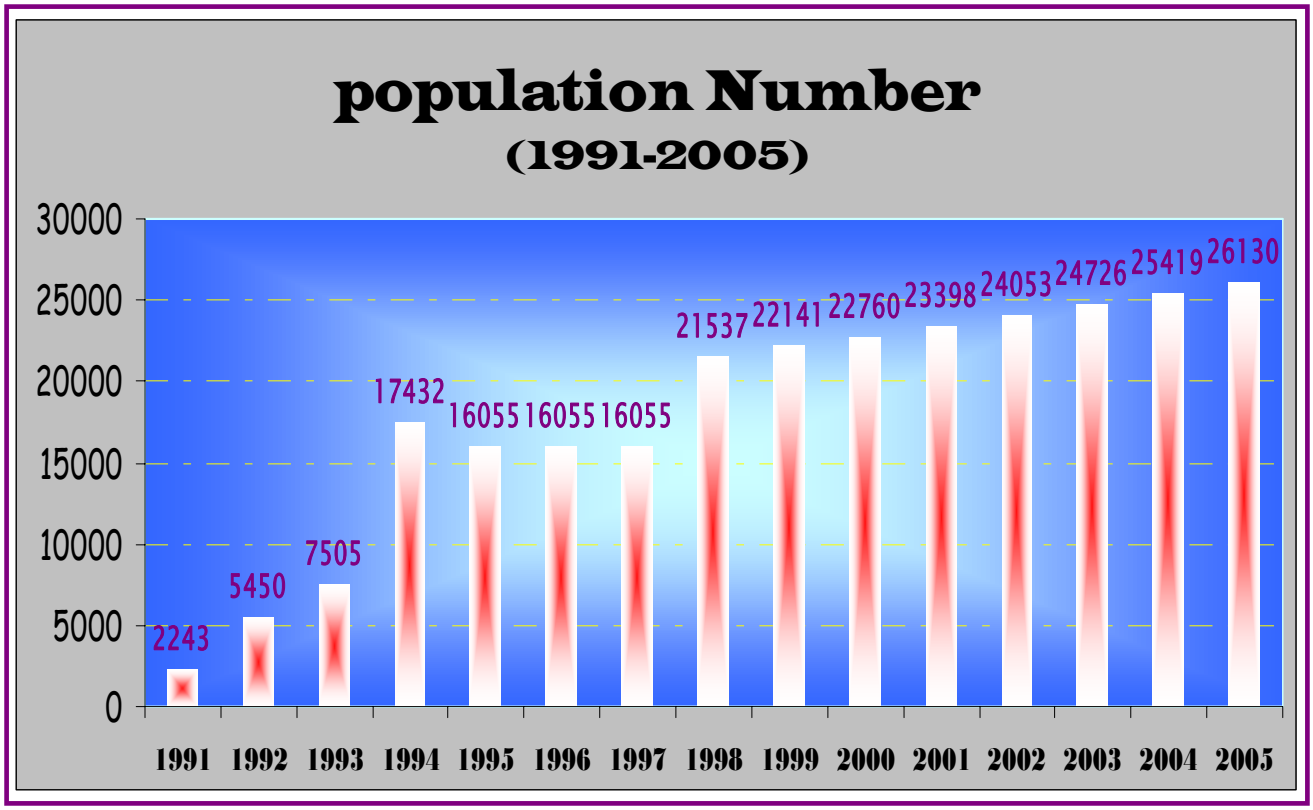

Fig 3.10.Population of Finchaa Valley (ANUTECH 1994, Modified)

Several reasons can explain the fast population growth in the area. Some of these factors include provision of better facilities and services, job opportunities, mitigation of epidemics, large proportion of productive Age groups, the expansion of the irrigation project and many others. The population growth trend goes with the expansion of the irrigation as it is labor intensive sector. The beginning of cane plantation in 1994 primarily attracts large number of productive age groups. And the next trend escalates up continuously.

CHAPTER FOUR

4. Impacts of the Irrigation project on Vegetation and Soil

4.1. Impacts of the Irrigation project on vegetation cover

4.1.1. General Conditions of Natural Vegetation Cover

In developing countries the attention given for vegetation conservation is less compared to the need for development. In realizing their policies for food self sufficiency and agricultural productivity preeminent value is given for irrigation developments even some times at the expense of environmental considerations.

Depending on the management system irrigation projects can have both positive as well as negative impacts on vegetation cover. Undoubtedly the expansions of irrigation projects have many advantages. However, in most cases there happens change in the natural ecosystem following large scale irrigation developments. Obviously in order to under take large scale irrigation projects the vegetation cover in the area needs to be cleared and different construction activities should be carried out. Natural Vegetation as one of the eminent part of the ecosystem is negatively affected with such development activities. Large scale forest resource degradation can change the natural environment. This in turn puts the sustainability of irrigation projects in question. Conversely if appropriate consideration is given for vegetation conservation the forest area can be delineated and effective afforestation and reforestation can be carried out. For that matter vegetation resource can be keep hold around the hills, on vacant and marginally suitable lands. The conservation of natural vegetation can fix the problem of soil erosion, micro climatic disturbances, biodiversity and it balances many of the environmental systems.

Well planned irrigation schemes have good natural vegetation conservation and management plans. Effective management and proper balancing of these seemingly conflicting issues should be treated wisely.

> *"The need to intensify agriculture using irrigation in the economy of those countries, which are of short of food, is un doubtless. In doing so, excellent management is required to obtain the maximum benefit with the least negative impact. Failure to have an appropriate management entails disastrous effects on livestock and crop production, human health, the environment and the living condition of the community and as a whole on the countries economy".* Mintesinot et al. (2004)

Finchaa valley in the pre 1975 years was virtually under natural vegetation cover. The tall savanna grasses mixed with short and medium trees predominate the elevation below 1600m.The steep escarpments and the far down stream areas experience dense vegetation growth. The gallery forests occupy the networks of major rivers and their tributaries. As it is evident from the MSS satellite image of 1972 there was no apparent human intrusion to the valley. (See figure 4.1) From unstructured interview made with local elders there were some individuals who went to the area to collect wild honey from trees and hunters for valor.

The first intrusion to the valley was successfully made by the state farm in 1975. Since this time it is estimated that the state farm cleared about 3,500 hectors of land (vegetation) .The 1986 TM image reveals that some parts of the eastern and western banks of Finchaa River are occupied with some food and commercial crops. (See fig 4.2) Even at this moment most part of the valley was under the natural vegetation cover.

The construction of the road dawn the escarpment made the forest resources accessible and vulnerable for human interference. This opened up a new episode for the forest resource exploitation. Still to the present Finchaa valley is considered as an ideal site for hard wood and bamboo forests used for fire wood and construction activities.

The beginning of 1990s can be seen as the second turning point in the forest history of the area. In these years Finchaa valley was selected as the most suitable site for sugar cane plantation and industrial development. In the mean time the state farm abandoned the farm and handed over the area to Finchaa sugar Factory. In 1991 the Finchaa sugar project started extensive mechanized vegetation clearance and land preparation.

> *"It will be recommended that where ever possible some of the larger trees should be remain provided that they do not interfere with the canals, roads or irrigable area…land(vegetation) clearing operation will be accomplished by a combination of mechanical equipments and hand labor."* Shawnigan Design Report (1981).

This was the statement by Shawnigan Company that carried out the feasibility study. Further large scale Land clearance was carried out with such justification. From the three major Companies that carried out the feasibility study any of them did not recommend for any single area buffering for natural vegetation conservation. Almost all attention was on sugar cane production and strategies for expansion. Accordingly the west bank of Finchaa River was considered more suitable and fertile and at present about 8,064.88 hector is under sugar cane plantation. (See fig 4.3)The factory neglected the east bank until the recent years. This year Vegetation clearance and land preparation has been taking place on the eastern bank. The total area of 7,108 hector is expected to be irrigated. Despite the fact that the expansion escalates the industrial productivity, it further aggravates the problem of deforestation in the valley.

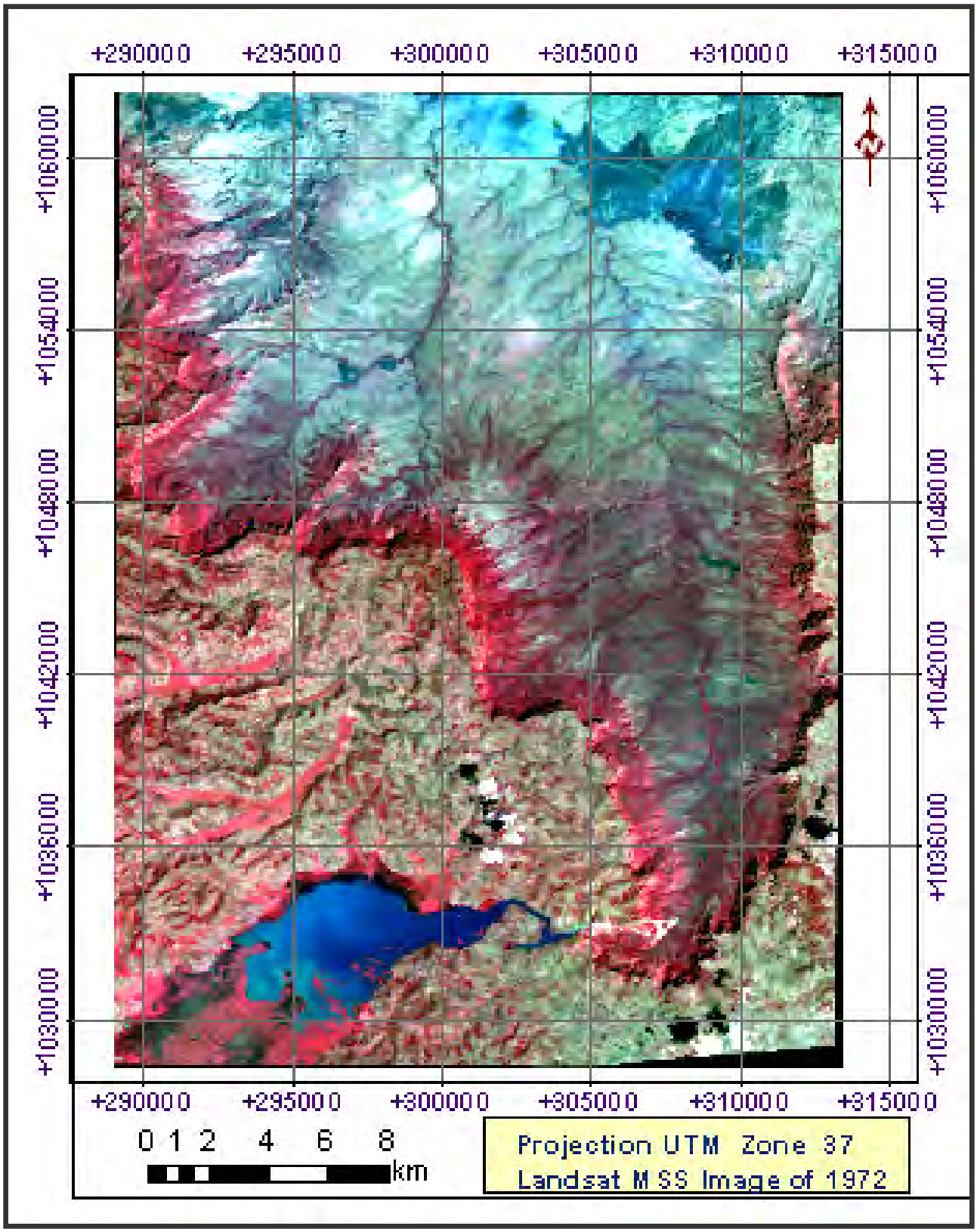

Figure 4.1. RGB/321 MSS satellite images of Finchaa Valley Area 1972 with 30 meter resolution.

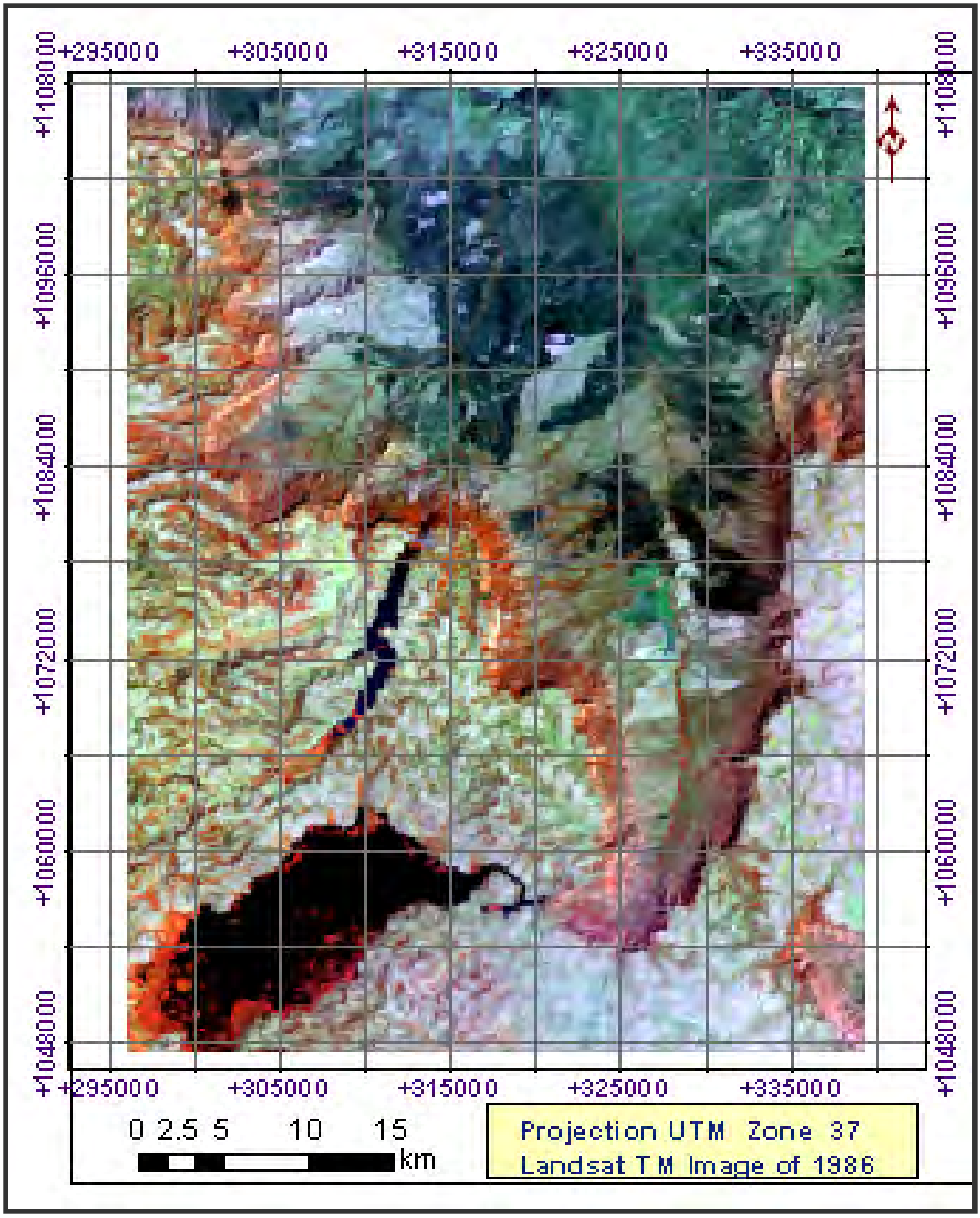

Figure 4.2. RGB/321 TM satellite images of Finchaa Valley Area 1986 with 30 meter resolution.

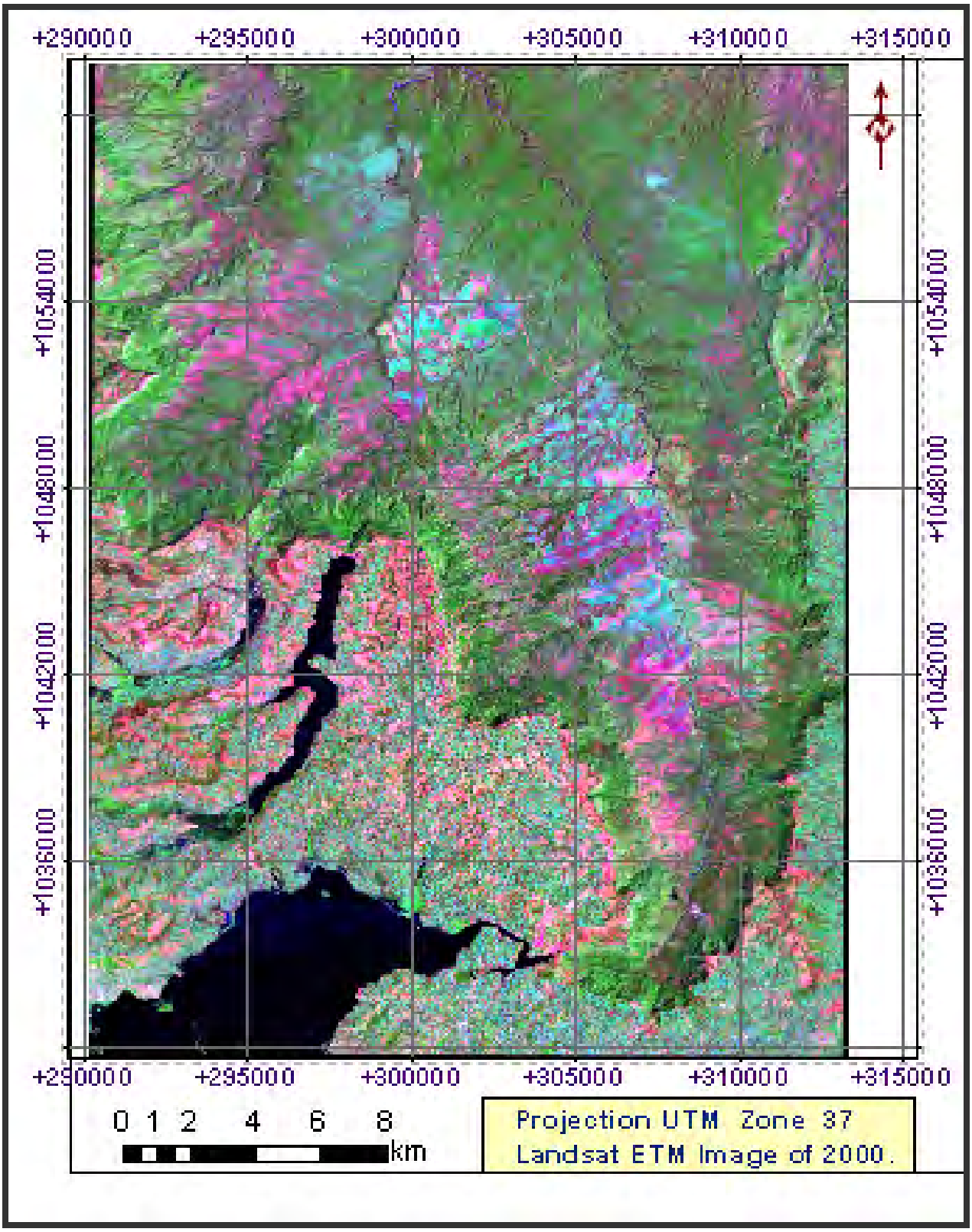

Figure 4.3. RGB/321 ETM satellite images of Finchaa Valley n Area 2000 with 14.5 meter resolution.

From the visual image interpretation it is evident that there is land cover change. Some features like the vegetation biomass are diminishing while some others like Finchaa Lake are increased in size. Even though there is large scale vegetation clearance there are efforts made by the factory to plant trees on unused areas. To the present Finchaa sugar factory under forestry department planted 600 hectors of land in the afforestation program. One of the tree species preferred is eucalyptus tree .This was so for the accessibility of the tree. Currently the department has the plan to cover 2,200 hectors of land under the reforestation and afforestation programs. However, this amount is very less with respect to the vegetation clearance which has been taking place for long years in the area.

In comparison to the vegetation that has been cleared the present afforestation program reclaim for not more than 7.5 percent of the land under irrigation. Even if the future goal of the department is attained it reclaims only for about 27.3 percent of the present land under irrigation. At the time 13,000 hectors of land is irrigated if only 2,200 hectors of land is under forest cover it means that less than 17 percent of the cleared land is revitalized.

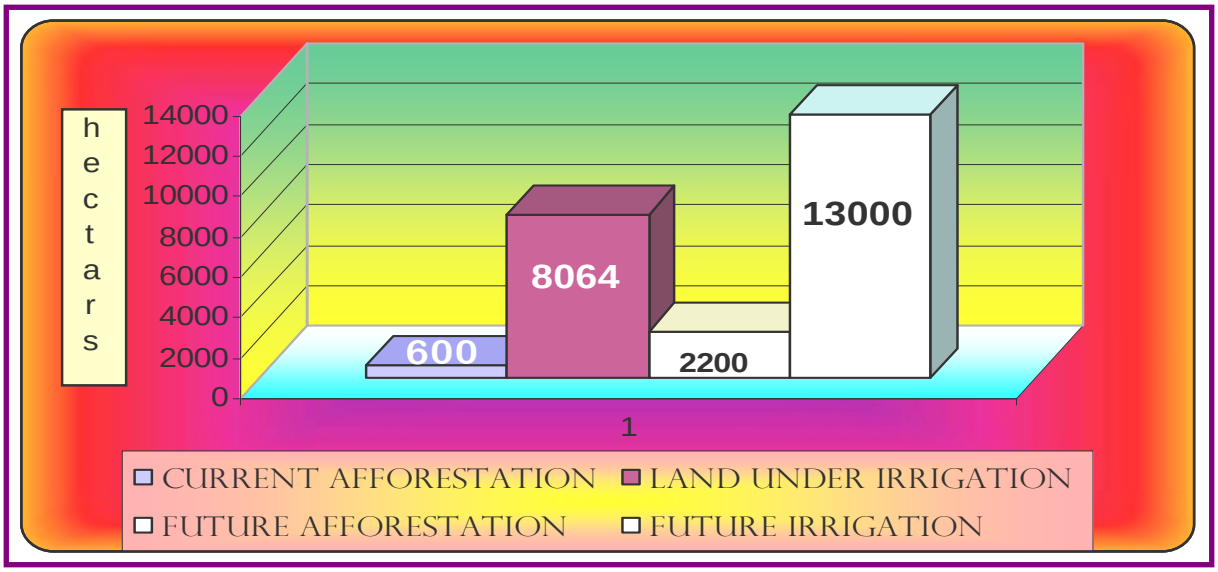

Figure 4.4. Present and future land for Irrigation and Afforestation.

Figure 4.4 shows that the irrigated field has increased a lot. In 1997/98 about 932.27 hectors of land was harvested and after eight years that is in 2005/06 it increased by more than seven folds. By implication the vegetation cover is retreating with the same or even more rate.

Deforestation is the major problem in Finchaa valley area. The large scale vegetation clearances by the factory together with individuals earning a livelihood from forest products are devastating the vegetation resource. Forest fire is one of the critical causes for the vegetation degradation. In addition to the naturally instigated fire the factory and some individuals play a significant role in triggering the problem. The fire escaping from the frequent cane burning by the factory and irresponsible action by individuals who are looking for timber, charcoal, fire wood, Wild honey collection, construction wood and others exacerbate the obliteration.

4.1.2. The Normalized Difference Vegetation Index

Normalized difference vegetation index (NDVI) is a method used to analyze the vegetation cover of an area. NDVI is calculated from reflectance measured in the visible and near infrared channels from satellite-based remote sensing. NDVI shows the temporal and spatial change of Vegetation cover. The difference between two images is calculated by finding the difference between each pixel in each image and generating an image based on the result.

The NDVI Analysis of the 1972 Multi spectral scanner (MSS) image of Finchaa valley area reveals that there is more vegetation biomass in the study area (NDVI>0) compared to the later years.

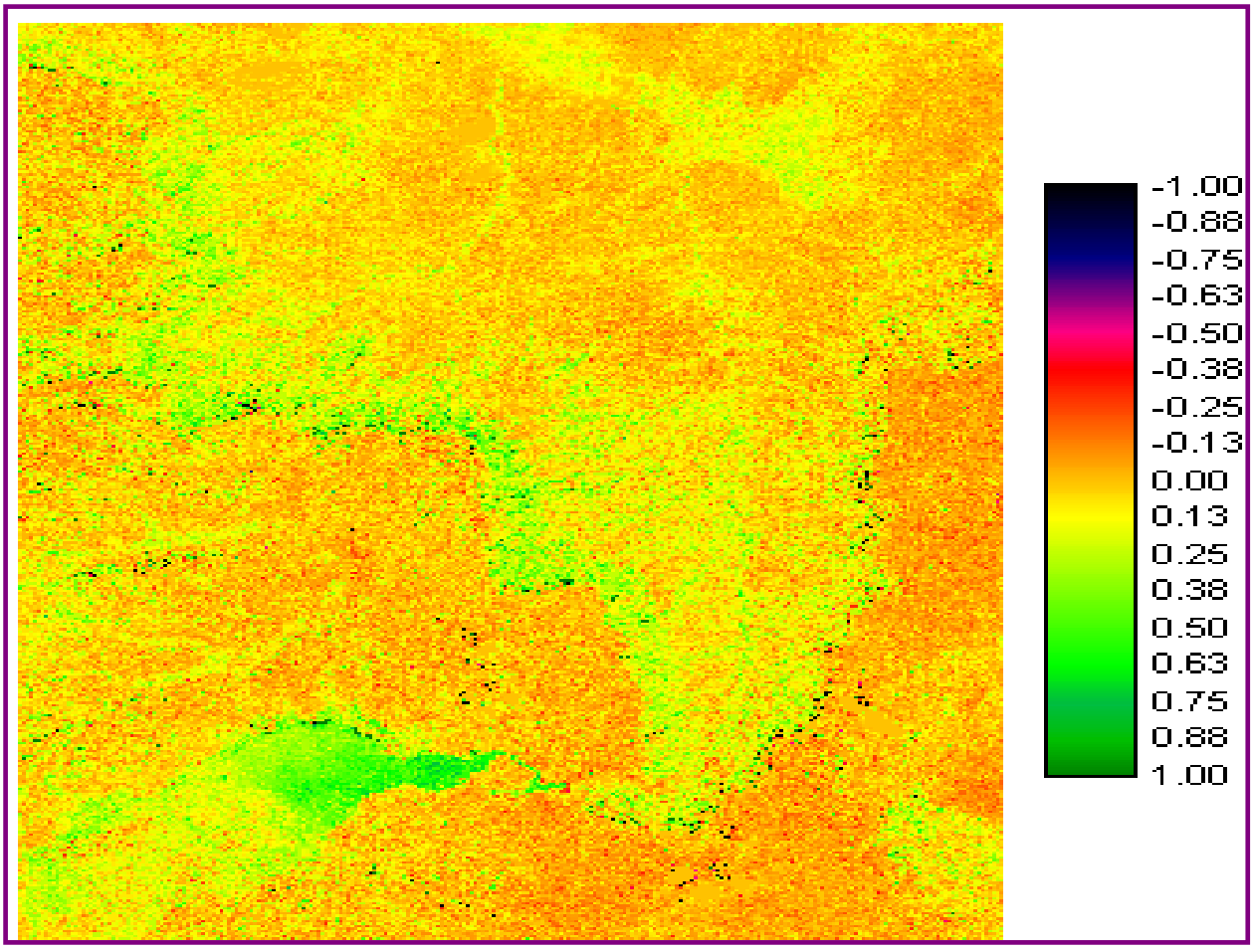

Figure 4.5.The Normalized vegetation Index results of Dec.1972 TM image.

The Normalized vegetation index of 2000 image shows lesser vegetation biomass compared to the 1972 image. The expansion of cultivated areas, bare lands and built up areas are apparent in the NDVI analysis. These areas appeared as deep red and NDVI < 0.0. This means that many areas that were formerly under vegetation cover are turned up into Human made features.

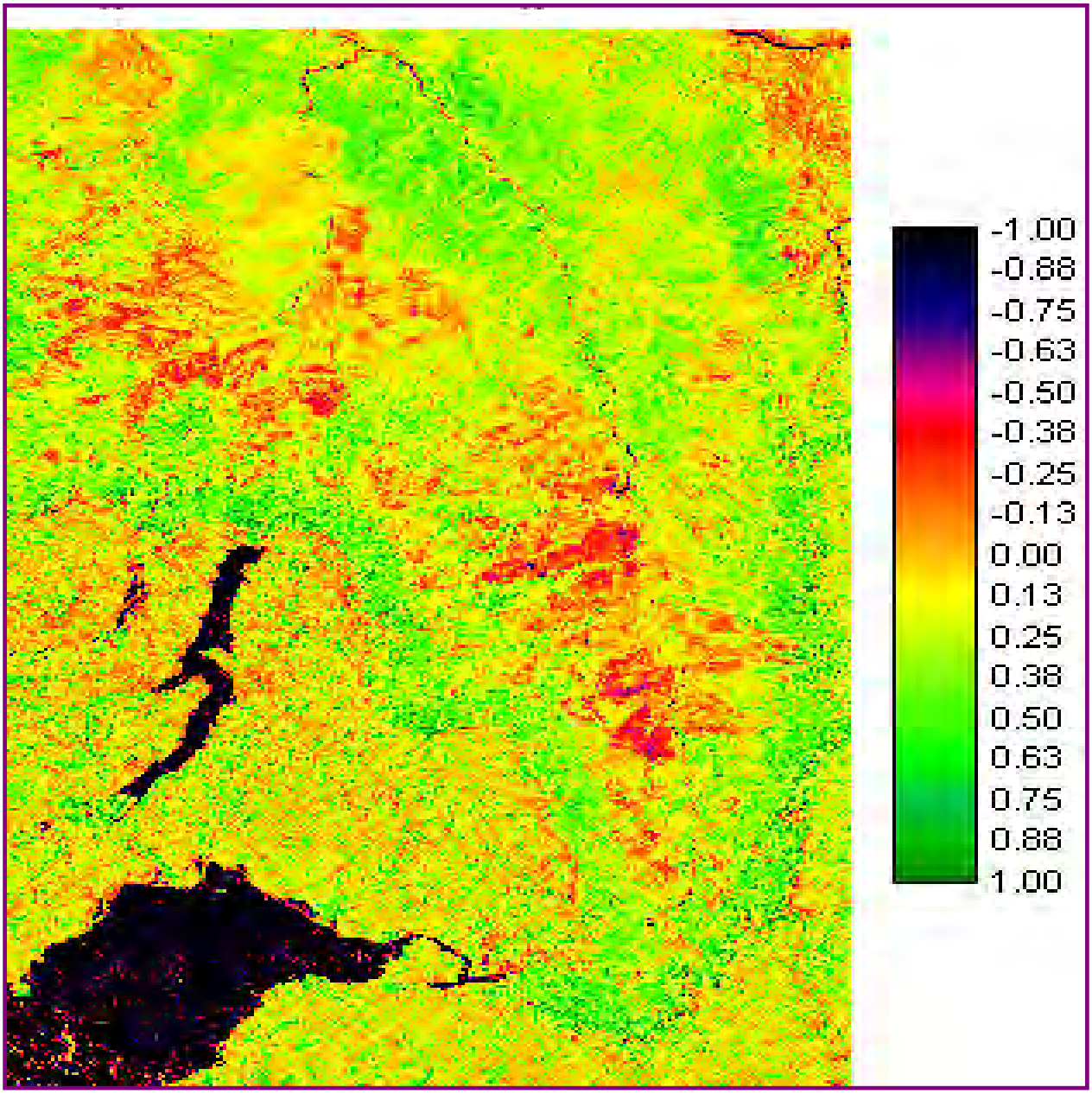

Figure4.6. The Normalized vegetation Index results of sept.2000 ETM Image.

Table 4.1: The Normalized Vegetation index result of the 1972, 1986 and 2000 satellite images.

Year	Landsat MSS		Landsat TM		Landsat ETM	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
1972	87.3427	66.2614	-	-		
1986	-	-	80.4064	63.1612		
2000					68.2834	58.5612

Table 4.1 Reveals that the mean and standard deviation of the 1972, 1986 and 2000 images has been decreasing. This could indicate the rate of vegetation cover destruction.

Generally the Visual image interpretation and the Normalized vegetation index results confirm that the vegetation biomass of Finchaa valley area has been diminishing. There are three major factors that can explain this circumstance. These are the expansion of agricultural lands, growing settlement areas and large scale deforestation that has been taking place for many years. Still the present trend indicates that the deforestation will continue to the virgin lands. By taking the aspiration of the factory for expansion in to consideration large effort should be made in afforestation and reforestation projects. Strict measures should be taken to stop illegal forest resource exploitation and the frequent fire. Afforestation and reforestation activities should not be considered as a superfluous activity. Beyond harmonizing many of the natural systems they can serve as a means to solve many problems like soil erosion, hot weather conditions, degradation of biodiversity, fire wood and wood product requirements and many others.

4.2. Impacts of the Irrigation project on Soil

Soil is one of the most decisive natural resources. It has been supporting the increasing number of life in our planet earth. Now a days the large number of population increased the demand for food, this in turn put forth full-size pressure on land /soil resource. Areas formerly considered as marginal are currently being cultivated. The demand for big yield created enthusiasm to look for alternative means. One of these is getting bigger yield through customary agricultural practices like irrigation systems, use of fertilizers, pesticides, herbicides and many other agricultural inputs.

Irrigation schemes beside their positive contributions have many shortcomings on the physical and chemical properties of soil in particular and the environment in general. The FAO repository document mentioned some of the adverse impacts of irrigation schemes on soils which include Salinization, Alkalization, Water logging, soil pollution and Soil acidification.

There are two dominant soil types in the project area; these are the Luvisols and vertisols. Luvisols covers 75 percent of the irrigated land. These soils are partly made of alluvial and colluvial materials from the surrounding escarpments. Luvisols has limited fertility and agricultural suitability.

> *From the total area identified as being suitable for irrigated sugar cane in Finchaa valley 36percent of the soil is found to be highly suitable, 38percent suitable and 26percent marginally suitable. The soils in the area have limited fertility. These necessitate well designed soil management and planning.* Shawinigan company (1981)

Water logging is not a vital problem in the area as the factory is using over head sprinkler irrigation system. This consecutively evades the problem of salinization.

In order to maximize production the Agro-chemicals have been used in the irrigation fields .The most common ones are fertilizers, pesticides and herbicides. The two commonly applied fertilizers are Urea and Dap. The brief summery of the total amount of agro-chemicals is presented in table 4.1. (See Appendix 4 for the details)

Table 4.2. The Agro-chemicals applied in the irrigation Fields

From1994- 2005.

Year	**Fertilizers (Qunt.)**	**Pesticides(Lts.)**	**Herbicides(Lts.)**
1994/95	219.4	480	5
1995/96	5,224	20,074.5	8
1996/97	5,806	10,403	267
1997/98	4,003	311.8	20
1998/99	15,952.68	5,278	716
1999/00	17,264.9	10,914.56	216.51
2000/01	23,097.01	25,794.31	2,943
2001/02	19,444.25	17,585.9	2,330
2002/03	23,274.7	15,899.51	1,019
2003/04	25,760.3	14,370.63	2,368
2004/05	36,538.69	17,837	2,712
Total	**176,584.93**	**138,949.21**	12604.51

Table 4.2. Shows that the use of fertilizers, pesticides and herbicides has been increased in an alarming rate with the expansion of irrigation. The Use of large scale agro-chemicals alter the physical and chemical properties of the soil which can damage the soil quality and use full living organisms.

In order to see whether there is change in the soil physico-chemical properties of the dominant Luvisols in the irrigated fields samples are collected and analyzed. Luvisols are preferred for analysis because 75 percent of the irrigation is carried out in this soil. The samples are taken from three sites in three layers. The first site is the non irrigated field where there is no human interference. The second site is ploughed but not yet planted field. In this site none of the agricultural inputs are applied. The third site is the irrigated field where the agricultural inputs have been used. In each of the three sites soil samples from three spots are collected and mixed to form only one composite soil sample. The three layers are the top layer (0-30 cm), the middle layer (30-60) and the bottom layer (60-90cm).Totally nine samples were investigated and the result will be presented under 4.2.1 and 4.2.2.

The three spots are believed to show the possible positive and/or negative impacts of irrigation scheme on the physical and chemical properties of the soil. In addition the comparative results of samples from cultivated but not planted and non irrigated spots can reveal weather the change is due to human intervention or natural causes. The soil sample from vegetation cover area is supposed to reveals the natural properties of the Luvisols in the area. Thus, the site selection for soil samples is intentional and made in such away that shows the impacts of irrigation on the physical and chemical properties of the soil.

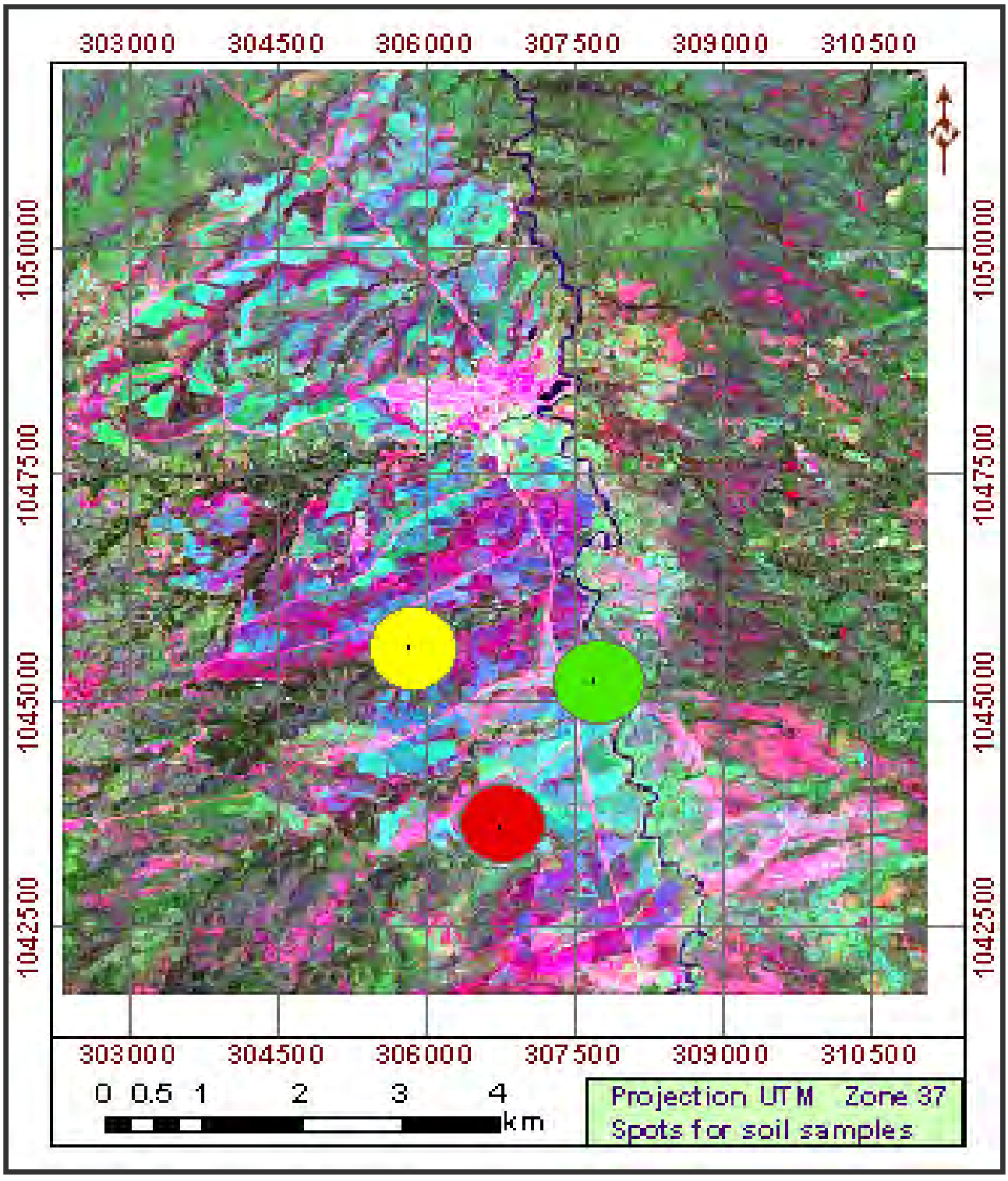

Figure 4.7. The irrigated (red), ploughed but not yet planted (Yellow) and the vegetation Areas (green) for the Soil samples.

4.2.1. Irrigation and Physical properties of the soil

The Luvisols and vertisols occupy more than 95 percent of the Finchaa valley area. Luvisols have reddish brown color and weakly developed structure. They have also shallow profile and limited fertility. Luvisols are composed of sand which decreases with increasing depth. This soil is the most exploited soil in the valley. About 75 percent of the irrigation is carried out on Luvisols. The vertisols on the other hand have black color and shallow profile. Vertisols contains more clay materials with increasing depth.

Table 4.3.The physical properties of the Luvisols from irrigated, Ploughed but not planted, and vegetated area in three layers. (0-30, 30-60, 60-90)

Luvisols	**From Irrigated Field**			**From Ploughed But Not Planted**			**From Vegetated Area**		
Depth(cm)	0-30	30-60	60-90	0-30	30-60	60-90	0-30	30-60	60-90
Total sand (percent)	63.55	57.33	53.34	51.16	41.87	41.78	51.56	35.78	41.35
Silt (percent)	4.17	2.08	7.26	7.60	4.39	4.39	12.37	25.27	11.52
Clay (percent)	32.28	40.59	39.40	41.25	53.74	53.83	36.07	38.95	47.13
Texture class	SCL	SC	SC	SC	C	C	SC	CL	C
Ph-H2o(1:2.5)	5.62	5.20	4.89	5.62	5.04	5.04	4.86	4.48	4.56
Ph-kcl(1:2.5)	5.16	4.79	4.76	5.08	4.57	4.58	4.42	4.00	3.87
Ec(ms/cm)(1:2.5)	0.03	0.04	0.02	0.03	0.01	0.01	0.06	0.02	0.01

Table 4.3 illustrates that the total sand content of Luvisols decreases with increasing soil depth in all sampled layers. The silt content of the soil from vegetated area is higher. This can be due to the lesser amount of erosion in vegetated areas compared to the cultivated areas. The clay content of the soil in ploughed and vegetated areas increases with the increasing depth. Unlike the non irrigated fields the clay content of the

soil from irrigated site is higher in the 30-60 cm depth. This can be due to the excess water that dissolves soluble minerals and percolates down. On its way it accumulates the insoluble clay in this horizon.
Generally the texture class of the Luvisols in all locations ranges from sand clay loam (SCL) to clay (C). Such soils are known to be suitable for irrigated cane plantation with cautious soil management.

The soils in all the three spots of the three layers are found to be acidic. The PH is less than 5.6. It is investigated that there is perceptible PH difference between irrigated and non irrigated soil. The average PH value of the soil in the irrigated area is 5.3 where as in the vegetation area the value is 4.6. This shows that the soil in the vegetation cover site is more acidic than the soil in the irrigated field. Theoretically the fertilizers, pesticides and herbicides that have been applied to the cane fields seem to increase the PH of the soil. But the result shows that the soil in the irrigation field is less acidic than in the vegetation area. Three main reasons can explain this result. In the first place the surplus water use in the irrigated areas can wash the chemicals vertically and laterally. Secondly cultivation by itself can alter the inherent Ph of the soil by exposing the soil. Finally the respective composition of the soil forming parent material can be different in the sample sites.

4.2.2 Irrigation and Chemical properties of the soil

The Normal Soil chemical properties can be altered by natural and human made factors. Industrial toxic wastes, hazardous chemicals, Agricultural malpractices and inputs, and many others constitute the human factors. Alternatively due to some natural processes in the system there may be alteration of soil chemical properties. In this respect the physico-climatic conditions play a key role to change the chemical properties of the soil.

The soil chemical analysis from Luvisols in the three spots with three layers is presented here under.

Table4.4. The chemical analysis of the Luvisols from irrigated, ploughed but not yet planted and vegetated area in three layers. (0-30, 30-60, 60-90 cm)

Luvisols	**Irrigated field**			**Cultivated but not planted**			**Vegetated area**		
Depth in cm	0-30	30-60	60-90	0-30	30-60	60-90	0-30	30-60	60-90
Exch. Na(meq/100gm of soil	0.13	0.16	0.13	0.15	0.13	0.17	0.13	0.11	0.13
Exch. K(meq/100gm of soil)	0.20	0.15	0.16	0.27	0.20	0.21	0.48	0.18	0.16
Exch.Ca(meq/100gm of soil)	5.82	5.82	5.18	9.50	8.72	8.72	4.99	3.36	3.36
Exch. Mg (meq/100gm of soil	4.16	4.20	2.59	6.05	2.62	4.36	4.99	4.20	5.04
Sum of cations (meq/100gm of soil)	10.48	10.54	8.19	16.13	11.90	13.69	11.39	9.66	11.34
CEC(meq/100gm of soil)	14.02	14.48	14.56	23.95	25.12	26.54	24.87	21.46	15.52
Organic carbon (percent)	1.17	0.58	1.69	0.90	0.65	0.65	1.40	1.14	0.78
Nitrogen (percent)	0.14	0.10	0.14	0.13	0.09	0.09	0.09	0.07	0.05
Available P(mg p_2o5/kg soil)	29.20	5.10	4.00	7.80	2.80	2.80	2.60	2.70	2.70
Exchangeable Acidity	0.17	0.21	0.13	0.13	0.22	0.22	0.38	1.79	2.65

As it is illustrated in table 4.4 the average amount of chemical elements in the three sample areas are different. The amount of exchangeable bases (Exch. Na, K, Ca and Mg) varies with increasing depth. Generally speaking the amount of Potassium, Calcium and Magnesium decreases with increasing depth while sodium increases with depth.
Exchangeable calcium and sodium is higher in the irrigation and cultivated but not planted fields than the vegetated areas. The total percentage of Nitrogen is higher in the irrigation field. The Available phosphorous is extremely high in the top layer of the irrigation fields. These higher amounts in the irrigation field are due to the fertilizers (Urea and DAP) that have been used in the irrigated areas. The organic carbon is found in higher quantity in the vegetated area.

The soil sample from the vegetation area are found to be more acidic than the irrigation Fields. This is mainly due to high organic content in the vegetated areas. On the other hand the less acidic nature of the soil in the irrigated area is related to the exposure and excess water use in the irrigation fields.
In addition the acidic nature of the soils in the vegetation areas shows that the soil in the area is naturally acidic and the human intervention minimizes the soil acidity.

Generally the analysis of the three soil samples indicates that there is alteration of some of the soil physical and chemical properties as a result of the irrigation scheme. The level of alteration hardly results in full-sized soil pollution at this level. However the cumulative impact could grow in to soil quality degradation. Thus there are signs of soil pollution in the Irrigated areas. There are several reasons that can explain this condition of which application of the agro-chemicals is one.

4.2.3. Soil Degradation

It is found out that one of the preeminent problems of soil in Finchaa valley area is erosion. There is active soil erosion in the surrounding areas and irrigated fields. The surrounding steep escarpments with average slope ranging from 5 to 65 percent create favorable condition for erosion. There is also high rain fall intensity (90-120mm/hr) which is highly erosive. Rain fall intensity greater than 50mm/hr is believed to be erosive.

In Finchaa valley area human intervention exacerbates the problem of erosion, especially deforestation and road construction. The large scale deforestation exposed the soil for agents of erosion and contributes for high runoff. Due to terrain inconvenience the roads have been constructed by dissecting hills and uplands which facilitate the birth and intensification of sheet, rill and gully erosions. Road construction and the frequent maintenance also play a vital role in aggravating the problem.



Figure 4.8.The frequent Road construction and maintenance dissecting the uplands.

The energetically operating sheet, rill and gully erosions around the escarpment donate the fertile top soil to the valley floor. This partly fed fertile soil to the irrigation fields. On the other hand however, the high runoff from elevated ridges accelerates the formation and intensification of gully and considerable deposition on the roads and cane fields. The active erosion and expansion of gully in the road side made road construction a year round activity. In addition beyond taking the fertile top soil erosion has been expanding active gullies and turns the potentially irrigable lands in to bad land.

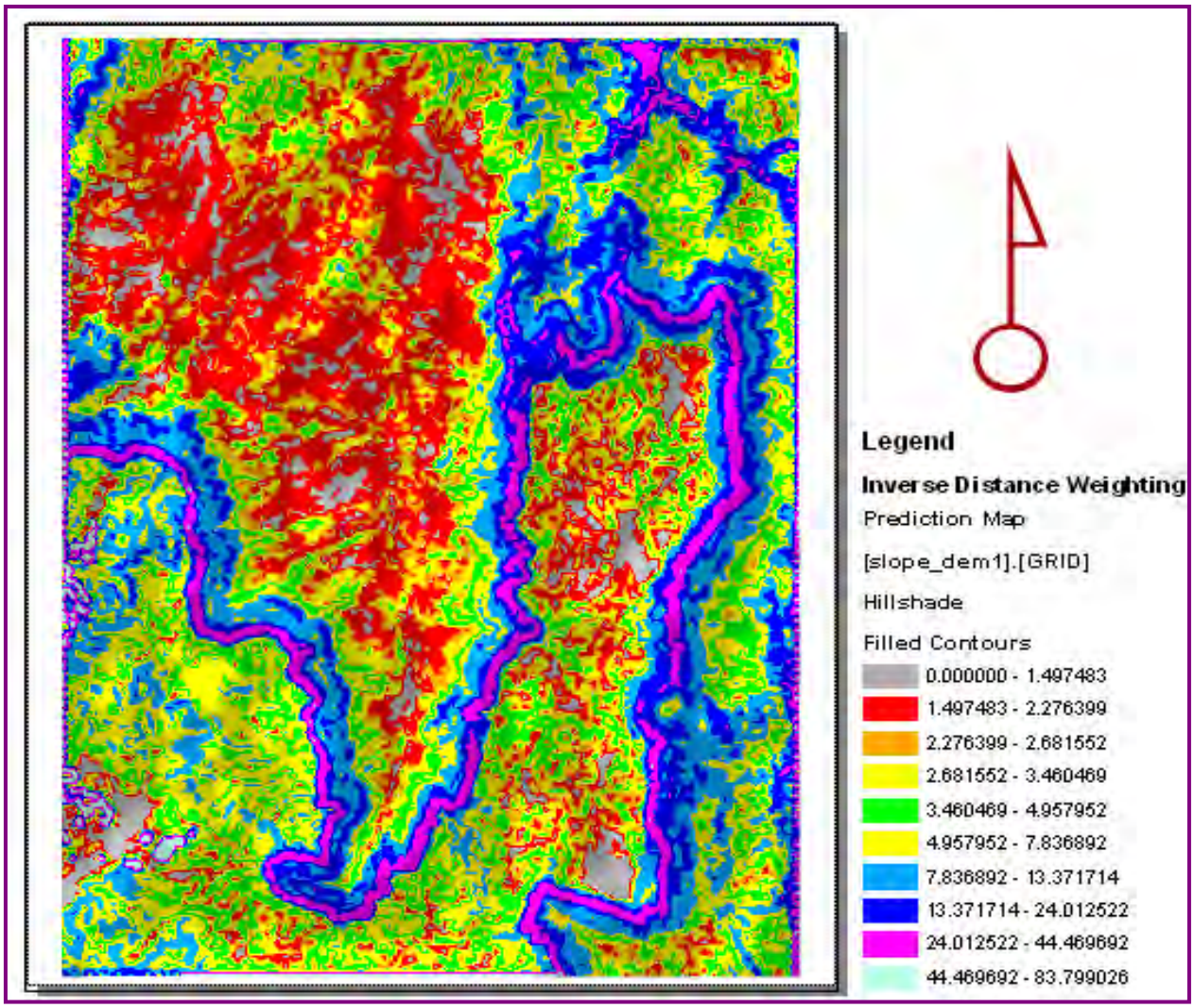

Figure 4.9. Slope based Interpolation Map showing General Conditions of erosion.

There is a general elevation decline from south to north and from the eastern and western edges to Finchaa River. This indicates that the general trend of erosion is to Finchaa River first and finally to the Abay gorge. The tributaries fed fertile soil to Finchaa River and the soil finally transported to Abay River.

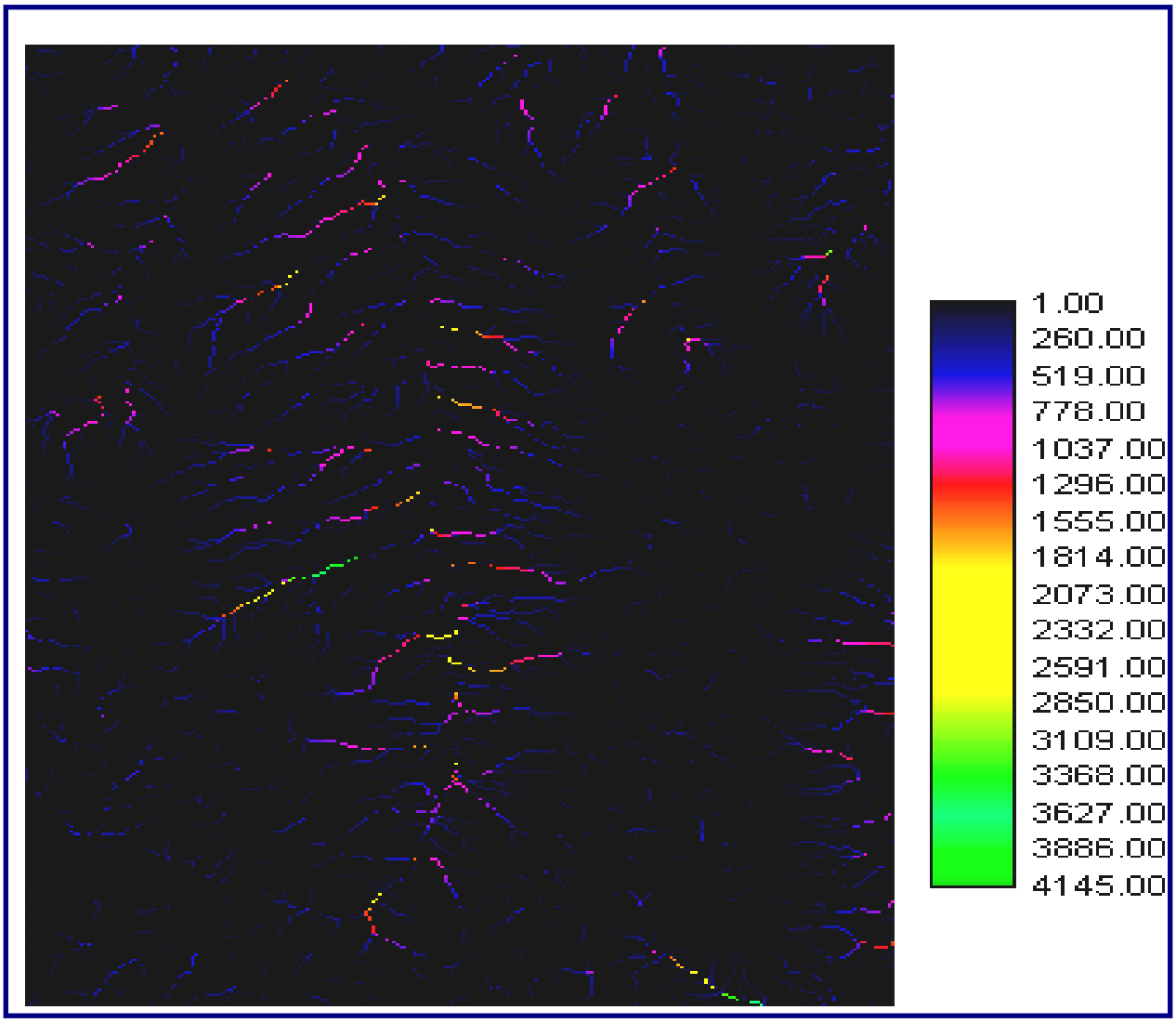

Figure 4.10 Digital Elevation Model based Runoff estimate.

The digital elevation model based run off estimate indicates that there is high runoff pattern in the areas that lies from the eastern and western escarpments to the banks of Finchaa River. This is due to the steep slope

down the escarpment to the valley floor. Obviously the high runoff in these areas contributes for high rate of erosion. Thus the topographic set up and human activities make soil erosion to be a critical problem in the study area.

In a nutshell one of the critical problems of soil resource in the project area is erosion. The use of agro-chemicals in the irrigation fields has also its own share to degrade the soil quality. Soil pollution emanating from chemical pollutants is found to be moderate in the study area. This can be due to soluble nature of chemicals that have been applied and the quantity in proportion to the total sampled soils. But there is greater possibility of the agro-chemical use in the irrigation fields to alter the soil quality in the long run.

The Soil erosion mainly takes the fertile top soil and contributes for expansion of gullies and there by reduce the potentially irrigable lands. These two major soil problems needs proper follow up and management. If the present trend continues, in the long run the problem of soil/land degradation can put the sustainability of the project in question. Persistent and considerable efforts should be made to mitigate the impacts of erosion on the soil and potentially irrigable lands.

4.2.4. Land use and Land cover

Finchaa valley area have transformed from primary to secondary and tertiary economic activities; from traditional agriculture to industrial and commercial activities. There is land use land cover change in the area since 1975.

> *"There is remarkable land use and land cover change in Finchaa valley area. These changes were mainly due to agricultural and industrial developments and their expansion. Agricultural lands increased and the vegetation cover is decreasing. These changes have a negative implication on land and other biodiversities."* Zeleke Kebebew (2005)

In the pre 1975 years there were no considerable land use classes in Finchaa valley area. Most of the areas were under the natural vegetation cover. From 1975-1991 the state farm used to produce some food and commercial crops on about 3,500 hectors of land in the valley floor. This incident attracted few people to the area to get jobs in the farm but still the number was not that much substantial. During this period there were no significant land use classes except for the state farm and few fragmented private holdings out side the valley. With the beginning of the sugar project in 1991 extensive land has been cleared and irrigated. Currently the irrigated land is about 8,064.88 hectors and the built up areas occupy approximately 200 hectors of land in the valley. The dominant land use classes are irrigation agriculture, Rain fed agriculture, built up areas, roads, artificial reservoir, lakes, and others.

The land cover of the study area can be categorized in to two classes. These are the natural and artificial land covers. The human made features in the area composed of towns, roads, drainage canals, ponds, agricultural and irrigated fields, and artificial lakes. Only a few artificial structures are observed near Finchaa dam in the MSS image of 1972

following the construction of the dam. (See figure 4.1) In these years approximately more than 95percent of the area was under natural environment.

In the TM image of 1986 some artificial developments have been observed (See Figure 4.2).This is mainly because of the introduction of the state farm to the valley and slight population growth in the surrounding high lands. From this time on wards agricultural lands have been expanding in the valley and the surrounding areas.

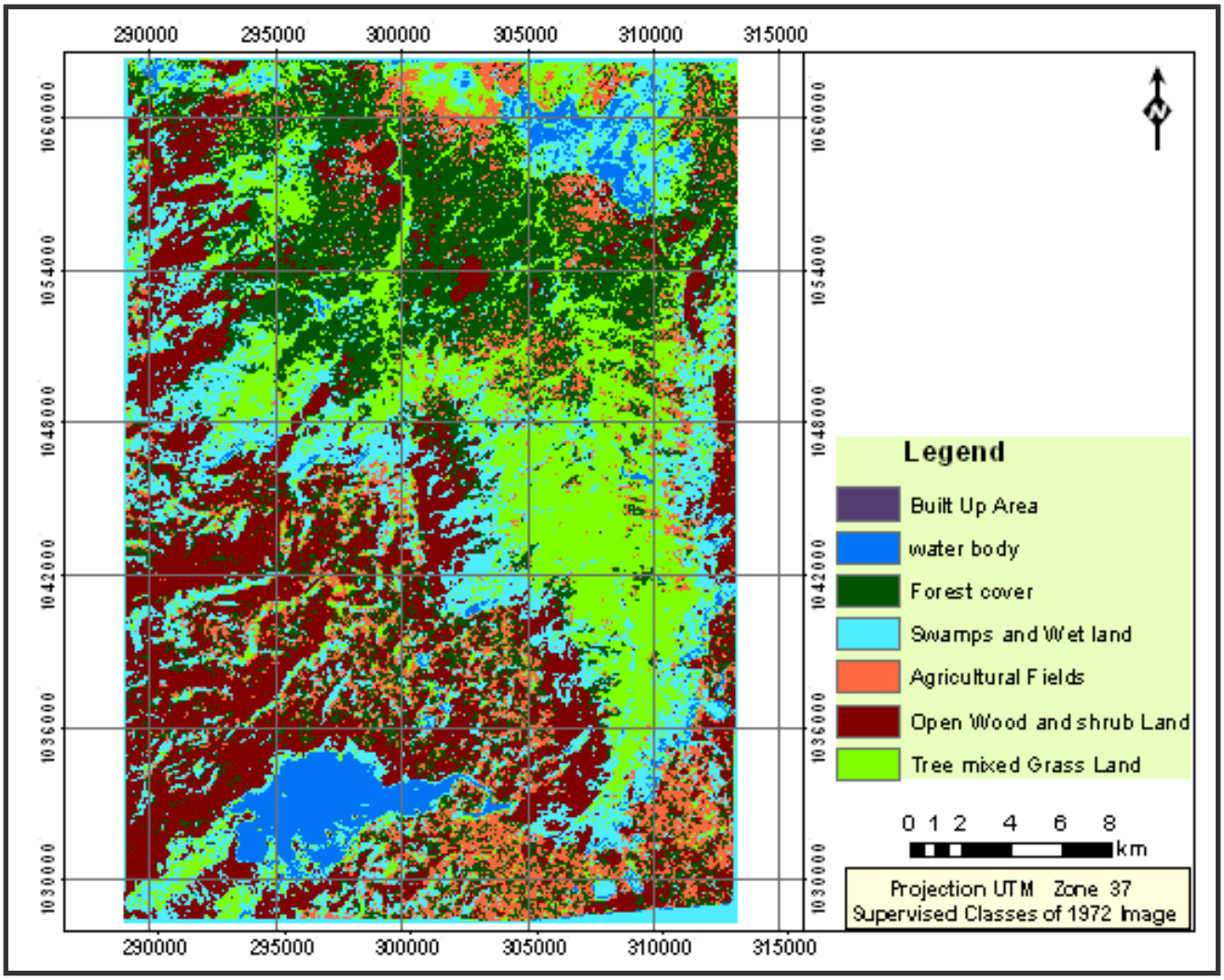

Figure 4.11. Supervised Land use/ land cover Map Of 1972 image.

From figure 4.11 it is evident that many of the area were under Savanna grasses, open wood land and dense forest. There were no significant land use classes in this year. The present Amerti Lake was in its swamp stage. In the upper right corner the area that appeared as lake is incorrect .Rather it is spike involved during Satellite image acquisition. In the land use classification of 1972 the built up area category is very small and insignificant and therefore not represented in the unsupervised classification. In this year very few agricultural plots are observed.
In the ETM image of 2000, which is after 22 years, significant human made features are evident in and around Finchaa valley. The vast irrigation fields and built up areas have increased. By implication the vegetation biomass in these areas has diminished. (See fig 4.3)

In the surrounding areas the rain fed agricultural plots have intensified. Some smaller towns and villages are observed including Finchaa town, Achane, Homi and Kombolcha villages. The size of Finchaa Lake is also increased compared to the pre 2000 years. However from the field observation it is perceptible that in recent years the size of the lake is diminishing. In the unsupervised classification map agricultural land, built up areas, bare lands and the size of the lake have increased in size. The Amerti swamps grow in to a perennial lake. Conversely the total share of dense forest, open wood land, savanna grass lands have diminished.

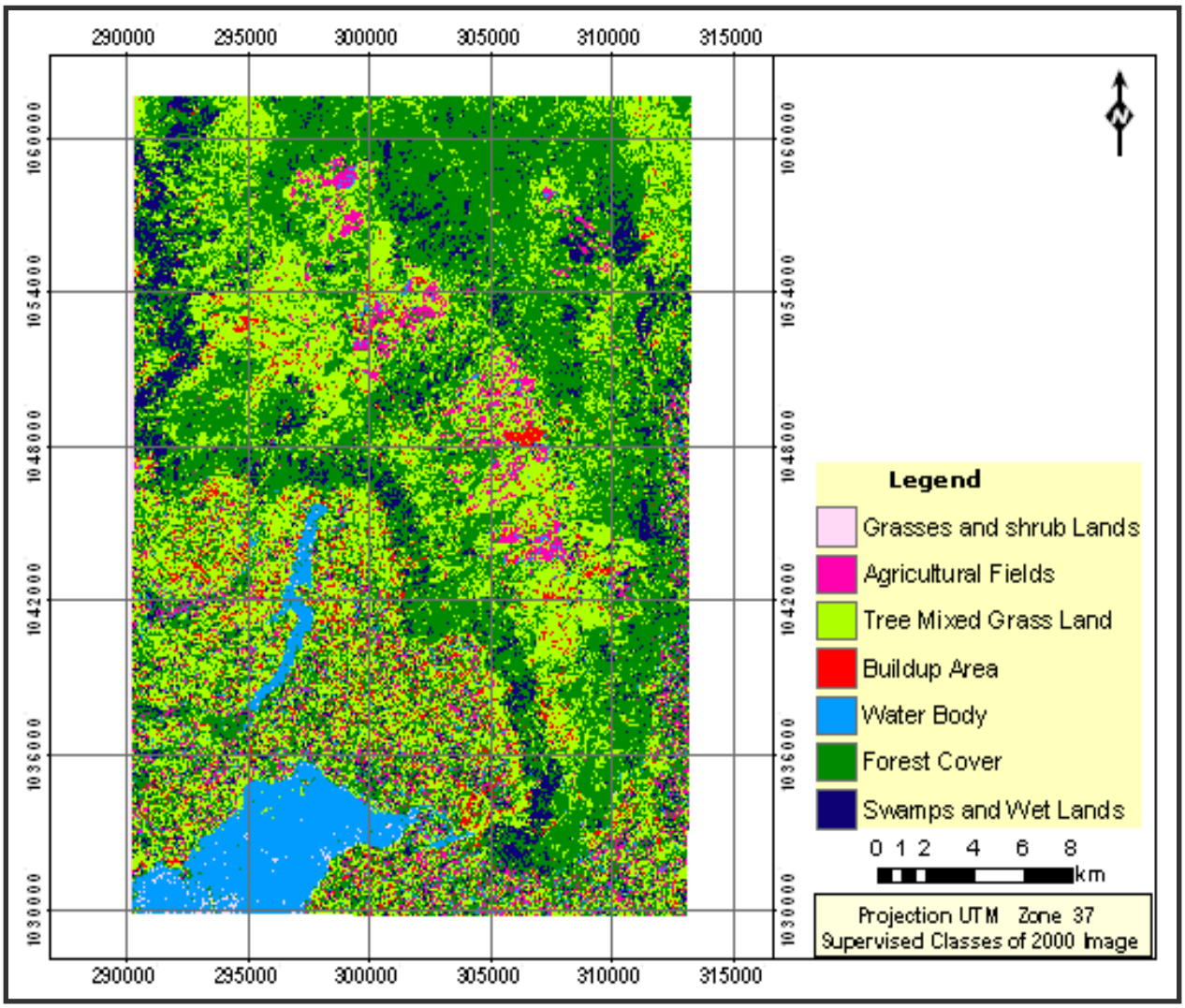

Figure 4.12. Supervised Land use/ land cover Map Of 2000 image.

Generally there have been land use and land cover changes in the study area. This is mainly due to favorable climate and environmental conditions which instigate agricultural and industrial development activities in the area. This phenomenon was in turn followed by population growth and intensification of agriculture and industrial developments. The development of the irrigation scheme in the project area facilitates the alteration of the natural ecosystem and brought changes in the land use land cover of the study area.

4.2.5. Image Differencing

The image differencing analysis of the 1972 and 2000 images indicates that some features have increased in size while some others decreased. The size of Finchaa and Amerti lakes, the valley mouth and artificial structures including agricultural fields have increased. On the other hand the vegetation biomass, swamps and bare lands decreased. These changes are partly related to the population explosion and expansion of agricultural and industrial developments in the area.

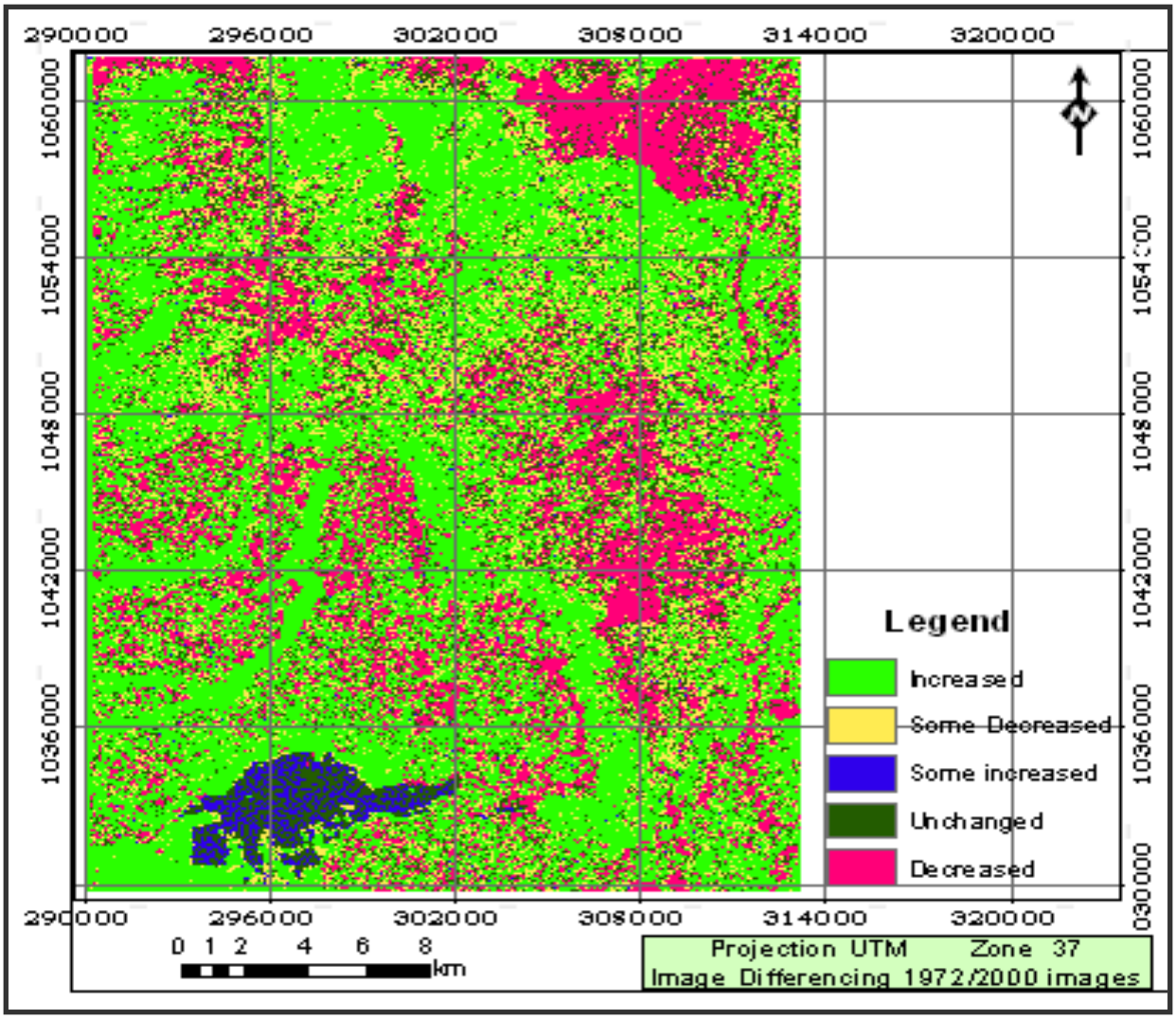

Figure 4.13. Image differencing results of the 1972 and 2000 Images.

CHAPTER FIVE

1. The Irrigation project and water Quality, Climatic and Health Conditions

5.1. Impacts of Irrigation project on Water Quality

5.1.1. The Water Resource

Water is one of the most valuable resources on our planet earth. Water covers 75 percent of the globe but potable water accounts for not more than 3 percent. This small amount is exposed to pollutants to a lesser or greater extent. In most cases toxic wastes from different sources are damped to the surface and subsurface water. This phenomenon alters the natural properties of water.

Now a days Water pollution is becoming a grave problem and makes life a challenge to many living organisms.

> *"Pollution, Contamination of streams, lakes, underground water, bays, or oceans by substances harmful to living things. The pollution of rivers and streams with chemical contaminants has become one of the most critical environmental problems. Industrial pollutants that run into streams, rivers, or lakes can have serious effects on wildlife, plants, and humans*." Encarta Reference Library (2005)

In most cases minor attention is given for water resource conservation and waste water treatment. Many industries in third world countries do not have well organized waste water treatment and sewerage systems. Due to the flow gradient soluble solid and liquid wastes join the surface or subsurface water. Some pollutants by their very nature can remain

and travel for long distance in the water. Even there are incidents where the pollution interacts with rain fall and indirectly affect large areas as the case in acid rain.

Rivers and stream pollution is not uncommon problem in many countries. It affects all the areas lying with in the drainage system. There are incidents where the Trans-boundary water pollutions spoil the peace full coexistence of nations. This makes water pollution a sensitive and critical issue.

5.1.2. General Conditions of water in Finchaa Valley Area

In the study area the Finchaa and Amerti-Nashe rivers form the main drainage system. They both join the Abay River in the far down stream area. The irrigation field and the Finchaa sugar factory lie with in the networks of Finchaa river system. They both relay on this river to meet their water requirement. Finchaa River is diverted to cane fields near the power house in the upstream area through concrete canals. At present the west bank canals run for about 44 kilometers. Water from the canal is pumped to irrigation fields and finally sprinklers shower the water to the growing cane. The extra water from cane fields flow to the near by ditches and join one of the nearest tributary streams.

On the other hand the industrial waste water is taken to the treatment plant which is situated to the east of the factory. The factory uses a rock filtration treatment method. However some of the instruments of the treatment are nonfunctional. The waste water coming from the factory over flows due to these broken parts and two stream-sized crude waste water flows to Finchaa River.

These direct leakages together with the agro-chemicals from irrigation fields indisputably alter the physico-chemical properties of the water.



Figure 5.1. Industrial Waste Water Treatment Plant near the Factory.

This phenomenon affects the living organisms in water in particular and the environment in general. Again Finchaa River as one of the tributaries of Abay River crosses the boundaries of Sudan and Egypt. Any water quality problem in this place arise dispute with these countries. Thus strict water quality control works should be carried out in and around the industrial and agricultural sites.

5.1.3. The Physico-Chemical Properties of the Up Stream and Down Stream Water

The physical and chemical properties of water characterize the water quality. These properties of water are susceptible for change. The addition of toxic wastes to the surface or sub surface water alters the normal composition. The PH for instance is sensitive and decisive factor for the survival of living organisms in water.

On experimental lakes in North West Ontario Schindler (1988) find out that due to change of PH from 5.4 to 5.1 over all, the number of species in the lake at PH 5.1 was 30 percent lower than in the pre acidification years.

In order to asses the impacts of the agro-chemicals and industrial wastes, water Samples from the up stream and down stream areas are taken and analyzed. (See Appendix 5)

The up stream area refers to the water near the power house where the water does not get in contact with water from irrigation and industrial wastes sites. The down stream comprises the water after it mixes up with water from streams in the irrigated and industrial waste sites. (See Figure 5.2 for sample sites)

In order to increase the accuracy of the results water sample was not taken from the irrigation ditches and direct industrial waste water. Rather the Mixed down stream water was preferred so as to avoid inaccuracies and exaggerated results.

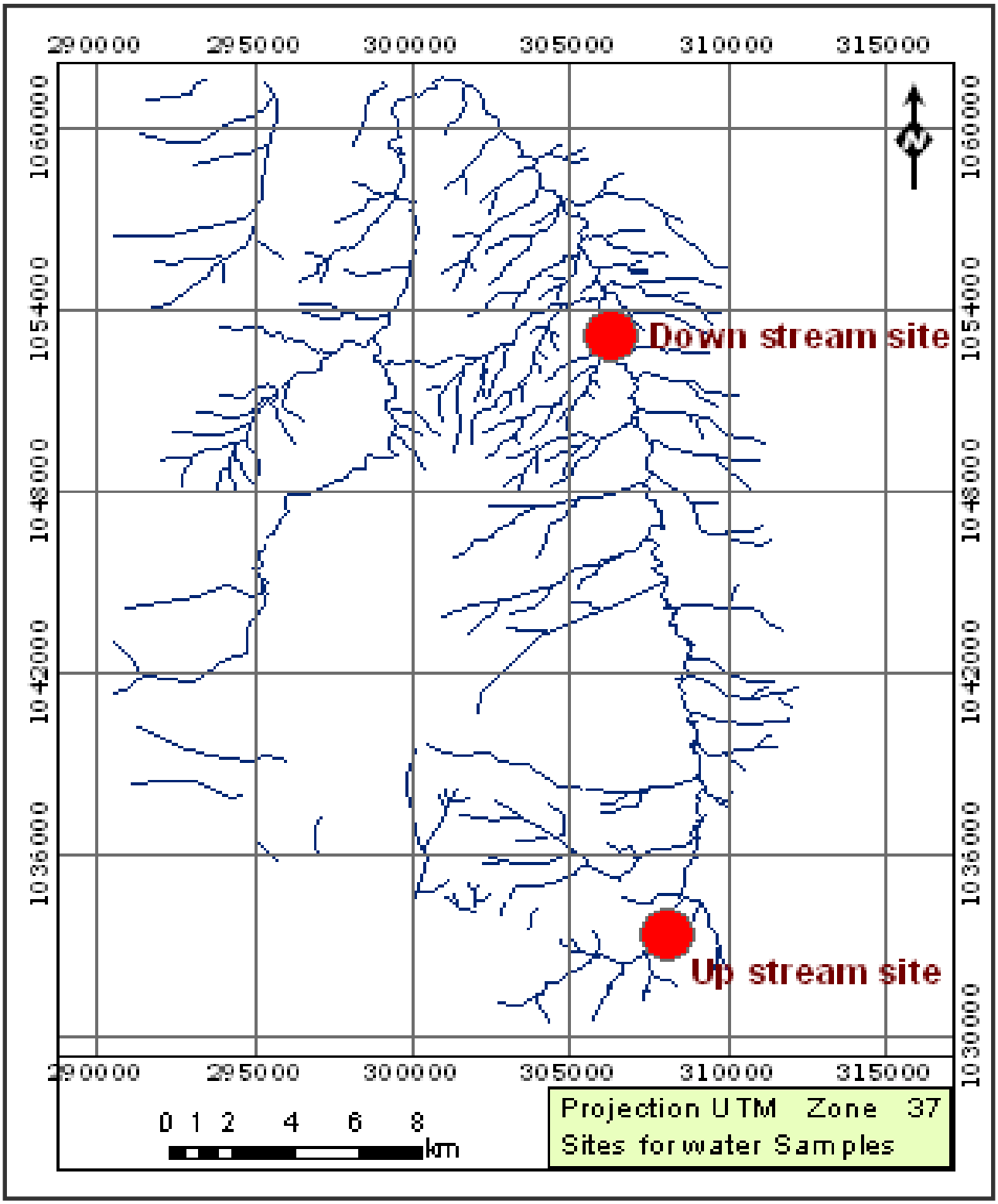

Figure 5.2. Upstream and down stream sites for water Samples.

The physical properties of water like pH, EC, Odor and color are found to be different in the upstream and down stream areas. The PH and EC are lower in the upstream water compared to the down stream water. This could be due to difference in the chemical constituents in these two sites. The color differences are also discernable.

The results of the water chemical analysis also indicate that some elements are found in a higher quantity in the down stream than the upstream water. (See appendix 5)

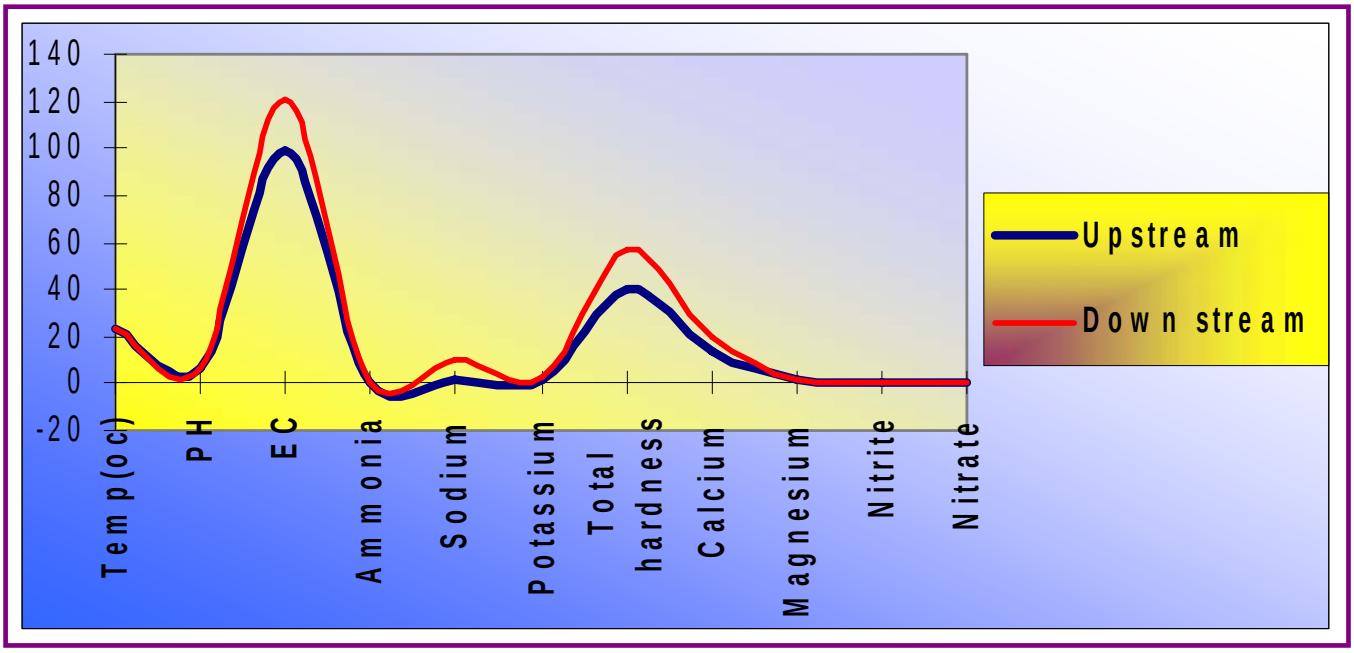

Figure 5.3. The physical and chemical properties of upstream and down Stream Water from Finchaa River.

As it is evident from Figure 5.3 almost all of the inspected elements are found to be higher in the down stream water. This could be due to two major reasons. In the first place the extra water washed the agro-chemicals from irrigated fields and joins the river. The Second main reason is the liquid waste from the industry and the urban areas that directly or indirectly drains to surface or subsurface water. These two cases comprise the point and non point source for the pollution. The

industrial waste water escaping from the treatment plant forms the point source pollution while the agro-chemicals from irrigation field cover the non point source for the pollution.

In an effort to alleviate the problem of water pollution the point and non point sources should be given priority. As a point source the contribution of waste Water from the industry can be addressed by continuous follow up and maintenance of the treatment plant. It is again advisable to replace the treatment plant with modern and effective instruments and methods. And the problem of non point source can be mitigated by avoiding the direct contact of the excess water from irrigation ditches and metropolitan wastes with the river and tributary streams. This can be possible by creating a buffer around Finchaa and Amerti-Nashe Rivers and major tributaries. (See figure 5.4)

The buffered zone needs to be covered with vegetation so as to enhance soil and plant litter filtration and purification. As an alternative approach the extra water from the irrigation field can be collected in an artificial reservoir and treated before it discharges to the main rivers.

Generally, the water samples from Finchaa River indicate that there is water quality difference between the upstream and down stream area. This shows that, to a greater or lesser extent, there is water pollution in the River. The discrepancy in the physico-chemical properties of water is supposed to be from the industrial wastes, agro-chemicals from irrigation fields and to a lesser extent metropolitan wastes forming the point and non point sources.

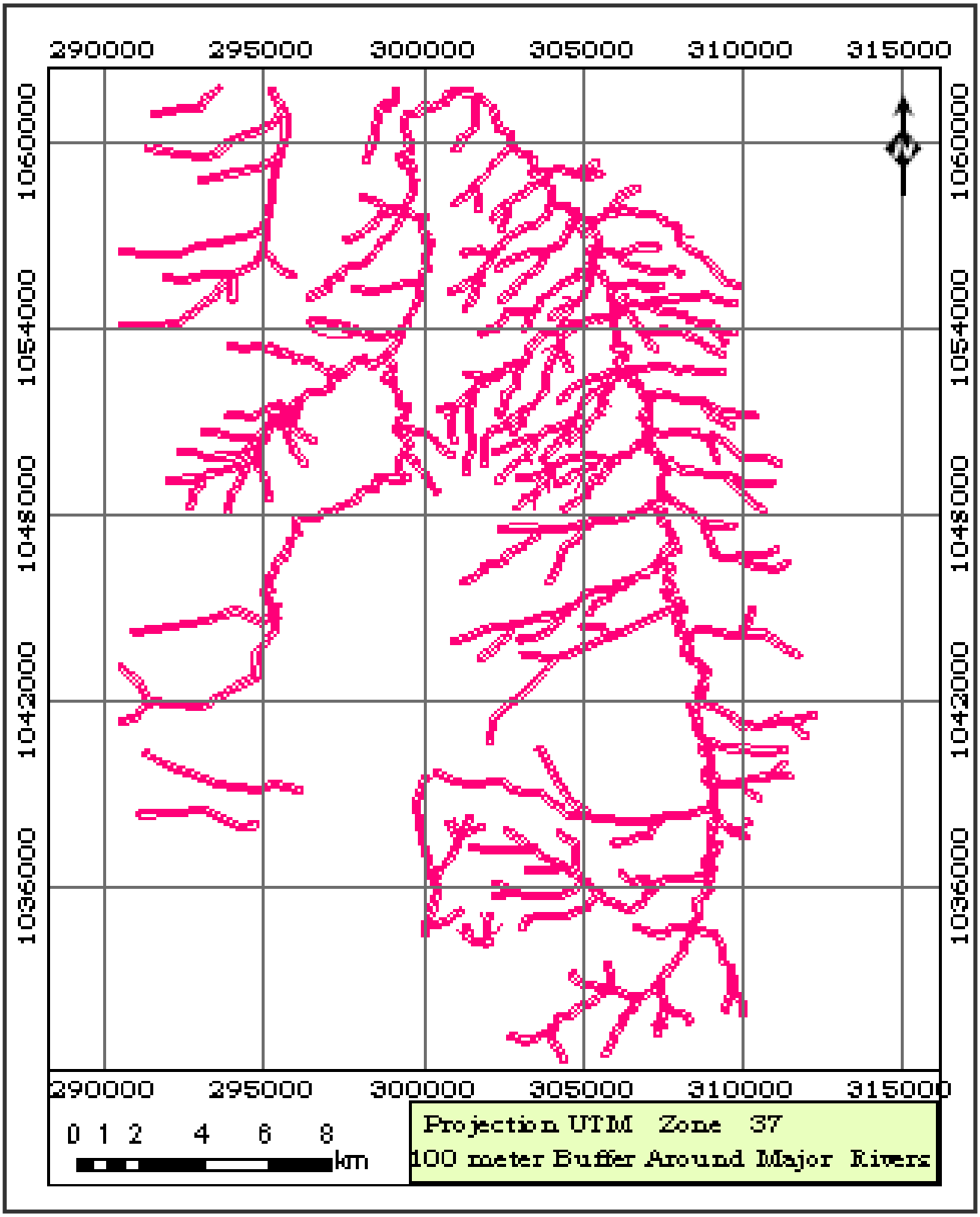

Figure 5.4. 100m Buffer around the Finchaa and Nashe rivers and their major tributaries.

5.2. The Climatic Conditions of Finchaa Valley Area

Climate is the cumulative weather conditions for long years. There are five decisive factors controlling the climate of an area. These are altitude, latitude, wind movement, distance from the sea and ocean currents. Of these; altitude, latitude and wind movement play an important role in controlling the climate of the study area.

The altitude of the project site ranges from 902 meter to 2449 meter. This substantial variation made the area to experience different weather conditions with in short distance. For instance, the weather conditions of Finchaa valley and Shambo (60 km away) is not the same. In terms of elevation based classification the project site is grouped under "Woina Dega" to "Kolla". The topography plays a pivotal role in controlling the micro climate of the area. The valley is warmer day time and cold during the night. Generally speaking the valley floor is hot weather conditions than the surrounding high lands.

The tropical setting, more specifically the equatorial location, of the area also contributes for the existence of distinct wet and dry seasons. The south westerly and north easterly trade winds provide "Kiremt" and "Belg" rain respectively.

The climate of Finchaa valley and the surrounding high lands ranges from temperate to semi-arid climate. The Rain fall and temperature are the most decisive components of the climate. There is a distinct wet and dry season but there is no uniform distribution of rain falls through out the year. June, July and August are the wettest months. On the other hand January, February and March constitute the driest months.

The human interference has been taking place for about 30 years in the project area. There is a change in the natural ecosystem and the alteration has repercussion on the environmental components which in

turn can affect the micro climate of the area. But it is hardly possible to distinguish slight anomalies by using the ordinary temperature and rain fall data from the existing meteorological station.

5.2.1. Precipitation/Rain fall

Finchaa valley area is found in the wettest part of the country. Relatively speaking there is high rain fall throughout the year except for few months. The rain fall mostly comes in showers. The average rain fall of Finchaa valley area is about 1300mm per year. The highest rain fall maxima is received in the summer season. (See Appendix 2)

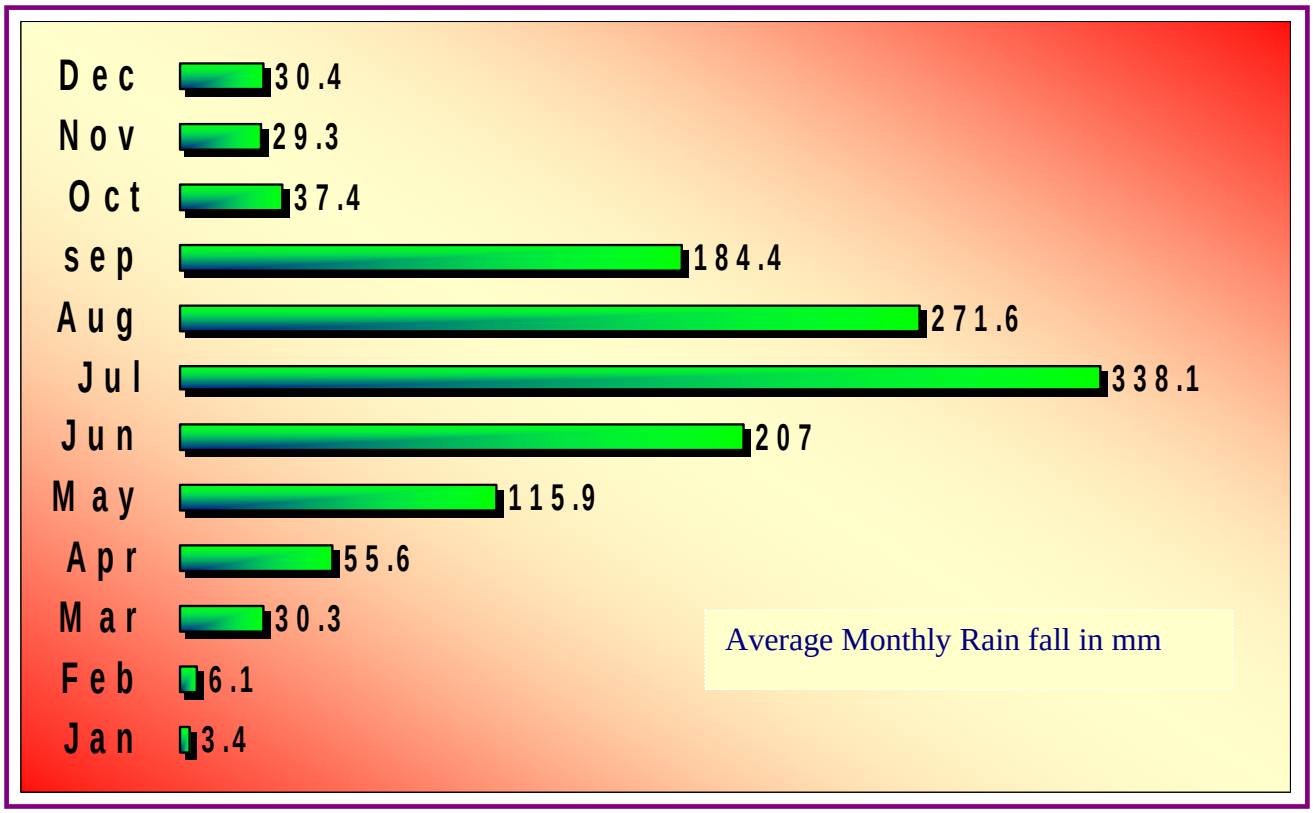

Figure 5.5. The Long years Average Monthly rain fall Data
(FSF Meteorological station)

As it is evident from the figure the average monthly rain fall varies from season to season. Almost 80 percent of the rain fall is recorded with in four months. The months of December, January and February account for not more that 5 percent of the rain fall and constitutes the dry season.

This rain fall pattern helps the rain fed agriculture. Conversely it may give good opportunity for high rate of erosion during the rainy season.

To see the impact of human interference on climate long year data is required. This task is very difficult if the level of human interference is very small like the irrigation project. The available climatic data shows no significant and meaningful change after the launching of the irrigation scheme in the area.

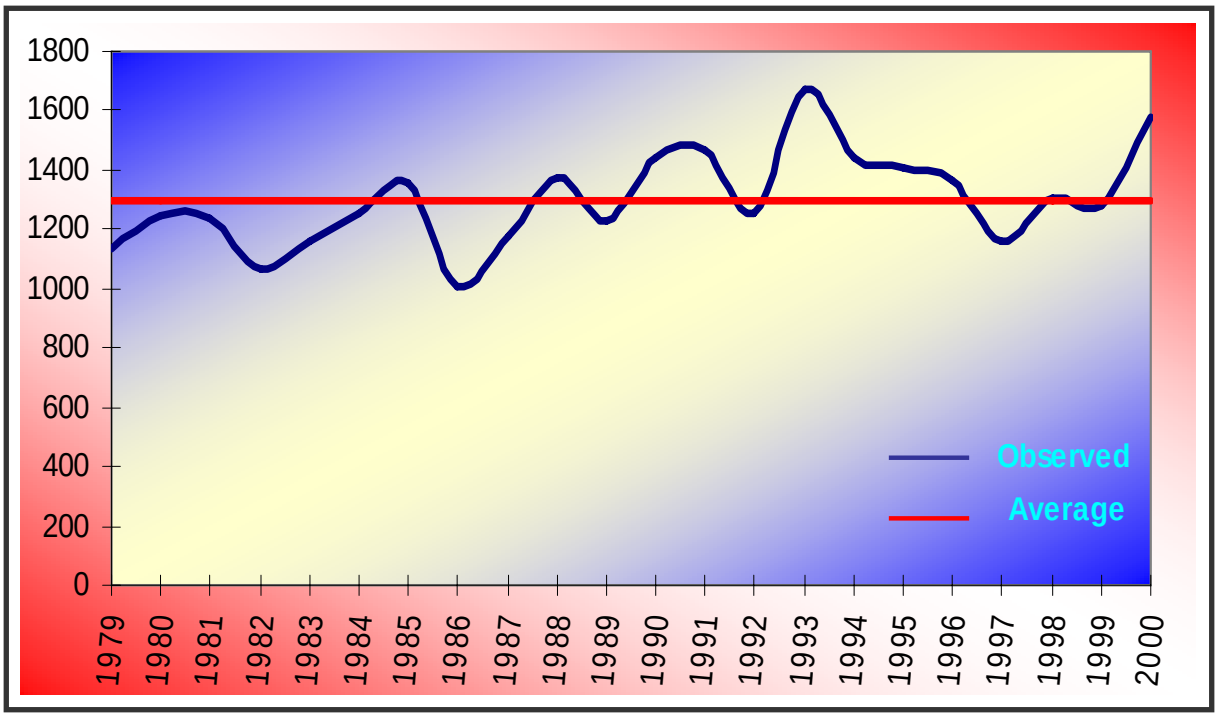

Figure 5.6.Long year Average annual Rain Fall of Finchaa valley area
(FSF Meteorological station)

Figure 5.6 illustrates considerable fluctuations on the average annual rain fall for twenty two years. At the end of 1980s and beginning of

1990s highest rain fall was recorded. But it is difficult to identify any sequential pattern over time and give explanation on the markedly fluctuating years.

5.2.2. Temperature

Finchaa valley is hot compared to the surrounding elevated areas. The temperature varies from 14°c early in the morning to 36°c early hours in the afternoon. The average temperature is about 23°c.The topographic effect of the valley is noticeable from high diurnal range of temperature. (See appendix 1). The valley is usually very hot day time and cold night time. Normally the highest temperature is recorded in spring which is before the start of the rainy season.

The long year average annual temperature is about 23°c. The average annual range of temperature is not more than 2°c

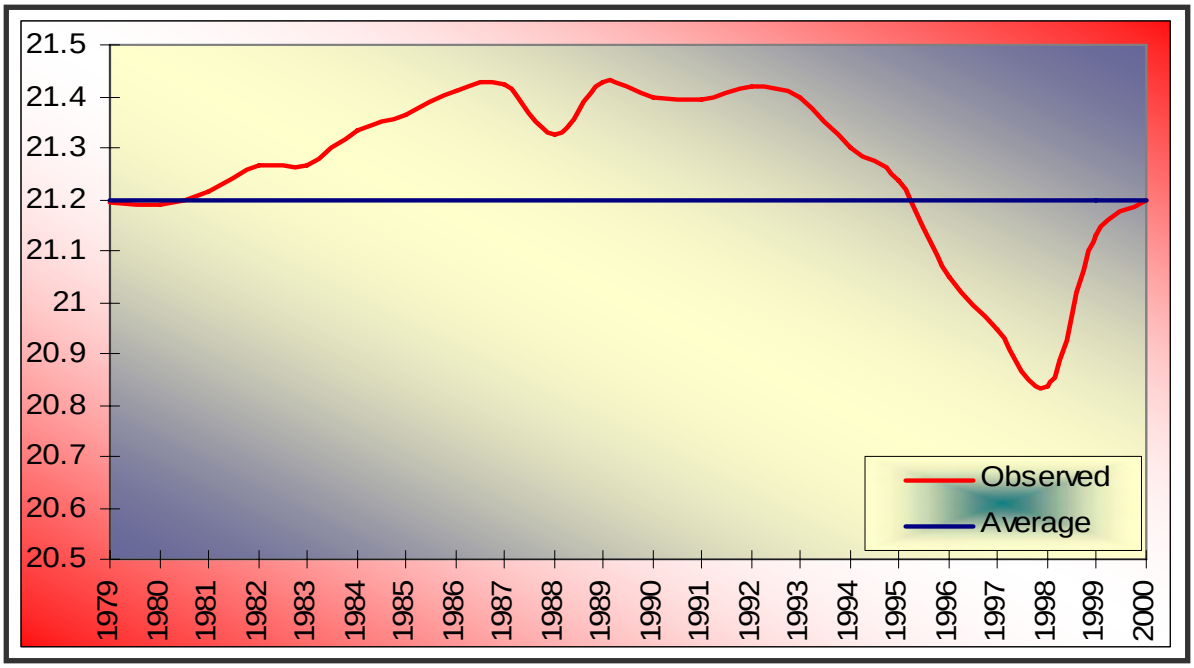

Figure 5.7.Long years Average Temperature of Finchaa valley area.
(FSF Meteorological station)

According to Figure 5.7 there is slight fluctuation of the annual average temperature. Still depending on this data it is difficult to see any pattern and apparent change after the irrigation project. Rather informally it could be possible to tell the daily weather in relation to the former years. In this respect the inhabitants claim that the area is getting hotter compared to the former years.

Thus from the twenty two years average temperature data it is hardly possible to tell any declining or inclining pattern. This could be due to the sluggish response of climatic parameters to small scale disturbances.

5.2.3. Humidity

Humidity refers to the moisture content in the atmosphere. Humidity contributes for the hotness or coldness and plays a role in balancing the weather condition.

> *"Humidity provides an apparent temperature, or how hot the air feels. For example, an air temperature of 38° C and a relative humidity of 60 percent produce an apparent very hot temperature…. If air cools to the point that its relative humidity reaches 100 percent, then the air is saturated and can not hold any more water vapor. Above the ground, the extra moisture will condense into cloud droplets or ice crystals and form clouds or fog. Under the proper conditions, rain, snow, sleet, or hail may fall from clouds." Encarta Reference Library (2005)*

The amount of humidity in the study area varies from place to Place. The River networks and the irrigation water contribute for maintaining the daily loss and gain of humidity. Out side the valley the extensive chomen swamp, Finchaa Lake and Amerti Lake sustain moisture balance and keep up the micro climate of the vicinity.

Table 5.1. Long years average humidity of Finchaa valley.

(FSF Meteorological station)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Aver.
1990	-	-	81	73	81	88	95	95	95	89	85	80	86.2
1991	74	64	70	79	83	92	95	96	95	91	85	83	83.9
1992	80	73	68	69	85	94	95	96	95	94	92	92	86.1
1993	86	74	68	86	87	95	96	96	95	93	85	78	86.6
1994	66	60	58	64	93	94	95	96	94	89	92	84	82.1
1995	69	55	54	64	86	93	96	96	95	93	84	83	80.7
1996	78	61	73	79	93	95	96	96	96	94	87	77	77.9
1997	72	55	64	77	88	95	96	96	94	92	91	85	83.8
1998	74	61	65	54	84	95	96	96	96	95	89	78	81.9
1999	74	55	47	61	88	94	96	96	95	95	87	86	81.2
2000	74	57	55	80	88	95	96	96	96	95	90	84	83.8
Aver.	74.7	61.5	63.9	71.5	86.9	85.5	95.6	95.9	95.1	92.7	87.9	82.7	82.83

From table 5.1 the long year average humidity varies form one month to the other. The maximum recorded average humidity is 95.9 and the minimum is 61.5 percent. The average relative humidity is about 78.7 percent. The highest humidity is recorded in the rainy season. There is no constant variation and therefore no distinct pattern is observed.

In summery from the collected temperature, rainfall and humidity data it is difficult to find any observable impacts of the irrigation scheme on the climate. This difficulty arises from various factors. First of all it is impossible to see minor changes using the twenty two years ordinary meteorological data. In addition it is not only the micro environmental components that bring about climatic change but also the global circumstances. Thus no defensible conclusion can be made on the negative or positive impact of the irrigation scheme depending on these climatic parameters.

5.3. Health Conditions in the Post Development Years Of the Irrigation project

There is no recorded health status data before the establishment of Finchaa sugar factory as there was no settlement in the valley. However, from unstructured interview made with local inhabitants some people asserted that the area had been affected by epidemics even before the arrival of the state farm. The interviewee sited the problem as one of the impeding factor for permanent settlement not to take place inside the valley in the former years.

Booker international agriculture Ltd (1977) in the feasibility study for Finchaa sugar project affirmed that there exists Malaria and Tsetse fly in the valley. The company added that this could be a challenge for the project workers and residents of the valley.

Currently there is one health center in the valley and some recorded case information is available. Accordingly the intestinal and malaria cases have been increased from 1992 on wards. From the informal interview made with the staff of the health center three possible rationales can explain this scenario. In the first place the water used for drinking is pumped from the canal with diminutive treatment. Secondly the expansion of irrigation can facilitate the spread of malaria and access to unclean water. Finally the population explosion in a short period of time may inflate the proportion of patients compared to the early years.

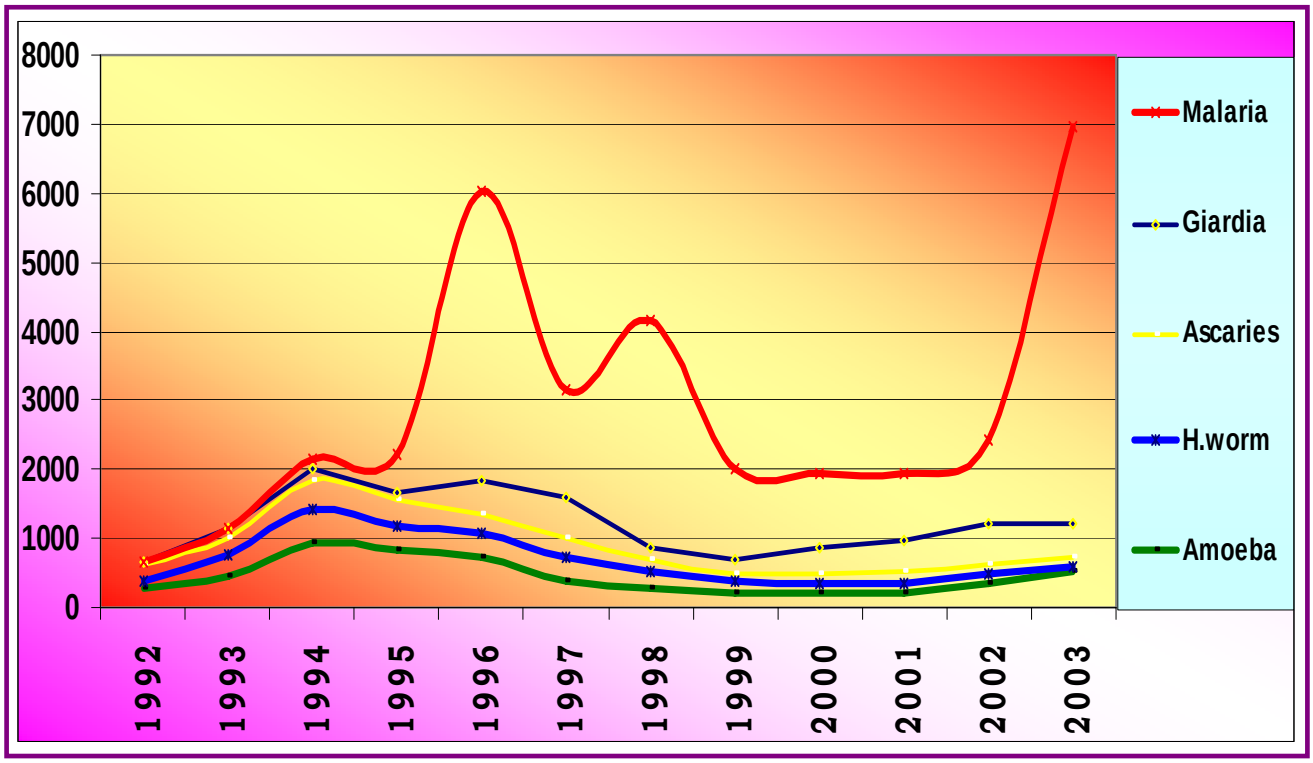

Figure 5.8.Maleria and Intestinal Parasite case record data

(FSF Health center)

According to figure 5.9 Malaria is the top health problem in the last 12 years. The fluctuating Weather conditions together with the expansion of irrigated fields and ditches can be the factors behind the problem. The fluctuation in malaria case records arises from the inconsistent use of anti-malaria chemical sprays and expansion of irrigated lands. The Second and third top health threats are Guardia and Ascaries. These intestinal problems in most cases are water born disease which can be related with unhygienic water use for drinking.

The haphazard increment of intestinal parasite and malaria case records can be due to natural or human made reasons. On one hand the natural set up of the valley and the climatic conditions can facilitate the birth and growth of pathogenic organisms in the area. On the other way round human interference have changed some of the existing natural systems.

In other word the expansion of human made environments results in alteration and degradation of the natural ecosystem.

These environmental modifications create a fertile ground for some insects and pathogenic organisms which give birth to the spread of diseases. The classical example here is the expansion of irrigation and increasing malaria case records.

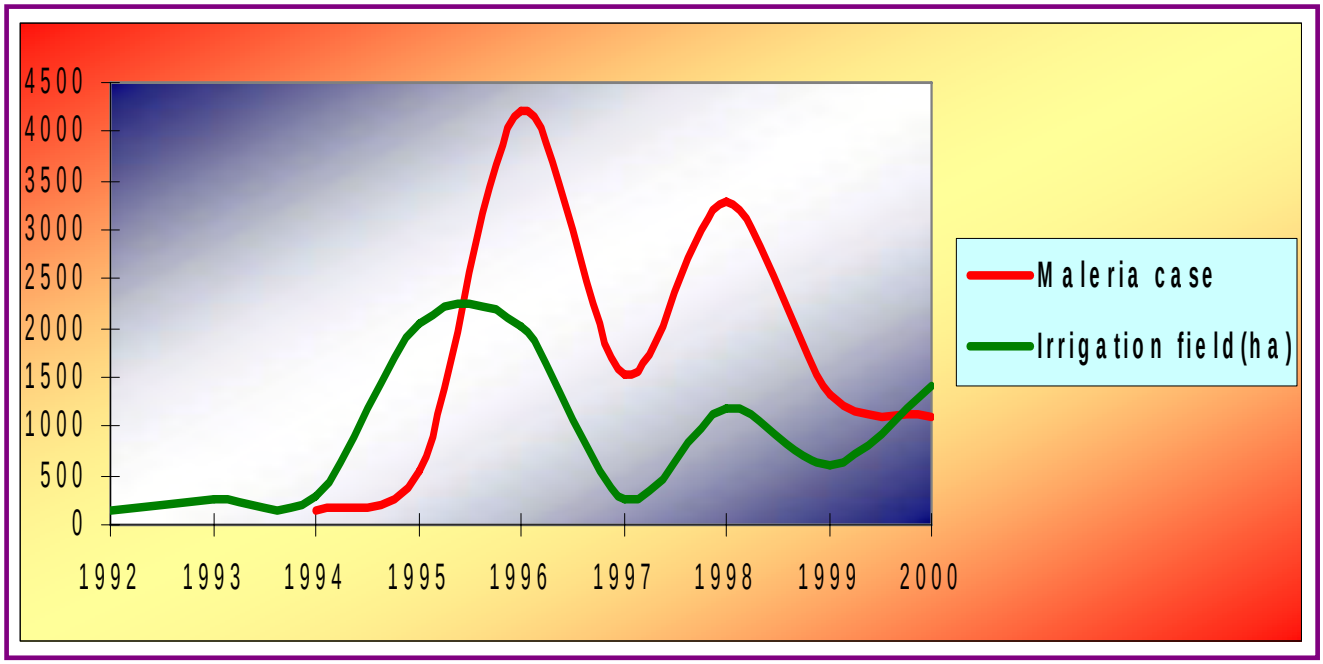

Figure 5.9.Expansion of Irrigation fields Vs Malaria case records.

As it is evident from figure 5.10 Malaria cases are increasing with the expansion of irrigation fields. In the beginning few malaria cases were seen in the valley. For the 1992 and 1993 there were no recorded malaria cases data available in the health center. But for the consecutive two years fewer malaria cases were recorded. From 1995-1997 large number of malaria cases were observed. (See appendix 3) In these years extensive sugar cane plantation was carried out in the valley. The lag time between highest malaria case and the expansion of irrigation could be due to the time taken for reproduction and stages of development in human body.

In general there is no health data available on the pre irrigation development years of the valley. Since 1992 malaria and intestinal parasite case records have increased. Conversely the health facility given in the valley has improved a lot since 1992.It is found out that there is a positive relation ship between malaria cases and expansion of irrigation fields. The intestinal health threats are also interlinked with unclean drinking water. Well organized preventive and controlling measures should be implemented as the health cases are interrelated with workers productivity.

CHAPTER SIX

6. Conclusion and Recommendation

6.1. Conclusion

In order to see the possible environmental impacts of irrigation projects some parameters were selected. Some of the Geographic information system and remote sensing techniques were also used. Accordingly, it is observed that the natural environment in Finchaa valley has been modified due to agricultural and industrial developments since 1975. Following this modification the irrigation project have both positive as well as negative impacts on the environment.

From the positive contributions the project opened up large scale job opportunities for many thousands of people. It has also many socio-economic benefits for the valley and surrounding people. In addition Finchaa Sugar factory play a key role to address the current sugar demand in a local market. There are also many efforts to exploit the byproducts of the factory for other extra purposes like using ethanol for fuel. The project has also an important role for the growth of national GDP and GNP.

On the other hand the attention given for natural resource conservation is less and this has been devastating some of the environmental components. There has been large scale vegetation clearance taking place in the study area. The NDVI image analysis of the 1972 MSS and the 2000 ETM images shows that the vegetation biomass is diminishing. The intensification of agricultural and industrial developments together with population explosion has the coin share for the decrement. The large scale deforestation has been devastating the vegetation and wild life

resources in particular and the biodiversity in general. There are efforts made by Finchaa sugar factory to rehabilitate the forest resource. But the amount and rate of deforestation in one side and the reforestation and afforestation projects on the other side are incomparable in any measure.

In addition deforestation is facilitating the progress of runoff and accelerates erosion. Accordingly soil erosion is a critical problem in the project area. The active erosion, beyond taking the fertile top soil, is changing some of the potentially irrigable lands in to Bad Lands. In some areas there are gullies that extend for about 30 m. The topographic set up and Human induced factors are responsible for the active erosion in the area. The steep slope in the escarpments surrounding the valley promotes greater runoff. The Road construction and the frequent maintenance down the valley made the soil ready for erosion.

The physical and chemical analysis of the soil samples taken from irrigated field, cultivated but not yet planted and Vegetation cover area are found to be different. The total sand content of Luvisols decreases with increasing soil depth in all sampled layers. While the clay content increases with depth. The exchangeable bases are higher in the irrigated and cultivated area than the vegetation cover area. Relatively Organic carbon, Nitrogen and phosphorous are found in large quantities in the irrigation fields especially in the upper layer (0-30cm). The use of agro-chemicals in the irrigation fields are supposed to contributes for this result. In general some of the physical and chemical properties of the soil in the irrigated and non irrigated sites are found to be different. This shows that, to a lesser or greater extent, there is soil contamination that could lead to full-size soil pollution.

The result of water samples from up stream and down stream areas indicates that the physico-chemical properties are different in these two

areas. The down stream water contains more chemical substances than the up stream water. The point and non point sources contribute for the pollution. The point source comprises the industrial waste water that escapes from the treatment plant and join the river. The non point sources involve the use of agro-chemicals (fertilizers, pesticides and herbicides) and the metropolitan wastes that join the tributary streams. Thus, based on the water samples inspected there is water pollution emanating from poor industrial waste water treatment and the leftovers of the agro-chemicals used in the irrigation fields.

In most cases climate is the reflection of the natural environment. Any system disturbance on the environment can affect the climatic conditions. The analysis of the 22 years rain fall, temperature and humidity data can not meaningfully imply any climatic change as a result of the irrigation project. This is due to the sluggish and unpredictable nature of climatic anomalies. It is reasonable however to say that there is imperceptible changes following the environmental degradation. Still it is open for further specific and detailed works to see the impacts of irrigation on the local climate.

Case records of Malaria and some water born disease have been increasing following the opening of Finchaa irrigation scheme. There is a positive correlation between malaria case records and expansion of irrigation fields. Although the health care facility given has improved a lot, the number of patients boost up by a large number. This shows that big attention is given on disease control than prevention. The environmental modifications and the diminutive prevention measures contribute for the large number of malaria and water born diseases case records.

Generally despite of its positive consequences, the irrigation project in Finchaa valley area has a negative impact on the environmental components. Especially on the vegetation cover, soil quality, water quality and partly on some health conditions. But this does not, in any way, mean that the problems out weight the benefit of the factory and that the problems are out of control. The degradation is in its early to moderate stage and even not difficult to address and alleviate them all. The possible solutions are much easier and cheaper in this moderate stage of the environmental degradation. But undoubtedly if the current trend keeps on the problem would get more complex and difficult to reclaim. Thus, urgent attention should be given for the environmental rehabilitation and conservation.

6.2. Recommendations

In line with the findings of this selective parameter based environmental impact assessment the following recommendations are presented:

1. The environmental considerations should not be disregarded in any way and with any justification seeing that well organized environmental management positively contribute for better productivity and sustainability.

2. The rehabilitation of devastated vegetation biomass should be given first line attention as it helps to maintain the soil, water, climate and biodiversity of the area. Finchaa sugar factory should tackle the problem of frequent Forest fire and large scale deforestation that are observed inside the valley.

3. There should be well organized and effective afforestation and reforestation programs to reestablish the ecosystem. Some areas like the surrounding escarpments, river sides, agriculturally non suitable and marginal lands can be delineated and protected as the forest area.

4. There should be continuous follow ups and assessment of the physico-chemical properties of the soil in the irrigation fields. This helps to see the impacts of fertilizers, herbicides and pesticides on the soil quality and to take timely measures.

5. Strict physical and biological measures should be taken to impede the actively operating erosion and growing gully problem in the irrigation fields and the surrounding areas.

6. Finchaa sugar factory should establish a modern and efficient waste water treatment plant in order to stop the two stream-sized industrial waste water and irrigation field wash away leakages to the river. Further inspections should be carried out for the water quality problem in the down stream area and appropriate measures should be taken.

7. In addition to disease controlling strategies, research based preventive approaches should be adopted so as to mitigate the escalating malaria and water born disease case records and their far reaching impact on production and productivity.

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Appendixes

Appendix – 1

Long year Average temperature (1979-2000)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1979			24.75	25.5	23.6	22.55	21.1	20.45	20.8	21.5	20.9	21.3
1980	21.85	24.45	25.6	25.6	24.6	23.05	20.6	20.85	21.35	21.15	21.35	20.65
1981	21.85	22.2	24.75	24.5	24.1	23.1	20.7	20.45	20.6	19.95	21.2	20.2
1982	22	23.45	25	25.05	25	24.25	21.5	20.65	21.35	20.75	21.7	21.25
1983	21.05	23.45	25.8	26.1	25.5	23.8	21.9	20.95	21.5	20.9	21.3	20
1984	20.8	22.25	26.15	27.45	25	22.25	21	21.1	20.8	20.05	21.7	20.85
1985	21.2	22.5	25	24.85	23.4	22.7	20.3	20.15	20.4	20.15	20.4	20.6
1986	20.65	23.95	24.4	24.3	26.6	22.75	21	20.55	20.95	20.95	21.35	21.25
1987	21.5	24.6	25.4	26.85	24.6	22.85	22.3	21.15	22.2	22.15	22.35	22.8
1988	23.4	25.15	26.8	26.75	27.1	23.5	20.8	20.55	20.9	20.5	19.8	20
1989	20.3	22.45	24.3	25	24.9	22.85	21.3	20.75	21.25	21	20.75	21.75
1990	21.95	23.35	25.25	25.85	25.3	24	21.5	21.05	21.3	21.2	22.2	21.45
1991	22.85	22.8	25.65	25.55	25.1	24.1	21.4	21	21.6	21.35	21.55	21.15
1992	22.8	23.7	26.05	26.05	25	23.35	21.1	21.05	20.55	21.1	20.4	21.6
1993	20.75	23	25	24.4	24.3	22.8	21.2	21.35	20.85	21.4	21.3	22.2
1994	22.85	24.2	25.8	26.75	24.1	22.55	21.2	20.85	21.05	21	22.4	21.75
1995	22.1	24.55	25.55	26.65	24.5	23.35	20.2	21.1	21	21.2	22	22.35
1996	22.4	24.25	25	24.85	22.7	21.9	21	20.5	21.05	20.95	21.2	21.55
1997	22.3	22.8	25.5	24.25	23.3	21.5	20.6	20.7	21.45	21.55	21.65	21.4
1998	22.1	23.1	25.4	27.05	24.8	22.55	21.2	20.9	21.6	21.85	20.5	19.95
1999	21.5	23.25	24.55	26.1	24.7	22.8	20.5	20.6	21.4	21.45	19.95	21
2000	21.6	23.05	25.55	24.35	24.9	23	21.1	21	21.6	21.95	21.15	21.2
Aver.	21.8	23.45	25.33	25.63	24.7	22.98	21	20.8	21.16	21.09	21.23	21.193

Source: FSF Meteorological station

Appendix – 2

Long years average rain fall (mm 1979-2000)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1979	-	-	17.7	9.7	135	172	288	249	167	30	30.8	31.5
1980	1	19	30.1	57.1	91	169	413	254	139	29.7	30.8	31.2
1981	5.2	0	27.8	56.6	134	142	353	187	244	28.9	30.3	30.9
1982	12	18	32.5	26.5	41	90.9	454	195	136	28.3	30.3	31
1983	1.6	25	17.1	16.9	135	110	311	276	206	27.9	29.8	31
1984	0	2.8	10.1	3.2	129	244	321	201	255	29.8	30.9	31.2
1985	3	0	13.3	30.8	117	157	327	426	194	28.8	29.8	30.6
1986	0	19	39.1	68.7	14.8	191	289	187	126	29.4	31.5	32.1
1987	1.8	6	44.4	96.5	160	190	266	220	105	29.8	32.2	32.9
1988	0.9	17	19.9	20.9	33	242	490	307	172	27.6	29.4	30.7
1989	0	1.6	85.8	62.2	41.5	168	311	332	138	29.2	31.1	30.2
1990	1.1	8.4	46	67.2	80.8	206	410	327	212	29.5	31.4	32.8
1991	0.6	2.8	66.2	62.3	88.6	223	381	347	203	29.9	31.2	31.5
1992	8.1	6.4	53.5	72.5	112	304	256	237	131	27.6	28.2	30.8
1993	0.1	0.3	18.1	112	148	200	475	332	292	28.9	30.9	33.1
1994	0	0	24.7	55.5	223	251	357	280	154	30.4	31.5	32.7
1995	0	0.7	32.9	51.8	242	242	315	250	181	30.6	31.6	31.9
1996	7.1	0	40.9	70.8	146	160	399	236	215	30.7	31.1	31.3
1997	9.8	0	19.5	90.1	147	239	215	224	138	30	30.2	31.3
1998	0	1	24.6	13.7	179	196	296	303	206	26.2	29.4	30.6
1999	18	0	1	63.7	78.5	322	249	333	149	27.5	25.9	30
2000	0	0	0.9	115	73	335	262	272	293	212	6.4	9

Source: FSF Meteorological station

Appendix-3

Health data on some health threats in Finchaa valley.

Year	Amoeba	H.worm	Ascaries	Giardia	S.Mansoni	Taenia	Setercoralis	H.nana	Entrobius	T.trichuria	Malaria
1992	260	128	224	35	123	121	21	13	7	4	-
1993	462	315	213	155	178	42	61	31	17	13	-
1994	928	487	415	172	139	50	86	57	18	15	144
1995	820	357	396	97	93	53	77	43	21	9	553
1996	715	360	275	470	57	66	92	71	20	9	4202
1997	380	352	268	605	80	130	136	26	6	14	1536
1998	260	252	185	164	82	84	62	96	2	13	3297
1999	218	149	119	202	59	175	60	63	1	1	1334
2000	204	144	122	381	57	83	109	78	8	9	1104
2001	196	152	181	434	57	16	67	109	4	7	982
2002	337	143	152	578	148	25	79	116	6	3	1227
2003	506	89	118	486	186	6	52	134	5	2	5767

Source: Finchaa sugar Factory Health center

Appendix- 4

Kind and Amount of Agro-chemicals used in Finchaa irrigation Fields.

Description	Unit	94/95	95/96	96/97	97/98	98/99	99/00	2000/01	01/02	02/03	03/04	04/05	Total
Fertilizer													
NPK	qt	204	5224	5806	4003								15237
DAP	qt	15				11193	11495	12898	11766	12987	12863	16661	89877
Urea	qt					4760	5770	10192	7678	10288	12898	19878	71463
N.P	qt							4	1				5
K_2s04	qt							3					3
Herbicide													
Gesapax Conbi	lts	376	2883	750	98	5144						60	9311
Gesapax H500 EC	lts		15834	5729									21563
Gramaxon (Parqat)	lts	11		3			245	61	45				365
Atramet Combi	lts						9856	18099	12529	10639	8008	12965	72096
2-4D Amin	lts	84		777	24		65	3367	1145	2686	3475	3593	15216
Velpar	lts		1302	3138.5	189				40				4670
Velpar	kg						748	2371	2978	1855	828	173	8953
Glyphosate	lts							1604	611	271	1216	573	4274
Stiker													
Teepol	lts								234	75	388	75	771
Cittowet	lts	9	55.5	6	0.8	134		294	4	33			536
Activater90	lts								0.6	340	457	399	1196
Pesticide													
Malathinon	lts			267	20	716	162	1191	142	105	96	9	2708
LINDON											6		6
Dursban (Perinix)	lts							1625	1983	318	1746	2454	8127
Diazenone/	lts									48	11		59
Fungicide													
Lysol	lts	5	8				54	126	50	145	245	143	776
Benomyl	kg							2	155	403	263	105	928

Source: Plantation Department of FSF.

Appendix- 5

The Laboratory Results of the Up Stream and Down Stream Water Physico-Chemical Analysis.

No.	Elements	Upstream water	Down stream water
1	Temp(^{o}c)	23.7	23.3
2	PH	6.3	6
3	EC	99	121
4	Ammonia(mg/I NH_3)	0.29	0.4
5	Sodium(mg/l Na)	1.7	9.5
5	Potassium(mg/l K)	1.2	2.3
6	Total hardness(mg/l Ca Co_3)	39.6	57.2
7	Calcium(mg/I Ca)	13.35	19.58
8	Magnesium(mg/I Mg)	1.6	2.16
9	Nitrite(mg/I NO_2)	0.05	0.06
10	Nitrate(mg/I NO_3)	0.25	0.37

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Declaration

I, the undersigned declare that this thesis is my original work and has not been presented for a degree in any other university and that all sources of materials used for the thesis have been duly acknowledged.

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Ahmed Amdihun

This thesis has been submitted for examination with my approval as a university advisor.

Name Lulseged Ayalew (Dr.)

Signature _____

Date of submission _____