ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

GIS BASED ANALYSIS OF LAND USE /LAND COVER,
LAND DEGRDATION AND POPULATION CHANGES.

(A STUDY OF BORU METERO AREA OF SOUTH WELLO, AMHARA REGION)

GIRMAY KASSA WELELA

JUNE, 2003 AAU

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By

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A Thesis submited to the School of Graduate Studies of Addis Ababa University In Partial Fulfillment of the Requirements for the Degree of Master of Arts in Geography

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Approved by board of examiners:

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Advisor

_______________________________ ___________________

Examiner

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Examiner

DECLERATION

The Thesis is my original work, has not been presented for a degree in any other University and that all sources of materials used for the thesis have been duly acknowledge.

GIRMAY KASSA WELELA

Addis Ababa

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List of Abbreviations

ANRS	Amhara National Regional State
AOI	Area of Interest
API	Aerial Photograph Interpretation
BoA	Bureau of Agriculture
CSA	Central Statistics Authority
EFAP	Ethiopian Forestry Action Program
FAO	Food and Agriculture Organization of the UN
EMA	Ethiopian Mapping Authority
GIS	Geographic Information Systems
GPS	Global Positioning System
GTZ	German Agency for Technical Cooperation
HF	High forest
LGP	Length of Growing Period
MOA	Ministry of Agriculture
MOWR	Ministry of Water Resources.
RS	Remote Sensing

Abstract

The North-Central high lands of Ethiopia have been exploited over centuries and their present status is alarming. A subsistence rain fed production using obsolete methods characterizes agriculture the predominant economic activity of the area. The study area which cover about 3088ha of South *Wello* found in *Tehuledere Wereda* known as *Boru-Metero* is one of the representative area of the highlands in the region where its land use and land cover has significantly changed due to demographic pressure.

Today in many parts of the North-central highlands, cultivated and grazing lands are commonly seen dissected by gullies and gorges of different sizes. Almost all natural forests have been cleared irrespective of slope steepness and are now under cultivation without proper land management. The size of farmland per household is very low due to population growth. Because of these and other factors the rural population of the region and the study area are vulnerable to food shortage every year.

The study is designed to address the above interwoven problems in the area related mainly to land use/land cover, land degradation and human population pressure. Accordingly two main objectives were designed: first, establishing the current status and trends in changes of population distribution, land use/land cover changes and identifying areas severely affected by the changes. Second, identifying the causes and consequences of temporal and spatial changes in population distribution, land use/land cover changes and land degradation.

In order to fulfill the above objectives, assessment of land use/land cover changes in relation to population growth was done using the available aerial photographs of 1936,1965, 1986 and 1994.

An-in-depth investigation of each aerial photographs of the study area was carried out using different raster and vector GIS soft wares such as photogrammetric workstation known as VIRTUOZO, ERDAS Imagine ver.8.3 Map/Info ver.4.1 Arc/view ver.3.2 and others. In order to support those GIS technologies analogue instruments such as Procom-2, pocket Stereoscope, field camera, handheld GPS-45 and others were used. With the help of these technologies and field assessment, land use/land cover changes taking vegetation cover as an indicator was investigated and rural population of the area was also estimated from the stated aerial photos and mapped for each year.

The 1936 aerial photographs of the Italians was interpreted for sample area of *Borur Sellassie* and *Gora* area and separately compared with the recent 1994 aerial photographs to evaluate land use land cover changes, land degradation and population distribution. While the 1965, 1986 and the 1994 aerial photographs were applied for the whole study area. All the stated year aerial photographs were converted in to digital formats using the above stated soft wares and then geo-referenced, land cover types identified are digitized.

The result shows that, cultivated land in *Boru-Metero* increased from 44.86 percent in 1965 to 49.44 percent and 49.62 percent in 1986 and 1994 respectively. In this respect the change of crop land was not significant because the areas suitable for cropland was already farmed by the 1980's and since.

Conversely, the natural vegetation cover declined from 3.43 percent in 1965 and became 2.74 percent in 1986 and 2.59 percent in 1994. The most

significant land cover change found was the increasing of tree farming of Eucalyptus trees. It was only 1.63 percent coverage in 1965 and increased to 4.71 percent in 1986 and 4.63 percent in 1994. This change was the result of the aforestation and enclosure of hill side program done in the 1980's as well as the increasing of financial income gained from the selling of fuel wood and poles that initiate farmers to plant Eucalyptus trees around their homestead and on their farms.

The result of land use/land cover changes investigated on aerial photographs of 1936 in the sample areas of *Boru sellassie* shows that, cropland which was 50.83 percent coverage in 1936 increased to 64.25 percent in 1994, which was 69.51 additional hectare within 58 years difference. This indicates that there was an expansion of farmland since the 1936 in the area.

The analyzed result for *Gora* area shows that, the cover of natural forest (dominated by Juniperous procera) declined from 18.22 percent in 1936 to 7.70 percent in 1994. The area coverage of natural forest in 1936 shows about 130.9 ha and declined to about 55.1ha in 1994. Therefore, the natural forest cover cleared within 58 years was 57.91 percent of the cover existed in 1936 around *Gora* area.

The investigation of rural population done from the stated aerial photographs show a population of 5404 in 1965, 8050 in 1986 and 9774 in 1994 settled in *Boru-Metero*. Based on this the population density of the study area shows 175 persons/km^2 in 1965, 261 persons /km^2 in 1986 and 317 persons /km^2 in 1994.

Population density regarding the sample area of *Boru Sellassie* area in 1936 shows 298 persons/km^2 and increased into 628 persons/km^2 in 1994. On similar trend the population density of *Gora* area during the 1936 accounted about 44 persons/km^2 and increased to about 364 persons/km^2.

CHAPTER ONE

1. INTRODUCTION

1.1 Background

Ethiopia Which is located between 3°N (Morale) and 15°N (the northernmost tip of Tigray) and 33°E (Akobo) to 48°E is a country with ecological and biological diversity. The altitude rang, from about 100 meters below sea level to over 4,500 meters a.s.l; rainfall range from less than 100 mm in the north eastern low lands to over 2,700 mm in the south western highlands while mean annual temperature changes from less than 10° to about 30°c. Rapid deforestation and accelerated land degradation has led to deterioration of the country's environment. The scarcity and depletion of the natural vegetation cover have implications for the whole ecosystem and have a fundamental influence upon the deterioration of the standard of living of the population. The annual rate of deforestation has been estimated in many recent reports at 150,000 to 200,000ha, which is equivalent to about 6% of the remaining natural high forest (EEAP 1994). A variety of factors including climate, and land use basically influence the rate of resource degradation. Primarily those involving agricultural practices have greatly increased the rate of degradation in many parts of Ethiopia. Soil erosion coupled with high population pressure has resulted in the expansion of cultivation on to topographic marginal lands, which are steep slopes up to 70% with less than 35 and 10 cm of soil depth in the Northeastern highlands where 89.6% accounts to Wello that includes the study area.

It is generally argued that the Ethiopian highlands are highly degraded due to rapid changes in land cover, land use, population density and soil degradation; yet there is very little spatial and quantitative data base that can substantiate these arguments. Such information is vital for establishing the past and present conditions and predicting the future trends of the population distribution, land cover, land use and the physical environment. It is also necessary to establish the potentials for expansion of various land use types and to develop conservation ideas and rational resource and environmental management programs. Therefore, data relating to land cover and land use, soil degradation and population distribution is an invaluable resource for sustainable land use and environmental management.

Empirical evidence of land cover changes generated by sequence of aerial photographs and/or satellite images can greatly contribute to planning more appropriate management of variable resources, especially in developing countries like Ethiopia, where other kinds of back ground data are often lacking. Repeated aerial photographs and/or satellite images play a major role in setting up inventories of material resources and allow the change of land use/land cover through time, because they give a visual assessment as well as quantitative information on the trade offs between different land use/land cover categories.

The integrations of remote sensing and GIS in environmental applications have become increasingly common in recent years. Remotely sensed images are an important data source for environmental GIS applications and conversely GIS capabilities are being used to improve image analysis procedures. (Atkinson, P.M. and Tate, N.J. (ed) 1999).

Black and white aerial photographs available since the 1930's provide a wide range of spatial data on land cover, land use, soil and terrain characteristics. The various land cover types, different configuration of the terrain and various attributes of the soils leave characteristic landscape features that are easily picked up by aerial photographs are transferred for analyses using computer assisted technology.

Land- cover analysis provides the baseline data required for proper understanding of how land was used in the past and what types of changes are to be expected in the future in relation to the population pressure.

The value of data generated through aerial photographs in mountainous landscapes like of the Ethiopian highlands is higher because it is not only difficult but also very expensive to carry out investigation on ground survey alone. The landscape study also makes aerial photograph interpretation very effective as many of the details regarding vegetation cover, land uses, soils and land form features can be easily identified from aerial photographs through simple stereoscopic to computer equipment. Population changes can also be estimated by identifying and enumerating settlements with their houses on the photographs and estimating the size per unit area.

The study area is selected based on its accessibility, availability of data, and the fast changing land cover, coupled with rapidly increasing population. The region as a whole is also vulnerable to drought and famine. In addition to these the study also benefits from the works of previous researchers in the area.

1.2 STATEMENT OF THE PROBLEM

In many developing countries the need to provide adequate food for a rapidly expanding population has put enormous marginal land under cultivation. This has resulted in deforestation of the natural vegetation where the soil is exposed to erosion and eventual desertification. For example, Crummey (1998) cited on an editorial of the Ethiopian Herald of January 12, 1995 on his article titled " commemorating years of Famine," point out:

> *Studies so far made on the Ethiopian famine conditions indicate that the root causes of the problem lie in the combined effect of population pressure, unreliable rainfall, overgrazing and over use of the soil and the erosion of the land base. Deforestation has especially wrought havoc on the environment leading to the present ecological imbalance.*

Crummey tries to substantiate his argument by noting that forest cover, which was 40% some seven decades back, has declined to less than 4%. But studies by scholars have pushed back the notion of deforestation to the remote past, for example Teweldebrhan G. Egzeabher (1996) cited in (Crummey 1998) argues:

> *Most of the highland had become deforested at least by the sixteen century, and probably as early as the sixth century. The claim that 40% of Ethiopia was covered in high forest only 1000(sic for 100) years ago is a myth which contradicts all historical records.*

Understandably, the northern provinces of Ethiopia could not be compared with the southern and western counter parts in vegetation resources. Having sustained states and civilizations for millennia, they exhausted a large portion of their natural resources in general. Although some studies done around *Wello* area agreed on the destruction of vegetation cover, it was not a recent phenomenon as Bahiru Zewde (1998) stated as follows:

> *The Italians, having had the occasion to observe things at a closer range for five years and an Italian forestry official concluded after a trip across eastern Wello that the whole region was "bare of forests, nay even of trees." He also tried to connect the phenomenon with over population and makes the assertion that Ethiopians do not know the benefits of forests and that they fell down and destroy trees for their ever growing need for agricultural land.*

Regarding the more recent deforestation process Crummey (1998) argues that *Wello* is marked today by many more trees and probably by considerably more woody biomass than it was in the 1930's. The study also indicates that, there doesn't seem to have been a major shift between cultivation and non-cultivation in the last sixty years. According to Crummey (1998) also supported by his statement; all historical records suggested that almost all the currently cultivated land in the *Wello* highlands was already under cultivation at least as far as the 1930's.

Engdawerk Assefa (2000) based on aerial photographs has also reported that forest and shrub land has increased by 3% and 70% respectively in 1996 as compared to 1965.

On the other hand, a study by Kebrom Tekle and Hedlund (1999) on land cover changes between 1958 and 1986 in *Kalu* district of south *Wello* taking aerial photographs of the indicated years has recorded that, cultivated area has increased by 2.1%, while shrub and forest lands decreased by 50.6% and 30.6% respectively.

Forest resources have shrunk, indicating that forest destruction has been endemic in times of political and social crises. The increment of forest resource according to Bahru Zewde (1998) is due to large-scale plantations of governments, private entrepreneurs and individual farmers.

On the other hand Belay Tegene (2000) on his study of land use and land cover changes in the *Derekolli* cachment of South *Wello* Zone using the 1957and 1986 aerial photograph and land sat TM image of 2000 and GIS technology found that the shrub land which apparently constituted the climax vegetation of the region, accounted for 16.4% of the cachment in 1957 declined to 6.9% in 1986 and to 2.5% in 2000. The study also indicates that shrub land is over degraded in the study area due to increased demand for fuel wood. The popularly held view that expansion of cultivation is a primary force of vegetation clearing and environmental degradation was not found not to hold true in the study of *Derekolli* as land cover conversion to crop land was not a major phenomenon in the cachament area.

From the above studies, two conflicting results are presented with regard to the vegetation cover in the last 50 years.

1. Some of the studies report that there has been a decline in the vegetation cover in their respective study area.

2.Others concluded that *Wello* area was a bare area since centuries back and there is an increment of woody vegetation cover in the last 50 years.

Thus further investigation of the vegetation situation in *Wello* became very important. To this effect the study applies all the remotely sensed data available for the region i.e. 1936 aerial photograph by Italians and the 1965, 1986 and 1994, and assed the cover change taking about 3088ha of a highland area known as *Boru-Metero* in *Tehuledere Wereda* of South *Wello*.

1.3 Objectives

1. To establish the current status and trends in changes of population distribution, land use/land cover and land degradation in the study area and identify areas changed their vegetation cover since 1936.
2. To identify the causes and consequences of temporal and spatial changes in population distribution, land use/land cover and land degradation

This is attained by:

- identifying different land cover / land use categories and establishing their characteristics.
- establishing relations between land use/land cover and population pressure.
- identifying factors responsible for the land cover, land use changes and land degradation
- assessing impacts of government policies, such as aforestation programs and land and tree tenure, and the changes in population distribution.
- applying appropriate GIS soft wares for the study such as Map/Info, Arc/View, ERDAS Imagine and photgrammetric work station soft wares.

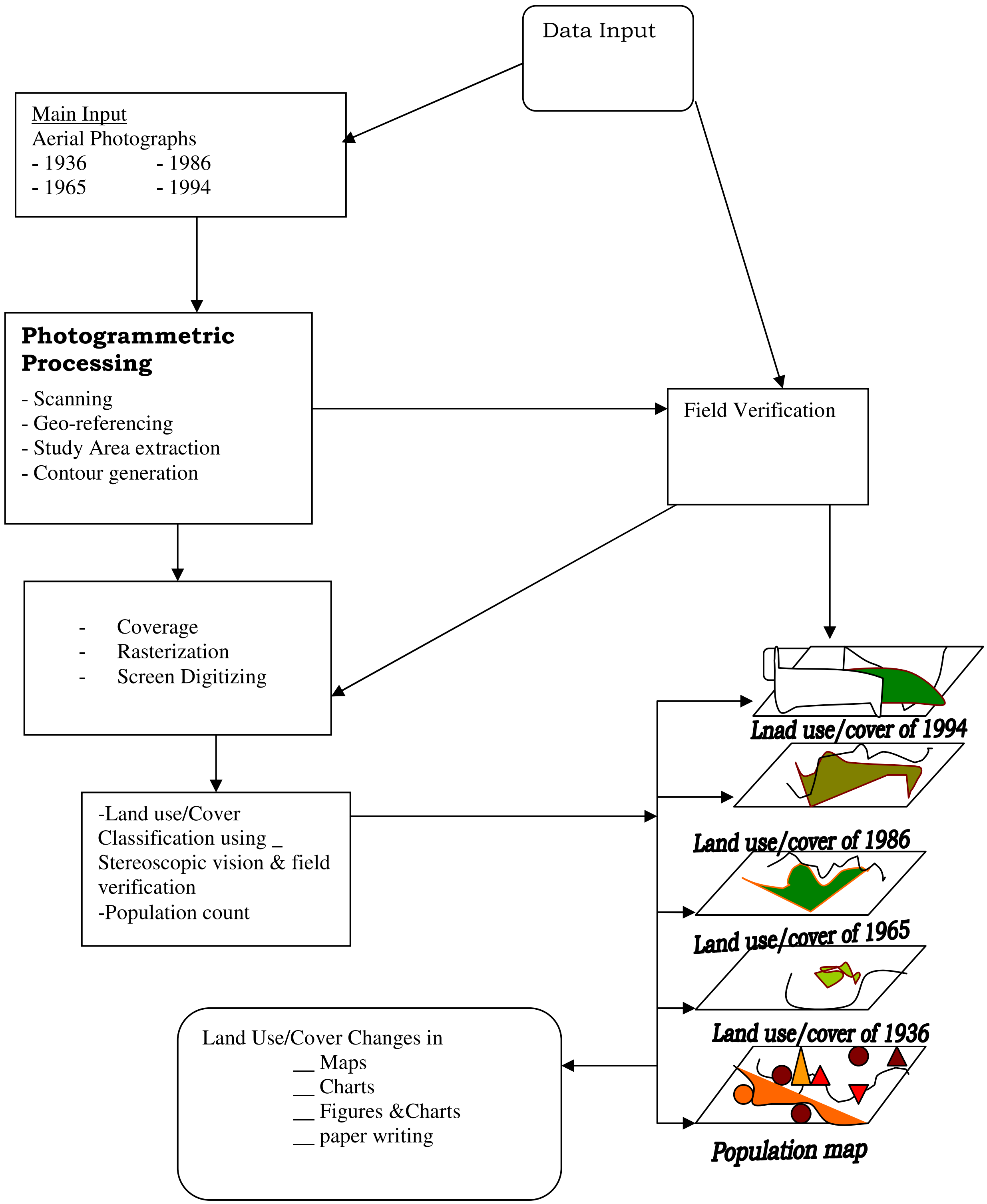
1.4. Significance of the study

Land degradation is one of the major problems that hinder rural development. Deforestation stems from indiscriminate human interference with the natural ecological balance. The rapid population growth coupled with the rising domestic food requirement and the need for fuel and construction wood has been very acute and people have been forced to depend largely on cow dung and crop residues for cooking and heating in the *Wello* high lands.

Improvement in crop production will not last long unless bottom-up watershed management with micro planning at the smallholder farmer level is effected. Therefore, knowledge of the geographic distribution of land degradation feature is crucial for classifying areas according to the severity of degradation and thus identifying priority areas for remedial action.

The information base combined with thematic maps, temporal aerial photographs, and statistical data with field verification offers an essential tool for inventory analysis and assessment of landscape and land cover changes. Direct observation of land cover changes by multi spectral images also allows identification of major processes of change and landscape dynamics. Accurate information on land use, land cover changes and the forces and processes behind is essential for designing a sound environmental planning and management. Land cover analysis using GIS technology at local level provides the base line data required for proper understanding of the past land use, land cover changes and what type of changes are to be expected in the future. Land cover change studies also yield valuable information for analysis of the environmental impacts of human activities, climate change and other forces.

1.5. SEQUENCE OF GIS ACTIVITIES



1.6. Limitations of the study

Of the many limiting factors faced in the data collection processing and management of the study area, the following were the most prevailing.

The quality of aerial photographs of EMA had some problems such as cloud cover particularly the 1986 aerial photos created on obstacle in interpretation and identifying features. In addition to this the surveyed ground coordinates of the photographs by EMA has some errors where contour generation and rectification process in GIS soft wares generate an error. Because of these problems, the land use/land cover map of 1986 was produced with out contour coverage,

The 1965 aerial photographs that covered the whole country do not have camera calibration file in EMA. Due to this problem the photogrammetric workstation software could not accept it for processing.

Another limitation to be stated here is the problems faced in field data collection. Due to the reshuffling of offices in the Amhara Regional state, archival materials relating to land use/ land cover could not be accessed.

Some limiting situations were also created in applying the GIS soft wares in analyzing the data of the study area, such as the capacity of MapInfo which did not enable to identification of the human errors created in screen digitizing of the aerial photographs of each year. This error has brought about an error on the coverage area of each land use land cover, but this problem was with an acceptable limit.

The biggest limitation faced during the study was the insufficient fund supplied by AAU for the research. The graduate school of AAU has provided only 5000Birr each for graduates of this year with out considering the type and cost of each proposal research. Even this 5000Birr grant was released very late and as a result the students could not start their research in time.

1.7 METHODS AND PROCUDERS APPLIED

1.7.1 Land use/land cover dynamics.

The use of medium scale black and white aerial photographs to map land use/land cover has been an accepted practice since the 1940's. Recently small-scale photographs and satellite images have also been utilized for mapping studies. (Kiefer P.W. & Thomas M. L 1994). Based on these sequential aerial photographs that covers the study area of *Boru- Metru* of South *Wello* were obtained from the Ethiopian Mapping Authority (EMA) and used to analyze the changes in land use/land cover, land degradation and population dynamics. The oldest Aerial photograph available was the 1936 Italian photographs (unknown scale), the 1965 and1986 photographs have scales of 1:50 000 while the recent 1994 with 1:10 000. The time interval between these photographs that are 29, 21 and 8 years respectively, are acceptable for change detection analyses of land use/land cover, land degradation and population changes.

1. 7.2 Methodology of data acquisition and analysis

Data on the type and characteristics of the past and present land use, and land cover change are generated from aerial photographs. Field observations, questionnaires, interviews and discussion with the land users are also employed to substantiate the information. Books and other published and unpublished documents are also assessed.

1.7.3 Aerial photograph processing and data extraction Procedures.

This study uses aerial photographs of 1936, 1965, 1986and 1994 applying GIS analysis of land use/land cover change using the recent photogrmmetric and remote sensing soft wares such as Virtuozo ver.31, ARC/Info, Map/Info, Arc/view and ERDAS Imagine 8.3 for the study of *Boru-Metero* watershed of the South *Wello* zone of Amhara Regional State. Even though the aerial photographs of 1936 do not provide vertical over views as the recent once, they are useful to verify the long history of land cover and to compare with the recent land use/land cover of the study area. The aerial photographs were supplemented by field verification with the help of field GPS.

Aerial photographs contain a detailed record of features on the ground at the time of exposure. In order to obtain the desired information from the series of photographs, interpretation should proceed on a systematic way. The pre-photo interpretation phase was done based on interpretation in relation to the study area. Once the overall aim was defined, the level of details and the categories of land use/land cover that needed to be distinguished were determined. Accordingly, interpretation was categorized in terms of the type of land use/land cover. In order to categorize the classes needed, knowledge of local land use practices of the study area was needed to keep the categories simple and providing the desired information. This was supplemented by the past written documents of the region where the study area is found, and the study area itself, such as the land use/land cover classification made by Gete Zeleke and Hans Hurni (2001). This led to the establishment of a preliminary legend for land use/cover classes in the study area. Categories of land use/land cover, which were identified in the study area, are described on the table1 below.

Table1. Description of land use/land cover classes used for analysis of changes between aerial photos of 1936, 1965, 1986 & 1994.

Land use/Land cover classes	**Description**
Cultivated Land	Contiguous areas used for rain fed and irrigated cultivation, including fallow plots, cultivated land mixed with some bushes, trees and rural homesteads but dominated by farmland.
Natural forest	Areas covered by trees forming closed or nearly closed canopies (70-100%); predominant species are *juniperus procera*
Mixed forest plantation	Areas include industrial and peri-urban plantations established and operated by the government/non government agents as well as community wood lots and catchmnet protection plantations mainly exotic trees such as Eucalyptus (*globulus* and *camalduresis*). And indigenous trees such as *Junipers Procero*, mixed with generated trees and bushes mainly *Acacia abyssinica* and Croton species.
Tree Farms	This includes planting of trees around compounds, eucalyptus wood lots and road side tree planting
Wood Lands	Land covered by an open stand of trees taller than 5m and up to 20m height and a canopy over of more than 20%.
Bush and Shrub land	Land covered by an open stand of trees/or-scattered shrubs 2 to 5m tall and canopy cover of more than 20% as well as short shrubs and thorny bushes with little useful woods found along rugged micro-relief.
Grass Land	Areas with permanent grass cover along ridges steep slopes and plain areas used for grazing; usually private as well as communal
Seasonal Swamps	Areas that are very flat and swampy in the rainy season and relatively dry during the dry season. It is used as supplementary grassland, which is a good source of grass for the dry season.
Bare Land	Areas that have little or no vegetation cover, mainly with gullies and exposed rocks. (Barren eroded lands mostly on top of mountains, open areas near homesteads).
Water Body	Areas covered with small lakes, ponds and permanently swampy areas not used for grazing and small streams.

Source: Adopted from Gete and Hurni (2000) and EFAP, (1994).

* Rural settlements are dominated by cultivated land and are included to it.

The photo interpretation phase was proceeded by a selection of representative photo pairs and stereoscopic analysis to describe the land use/land cover units. Each unit was described by the characteristics of aerial photos (tone, texture, shape, pattern and aspect). This was used to establish the preliminary legend for mapping land use/land cover classes based on 1965, 1986 and 1994 photographs. The intention here is to show the severity of the land degradation problem due to human activities and its future trends. The settlement location and expansion in the aerial photographs of each year was indicated separately. In order to support the analyses a very condensed overview of historical background, i.e. the physical and human environment of the high lands throughout the country and north and central highlands and the study area in particular derived from accounts of different scientific documents such as Hurni, H. (1988) Wright C. (1984) Bhan C. and Gruner M. (1988), Belay Tegene (1998, 2000 and 2002), Gete Zeleke (2000), Sebsebe Demissew, Bahru, Dessalegn Rahmato, Crummey, D. (1998), Kebrem Tekle and Hedlund, L. (2000) and Engdawork Assefa 1997 and 2000, Woldeamlak Bewket (2000) were assessed.

1.7.4 Interpretation of Aerial Photographs.

1. The 1986 and 1994 aerial photographs selected for the study were converted in to a transparent media (die-positive) and scanned using VX-4000 scanner in a Tag Image Format (Tiff). The year 1936 and the 1965 aerial photographs, which do not have camera calibration data, were scanned using VIDAR Tru/Info Scanning Solution and stored in Tiff format. The photographs were adjusted to similar scales of 1:12500.

2.The digital aerial photographs of each year were geo-referenced in to a map coordinate system using the Universal Transverse Marketer (UTM) geographic projection using control points. The 1936 and 1965 digital aerial photographs were geo-referenced using ERDAS Imagine8.2/8.3. The 1986 aerial photos were rectified based on the survey data of EMA, while the 1994 aerial photos were geo-referenced to UTM coordinates based on the interpolation coordinates collected from 1:50 000 topographic map of the study area. Then the VIRTUOZO software is used for removing all the errors in the aerial photographs and geo-referencing the images to UTM projection. Editing of the original image files was enhanced through sharpening with Adobe Photoshop Ver.5.0.

3.Contour coverage was generated for the study area at contour interval of 20m from the 1994 aerial photograph using the VIRTUOZO software. The input images of the study area at a scale of 1:12500 were printed using Design Jet 2500 plotter with 600 dpi in order to evaluate their qualities and extract the location of the study area. The last out put was then stored in a soft copy in order to use for the intended processes using different soft wares.

4.In order to extract the study area and fix the area of interest (AOI) for all years the digital photographs of each year were transferred from Tiff into image format using ERDAS IMAGINE 8.2/8.3 soft ware. Since the digital photo formats were changed into image and each image had to be rectified and referenced into UTM coordinates done because the coordinates were discarded when the image was imported from Tiff format to image format.

After the study area was delineated, the images were again transferred back in to Tiff format because Map/Info needs such format of image in order to process and extract the needed information. Using the 1936, 1965, 1986 and 1994 digital image of photographs screen digitizing was done for the land use/land cover features as polygon coverage in a vector format using Map/info professional 4.1.

The identification and classification of land use/land cover types from the aerial photos requires intensive use of mirror stereoscope for visual verification, because the photographs were black and white. The visual interpretation of various features on the characteristics of aerial photographs i.e. tone, texture, shape, pattern and aspect as well as location of the features was done with the support of field verification of each land use land cover features (Table1). As stated above the data input for land use/land cover was done by screen digitizing using Map/Info soft ware which has a capability of vector and raster processing. Based on the LABEL file columns in the PAT (Polygon Attribute Table) of Map/Info automatically creates ITEMS containing the internal record number, the perimeter, and surface area for each polygon, i.e. the land use/land cover features. In order to prepare an output map, theses classified coverage features were transferred in to Thematic Map module of Map/Info as coverage map. Based on the map composer module grid, legend of each features with their colors of the respective years, area of each class and percentage share, scale, all texts, etc. was incorporated and printed using Design Jet 2500 plotter with 600 dpi.

The out put maps are: Land use/land cover and distribution of rural household maps for the whole study area to the years of 1965, 1986 and 1994 and sample area of 1936. Population growth in the study area within the timeframe was interpreted entirely from aerial photographs. Assessment of population change was done based on a household count from the aerial photos of 1965, 1986, and 1994 as well as the sample aerial photos of 1936. Household numbers were then converted to population data by multiplying by five (on average age of the household). The 1994 aerial photos data was been compared with the census result of CSA, (1995). Household count from aerial photos was done with the help of analogue instruments, such as Procom-2 having a capability of enlarging films up to 23 times as well as pocket stereoscope. Households were identified and counted taking in to consideration of hamlets positions, shape, fences, etc. as well as the interview result of the informants. The counting method of household from aerial photos was done for two reasons: First the study area does not correspond with administrative boundaries that cannot use the CSA population data. Second, there were no census data available to the specific years of investigation. Based on the distribution of farming households maps were prepared for each year.

1.7.5 Ground Truth and data collection

Field verification is an important stage in land use/land cover studies. Even if the time gap between the field survey of the study and the aerial photographs does not match, the recent aerial photo of 1994 was used for fieldwork based on the printed map at scale 1:12500 from it. It is hardly possible to extract the necessary information from aerial photographs, maps and satellite images without being assisted by ground information. Sufficient field assessment and data collection were conducted in the study area using as a base geometrically corrected aerial photographs and printed maps. Global Positioning System (GPS 45) instrument with 10m accuracy, auger for soil depth, clinometers for slope measurement, field camera, compass and other necessary tools were used for identifying and locating features needed. Land use land cover features, and human activates of each sample studies were described in detail. In addition to this, important features were photographed using field camera in order to supplement the maps to be produced. The field observation was supported by the interviews held at random households (65) as well as with selected elders in the community. Additionally senior professionals who have had long-term experience in the area as well as local administrators and environmentalists who made studies on land use/land cover of the region in general and the sturdy area in particular were interviewed.

Relevant information was also collected from different governmental and non-governmental offices in the study area. Interviews were done with local administrators, Peasant Association officials.

Chapter Two

2. LITERATURE REVIEW

2.1 Land use /Land cover and land degradation in the North central high lands of Ethiopia.

Although land use and land cover are often used interchangeably they are quite distinct. Land cover refers to the different features covering the earths surface, such as water, forest, other vegetation, bare rock or sand, man made structure, etc. Land cover can be directly observed on aerial photographs and often on satellite imageries. Land use, on the other hand, relates to the human activities or economic function associated with a specific piece of land. (Kiefer R.W and Thomas M.L 1994). Land use features are difficult to observe directly from aerial photographs, it can only be confirmed by detailed field observation.

Land degradation caused by deforestation has become a global concern, with dramatic implications for human livelihood systems. Land cover analysis has also become important in providing the base line data required for proper understanding of how land was used in the past and what types of changes are to be expected in the future.

Deforestation which is the total conversion of forest land cover to other uses in which no forest remains is due to the clearance of 7.5 million ha of closed forests and 3.5 million ha of open tropical forests each year world wide. (UNFAO cited on Buchholz R. A. 1993). As Buchholz stated, the fundamental causes of deforestation are poverty, over population, insecure land tenure, misguided the past government policies, inequitable distribution of land and wealth and the need to put land in to more intensive use. More proximate causes are said to be agriculture, cattle grazing, encroachment, etc. Clearing forestland for crop cultivation is the most important cause of deforestation and reliance of the rural poor on wood as a source of energy is the second most important cause of deforestation causing land degradation.

The 1500 m contour line that is generally accepted to divide Ethiopia in to highland and lowland was chronically affected in deforestation and land degradation problems. The highlands have a rugged topography dissected by deep gorges with slopes ranging from very steep to almost flat land. In a substantial portion of the high lands, (60% of the total area), the general slope is greater than 16%. (Table.2)

The high lands covering nearly 44% of the total area are characterized by favorable climate condition and provide an excellent human habitat (Hurni et al 1988a). These highlands have been settled for millennia and agriculture, which is until today exploitative, has a matching history. The highlands are the most significant areas in economic terms as they support over 80% of the country's population and 75% of the livestock populations and generate more than 90% of an agricultural out put. (FAO 1986 citied on (Woldeamlak Bewket (2002) and Solomon Abate (1994), quoted from Tagoe 1983). The high concentration of population, coupled with many other physical, socio-economic and political factors, has led to serious degradation to the highlands.

Table.2. Generalized Slope Classes in the Ethiopian high lands.

Slope Class (%)	Area (km2)	% Total
0 – 8	113,500	21
8 – 16	102,500	19
16 - 30	144,500	27
>30	175,500	33
Total	536,000	100

Source: - Cloutier 1984 as cited on (Solomon Abate 1994).

Due to this fact, the Ethiopian high lands presently constitute one of the most degraded lands in Africa. Estimates by the Ethiopian Highland Reclamation Study (EHRS) show that, around 52% of the area in the high lands is affected by various degrees of land degradation. (Wright C 1984).

The study further warns that if the process of soil degradation is allowed to continue at the present rate, one third to one-half of the total area of the Ethiopian high lands will be completely unsuitable for crop production at some point within the next two decades. Various studies also show that soil erosion which is the major cause of soil degradation in the Ethiopian high lands is initiated and aggravated in particular by deforestation, over cultivation, overgrazing, over population as well as rural development policies. (Solomon Abate 1994).

In terms of agro ecological zoning, the MOA (1984) has classified the highland areas in to three zones: 1) The High Potential Crop Zone (HPP), 2) the High Potential Cereal crop Zone (HPC), and 3) the Low Potential Cereal Crop Zone (LPC). The distinguishing factors include severity of ecological degradation, vulnerability to soil erosion, soil fertility, amount of average annual rainfall, availability of major natural vegetation, and length of growing period. The HPP areas are mostly located in the South and Southern parts of the Country. The HPC areas are mostly located in the central and western parts of the country. Most of the northern high lands including the area selected for this study fall under the category of LPC. The areas classified under the LPC zone are known not only for their low potentiality but also for their vulnerability to degradation. (Markos Ezra 1997).

As many researchers point out, the shortage of cropland has pushed people into clearing the vegetation and exposed the cropland on to ever-steeper slopes in the northern highlands. Once the land is devoid of its vegetation cover, soil erosion becomes rampant, a process in tern accentuated by the rugged topography. Due to the shortage of land, croplands are also continuously utilized year after year, thus, leading to fertility depletion and giving diminishing yield. Animal manure and even crop residues and stables are used for fuel instead of soil fertilizers due to fire wood shortages, thus depriving farmlands of the badly needed nutrients and organic matter. According to (UNECA (1996) cited on ILRI 2000) almost all households (90%) fed crop residues to their livestock and only 40% is used manure to their farm lands in the highlands of Ethiopia. The depletion of organic matter causes the soil to retain less and less water and become more and more prone to drought, even with the best of rains, the productivity of the land decreases from time to time.

Centuries of exploitation, degradation and neglect have not only enormously reduced the productive capacity of the northern Ethiopian highlands, but have also diminished the ability of the land to withstand climatic inconstancy. A slight decline in rainfall becomes a period of famine. A slight increase in rainfall over and above the usual amount results in severe flooding and hundreds of thousands of tons of fertile topsoil that took thousands of years to build, are easily eroded and carried away by runoff. (Markos Ezra 1997)

2.2 Human Induced Land use / Land cover changes and Land degradation in the north central high lands with particular reference to *Wello* region.

In the North-central highlands, where the study area is located, various factors, such as population growth, frequent land tenure and economic policy changes, and unstable institutional set-up, are considered to be the major driving forces for the observed land use and land cover changes and the expansion of cultivated land towards marginal areas. (Gete, Zeleke 2000).

Population pressure refers not only to the unbalanced growth of population and food production but also to the stress caused by growing population on resources. Population pressure is one of the most frequently cited factors of land degradation since T.R. Malthus drew attention to it. The basic tenet of the Malthusian theory was the thesis that population tends to grow at a geometric rate, while food supply tend to grow only at an arithmetic rate largely because of the fixity of land. (Belay Tegene 1995).

Positive and preventive checks to curb population growth and balance population with resources were the conclusion reached by Malthus. Neo-Malthusians repeat the scarcity of resources in the face of population expansion and extend the argument to other resources such as fossil fuels. The recent developments such as fast population growth, increased pollution, depletion of the protective ozone layer, and increased environmental problems may suggest that limits may be possible such a view enjoys current acceptance by organizations and individuals. (Lowe and Bowlby 1992 as cited in Tegegne Gebregzeabher 1995). Organizations such as the United Nations Population Found (UNEPA), the World Commission for Environment and Development (WCED), the World Watch Institute hold a Neo-Malthusian view and argue that, one fundamental reason for the damage done to earth in the form of deforestation, pollution, plant and animal destruction is the rapid population growth and deducing the number of people will curtail the damage done to the planet.

Human activities significantly alter the place and pattern of erosion. The United Nations Environmental Programme (UNEP) estimates that as a result of human activities world- wide, some 10930 million km^2 of land have been seriously damaged by water erosion, 9.2 million km^2 by sheet and surface erosion and 1.37 million km^2 by the development of rills and gullies. The main causes are clearance of natural vegetation and forest (43%), overgrazing (29%); poor farming practices such as cultivation of steep slopes (24%) and over exploitation of natural vegetation (4%). Park C. (1997).

On the contrary Boserup (1965, 1981, 1990) noted on her thesis a positive correlation between population density and land productivity, because high population density creates demand for agricultural products and agricultural land leading to smaller holdings and labor-intensive cultivation. Certainly where population growth is accompanied by simultaneous rapid economic development, agricultural intensification, development of resource conservation, culture and improvement in resource management productivity of land is improved and population may not exceed the carrying capacity and may not cause severe pressure on resources. To Boserup population pressure determines agricultural intensity that is expressed in terms of decreased percentage of fallow land increased percentage of land under irrigation, increased multiple cropping, etc. She emphasized agricultural intensification, as a principal means of increasing agricultural output. Population pressure is a key factor that forces a shift from extensive to intensive systems of cultivation. Her thesis also emphasizes the positive effects of population growth on land use and it rests on the assumption that the problem of population pressure gives rise to its own solutions. (Lele and Stone 1989 cited in Tegegne Gebregzabher 1995).

Agricultural intensification heavily which is depends on four major technologies: mechanization, irrigation fertilization and the chemical control of weeds and insects has very adverse effects on the environment and hence in many cases improvement in productivity is attained at the expense of the environmental quality. As observed in many cases "… short term improvement in productivity can create different forms of ecological stress, such as the loss of genetic diversity in standing crops, salinization and alkalization on irrigated lands, nitrate pollution of ground water and pesticide residues in food". (WCED 1987 cited in Belay Tegene 1995).

In more general terms, the Malthusian view of 1798 and 1803, republished 1960 had been a benchmark for much of the popular discourse on population-environment relations.

A study made by the UN_DESIPA (Population and the Environment in Developing Countries 1994), concluded that perspective in the theoretical and conceptual frameworks of current researchers addressing population-environment relationships are various but they can be grouped in to three distinctive categories.

- the Malthusian and Boserupian perspective: which imply the direct relationships between population and environment or between population, technological change and environment. The Malthusian view point as stated above has had a direct influence in the ability of land to produce food is limited and exceeding those limits will in the long run result in degradation and declining productivity. Boserupian has also had an influence on current research, which examines the relationship between population, agricultural intensification and environmental impacts.

- the multiplicative perspective: which represents the view that population (size, growth and distribution) interacts in a multiplicative way with other factors, such as levels of consumption and technology to have used multipliers approaches, is the "I=PAT" equation. Total environmental impacts (I) are seen as a product of population size (P), the level of affluence or per capita consumption (A) and the level of technology (T).

· the mediating perspective: those of which emphasize that social, cultural and institutional factors play a mediating role in determining population-environment relationships. The influence of these factors on population-environmental relationships is viewed as multi-level, so that layers of mediating variables at the household, community, national and international levels must be considered.

Based on these views the study argues that land use/land cover change and land degradation in the northeastern high lands where the study area includes have been at jeopardy for many years. Land fragmentation has an acute problem where households cannot produce enough food in all areas of the northeastern high lands as indicated by numerous studies done on these areas. In this case the study should follow the Malthusian perspective.

On the other hand, the nature of demographic processes in the study area may influence by socio-economic institutional factors. Government and non-governmental institutions are seen played a positive role in mediating the catastrophic effects of drought and food shortage. Government policies are also influencing technology through which the relationship between population pressure and land degradation is mediated or neglected. The problem of drought, famine and environmental deterioration cannot be separated from socio-economic and political organization of society. Famine can occur even when sufficient food is available. For example, the 1972-1974 where the famine was quite devastating, people where dying of starvation even when food was selling at prices not very different from pre-drought times. Therefore, people not perish if governments take adequate measures ahead of time to cope with the consequences of drought. Wijkman and Timberlake, (1984:49). In this case the study should follow the mediating perspective.

Whatever different theories exit on the population growth and resource degradation, the reality exist in Ethiopia is that, very low technological input, absence of agricultural intensification, and poor land husbandry have ruled out the possibility of increasing the carrying capacity and averting the productivity loss on the already cultivated land. The increasing population can only be accommodated by expanding the cultivated land in to marginal and fragile environments at very high cost of degradation.

Due to this fact, environmental and natural resource degradation induced by population pressure has assumed disaster dimensions in the study area. The boundaries of agricultural and pastoral lands are progressively retreating in the face of expanding deserts. Once fertile lands are turning barren under the impact of worsening erosion, in the Ethiopian high lands. As forest areas are invaded by land hungry and energy needs, large as well as small interests, they are being stripped of their canopy and diverse biomass and genetic resources. In relation to this, Dedjazmatch Zewde G/Sellassie, 2000 stated on his paper pointed out follows:

> *…the Egyptian gathered rich harvests from the alluvial soil brought down by the Nile to transform fields as the river denuded, devastated and eventually changed the face of the once fertile plateau of northern Ethiopia into uninhabitable craggy hills and valleys which now resemble more like lunar landscape rather than earthly topographic formations.*

Today Ethiopia, especially its northern & central high lands face a variety of complex problems ranging from the climatic and topographic constraints that are beyond any body's control to the alarming trends in population growth and rapid ecological degradation. Current trends in population growth, land resource utilization and environmental degradation indicate very serious problems in the near future. (Markos Ezra 1997).

As Markos reported, since the early 1970's drought and famine have become recurrent in the country as many environmental studies indicate in the north and central high lands where *Wello* region is the most vulnerable. It may vary in the degree of its severity, but there was no single year where there was no drought or food shortage in the last tow decades. The general argument regarding the Ethiopian drought and food deficit is that, population pressure is impeding agricultural development and facilitating ecological degradation. Too much dependence on land and forest resources for survival is causing the rapid ecological degradation, but it needs micro level studies to investigate how people interact with land respond to such problems, which is basically one of the objectives of this paper.

For the rural people of Ethiopia, environmental and natural resource degradation directly translates in to a worsening of their means of subsistence. Their supply of energy resources, since natural resources degradation means decreasing crop production, reduced number of animal holdings, reduction of biomass at their disposal and these brought reduced caloric intake. The demand of energy also rises since degradation forces farmers to adopt more labor-intensive methods of crop production by traveling longer distances in to sources of water and fuel wood and grazing lands. These all are the feature of the northern high lands where the *Wello* region is found. The rugged terrain, erratic and torrential rain fall and the rising human and animal population pressure on the land collide to produce accelerated erosion that is depriving Ethiopia of an estimated 2 to 3.5 billion tons of top soil per annum (Yeraswork Admasse 2000 cited from Campell: 1991:5 and Hassison 1987:125)

The major force behind the changes in the rural areas comes from the rapid population growth, which approaches a rate of 3% per annum. This increment demanded food crops but also traditional fuels, animal feed and construction material that were highly scarce in the northern and central high lands. The key elderly informants of *Wello* region have the opinion that vegetation in their respective areas has been under threat for the last 30-50 years and many of the existing remnants will disappear unless measures are taken to stop the trend. They also believed that the major factors that aggravate the rapid destruction of the remaining vegetation are the expansion of agricultural fields, the cutting of trees to make charcoal and fire wood. (Sebsebe Demissew 1998).

In relation to land degradation the present vice-minister of MOA Gebremedhin Belay confirmed on the interview of Ethiopian Herald as follows:

From various forms of environmental degradation known, land degradation due to soil erosion constitutes the major environmental degradation in Ethiopia; threatening the overall agricultural economy and the very survival of the population today. Even though, an estimated some 5 million ha of degraded land has been treated with various soil and water conservation activities across the country in the specified period, environmental degradation is not arrested to the extent desired primarily due to the fact that exploitation of the natural resources is increasing as a result of population increase. The Ethiopian Herald (2003).

Based on theses facts the study has tried to show land use/land cover changes and investigating the possible causes and implications on land use and land cover changes, land degradation and population growth in the years of 1936, 1965, 1986 and 1994 aerial photographs available in EMA. Change in different landscape of vegetation cover, trends of expansion of cultivated land, and associated results were assessed. The study gives special emphasis to population dynamics as the assumed major causes of land use land cover changes in the area. It also gives a brief account of the current status and future trends of land degradation as one of the major results of unsystematic agricultural practices and vegetation cover changes.

2.3 The nature and magnitude of land use/Land cover changes and land degradation of the North-central highlands with particular reference to the *Wello* region.

The Vegetation cover of Ethiopia showed a wide variation caused by varied topography and the unevenly distributed rainfall changes in climate and the population pressure has increasingly influenced it. The result has been not a gradually but rapidly changing which above all in the northern part has totally altered in composition. Clearing of vegetation is driven by the demand for cropping and grazing land. In as much as access to such resources in commonly perceived as 'open' people find little reason to obtain from consuming woody biomass and changing the use of the land. (EEAP 1994). Therefore, degradation induced by deforestation involves both soil erosion and loss of soil fertility where the central and northern highlands were the most vulnerable. It has been estimated that in the 1986 half of the arable land of the highlands was moderately or seriously eroded and the remaining 50% had soils susceptible to erosion. Due to soil erosion the Ethiopian high lands loose annually a total of 1.9 to 3.5 billion tons of soil.

According to the estimates by the Ethiopian Highland Reclamation Study EHRS, (Wright 1984) 28% of the high lands are affected by very severe and accelerated erosion.

Fig.1: Severity of soil degradation caused by soil erosion in the Ethiopian Highlands

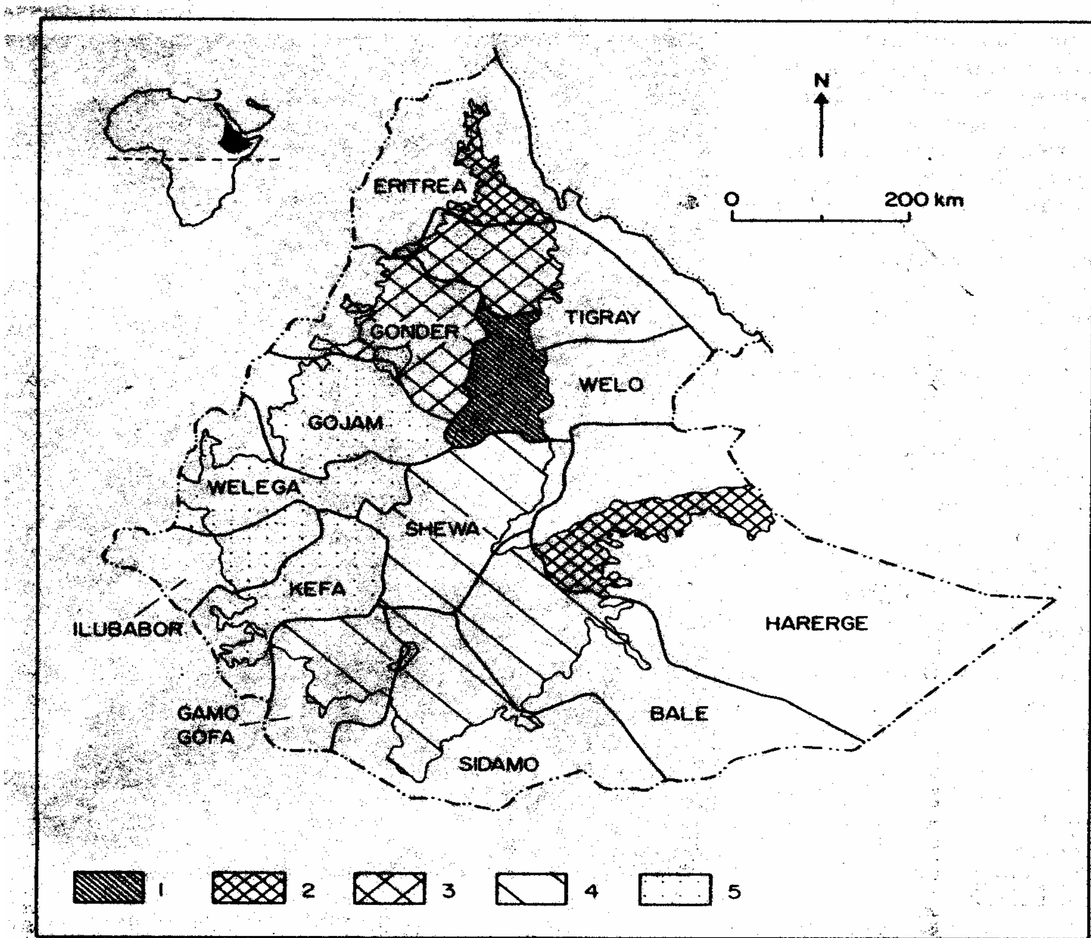


FIGURE 2. **Severity of soil erosion in the Ethiopian highlands.**
Key
1: extreme (over 80% of the soils are about 20 cm deep only, and the rest about 100 cm);
2: very serious (60–80%);
3: high (40–60%);
4: medium (20–40%);
5: slight (less than 20%).

Source: (Hruni H 1988b), generalized from Berber (1984) based on Henricksen(1983

The map on (fig1) shows both the severity and the distribution of soil degradation that has resulted from erosion in the Ethiopian high lands. Most affected are the northern and central regions of the high lands especially estimates indicate that around 60% of the most severe erosion damage occurs in these regions and the extreme over 80% of the soils which are only about 20cm deep are shown in *Wello* where the study area is located.

Accelerated deforestation has been taking place since the beginning of the 20th century. Historical sources indicate, based on the potential climatic climax vegetation about 42 million ha or the equivalent of some 35% of Ethiopia's land area might once have been covered by natural high forests (EFAP 1994). Between 1955 and 1979 Ethiopia lost 77% of the forested area it had in 1955. (Reusing M 1998 quoted from MOA, 1982).

During the last hundreds of years, the transformation of natural high forests to cultivated land was most severe in the northern and northeastern part of Ethiopia where population has been concentrated for many centuries. It was only in the south and south west of the country where many forest blocks still remained. As indicated on table3 there is no natural forest recorded in 1973 to 1990 in the northern Ethiopian administrative regions.

Table 3. Relative Forest Cover within Administrative Regions of

Ethiopia in the time periods of 1973_1976, 1986_1990

Region	Area Km²	Year	Closed HF (%)	Slightly Disturbed HF (%)	Heavily Disturbed HF (%)	Total HF (%)
Afar	82489	1973-76	0.0	0.0	0.0	0.0
		1986-90	0.0	0.0	0.0	0.0
Tigray	58580	1973-76	0.0	0.0	0.0	0.0
		1986-90	0.0	0.0	0.0	0.0
Amhara	161583	1973-76	0.2	0.3	0.0	0.5
		1986-90	0.0	0.0	0.0	0.0

Source: Reusing M (compiled) 1998, NRM and RD of MOA in Cooperation With GTZ.

The recent calculated annual deforestation rate 163,600ha corresponds to the figures, which are published in EFAP (1994) rating a yearly loss between 150,000 and 200,000 ha. This trend of deforestation shows that, there will be no considerable areas of natural high forest being left in the early decades of the coming millennium. Therefore, the massive removal of vegetative cover is the driving force behind land degradation.

2.4 The Consequences of Land use/ Land cover changes and land degradation in the North-central high lands with particular reference to *Wello* region.

It is well known that land degradation is widespread and serious in the high lands of Ethiopia. But until the Ethiopian High Land Reclamation Study (1994) was conducted, there were only general and usually qualitative estimates of its extent, severity and geographic distribution. The (EHRS) maintains that, the increasing high land population over the country has resulted in more and more soil erosion as a result of bringing areas with steep slopes under cultivation. Land is being progressively deprived of the organic matter essential for replenishing its fertility and farmers have no other choice but to grudgingly scrap from their fields all the dung and crop residuals as they have no other way of meeting their house hold fuel needs. In *Wello*, as in many other parts of the country, it is customary to burn animal dung when wood is scarce. Recent reports show that, throughout the country, the burning of dung for fuel rather than using it to regain soil fertility results in reduction of grain production by about 550, 000 tons annually. (Markos Ezra 1997).

The most important source of energy in most of the Ethiopian population is traditional biomass fuels such as wood, dung, crop residue and charcoal. As indicated on table 4, in 1990/91 modern fuels such as petroleum products and electric city accounted for a mere 5% of overall energy consumption in Ethiopia, This extraordinary dependence on biomass fuels had persisted over the last twenty years. (EFAP 1994).

Table 4.Estimate of household energy consumption by source in Ethiopia, 1992

Source of energy	Urban		Rural	
	1992 (%)	1014 (%)	1992 (%)	1014 (%)
Wood and charcoal	62	42	66	68
Dung	16	8	20	13
Crop residue	11	5	14	7
Electricity	3	15	-	5
Kerosene, gas	8	20	-	2
Coal	-	10	-	5
	100	100	100	100

Source: Mission estimate of EFAP 1994.

Due to serious land degradation induced by human and climatic factors, the subsistence farmers of the central and northern high lands of Ethiopia have less than 0.5 ha per household for crop production. The size of grazing land (ha/animal) is also very limited especially when considering the carrying capacity of the grazing land. Mohamed Hagos, (2000.)

In addition to these, land had to be divided and re-divided from generation to another and about one-half of the holdings were below 0.5ha, which is far too small to maintain a peasant household. This is a fact approved by the recent study in North *Wello* where several rounds of redistribution where the standard plot size was reduced and marginal lands are converted in to croplands. Due to the uniform rules of land distribution and the entire population is engaged in farming, there is a strong correlation between number of holdings and population size in North *Wello Weredas*. And the study concludes that the farm size distribution is a reflection of both the relative scarcity of land and the family size distribution. MOWR, (2001).

Large-scale destruction of forest resources is not the only change that has taken place at the national level. Major land cover changes have also occurred at the local level for all land types. For instance, a significant increase in cultivated land at the expense of forestland was found to have occurred between 1957 and 1995 in the *Dembecha* area, northwestern Ethiopia. (Gete Zeleke 2000). On a related study an increase of open areas and settlements at the expense of shrub lands and forests between 1958 and 1986 in the *Kalu* area of South *Wello* on the north central Ethiopia. (Kebrom et al, 2000). Between 1957 and 1986, the area under shrub land declined by 58% while those under shrub-grassland and grassland registered a net gain of 29.82 and 190.98%, in the *Derekolli* catchment area of South *Wello*. Belay, 2002). Deforestation is very high in *Wello* region, which has resulted in the decline of natural vegetation from 16% to 4% between 1954 and 1975 Sebsibe Demissew(1998:189). This resulted, that the *Wello* high lands is one of the most seriously affected area in the northern part, and as a result about 70- 2% (5 817,600 ha) of its highlands are covered by very hallow soils which are less than 25cm depth, (Hurni H 1988:125).

The overall picture is of the development of shallow soils on slopes of the highlands and an increase in the total area of the highlands covered by shallow soils (less than 35cm) is nearly 63% of the total area of the four administrative regions (*Tigray, Wello, Gondar* and at that time Eritrea). (Hurni H, 1985 cited on Daniel Gamachu 1988).

Out of these regions close to 90% area above 1500m a.s.l of *Wello* is less than 35cm of soil depth. (Table 5).

Table 5. - Shallow soils (less than 35cm), areas above 1500m a.s.l

Region	Area	Shallow soils (less than 35cm)	
	Km^2	% in the region	% in Ethiopia
Tigray	20660	58.2	11.8
Wello	29210	89.6	16.7
Gondar	22200	44.4	12.7

Source: Hurni H 1985, cited in Daniel 1988.

In general human and livestock population increase, the expansion of agricultural land becomes impossible with out fragile marginal lands become under cultivation. Available agricultural land per human or livestock population declines. Land use has become more intensive and fallowing becomes more rare or absent. The basic natural resources: soil, wood and grass are exploited beyond their capacity to generate themselves. Land becomes degraded through clearing, overgrazing and soil erosion. With little or no modern inputs in agriculture, crop yields decline and living standards fall. (Daniel Gemachu 1988). With no alternatives in rural areas and little or no cash savings, credit services or stocked grain, the rural population can give way to hunger and famine as it is already observed in most parts of the Ethiopian highlands, where more than 10 million people starved in the 2002/2003.

In the recent past, high population growth with out change in the traditional land use practices, coupled with the recurrent drought in many parts of the highlands have lead to serious land degradation, low productivity and the accompanying human misery. Steep slopes and marginal lands such as water logged plateaux and basins were brought under cultivation; and vast areas of forest and woodland were cleared. Therefore, wood becomes a scarce resource particularly in the north-central highlands of Ethiopia.

2.5 The Role of Aerial Photographs and Geographic Information systems (GIS) in the Analysis of Land use Land cover changes

For the understanding and management of land resources, the availability of information on them is a vital factor. The development of science and technology in the 20th century demand forever-greater volumes of geographic data that can be used for quickly and more accurately analyses, and presenting in map form. Similarly, with the technological (electronics) development on aerial photography and satellite based remote sensing, there has been an explosion of geographic data production for natural resources management.

Geographic data have traditionally been presented in the form of a map. They were represented as points, lines and areas drawn on a piece of paper or film. They were coded using symbols, textures, and colors that were explained in the map legend or accompanying text. Aronoff S. (1995)

Since the 1970's the problem of managing large amount of data has been overcome by the use of computer and has led to the development of Geographical Information systems 'GIS'. Mitchell C. (1991). The computer-based GIS were developed to provide the power of analyzing large volume of geographic data. It has the capability to handle collect, encode manage, manipulate and analysis data as well as to present out puts. (Aronoff 1991). An environmental scientist can normally mentally integrated field data, maps, and aerial imagery, however, with more data sets, it becomes increasingly confused unless applying GIS. To this effect GIS system needs sophisticated equipments, otherwise large amounts of data such as detections of land degradation using temporal and historical data cannot readily be managed or understood.

The power of GIS also goes to combining and analyzing of different layers that might be used to solve a particular problem. As problems change, the data can be processed in different ways to address different issues in a highly flexible way. Although the ability to handle spatial information in the form of maps is important, GIS can also handle non spatial attribute information and enable to store in data base system to use easily for analysis and to present as map form. GIS provides new and exciting tools to extend the art and science of cartography. Map displays can be integrated with reports, three-dimensional views, photographic images, degraded landscapes, land use land cover change variations and other outputs.

One way of understanding what a GIS can do is to explain by its capacity to handle many layers geo-information. Each layer describes a different aspect of its geography. For example one layer might hold data on geology, second layer on soils third layer might include data on land use and land cover in the area, land degradations with socio-economic characteristics of the human population that is the objective of the study. The study therefore, applies GIS based analysis in order to apply different layers such as rainfall, topography, vegetation cover, cultural sites & population data obtained from aerial photographs of 1936, 1965, 1986 and 1994.

Some studies relating to land cover changes in *Wello* have been carried out on aerial photographs and satellite images. Works, such as those of Halvor Wiøn (1995), Gete Zeleke (2000), Crummey D (1998), Kibrom Tekle and Hedlund L (2000) and Belay (2002) applied black and white aerial Photographs acquired since 1957. For instance, the study by Kibrom and Hedlund(2000) using the 1957 and 1986 aerial photographs assessed changes in nine land cover categories in an area of 110km^2 in the *Kalu* district of southern *Wello*.

The recent study by Belay (2002), carried out using image analysis and GIS techniques in conjunction with data collected through field verification, attempts to quantify land cover changes that took place in a smaller watershed of south *Wello*. Unlike (Kibrom et al 2000) the work of Belay (2002) is an outcome of a detailed (large scale) analysis of land cover changes in rather small river catchments. The study used the recent microcomputer based image analysis and GIS techniques in extraction and analysis of the land-cover data from the 1957 and 1982 aerial photographs as well as Land sat TM image of 2000.

According to the study of Belay Tegene (2002), up to eight major land cover types were identified on the 1957 and 1986 photographs and Land sat TM image.

The study of land use/land cover changes requires a repeatable survey that economical, accurate and consistent with the objectives and scale of the study. Remote sensing data within GIS offers an alternative approach to the conventional methods of field survey and can provide an effective means of establishing the rate and extent of land use and land cover changes. The use of panchromatic, medium scale photography to map land use/land cover has been an accepted practice since 1940's and has proven to be a sufficiently accurate and rapid method of assessing land use/land cover changes. (Zobeiry M 1985, Virgo and Subba 1994, Ihsem 1995 cited on Al-Bakri J T, J C Taylor and T R Brewer 2001).

Application of aerial photograph interpretation is useful to tree species identification, timber cruising and forest damage assessment. Additional applications include forest land appraisal, timber harvest planning, monitoring logging and reforestation planning, assessing applications of herbicides, monitoring fertilizer in forest stands, assessing potential slope failures and soil erosion, planning forest roads, inventorying forest recreation resources, etc. The use of air photos and conventional ground methods of observations and measurement are typically closed intertwined. Population estimates can be indirectly obtained through aerial photo interpretation. Medium to large-scale aerial photographs are used to estimate the number of dwelling units of each housing type in area (single family, two-family, multiple family) and then multiply the number of dwelling units by the average family size per dwelling unit for each household. (Kiefer et al1994).

Based on this method the population of the study area was estimated from the respective years of aerial photographs, (1936, 1965,1986 and 1994).

With the help of the elements of photo interpretation (shape, size, pattern, tone, texture, shadows, site and association) topography, drainage pattern and texture, erosion, vegetation and land use and land cover can also determine the boundaries between them.

Within the last decades, computer technology has changed rapidly and has generally become more accessible also in developing countries. During this time specific applications associated with natural resource management have been developed. GIS and image processing of remote sensing data are applied to perform change detection analysis at regional and local level to estimate deforestations. Based on these, the study applies GIS technology using repeated aerial photographs of 1936, 1965, 1986 and 1994 which play a major role in setting up inventories of natural resources and socio-economic activities, that gave a visual assessment of land cover changes over a period of time.

CHAPTER THREE

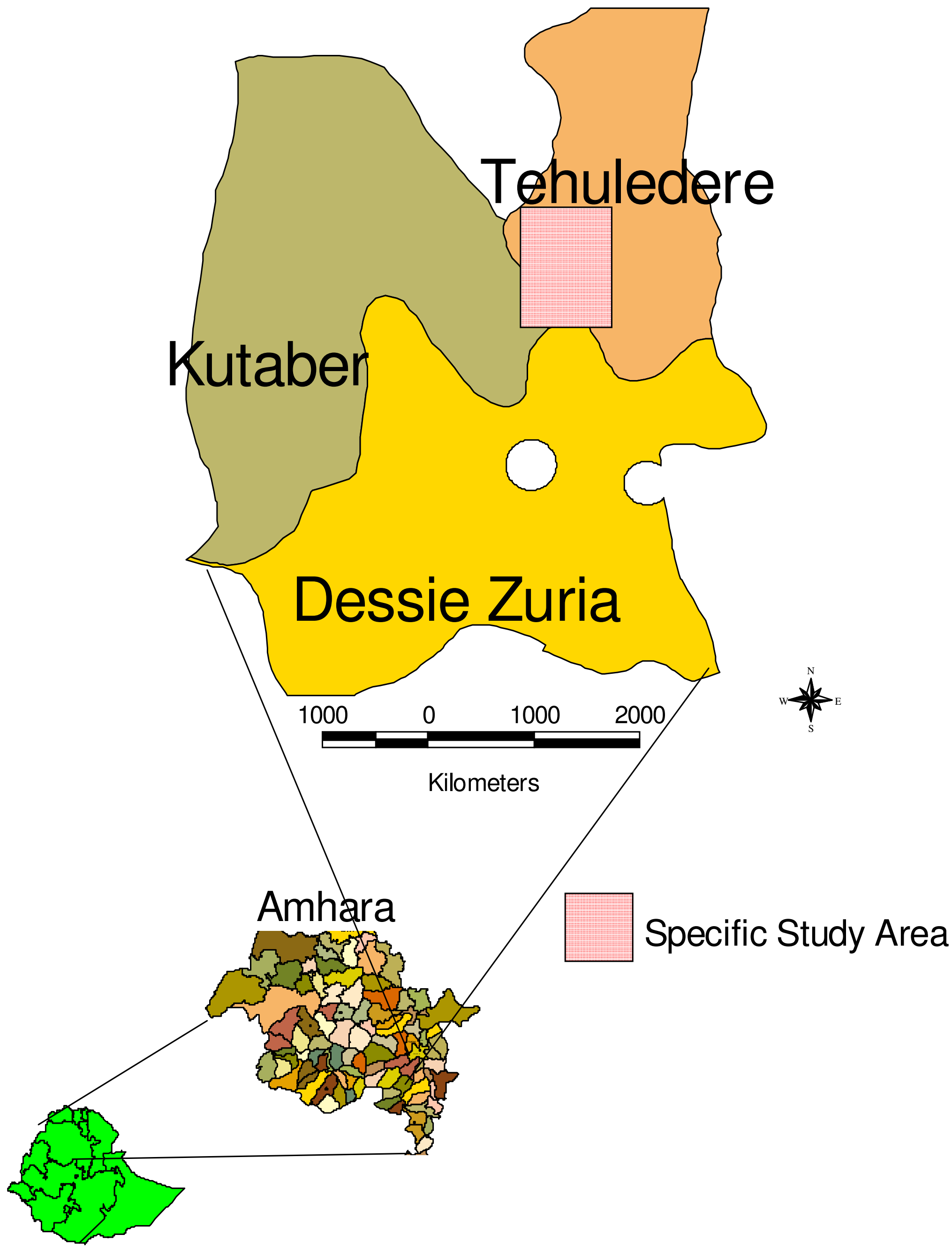
3. Description of the study Area

3.1 Location and Topography of the study area

Beru-Metero which constitutes the study area covers about 3088ha located between altitude of 11^0 12' and 11^0 15' N and longitude 39^0 37' and 39^0 40' E, about 9kms NNE of *Dessie*. The altitude ranges from 2600-2855 m a.s.l. Its larger portion of the area (over 90%) is within *Tehuledere Wereda* and the remaining small portion within *Kutaber* and *Dessie Zuria Weredas*. (Fig.2). Highly variable relief, dissected terrain and rugged topography mark the area's landscape. The known steep mountains and ridges in the study area are, *Kundi* ridge with an altitude of 2700 to 2900m a.s.l located along the center and west of *Boru Sellasie* market area. *Gorra* ridge located to the northern end of the study has an altitude of 2450 t0 2650m a.s.l. The eastern part of the study is within the hilly area known as *Gelana* ridge at an altitude of 2550 to 2650m a.s.l. These local hilly areas were well known in their vegetation cover. The Boru plain found to the West covers more than 13% of the study area. This plain is an important grazing land during dry season but inundated by the upper segments of the *Borkena* River during rainy season. Its area is now decreasing due to the expansion of cultivated and tee farming activities. The other smaller grazing land located near *Boru* market town is *Sendeg* plain with temporary grass. Like the *Boru* plain Sendeg is also inundated by water every rainy season.

Regarding streams of the area, there are three streams, which starts their headwater in the area. *Tengego* begins flowing from *Sendeg* plain and drain in to *Nibo* River North of the study area. Another stream *Messal River* starts from the center of the study area around *Gorra* ridge and joined *Tengego* before the letter flows in to *Nibo* River. The third stream is *Gelana* found East of the study area flowing from *Heto* pond and joined to the locally known as *Moletis* river at the North east of the study area. *Borkena* River where its headwater is around *Kutaber* town passes through *Boru* plain West of the study area.

Fig 2 Location Map of The Study Area



According to SIDA report of 1987 some 25% of the *Wello* area consists of very steep slopes, with gradients of 50% or more; 30% is land with slopes of 25-50%. Only about 15%of the area is made up of bottomland and level plateau. Given such rugged land cape, with the growing land scarcity more and more hillsides have been cleared of their vegetation cover and turned in to farms (Dessalegn Rahmato, 1998).

Tehuledere Wereda constituting part of South Wello comprise has 48% hilly, 26.4% mountains; 12.3% valleys with very steep slopes and only 13.3 % are plain. Because of this 17% of *W/dega* and 11.8% of the *dega* areas farmlands of the *Wereda* is found above 15% slope land. Survey data of *Tehuledere Wereda* (BoA, 2002).

Based on the above landscape of the *Wereda,* 69.5% of agricultural activity is found within 15-50% slope of land. (Table 6)

Table 6Cropland of *Tehuledere Wereda* by slope.

Slope in %	Cultivated land (ha)	Cultivated land (Percentage)
2-8	3707	17.21
8-15	2880	13.37
15-30	9262	43.00
30-50	5690	26.42
Total	21539	100.00

Source: Survey data of *Tehuledere Wereda* BoA, 2001

The study area has comprises of Bory Metero and Boru Sellassie Kebeles also similar characteristics. 75% of *Boru- metero* (06) *kebele* is sloppy land 20% steep slope and 5% with plain land. *Boru sellassie* (07) *kebele* consists of land with 70% slopy land and 30% plain land. (Survey data of DA's of the *kebeles* 1994 E.C).

3. 2. Geology and Soils

Geologically, the area belongs to the Trap series of Tertiary volcanic eruptions and is similar to most parts of central Ethiopia. The surface morphology of South *Wello* is an outcome of the various tectonic episodes and geomorphic processes that took place in the past geologic times. Most parts of zone and the *Amhara* region in general, such as the *Seimen* Mountains, central parts of South *Wello* and North *Shewa,* East and West *Gojjam* are covered by *Maqdela* group (upper miocene-Pleistocene) Ryhyolites, Trachytes, rhyolitis and trachytic tuffs, ignimbrites, agglomerates and basalts. (Amhara National Region Atlas 1999). Out of the different groups of lava *Tearmaber* basalt covers the region around *Dessie*. Along the road from ' *Hayk*' to *Kombolcha*' through *Dessie* violet and coarse-grained pyroclasts are seen exposed together with fine light gray tuffs (Mohr P, 1983 cited in Engdawerk Assefa 1997).

According to the Atlas of the region, Leptosols, Vertisols and Cambisols are the predominant soils. Leptosols occur on steep slopes and are shallow and stony suggesting the existence of high erosion. Most of the soil properties around *Gorra* ridge North of the study area are invariably young and this attributed primarily to the steep slopes, which encourage removal of the more weathered materials. The soils of *Gorra* area fall under Mollic Leptosols and Haplic Phaeozems at the second level of grouping. And on the other hand their transitional characteristics with Andosols also suggest their identifications as Andi-mollic leptosols and Andi-haplic Phaeozems at the third level of classification (Belay Tegene2000).

Field survey indicates that the average soil depth on bare land within 15-30% slope is about 21cm while the average depth on vegetated area on similar slope was found to be about 35 cm. On flat areas soils are deep and suitable for agricultural purposes. An eight-year (1982-1989) of data collection by the Soil Conservation Research Project (SCRP, 1996) indicated that, currently erosion by water on cultivated slopes of South *Wello* Zone is taking place at an average rate of about 35 t /ha/year (Belay Tegene 2000).

In the wetter high lands, a ‘dega’ and ‘W/dega’ zone where the study area is located, erosion by water is to some extent aided by mass wasting (Soil creep, land slide, etc). This was the reason why we observe many land slide occurrences in the study area. One of the largest landslides around *Gelana* ridge is shown on the field photo given below.

Fig3. Land sliding in *Beru-Metero*, photo by Girmay Kassa, 2003.

Tehuledere Wereda BoA ranked the fast natural disasters occurred in the *Wereda* as follows: soil erosion (very acute), landslides (acute); and river flooding (less acute). The Bureau also indicated that the acute landslides occurred in the *Wereda* were: in 1989, 1990, 1992 and 1993 E.C., which showed the annual occurrence of land slide in the Wereda.

3. 3 Climate

According to MOA (1988) Agro-Climatic Zone classification, *Tehuledere Wereda* in general and the study area in particular are found within the Tepid to Cool Moist Mountains and Plateau (Fig 4.). Mean annual temperature varies from 13 to 17^{0}c and the mean annual rainfall records at *Boru-Meda* located at an elevation of 2720, about 1.5km to the West of the study area shows 1236mm (Table7). The rainfall data for *Boru-Meda* suggest that the study area falls within the moderately cool-to-cool subtropical summer rainfall zone of the FAO/UNESCO (1990) climatic classification scheme (Belay Tegene 2000). The estimated mean annual potential evapo-transpiration varies from 1300 to 1850 mm. This sub zone is marked by both single and double growing periods. Areas with single growing periods have about 180 Length of Growing Period (LGP) and those with double growing period (locally known `*Kiremt*' and `*Belg*) have 60-100 days of LGP each.

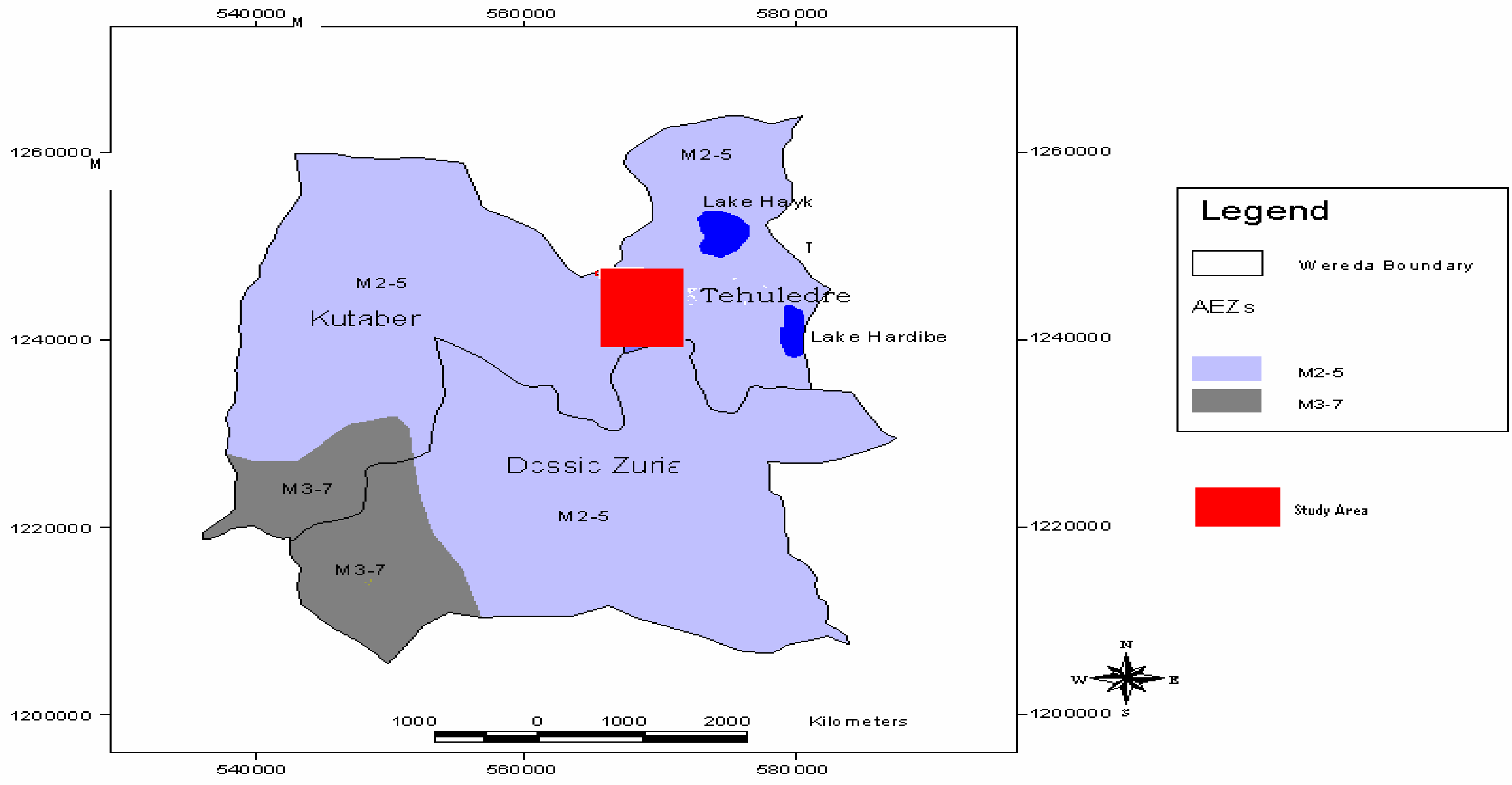
Table 7: Records of rainfall for Boru-Meda and temperature for Dessie

	J	F	M	A	M	J	J	A	S	O	N	D	Ann.
RF(mm)	31	35	84	123	108	39	315	292	148	24	20	17	1236
T (°C)	14	15	14	16	16	17	17	16	15	14	13	13	15

Source: Belay Tegene 2000

The average rainfall of the *wereda* was 374mm, from February to May and the average `*Kiremt*' rainfall was stated as 621mm from August to September.

Figure 4 **Agroecological Zones of the Study Area**



Source: MOA (1998) Agro-ecological Zones of Ethiopia. GTZ, 1998 Addis Ababa.

3.4 Natural Vegetation cover

3.4.1 The Status of Natural Vegetation in Historical Past

Wello like most of the northern provinces does not have a significant vegetation cover. Historical records, such as those of Italian forestry officials that report after a trip across eastern *Wello*, that the whole region was 'bare of forests' and they relate these phenomena to over population. Although far from exhaustive, it gives us some kind of base line against which to measure the state of forest resources in *Wello* in the post 1941 period. In the last decades, there has been such effort to document the information about vegetation cover of *Wello*.

Some litratures indicate that, about 800,000 ha (20%)of the land surface in *Wello* was covered by forests and the most important species being *Juniperus procera (Yabasha Ted)*, now remained as woods, bushes and shrubs in the region and *Podocarpus gracilior (Zegba)*, abandon at preset (Bahru Zewde 1998). The currentforest cover of Wello is estimated at about 1.2% of the land surface of *Wello* (Markos Ezra 1997).

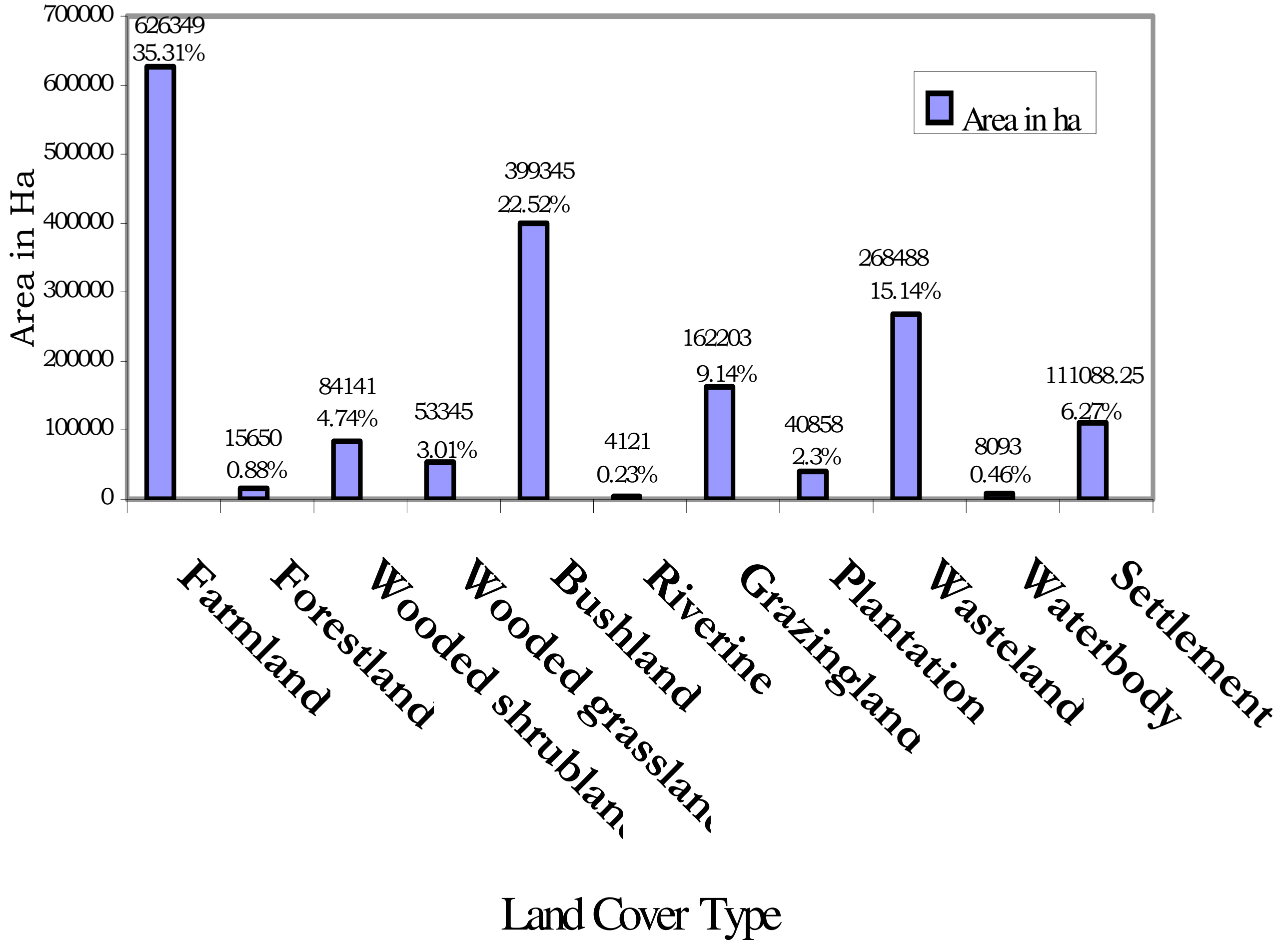
3.4.2 The Current Status of Natural Vegetation

Mesfin Tadesse (1993 cited in Sebsebe Demissew 1998), indicates that 50% of the existing natural vegetation of South *Wello* is made up of scattered trees and shrubs, about 30% dense bush lands and the natural forest make up less than 3% of the total vegetation cover.

Beru- Meda about 9kms on the road from *Dessie* to *Kutaber* is covered by grasses and sedges, with some herbs including *centella asiatica* and some bulbous plants such as the endemic *crinum* *abyssincum* (yejib shinkurt). This extensive grazing plain at present is encroached by expanding farmland and tree farming.

The area between *Boru Meda* and *Boru Debre Berhan Sellase* which includes *Kundi* hill which is at the center of the study area, is covered by dry evergreen afro-mountain forest and grass land. Some of the main floristic composition from *Dessie* and its surrounding in general and *Boru Meda & Boru Sellase* in particular include, the native tree species such as *Ekebergia capensis* (Sembo), *Erythrina brucli*, (Korch), *Jumiperus procera* (Yabesha Tid), Acacia Abyssinia (Bazra Girar), *Carissa eduli*s (Agam) and *Olea Africana* (weira). The shrubby species are *Berberis holstii* (Gewo), *Calpurnia aurea* (Digita); Succulents such as *Aloe debrana* (Ret), *plectranthus barbatus* (Yefiyel doka); herbs such as *Alchemilla sp.*(Wazsma), *Campanula eduls* (Yebeg Lat), *Cynoglassum Coeruleum* (Chigogot), *Eulophia rueppellii* (yelam t'ut), *Kniphofia foliosa* (Ashengdya) and *Nepeta azurea;* grasses include mainly species of *cynodon doteylion* (Serdo sar) and *Hyparrhenia hirta* (Senbelet); Exotic tree spices include *Eucalyptus Camaldulensis* (Key Bahirzat) and *Eucalyptus globuslus* (Nech Bahirzaf) (Sebsebe Demissew 1998).

Fig.5: Landuse / cover of S. Wello Zone (1990 E.C.)



Source: *S.Wello* Land use & Environmental Protection Section of PEDD, 1998

Different vegetation can be identified in South Wello (PEDD 1998) reported indicate forest coverage is only 15650 ha (0.88%), wooded shrub land coverage 84141 ha (4.74%); wooded, grassland covers 53345 ha (3.01%), shrub/bush land covers 399345 ha (22.52%); riverine trees 4121 ha (0.23%) and grazing land 162203ha (9.14%), cultivated land (35.31%) and bare land, settlement and water body together (21.87%) (Survey data of *S.Wello* BoA, 1993 E.C.). Based on the above data the major vegetation type of South *Wello* zone is shrub/bush land & the least coverage is forest and riverine trees.

On similar situation *Tehuledere Wereda* has natural cover of forest and dense wood land 1473 ha (3.22%), Plantation forest 1591 (3.47%), bush and shrubs 11101 ha (24.24) and grazing land 662 ha (1.45%). Therefore the major vegetation cover of the *Wereda* is bush and shrub land and the least coverage is that of natural forest. Out of those areas covered by vegetation are hills found in the study area such as, *Tengogo area* which is a forested area with natural vegetation species denominated by *juniperus procera* and very few *Acacia Abyssinia* and *carissa edulis*. *Kundi* ridge in *Boru Sellassie area* is another vegetated area covered with exotic *Eucalyptus globulus* and natural species dominate by *Juniperus P.* and *Olea africana* (Wiera), where 95% is covered by bush and shrubs while only 5% of the exotic tree coverage. *Gora ridge* is another known sloppy area covered by vegetation which is found in both *kebeles* (06 and 07) with an altitude of 2450-2640m a.s.l and covers an area of 114ha with vegetation species dominated by *Juniperus P.Acacia abyssinica* and c*arissa edulis.* Bushes and shrubs cover the area with about 60percent and 40percent by indigenous *Junipers P.* trees. A study done by Belay Tegene(2000), of *Gora Daget* forest has identified the major plant species as stated in (Table 8).

Table 8. Major plant species identified in the *Gora Daget* forest.

Local name	Scientific name	Local name	Scientific name
Tid	*Juniperous procera*	Kerchemo	*Myrsine africana*
Woira	*Olea europaea*	Attat	*Maytenus senegalensis*
Girar	*Acacia abyssinica*	Embuacho	*Rumeex nervosus*
Azamir	*Bersama abyssinica*	Yeset Kisit	*Asparagus falctus*
Embis	*Rhus glutinosa*	Chifrig	*Sida tenuicarpa*
Koshim	*Dovyalis abyssinica*	Kefeto	*Pavetta oliverana*
Askuar	*Nuxia abyssinica*	Busike	*Kalanchoe deficiencs*
Kega	*Rosa abyssinica*	Boter	*Plectranthus rupests*
Agam	*Carissa edulis*	Kibe Golgul	*Polygala rupicola*
Wulkif	*Domabeya torrida*	Kolo	*Echinops longisetus*
Fiyel Fej	*Clutia abyssinica*	Yekok Sar	*Panicum pusillum*
Kentaf	*Pterolobuim stellatum*		

Source: Belay Tegene (2000).

The fourth hilly land is *Kundi* ridge that is found near the church of Debrebrhan Sellase with an area of 235ha located in *Kebele* 06 with an altitude of 2640-2900m. This ridge as stated above is dominated by vegetation species of *Junipers P.*, *Olea Africana* and few *acacia Abyssinia* and exotic threes of *Eucalyptus globular*. This ridge has a cover of about 50% indigenous forest, 45% bushes and shrubs and 5% Eucalyptus trees. (Survey data of *Tehuledere Wereda* BoA, 1996). The known forest cover (exotic and natural trees) in the study area of *Boru Sellase* found in *Kudi* ridge some part of it belongs to the church around it. The forest estimated to cover an area of 235 ha which rises above it on the adjoining slope of the *Kundi* hill, a name by which the forest has been often known. The demarcation of the forest area goes back to the 1870's when Emperor Yohannes the 4th established a palace on the summit. The indigenous species of this forest which included Juniperus *pro*cera, *Olea affrican* and *Acacia abyssinica* (which is none at present) have been largely replaced by the exotic *Eucalyptus globulus* (Bahru Zewde 1998)

The reason of the expansion of Eucalyptus trees and the decline of natural forests according to the community leaders and *Wereda* officials is the population pressure. Farmers are also increasingly converting their cropland to tree farms. This was to grow into a strong tradition for instance, among the commercially minded *Boru* farmers in *Kebele* 06, most of them converting their plots into tree farm.

3.5 Socio Economic Aspects of the Study Area

Beru Sellase market center with a small town found in *(07) kebele* was a known market center in the Ethiopian economic history during the time of (*Sirara Negade*), before the Italian occupation. This rural town served as head quarter of *Tehuledere Wereda* until 1942 E.C., which is currently in *Hayk*. The aerial photograph of 1936 by the Italians clearly shows *Boru Sellasie* town with many modern buildings and planned roads, which were not seen on the recent aerial photos of 1994.

According to an interview with the elderly people, there were merchants (*Sirara Negade)* in the town who used to own more than 100-200 mules for transporting goods from *Asmara* to *Boru* and from *Boru* to *Gofa* in southern Ethiopia. These merchants have left a strong mark on the land use land cover and ecological changes by introducing Eucalyptus trees to the area. As stated by the local people the decline of this market place was due to the opening of the road through *Hayk* to *Dessie* by the Italians that left *Boru Sellase* off road.

3.5.1 Human Population

Demographic factors play an important role in the evaluation of the current as well as the potential land use, which is the product of interaction of man on land.

High population pressure is a reflection of the incidence of poverty and at the same time a key factor in accelerating deterioration of the natural resources base, particularly forest. (EFAP 1994). In both its distribution and size, as well as in its cultural orientation and practice, the population of south *Wello* in general and the study area in particular had a tremendous impact on the vegetation cover of their respective areas. Increase in population would exert additional pressure on land to meet the essential subsistence needs, such as food and domestic fuel when crop production is pursued under traditional technology. These growing and sometimes conflicting demands have led to a great proportion of land use/land cover being used in an unwise manner and in a wrong way.

The population of South *Wello*, estimated at 2,384,165 in 1998 and accounting for 15% of the total population of the ANRS, and growing at a rate of 2.8% per year has one of the lowest standard of living in Ethiopia (Dessalegn Rahmato 1991 as cited on Belay Tegene 2000). The rural population that accounts for about 90% of the total has a profound influence on the natural resources and the environment.

The rural population of *Tehuledere Wereda* was 107452 in 1984 and increased into 119240 in 1994. CSA (1991/95). According to the survey data of the *Wereda* (1990 E.C), the main livelihood system of the rural people of *Tehuledere Wereda* includes: mixed farming, which accounts 91.25%, livestock razing 3.4 % small scale rural manufacturing 0.15 %, daily laborers 3.6 % and 1.6 % traders.

Because of the rapid population growth the total area of land each farmer cultivated has fallen steadily and the population as well as agricultural densities have increased to one of the highest in South *Wello*. (Table 9).

Table 9: Population, total area, cultivated land their respective densities for South *Wello* (1990 E.C.1997-98)

Region	Total Area	Cultivated land	Population		Population density =T.PopX 100 Total Area	Agriculture density Rural Pop X 100 Cult. Land
	(ha)	(ha)	Total Pop.	Rural Pop	Persons/km²	Persons/km²
Tehuledere	45800	21539	130477	116743	284.90	542.00
Tenta	134687.50	47874	158894	151298	118.00	316.00
D. Zuria	180100	69909	289295	286703	160.60	410.10
Mekedela	150875	34065	130287	127913	86.35	375.49
Legambo	107687.50	41501	150707	145715	139.95	351.11
Kalu	117187.50	40674	210928	193120	179.99	474.80
Kellala	159031.25	61965	126410	121703	79.49	196.41
Kutaber	72343.75	14287	102998	99680	142.27	697.70
Ambasel	92700	23756	121093	116511	130.63	490.45
Werebabo	70500	16822	98557	93269	139.80	554.45
Wegidi	112187.50	40964	113516	111560	101.18	272.34
Saint	204300	68178	196032	193622	95.95	283.99
Debresina	97687.70	41421	147059	140641	150.54	339.54
Wereillu	99687.50	51263	131613	121235	132.03	236.50
Jamma	129281.25	52131	116940	112618	90.45	216.03
Total	1773681.25	626349	2384165	2132331	135.52	383.79

Source: South *Wello* BoA, Land Use and Environmental Protection section, 1990 E.C.

Table 10: Population, total area, cultivated land and their respective densities of *Kebeles* (PA) in the study area 1994 EC.)

Kebele	Ave. family size	Land holdings per household	Pop$^{\underline{n}}$ (Rural)	Area (ha)	Cultivated land (ha)	Pop$^{\underline{n}}$ density	Agric. density
06(Borumetero)	5	0.80ha	7347	1770	898	415.08	818.15
07(Boru Sellase)	5	0.77ha	4579	1587	635	288.53	721.10

Source: Survey data of DA's of *Kebele* 06 & 07, 1994 E.C.

As it is shown in (Table9), the population and agricultural densities of South *Wello* on the average was indicated as 135 and 383 persons/km^2 respectively. While *Tehuledere Wereda*, has a population density of 285 and agricultural density of 542 persons/km^2. As indicated in (Table 10), the population density of *Kebele* 06 (*Boru- Metero)*, has 415.08 persons/km^2, and agricultural density is 818.15 persons /km^2 and 07 *Kebele* has a population density of 238.53 persons/km^2 and 721.10 persons/ km^2 of agricultural density.

The population pressure and the ever-increasing need for more land to maintain required food production is forcing farmers to encroach on to marginal areas such as steep slopes, dry area, grazing lands, etc. The rapid population growth increasing scarcity of suitable cropland and contracting land holding per family combined with the widespread poverty have left the farmers with no option other than encroaching more and more into the fragile environment with little concern about its long - term impacts.

3.5.2 Land use, Farming System and Crop Production

The overall farming system is strongly oriented towards grain production dependent on the use of oxen for land preparation. Traditional grazing on communal lands has also been practiced for thousands of years with little or no modification. In addition to the long years of agricultural activities in the area the present size of human and livestock population pressure has led to the over utilization of land resources where people are faced to turn mountain slopes in to farmlands.

The arable land holding of most house holds is less than one hectare on which the zonal average being 0.63 ha where the minimum farm size required to sustain for an average household size of 5.63 persons is estimated as 1.75 ha (Yeraswork, 1995, DPED 1993 cited in Belay Tegene 2000).

According the survey data of the *wereda* BoA (2002), the average landholdings of households (5 family member) in 06 and 07 k*ebeles* was 0.80ha and 0.77ha respectively. Similarly the sample respondents (65 farmers) selected from the two *kebeles* of the study area reported that on the average as 83.08% 0f the farmers 0.50 - 0.75ha of farmland.

Table 11: Cropping system at *Wereda* level

Agro climatic Zone	Fallowing %	Shifting cultivation %	Crop rotation %	Continuous Cropping	
				Mono %	Mixed %
Dega	0	0	10	85	5
W/Dega	0	0	5	90	5
Kola	0	0	20	70	10
Total	0	0	11.68	81.66	6.66

Source: - Survey Data of *Tehuledere Wereda* BoA, 2002

The demographic pressure and shortage of farmland has forced farmers to adopt continuous cropping systems abandoning completely even seasonal fallowing (Table11). Farmers of the study area pointed out that continuous cultivation of land are the only coping strategy they adopt to provide food for their families.

In rain fed crop production system, the extent of the area to be cultivated is also determined by the efficiency of tillage operations, which is dependent up on the availability of oxen. According to the Survey of Planning and Training Team of MOA, (1989), out of 24500 farmers of the *Wereda* 6125 (25%) have no farming oxen; 11686 (47.7%) have one ox, 6419 (26.2%) have pair of oxen and only 270(1.1%)have three oxen.

As it is indicated in the introduction the *Wereda* has an extended growing period in two seasons locally known as *Belg* and *Meher.* '*Belg*" season begins in January and ends in June, while *Meher* begins in June and extends up to September.

Table12: Cropping Calendar of T*ehuledere Wereda* for major crops.

Meher			
Crop	Laughing Period	Sowing Period	Harvesting Period
Sorghum	Jun-Feb	March - April	Dec 20 –30
Teff	March-June	July 5-12	Nov 15- Dec 15
Barly	March - May	June - July	Nov - Dec. 15
Wheat	March - May	10 June – July	Nov - Dec.15
Emmer-Wheat	March - May	10 June - July 10	Nov - Dec.15
'Belg'			
Barley	Sept - Jan 20	Jan1 - Feb. 10	May 20 - June 20
Wheat	Sept 15- Jan 20	Jan1 - Feb. 10	May 20 - June 20
Teff	Dec 1 - Jan 15	Feb1 - 30	May 15 - 30
Emmer Wheat	Sept 15 - Jan 20	Jan1 - Feb. 10	Jan1 - 30

Source: Survey data of *Tehuledere Wereda* BoA, 2002

The *Wereda* share of *Belg crops* is 40.58% for *dega* areas and 17.96 % for *W/dega* areas. Where as '*Meher" share* is 59.42% for the *dega* areas and 82.04% in the *W/dega* regions (*Tehuledere Wereda* BoA, 2002).

A variety of crops are produced on the cultivated land of South *Wello* in general and *Tehuledere Wereda* in particular. As it is indicated on (Table 13), the major corps grown in the *Wereda* during *Belg* season are, Barley, Wheat, *Teff* and Emmer Wheat while Sorghum, *Teff*, Barley, wheat and Emmer wheat are the major crops grown in '*Meher'* Season by order of importance.

Table 13: Major cultivated crops of *Tehuledere Wereda* in order of importance.

Type or crop	Scientific Name	Local Name
Barley	*Hordeum Vulgare*	*Gebs*
Wheat	*Iriticum vulgare*	*Sinde*
Sorghum	*Sorghum bicolor*	*K/zengada*
Teff	*Eragrostis teff*	*Teff*
Maize	*Zea mays*	*Bekelo*
Emmer wheat	*Avena sativa*	*Aja*
Horse Beans	*Vicia faba*	*Bakela*
Field peas	*Pisum sativum*	*Ater*
Chick peas	*Cicer arietinum*	*Shimbra*
Lentils	*Lens culinaris*	*Misir*
Vetch	*Vicia sativa*	*Guaya*
Finger seed	*Eleusine coracana*	*Dagusa*
Flax (linseed)	*Linum Vsitatissimum*	*Telba*
Sesame	*Sesamum indicum*	*Selit*
Fenugreek	*Trigonella Foenum -grecum*	*Abish*
Bishops weed	*Trochyspermum Copticum*	*Nech Azmud*

Source: Survey data of *Tehuledere wereda* BoA, (2002) and Wolde Micheal Kelecha, (1987).

The literatures identify three problems regarding south *Wello*: 1) Degradation of land 2) a static land tenure system and 3) Rapid population growth. Each one of these factors individually or collectively has had negative impacts on the average farmland size per peasant household. Out of these factors rapid population growth has more effect on access to farmland due to two reasons: 1) its effect to farmland is more immediate than the other two factors and 2) the coping strategies in relation to population growth are more visible and easy to identify than the coping strategies in the other two factors. Based on these, some forced fragmentation is going on as a result of the increasing demand for farmland. Since there is no other alternative solution in the area, the current holdings are so small that further fragmentation to meet the demands of growing household size are unlikely to continue as a coping strategy.

3.5.3 Tree Farming (an emerging land use type)

Agro forestry activities have a long tradition in Ethiopia. In peasant areas there are often many trees left in the field. They are mostly remnants of the forest community that once covered the fields, but also to secondary forests and woodlands that established and occupied the area after the logging and clearing activities that destroyed the virgin forest. However, balanced system of agro forestry would have great advantages from an ecological point of view among the ecological advantages are the improving re-circulation of nutrients and improved biological control by increased diversity.

Change in vegetation cover causes complex hydrological changes. Suppressing or removal of vegetation cover will result in drastically increased run off. Besides this, farmers in the study area and in the region at large do not have more experience with indigenous tree husbandry. Trees are retained on farm, which are exotic to provide fuel wood, or planted around homesteads for fuel and pole production purposes, but are less likely to be planted in fields and integrated with the farming system. This is because of many influencing factors, such as the current constitution on land which does not confirm land ownership right, the size of land holding and level of fragmentation are the main once.

The rural people of south *Wello* in general and the PA *kebels* of the study area in particular, faced with a growing population, declining agricultural production, prevailing of drought and scarce of farm lands which hesitate to implement development activities on their own land, or to accept new agricultural packages. This is obvious that the peasants of the area have experienced in time and space that they were allocated land at a time and displaced the other time leaving the developed or under developed land to have new possession but smaller than before.

The farmers which tied with such unsecured land use system and natural hazards, do not accept heartily an appropriate agricultural technologies, instead they damage built up soil and water conservation structures and destroying community and state forest reserves recklessly. The areas put under plantation in the last three decades a little more than 40000 ha, which is only 2.3% of the area of south *Wello*. (Fig.5). These plantations have not yet significantly contributed to the vegetation cover of the high lands. More over, because the plantation forests were imposed on the community, the peasant farmers following the fall of the 'Derg' regime destroyed considerable proportion of them (South *Wello* Planning and Eco. Dev. Department, 1993). This is the reason why we see at present along homestead that is usually located at the periphery of the settlements and generally allocated for wood lots, gardens and communal infrastructure is more developed or preserved than distant lands since homestead lands are more or less secured. Regarding this, a study conducted by Yeraswork Admassie (1995), stated that, one-third of the farmers in three administrative *weredas* of *Wello* to completely or partially change their cultivated plots three or more times because of the redistribution induces tenure insecurity and reduces the farmer's incentive to invest on conservation and other management practices on the land. (Belay Tegene 2000). Currently as observed on the field assessment of the study area (March 26 - April 20,2003) farmers are beginning planting trees, usually Eucalyptus, on their farm and grazing lands due to the increasing price of fire wood & poles and they also used to secure the ownership of farm land, because a farmer who has a permanent plantation may not be redistribute again his land in the future. (The DA'S of *kebele* 06 and 07).

The types of planted trees are commonly Eucalyptus (*globulus* and *camalduresis*) as stated above around the homesteads, along roads and at some lower back slopes, and recently on plain farm and grazing lands. People continuing to increase plantation those trees, instead of the indigenous plant species such as, i.e. *Juniperus procera*. The reason is clear, firewood and poles of Eucalyptus tree becomes an important source of income of many households in the study area. The planting often occurs in one or two rows around the compound perimeter at 30 to 50 cm spacing. (DA'S of *Kebele* 06 and 07,2003). This tree planting usually permits a harvest of firewood and small diameter poles within three to four years from planting (Fig. 6).

Fig.6 Poles of Eucalyptus tree prepared for sale to Desse from *Boru Metero*, (Photo by Girmay Kassa 2003).

But planting trees, like *Juniperus procera*, have long gestation periods, and the decision to plant trees is greatly influenced by the farmer's perception of risk.

For rural house holds of the study area, tree farm offer means to acquire self-sufficiency in energy and a way to earn income by selling poles and fuel wood in local markets mostly to *Dessie* as shown from the real photo below on (Fig.7).

Fig.7 Fuel wood and poles loaded and enter to *Desse* market from *Boru Metero* area. (Photo by Girmay Kassa, 2003).

The price of one pole goes up to 5-6Birr, and a load of firewood is 5 Birr per donkey and 6-8Birr per mule or horse (Discussion with the farmers of *Boru* area). This is also confirmed by the questionnaire result survey as shown in Table 14.

Table 14: Respondent result regarding energy resources, Source of fuel wood and tree planting.

Type of Energy source	No. of respond-ants	%	Source of fuel wood	No. of respon-dants	%	Reason for increasing plantation			
						Financial	%	Soil Protection	%
Wood (Eucalyptus)	63	96.92	Homestead trees	62	95.38	56	86.15	9	13.85
Crop residue	30	46.15	Farm wood lots	45	69.23				
Cow dung	59	90.77	Community forest	15	23.08				
Charcoal	1	1.54	Natural forest	1	3.08				
Other	2	3.08							

Source: - Field Survey, 2003

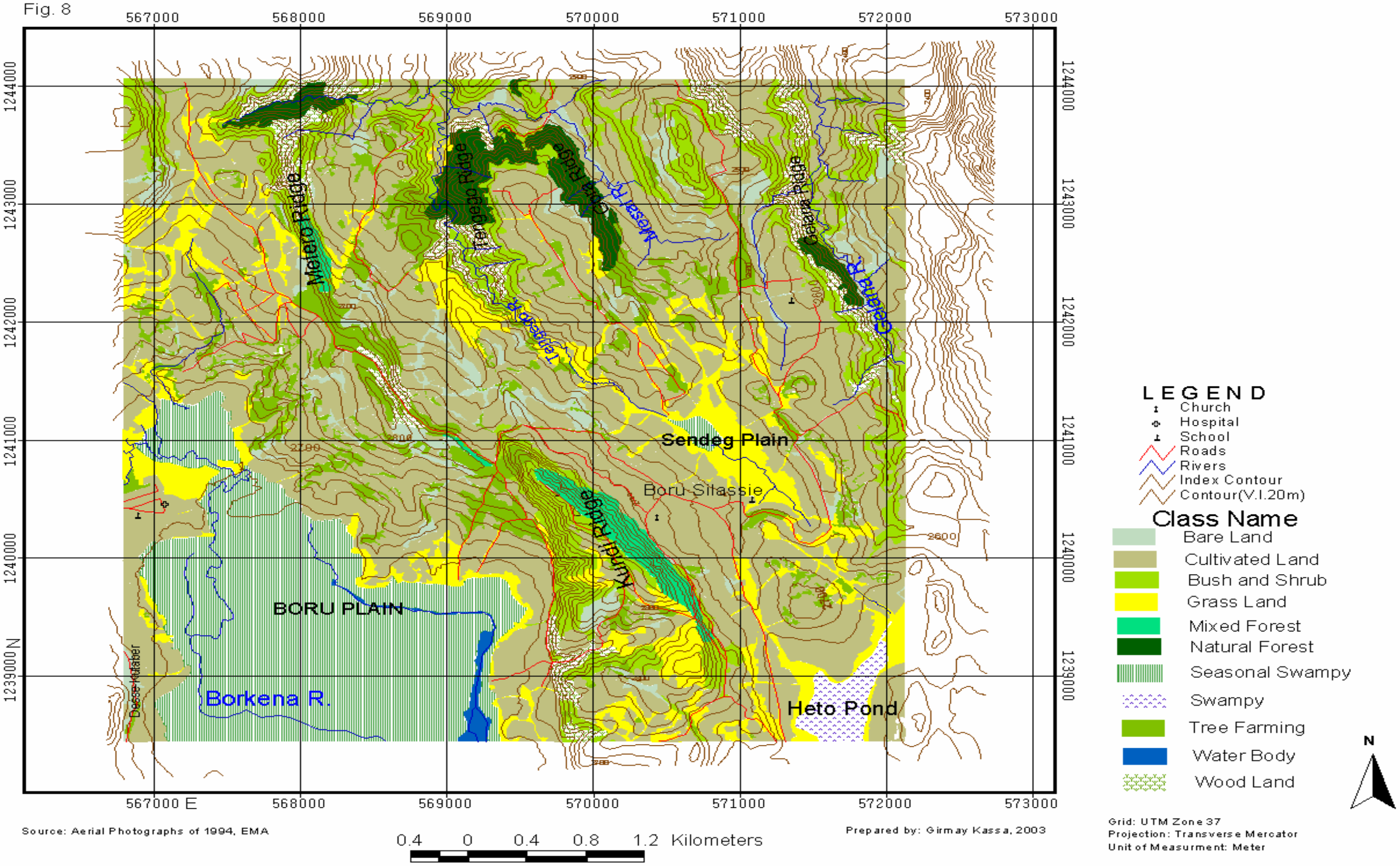
Individual farmers, Peasant Associations and government offices participated in the Plantation of Eucalyptus trees. With the increasing population and deforestation, the ecology of the area is changing to an alarming rate, as discussed with the environmental protection official's of the *Wereda.* There is a rapid change of grazing and farmlands to Eucalyptus plantation in the area. The basic reason for the increment of farm tree plantation is due to financial benefits (Table14). During the field survey, a farmer from *kebele* 06 near *Beru Sellaseie* town has sold 10,000 Birr of eucalyptus from a wood lot of 12.5 by 10m area. This shows that the income from tree planting in the study area comes more than the annual crop production of household, and the *Kebele* DA'S have estimated as 50-70 % of the annual income of household in their respective *kebeles* come from fire wood and pole tree selling. As stated on EFAP, 1994, following the 1990 proclamation regarding usufruct rights to land, increasing numbers of farmers reported to plant small on farm wood lots in peri-urban areas where the returns from the sale of fire wood and poles are attractive. Calculations suggest that these may be greater than the return to cash cereal crops.

However, regarding the future ecological balance of the area, as indicated above is alarming. Eucalyptus tree has a negative effect in the local environment. This tree in particular is efficient in drying up its habitats, making it unsuitable for water conservation activities. As they also suppress the ground cover and have poorly developed horizontal root systems they are unsuitable for soil conservation activities as well (UNDP/FAO, 1984:41 cited from Messerli and Aerni (1978).)

The farmers, as observed during discussion, recognize the negative effect of eucalyptus tree in the study area that they saw many springs, which were used for many years, dried at present. In addition to this, grass species such as (*cynodond actylon*) locally known as (Serdo) and which were important for grazing animals are now disappearing from undergrowth of eucalyptus plantations. But this grass is seen under woodlands of (*Juniperus procera*) which is indigenous to the area. Field observation indicates that most of the domestic animals frequently graze under the *Juniperus procera* woods but not under eucalyptus plantations.

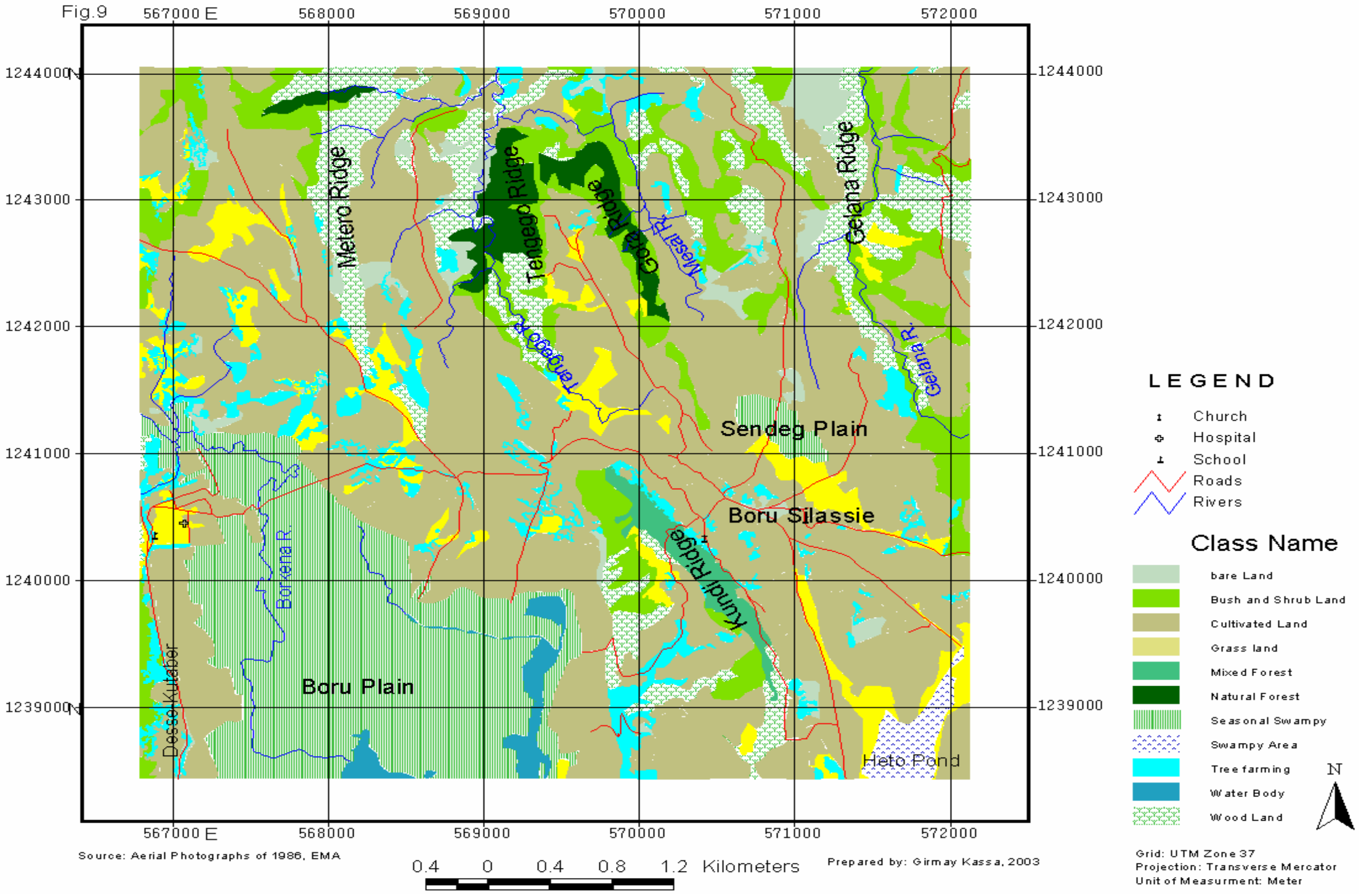
LAND USE/ COVER MAP OF BORU-METERO, SOUTH WELLO, 1994

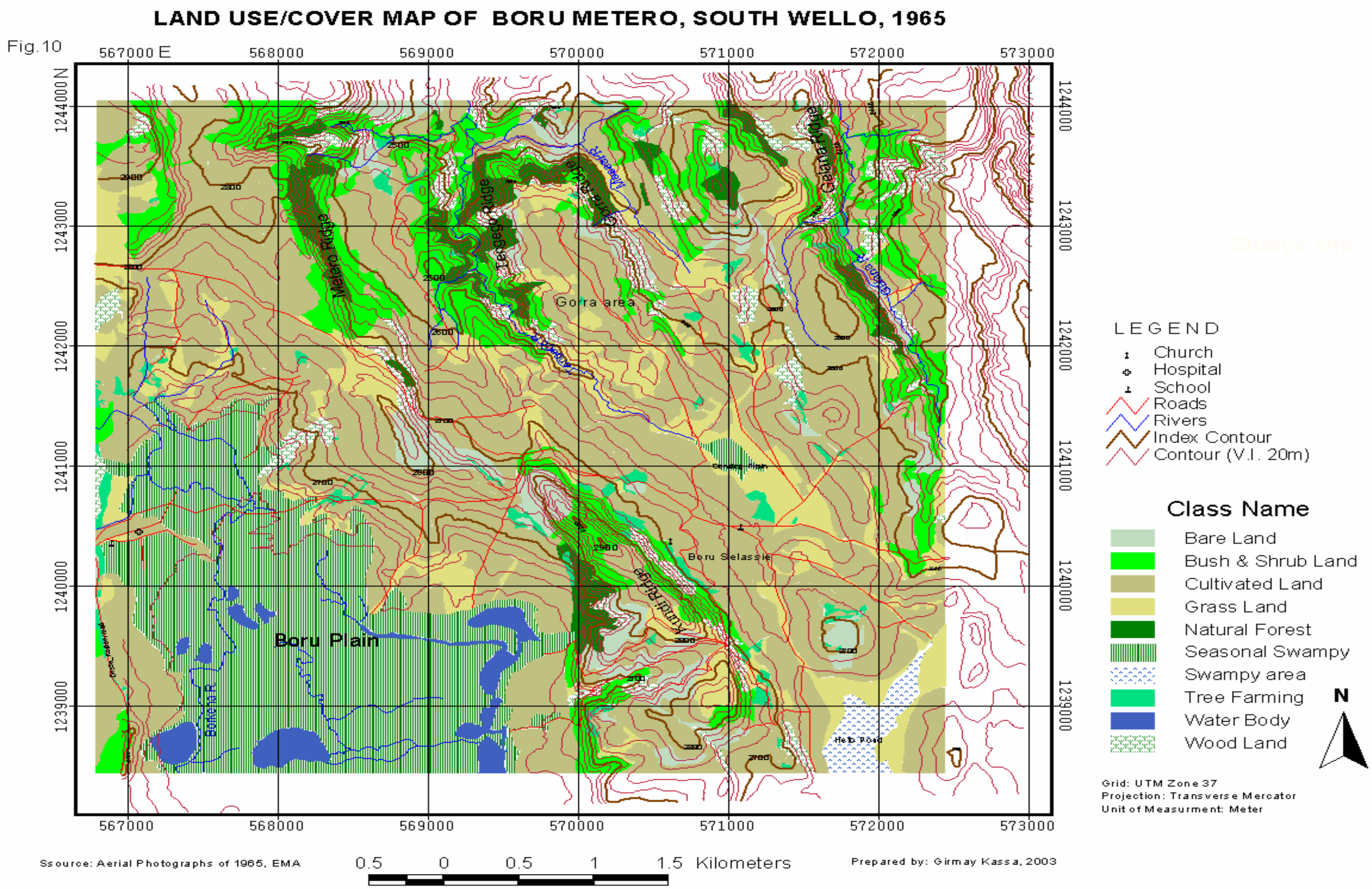
Fig. 8



LAND USE/COVER MAP OF BORU -METERO AREA, SOUTH WELLO, 1986

Fig.9





LAND USE/COVER MAP OF BORU METERO, SOUTH WELLO, 1965
Fig.10
567000 E
568000
569000
570000
571000
572000
573000
1244000 N
1243000
1242000
1241000
1240000
1239000
Metero Ridge
Gorra area
Boru Plain
Boru Selassie
Kundi Ridge
LEGEND
Church
Hospital
School
Roads
Rivers
Index Contour
Contour (V.I. 20m)
Class Name
Bare Land
Bush & Shrub Land
Cultivated Land
Grass Land
Natural Forest
Seasonal Swampy
Swampy area
Tree Farming
Water Body
Wood Land
N
Grid: UTM Zone 37
Projection: Transverse Mercator
Unit of Measurment: Meter
Ssource: Aerial Photographs of 1965, EMA
0.5 0 0.5 1 1.5 Kilometers
Prepared by: Girmay Kassa, 2003

CHAPTER FOUR

4. Land use/ Land cover Changes of *Boru-Metero* area of South *Wello*

Plant community plays an important role in indicating landscape changes, which are distinct and the boundaries are abrupt enough for easily mapping. But sometimes the change is gradual, perhaps imperceptible within given years. Plant communities are dynamic systems subject to a complex range of influences of natural as well man made factors. Therefore, in the study of land use and land cover changes, taking vegetation cover as an indicator, it is not easy to arrive at to the intended result easily without applying temporal spatial data of a longer periods of time.

4.1.1 Land use /Land cover changes Observed in *Boru-Metero,* in the years of 1965, 1986 and 1994.

Land use/ land cover data derived from 1965, 1986 and 1994 aerial photos and verified through field survey has revealed the data in Table 15. The result shows that natural forest cover declined from (3.43%) in 1965 to (2.74%) in 1986, and farther decreased to (2.59%) in 1994.(Fig.8, 9, and 10. Woodland coverage is increased from (4.36%) in 1965 to (8.17%) in 1986, primarily because of the modification of the forest cover to woodland. But woodland coverage itself has decreased from (8.17%) in 1986 to (3.30%) in 1994.

An interesting change in the sated aerial photos was the increasing of tree farms (Eucalyptus) since 1965. These farms, which accounted for only 1.63% in 1965 increased to (4.71%) in 1986 and (4.63%) in 1994. The reason is as Crummey (1998) stated, the

Wello farmers were keenly aware of the trees commercial value as they sell wood and poles for cash. According to the informants of *Boru Sellase* PA, farming of eucalyptus increased not only on marginal lands but also on private farmlands, as the financial benefits obtained were much larger than those obtained from other crops.

The expansion of Eucalyptus plantation with the dwindling natural forests has resulted a mixed type of forest cover near *Boru Sellasse locally knon as Kundi* ridge since 1986. (Fig. 9 and10). As a result mixed forest, which was 1.02% in 1986, increased to (1.26%) in 1994.

The major changes in vegetation cover in the area took place between 1965 and 1986 where of the 1965 forest cover was reduced by about 20 percent. Bushes and shrub lands also decreased from about 12 percent in 1965 and became (9.11%) in 1986 and (9.52%) in 1994. It was found that a decrease of (25.01%) of 1986 and (21.68%) of 1994 bush and shrub land of the 1965 bush & shrub land of 1965, which may encroached by crop land and tree farms.

Grassland coverage shows an abrupt decrease from 10.28 percent in 1965 to about 5.125 percent in 1986 and shows an increase to 9.94percent in 1994. Its area in 1965 was 317.5ha and declined to 158.1ha in 1986, which was about 159ha of grassland converted into other uses. The time between 1965 and 1986 was the changing of land ownership by the proclamation of 1975. Therefore, the declining of grassland coverage may be due to the expansion of cropland to the marginal lands and the aferestation program of 1980's. Bare land coverage shows a slight difference from 1965 which was (4.57%) and (3.37%) in 1986 and (4.05%) in 1994.Here, the was no as such a major due to the fact that all suitable land was already covered in cropland and plantations as well as farm trees. And status of bare land remains somewhat constant because of its rocky coverage more of located along steep slopes that cannot be used for economic activities easily. The extensive dry period grazing land of the area, classified as seasonal swampy area locally known as *Boru-Meda* and *Sendeg-Meda*, decreased its coverage from 16.10 percent in 1965 to 14.56 percent in 1986 and to 13.91 percent in 1994. Even though the area of change was so small, the reason is significant which is due the expansion of cropland and tree farming as observed during the field verification.

Table15: - Land use/Land cover changes of *Boru-Metero* in 1965, 1986 and 1994

Land use/Land cover Classes	Land use/Land cover area changes						Changes in land use/ Land cover		
	1965		1986		1994		1965-1986	1986-1994	1965-1994
	Area (ha)	%	Area (ha)	%	Area (ha)	%	(ha)	(ha)	(ha)
Bare land	141.3	4.57	104.03	3.37	125	4.05	-37.27	+20.97	-16.30
Bush & shrub land	375.4	12.15	281.27	9.11	294	9.52	-94.13	+12.73	-81.40
Cultivated land	1385.9	44.86	1526	49.44	1532	49.62	+140.10	6.00	+146.1
Grass land	317.5	10.28	158.1	5.12	307	9.94	-159.4	+148.9	-10.5
Mixed forest plantations	0	0	31.43	1.02	39	1.26	+31.43	+7.57	+39.00
Natural forest	105.9	3,43	84.77	2.74	80	2.59	-21.13	+4.77	-25.9
Tree Farming	50.38	1.63	145.4	4.71	143	4.63	+95.02	+2.4	+92.62
Swampy area	28.6	0.93	25.5	0.83	26	0.84	-3.1	+0.5	-2.6
Seasonal Swamps	497.4	16.10	449.5	14.56	429	13.91	-47.9	-20.5	-68.4
Water body	51.99	1.68	28.36	0.92	10	0.32	-23.63	-18.36	-1.99
Wood lands	134.7	4.36	252.1	8.17	102	3.30	+117.4	-150.10	-32.7
Total Area	3089.07	100.0	3086.86	100.0	3087	100.0			

Source: Analyzed of land use/cover of the 1965, 1986 and 1994 Aerial Photos by the researcher.

The total areas of each year slightly varies due to factors such as, scale variation i.e. the 1965 is about 1:50000, the 1986 is about 1:40000 to 50000, while the 1994 is 1:10000. And other possible error comes from digitizing causing omission or addition of areas.

Surprisingly, the total area of the mixed forest cover in 1986 increased by 7.57 percent between 1986 and 1994 apparently because of the aforestation and enclosure of areas in the 1980's around *kundi*, *Tenegego, Metero, Gora* and *Gelanna* ridges of the study area. Similar expansion of mixed forests was observed between 1957 and 1986 in the *Mafud* escarpment, around the town of *Debresina* in Northern *Shewa* (Wøien, 1995). Wøien's report showed an increase of Eucalyptus plantation between 1957 and 1987, a decline in dispersed vegetation, and increase in concentrated forms of vegetation cover in *Mafud.* The explanation given to the increased of wood vegetation was intensive planting of eucalyptus and hillside enclosures, which was initiated in the region by the '*Derg*' since 1981. Although individual farmers and traders of the area introduced eucalyptus tree to *Boru- Metero*, the increasing of plantation cover in the 1986 & 1994 was the result of the same government aforestation hillside enclosure program.

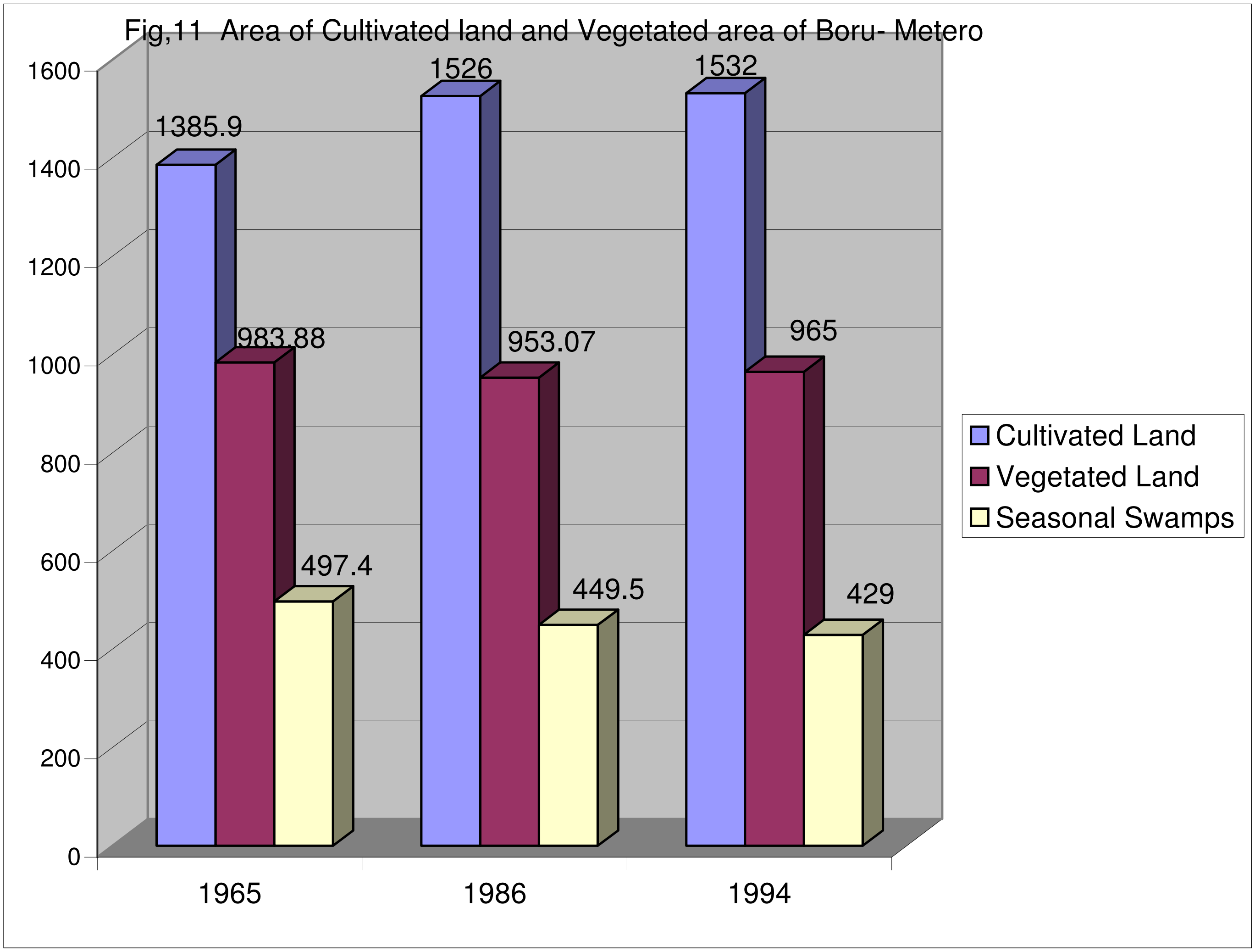
From the point of view of environmental protection the increasing of vegetation cover (indigenous) since 1980's is a positive development. But the increasing plantation and farming of eucalyptus trees appear to have a negative effect in the area. As it is indicated in chapter three, the sample informants have reported the drying of springs, the disappearance of doctylion (Serdo Sar) and declining of crop production near the plantations.

As it shown in the (table 15) cultivated land coverage was (44.86%) in 1965 and increased to (49.44%)in 1986 and slightly increased into (49.62%) in 1994. Most of the expansion occurred between 1965 and 1986, shown (10.11%). The change was not considerable as the area was under cultivation for centuries.

A comparison of cultivated land with the combined vegetation cover of natural forest, tree farm, mixed forest, woodland, grassland, and bush and shrub lands in 1965, 1986 and 1994 (Fig.11). It shows that cultivated land increased from 44.86 percent in 1965 to 49.44

and 49.92 percent in 1986 and 1994 respectively, while the combined vegetation cover of the respective years show almost constant cover, which is 31.85 percent in 1965, 30.88 percent in 1986 and 31,26 percent in1994. Here cultivated land is increased more than the total vegetated cover of the area is because of the encroaching of cultivated land more to the seasonal swamps and small portion to grass lands (Tablle15 and Fig.11).

The reason why it varies plantation cover of South *Wello* which was estimated as 2.3% is that, the area under study land cover land use is more of cultivated land (up to 50%) and seasonal swamps (up to 14%) but the cover of mixed plantation is only 1.26%. On the other hand the estimated data of plantation done by the zone was in 1990 was not updated.


Fig,11 Area of Cultivated land and Vegetated area of Boru- Metero
1600
1400
1200
1000
800
600
400
200
0
1385.9
983.88
497.4
1526
953.07
449.5
1532
965
429
1965
1986
1994
Cultivated Land
Vegetated Land
Seasonal Swamps

LAND USE/LAND COVER MAP OF BORU-SELLASIE AREA, 1994

Fig.12

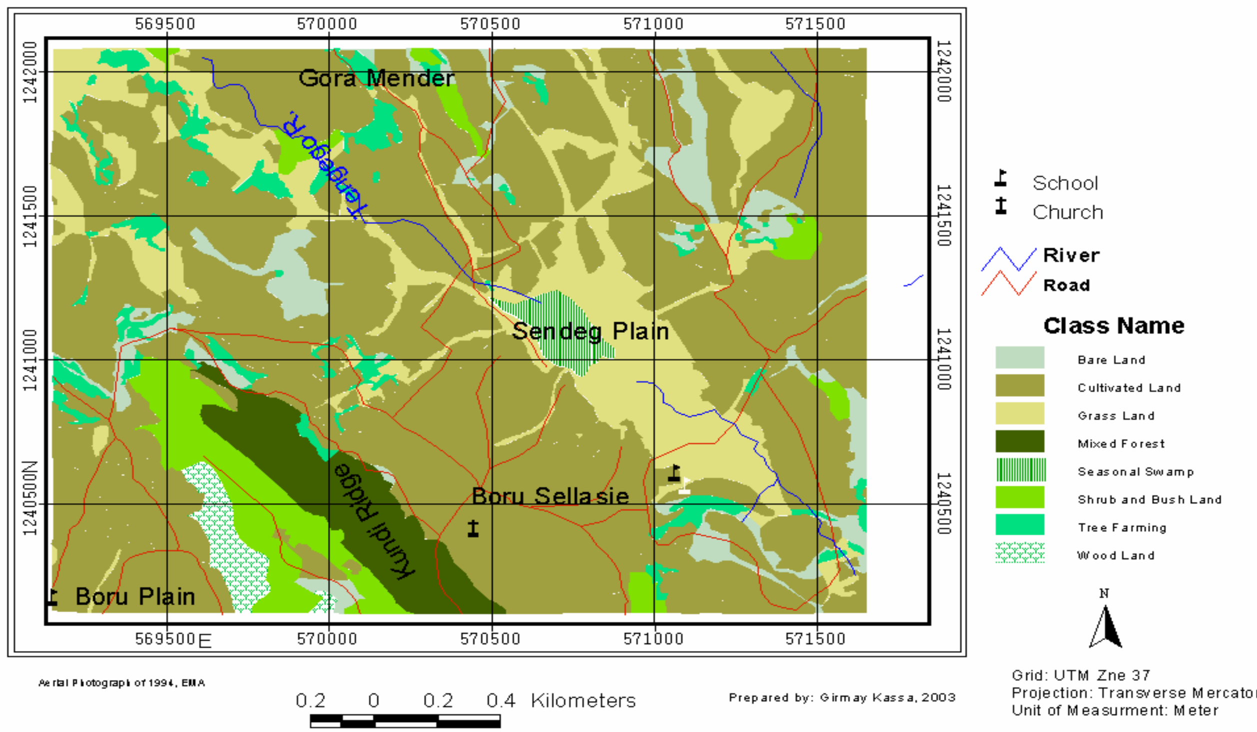


Fig.13

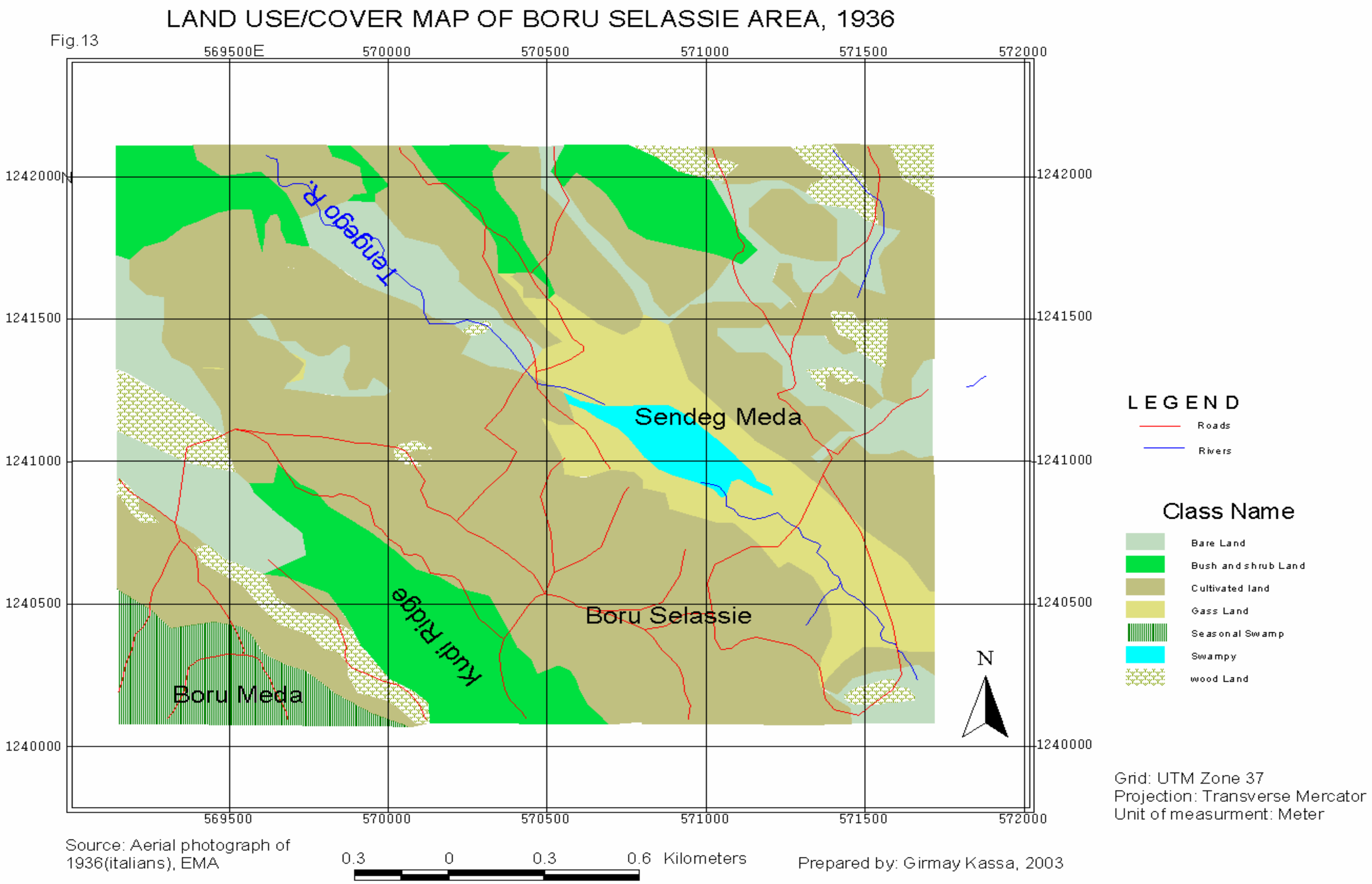
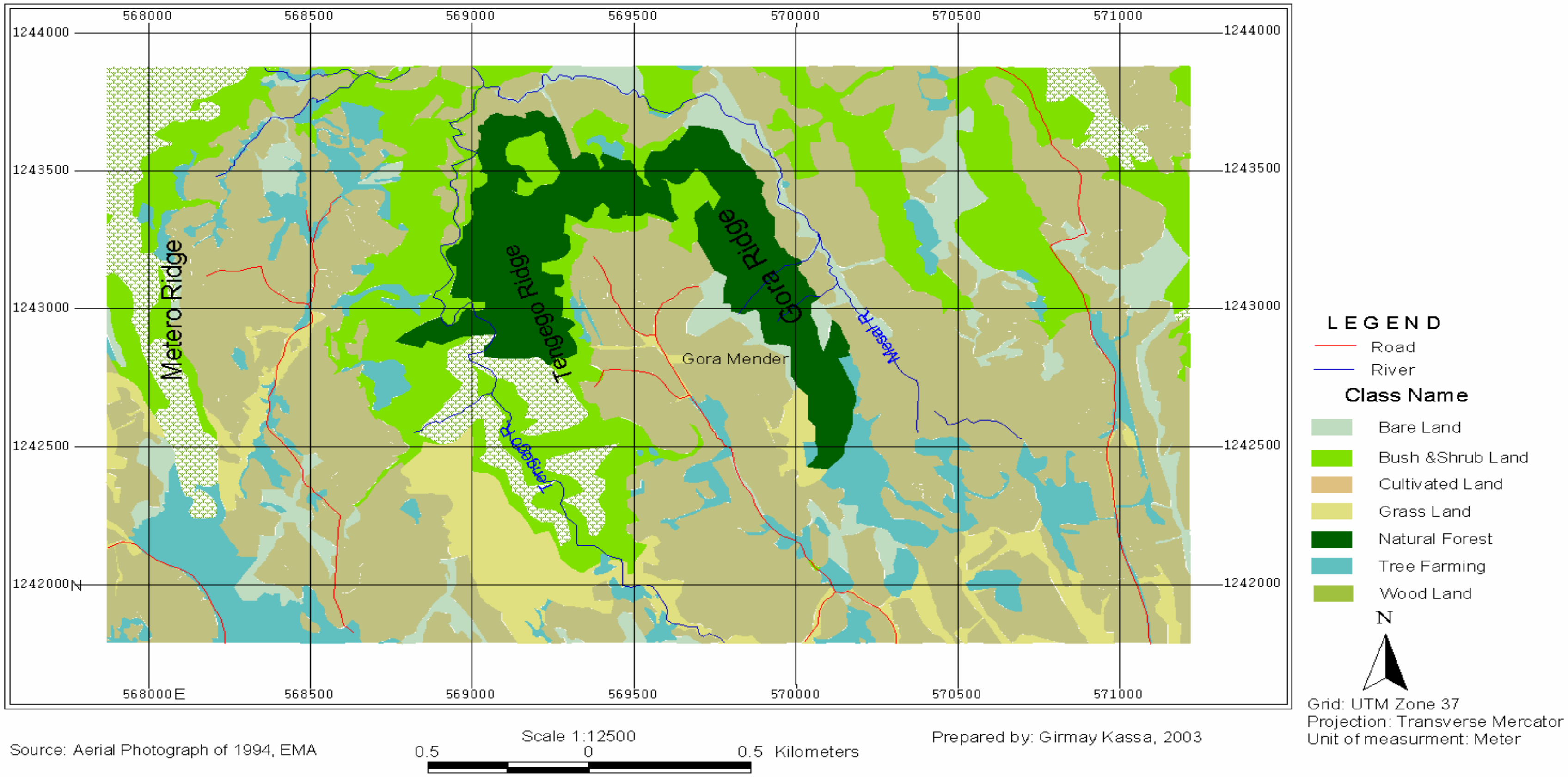

LAND USE/COVER MAP OF BORU SELASSIE AREA, 1936
569500E
570000
570500
571000
571500
572000
1242000N
1241500
1241000
1240500
1240000
Tengego R.
Sendeg Meda
Boru Selassie
Kudi Ridge
Boru Meda
N
LEGEND
Roads
Rivers
Class Name
Bare Land
Bush and shrub Land
Cultivated land
Gass Land
Seasonal Swamp
Swampy
wood Land
Grid: UTM Zone 37
Projection: Transverse Mercator
Unit of measurment: Meter
Source: Aerial photograph of 1936(italians), EMA
0.3 0 0.3 0.6 Kilometers
Prepared by: Girmay Kassa, 2003

Fig.14 LAND USE/LAND COVER MAP OF GORA AREA SOUTH WELLO, 1994



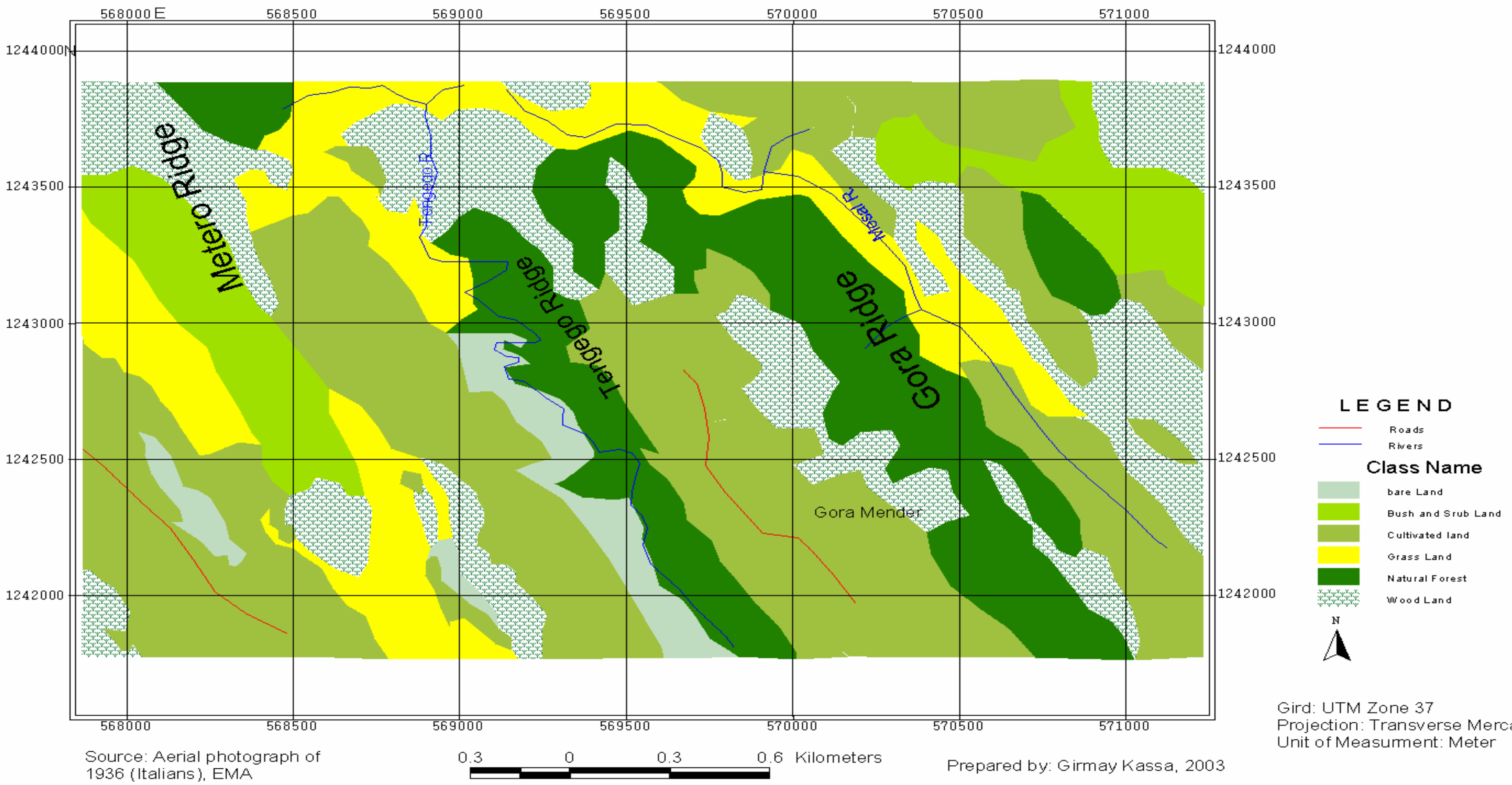
Source: Aerial Photograph of 1994, EMA

Scale 1:12500
0.5 0 0.5 Kilometers

Prepared by: Girmay Kassa, 2003

Fig.15

LAND USE/COVER MAP OF GORA AREA, 1936



Source: Aerial photograph of 1936 (Italians), EMA

Gird: UTM Zone 37
Projection: Transverse Mercator
Unit of Measurment: Meter

Prepared by: Girmay Kassa, 2003

4.1.2 Land use/Land cover changes Observed in *Boru sellassie* area between 1936 and 1994

The analysis of land use and land cover changes carried out in a sample areas of about 513 ha based on the aerial photos of 1936 and 1994 showed the cropland (50.83%) in 1936 and increased to (64.25%) in 1994. (Table16, Fig 12 and 13). However contrary to general expectations, the change was not so much, which is only an increase of 1.18 ha/yr). But *Kundi* ridge near *Boru* town was covered with only bush and shrubs in 1936 but forested with juniperus procera and eucalyptus trees in 1994 (Table16).

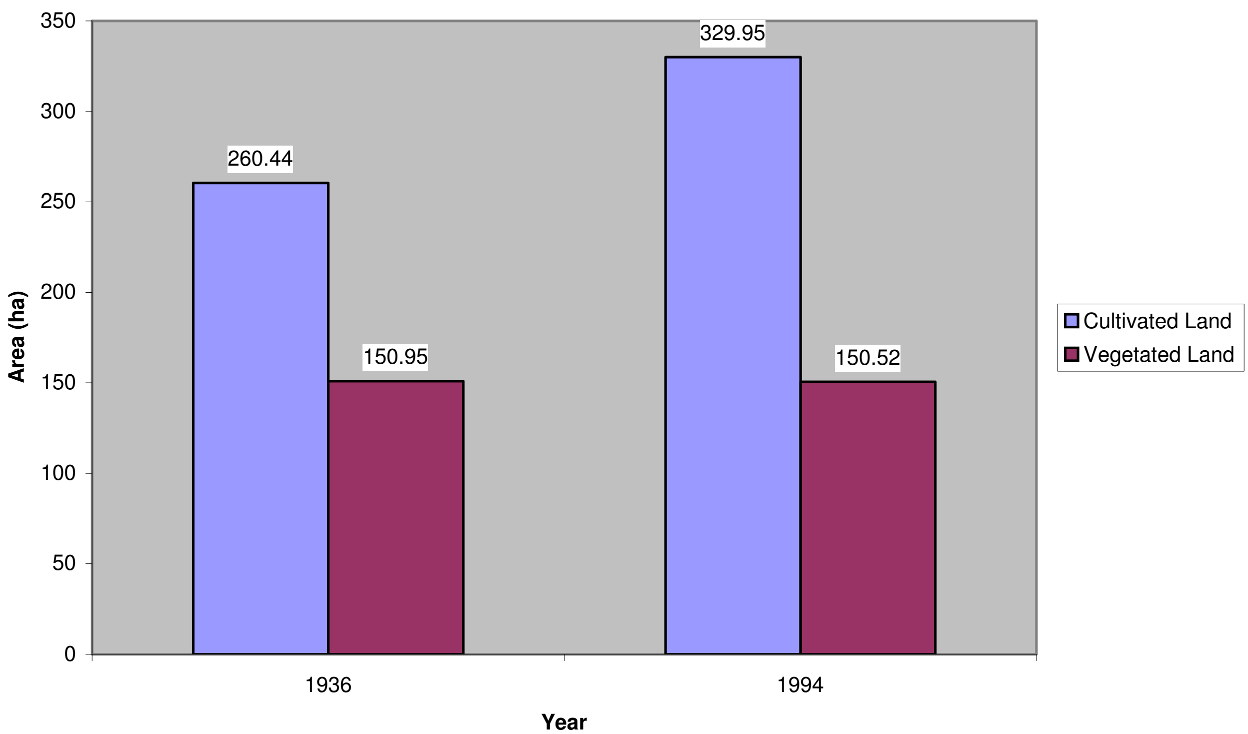
Table16: - Land use/Land cover changes of *Boru Sellassie* area, between 1936 and 1994.

Land use /Land cover type	Land use/Land cover area changes				Changes in land use/ Land cover (in ha)
	1936		1994		1936-1994 (ha)
	Area (ha)	%	Area (ha)	%	
Bare land	70.48	13.76	27.58	5.37	-42.9
Bush & shrub land	70.40	13.74	27.36	5.33	-43.04
Cultivated land	260.44	50.83	329.95	64.25	+69.51
Grass land	54.04	10.55	72.64	14.14	+18.6
Mixed forest	0	0	23.69	4.61	+23.69
Tree Farms	0	0	20.31	3.96	+20.31
Swampy area	7.95	1.55	0	0	-7.95
Temp. Grass land	22.53	4.40	5.51	1.07	-17.02
Wood Land	26.51	5.17	6.52	1.27	-19.99
Total	512.35	100	513.56	100	

Source: Analyzed from 1936 and 1994 aerial photos.

It was found that the total vegetation cover, taking i.e. (mixed forest, tree farming, grass land, wood land & bushes & shrubs), decreased from (29.46%) in 1936 to only (29.31%) in 1994. (Fig. 16), while cropland shows an increase of 50.83 percent in 1936 to 64.25 percent in 1994. The increment of cropland was to the bare lands and seasonal swamps (Table16).

Fig. 16 Area of cultivated land and Vegateted land of Boru Selassebetween 1936 and 2994



4.1.3 Land use/cover change observed in *Gora* area between 1936 and 1994

Gora area is another sample different from *Boru Sellassie* with considerable forest cover. During the period between the two aerial photographs (1936-1994), a major part of the area was under cultivation. Cropland increased from 37.22percent in 1936 to 48.91percent in 1994 with only an increase of 1.41 ha/yr. The natural forest cover declined from 18.22percent in 1936 in to

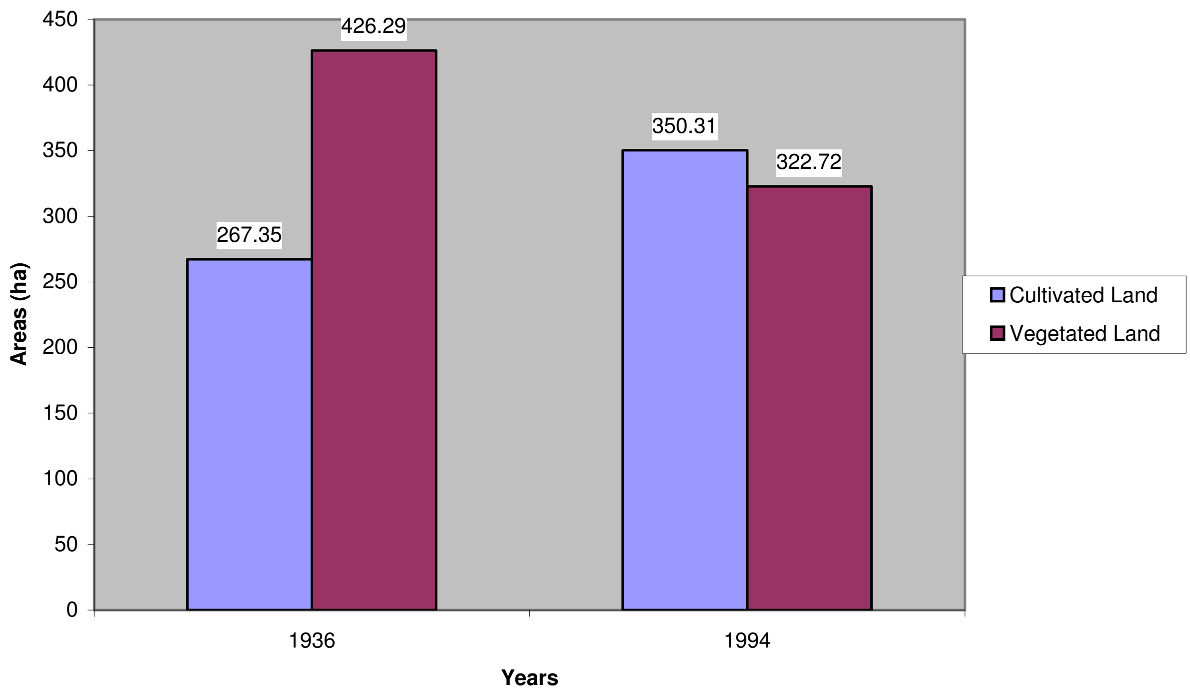
7.70percent in 1994 (Table17and Fig.14, 15 and17). This shows that about 57.91% of the natural forest was destroyed between 1936 and 1994. Similarly woodland has decreased from 17.91percent in 1936 to 6.0percent in 1994.

Table17: Land use/Land cover changes of *Gora* Area, between 1936 and 1994 .

Land use /Land cover type	Land use/Land cover area changes				Changes in land use/ Land cover (in ha)
	1936		1994		1936-1994 (ha)
	Area (ha)	%	Area (ha)	%	
Bare land	24.61	3.43	43.27	6.04	+18.66
Bush & shrub land	61.42	8.55	118.2	16.50	+56.78
Cultivated land	267.35	37.22	350.31	48.91	+82.96
Grass land	96.64	13.45	42.43	5.92	-54.21
Natural forest	130.9	18.22	55.1	7.70	-75.8
Tree Farming	0	0	63.98	8.93	+63.98
Wood land	137.33	19.12	43.01	6.00	-94.32
Total	718.25	100	716.30	100	

Source: Analyzed from 1936 and 1994 aerial photos.

Fig 17 Area of culticated land and vegetated land of Gora Area in 1936 & 1994



The comparison done between cropland and the total vegetation cover i.e. (natural forest, grass land, wood land, bushes and shrubs as well as plantation) show that the total vegetated area declined from 59.35percent in 1936 to 45.05percent in 1994 and crop land has increased from 37% in 1936 to 49% in 1994 (Fig 17).

4.2. Implications of the observed land use/ Land cover changes.

The land use/land cover change observed in the study area and elsewhere in the nation has a negative impact on both the environment and socio-economic settings. For instance the expansion of cultivated land in the study area was at the expense of grasslands, woodlands and natural forests. Due to the expansion of farmland on to the steep slopes, land has greatly deteriorated.

Accelerated erosion on cultivated slopes was encouraged. As Belay Tegene (2000), stated the factors that directly contributed to accelerated erosion on cultivated land in the South *Wello* are the cropping and land management practices, as crop cultivation is practiced on steep slopes and on shallow soils without appropriate conservation measures. An increase in forest cover in some parts of the study area does not imply environmental rehabilitation, because most of the planted forests consist of not endogenous but eucalyptus trees, which bring in disturbance in the ecological system of the area..

The observed increases in afforested areas did not improve the hydrological conditions of the area. Conversely most of the eucalyptus trees planted are known to absorb a great amount of water, as the local informants and elderly people mentioned its effect in drying many springs, is very well observedaround *Boru Selasse* area.

The general loss of vegetation (indigenous) cover and its possible implication of ecological disturbances of the area in particular and the country in general have already led to problems of land degradation and many also lead to further destructive scenario for the future. As discussed by many scholars regarding the 1973 famine in *Wello* was associated with the activities of deforestation and clearing of vegetated areas for cultivation.

The study has a remarks to the conflicting conclusions made by the past studies regarding vegetation cover in Wello area as stated in the statement of problem. According to the 1936 and 1994 aerial photos of Boru Sellassie area shows an increased of vegetation cover in 1994 than in 1936. On the other hand the study done for

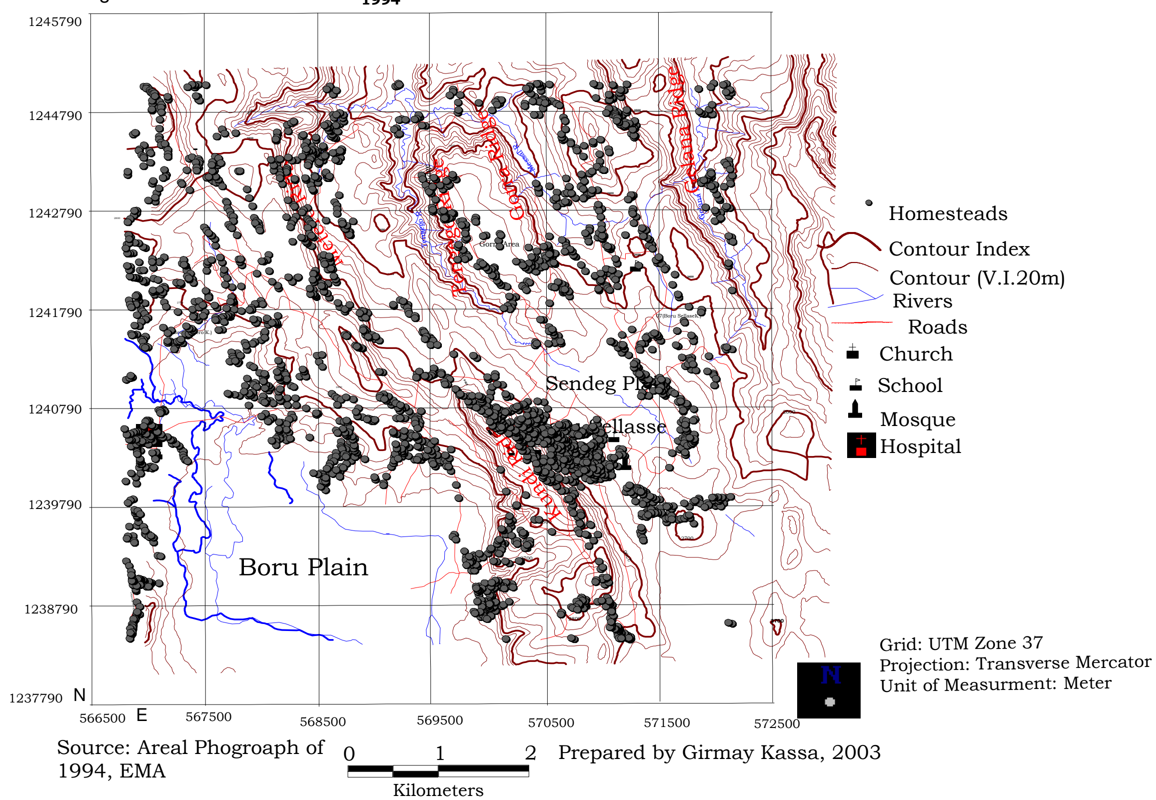
Gora area of the same years showed less vegetation cover in 1994 than 1936. This shows that the study of land use land cover in the region at local level depends on whether the area has some plantation activities or not in the past years has to be investigated.

4.3. Contributions of population growth to land use/ Land cover changes.

Land use land cover changes are caused by a number of natural and human driving forces. The effects of human activities are immediate and often radical, while the natural effects such as climatic change has a prolonged one. Analysis of the aerial photographs showed that the rural population the study area in 1965, 1986 and 1994 years was 5404, 8050, and 9774 respectively. This population concentration shows 175 persons/km^2 in 1965, 261 persons/km^2 in 1986 and 317 persons /km^2 in 1994 (Table18). The agricultural density of the area was estimated at 389.93in 1965, 572.52 in 1986 and 637.99 in 1994 persons/km^2 of cultivated land (Table18). This density also shows an increasing rate. Such huge concentration of rural population has no other alternatives except to use all resource of the land. As clearly pointed out by the World Commission on Environment and Development, "Those who are poor and hungry will often destroy their immediate environment in order to survive….", (1987:28, cited on Belay et al 2000). Due to this reasons land degradation is sever in the area.

Fig.18

Distribution of Rural Households of Boru-Metero, S.Wello 1994

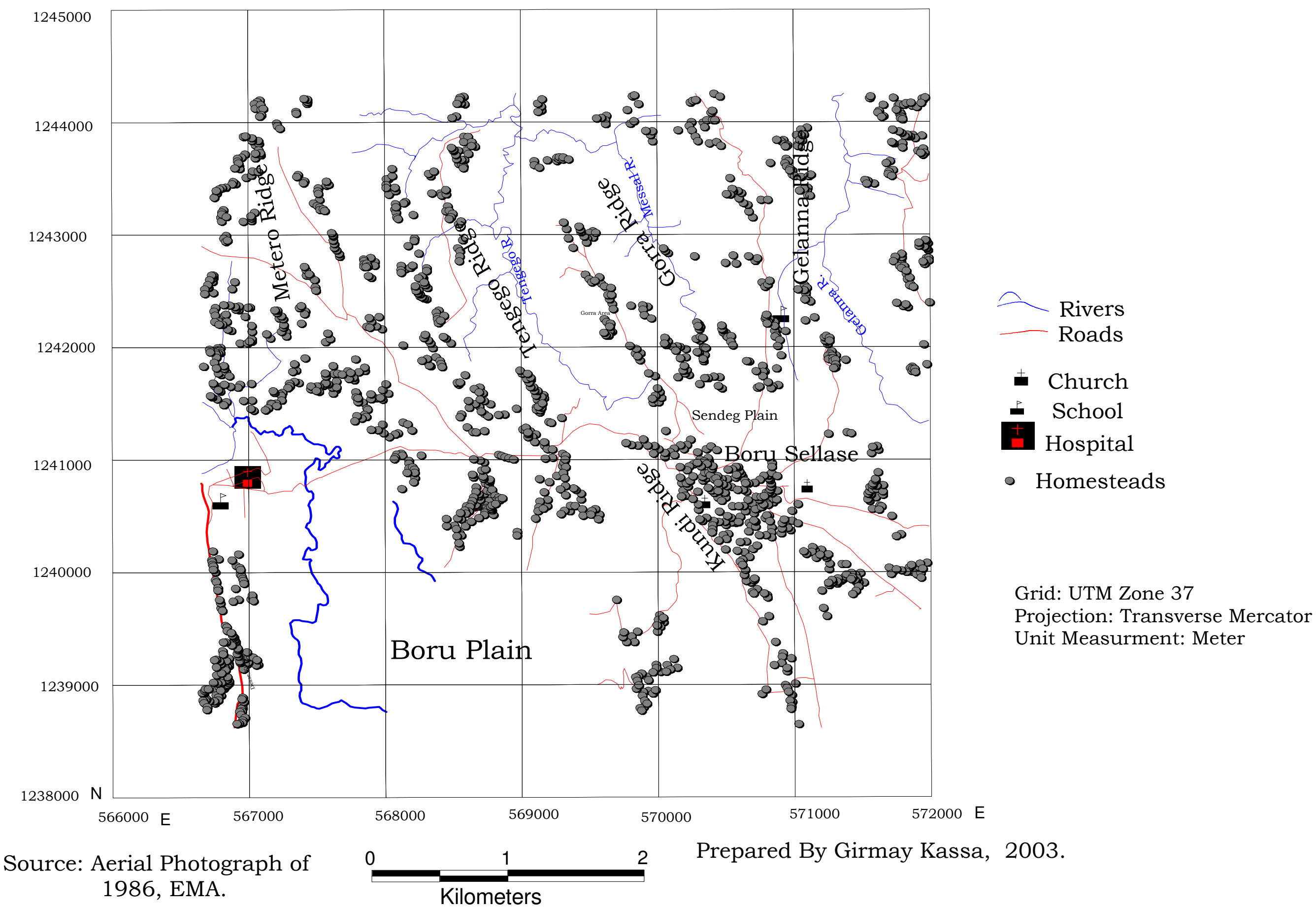


Source: Areal Phogroaph of 1994, EMA

Prepared by Girmay Kassa, 2003

Fig.19

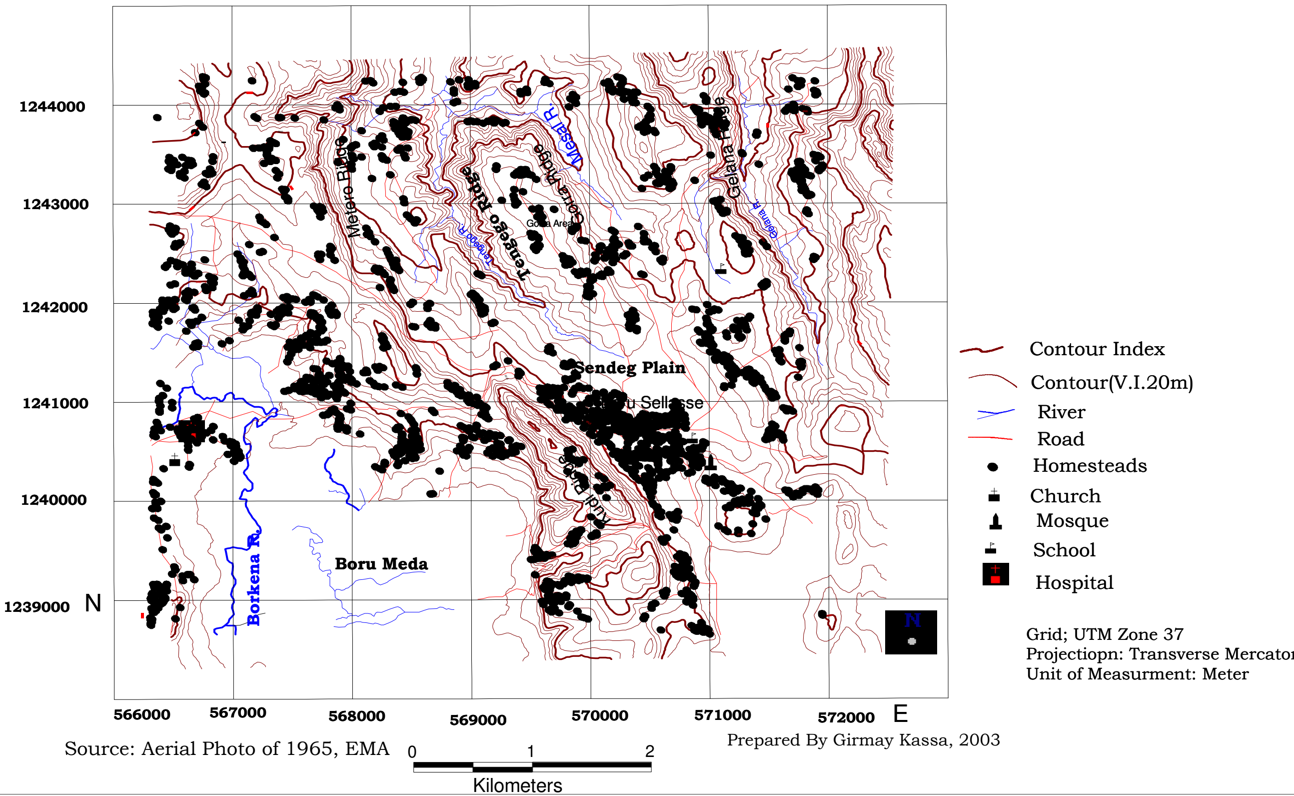
Distribution of Rural Households of Boru-Metero, S.Wello 1986



Source: Aerial Photograph of 1986, EMA.

Prepared By Girmay Kassa, 2003.

Fig.20 **Distribution of Rural Households in Boru -Metero, South Wello 1965**



Source: Aerial Photo of 1965, EMA

Prepared By Girmay Kassa, 2003

Fig 21

Distribution of Rural households of Boru Sellassie, 1994

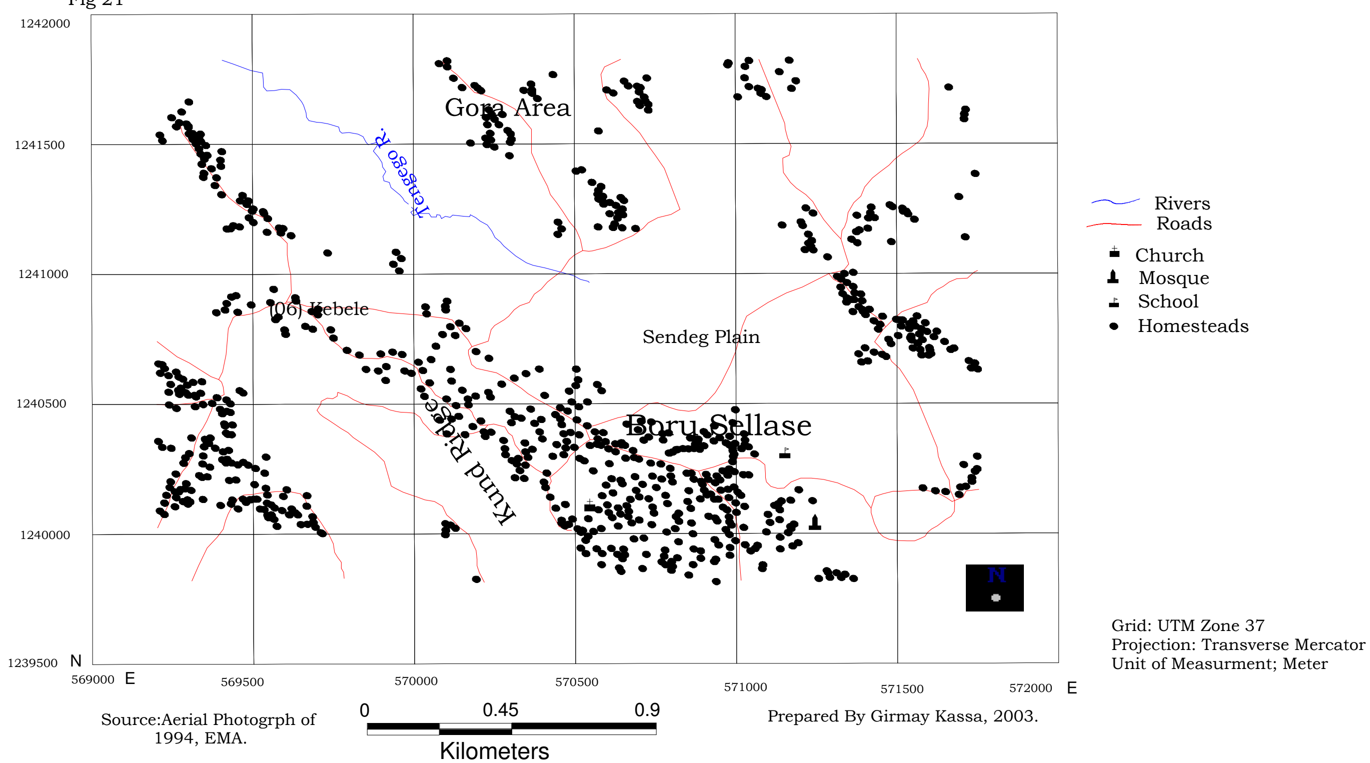
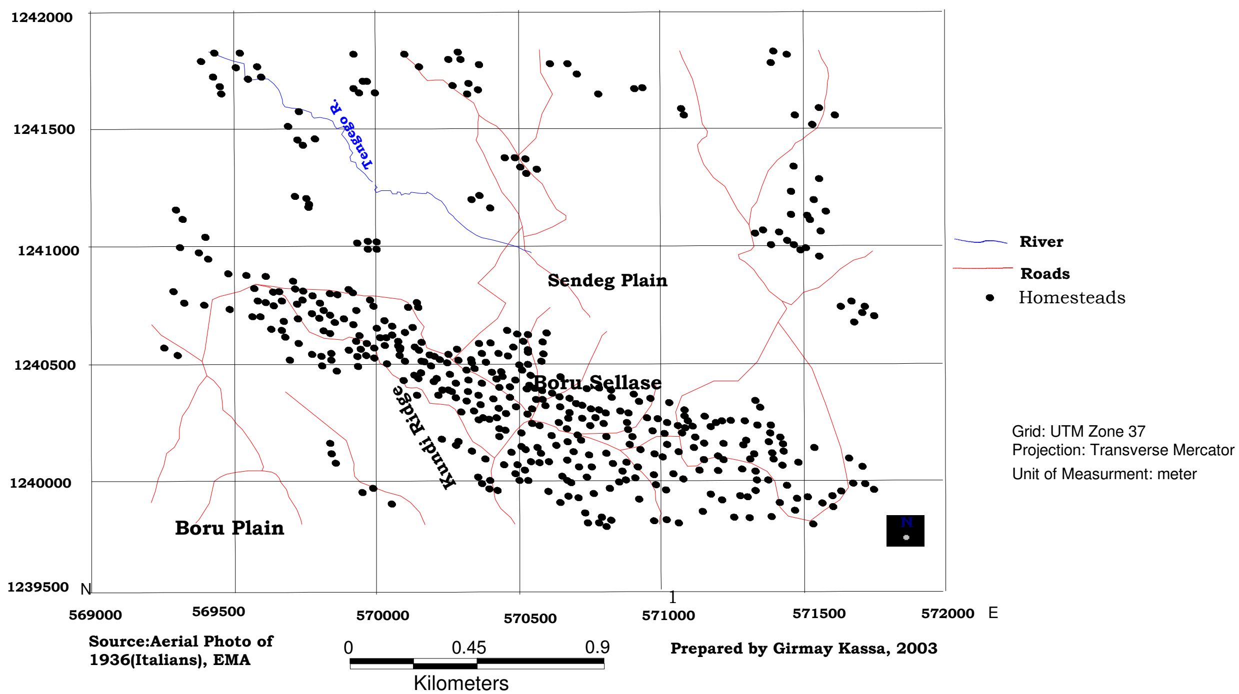
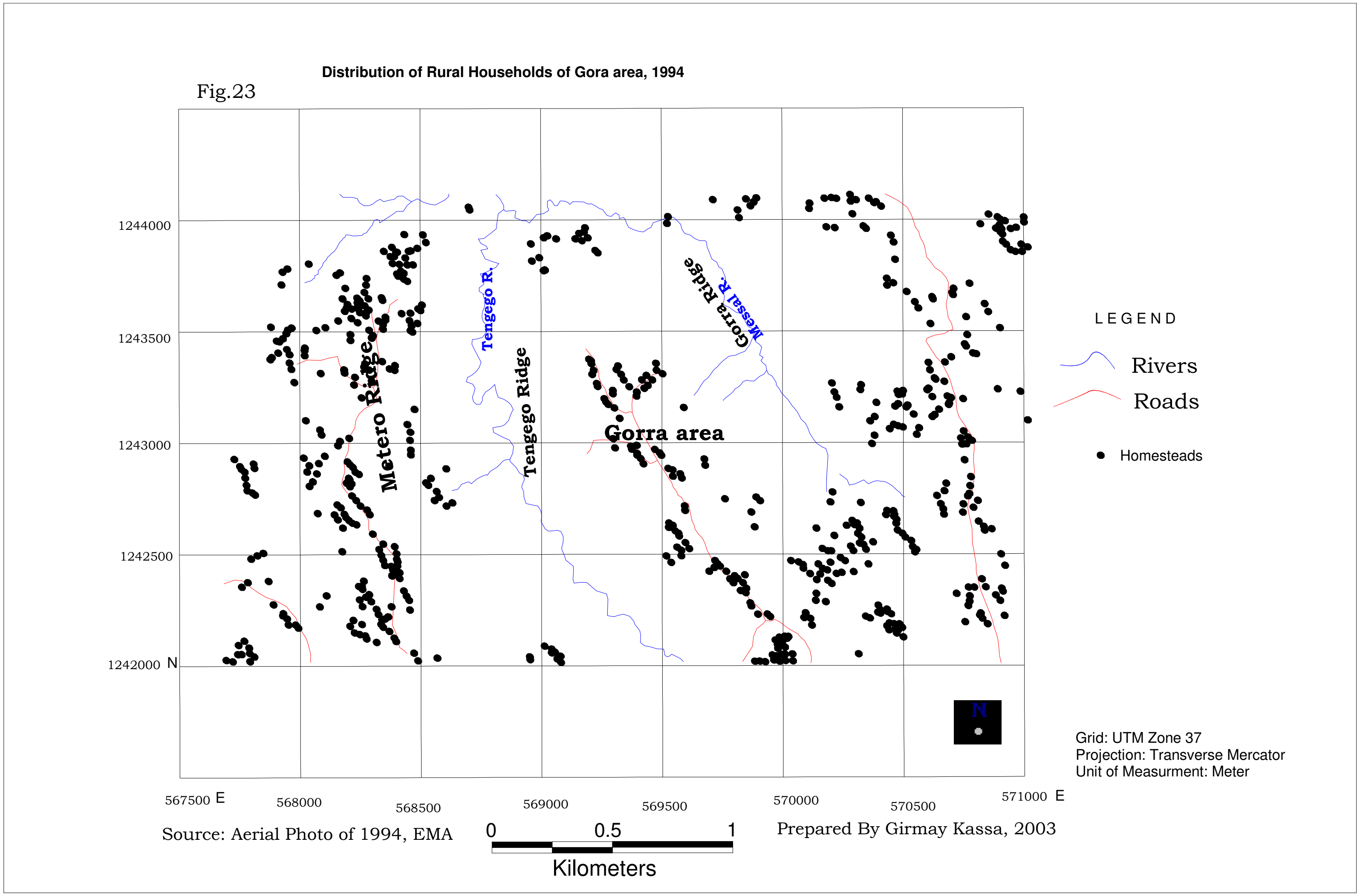


Fig.22 Disribution of Rural Household of Boru-Sillassie, 1936





Distribution of Rural Households of Gora area, 1994
Fig.23
1244000
1243500
1243000
1242500
1242000 N
Tengego R.
Metero Ridge
Tengego Ridge
Gorra area
Gorra Ridge
Messal R.
LEGEND
Rivers
Roads
Homesteads
N
Grid: UTM Zone 37
Projection: Transverse Mercator
Unit of Measurment: Meter
567500 E
568000
568500
569000
569500
570000
570500
571000 E
Source: Aerial Photo of 1994, EMA
0
0.5
1
Kilometers
Prepared By Girmay Kassa, 2003

Distribution of Rural Households of Gora area, 1936

Fig.24

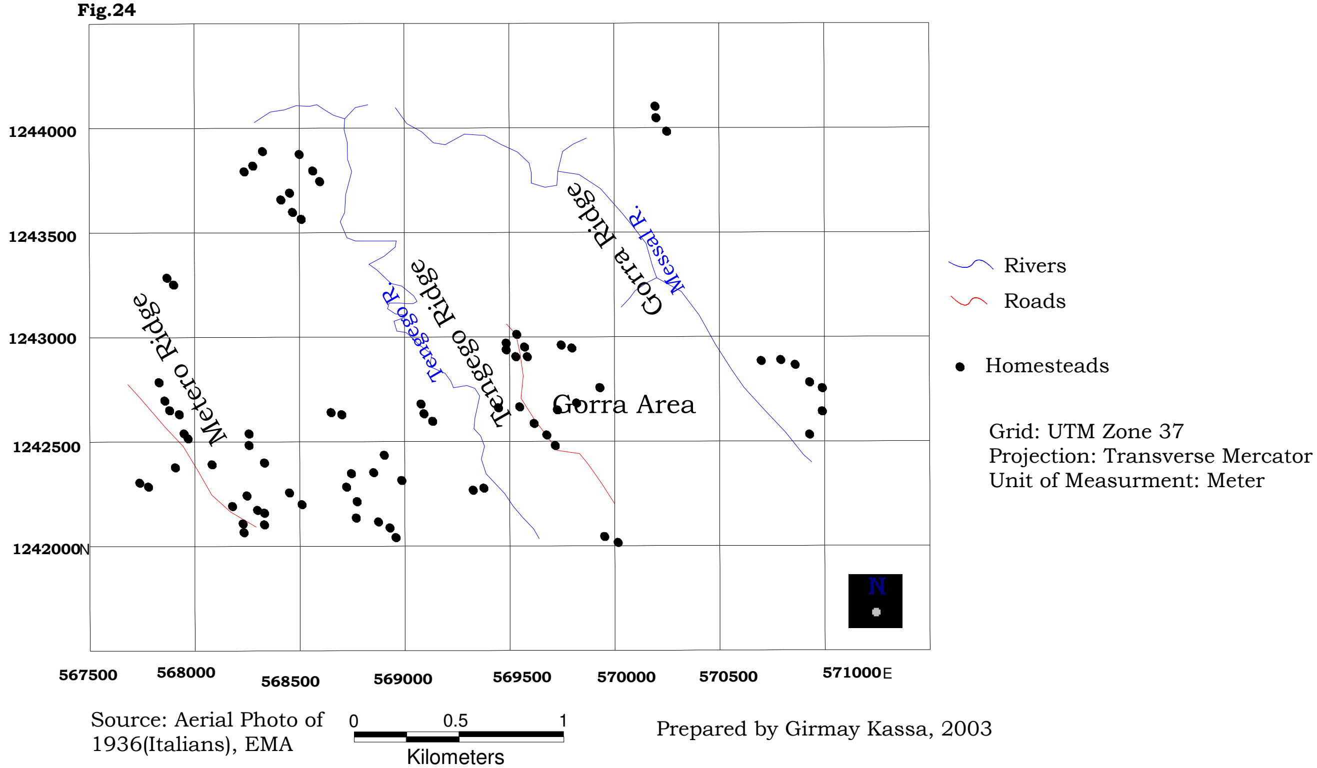


Table 18. Interpolated population changes based on a household count of Boru-Metero for 1936, 1988 and 1994 aerial photographs.

Study area	Year	Assumed family size	Number of household	Interpolated population number	Cultivated land (ha)	Area of the study (ha)	Agricultural density	Population density (person/ km^2)
Boru Meteo	1965	4	1351	5404	1385.9	3088	389.93	175.00
	1986	5	1601	8050	1526	3088	527.52	260.68
	1994	4.5	2172	9774	1532	3088	637.99	316.52
Boru Sellassie	1936	4	382	1528	260.44	513	586.70	297.85
	1994	4.5	778	3501	329.5	513	1062.52	682.46
Gora Area	1936	4	79	316	267.35	717	118.20	44.07
	1994	4.5	580	2610	350.31	717	745.05	364.02

Source: Analyzed from aerial photographs of 1936,1965,1986 and 1994 by the researcher.

* The family size for 1986 and 1994 was extracted from *Tehuledere WeredaBoA*, while an assumed number is used for1965 and 1936. The population size used here is only for rural households, except *Boru* Sellassie, which includes the market town.

The over all increase in population that was mentioned earlier and the fact that the region has one of the lowest per household land holdings (0.57 ha/household) (CSA 1995a) indicate the seriousness of population pressure on land resources. Although there are differences from one locality to another, high population concentration is observed in *Boru-Sellassie* area. To tackle the scarcity of land resources some communities have tried to integrate trading and animal rearing with crop production. If these activities were guided properly and supported effectively people might have changed their way of life and ease the pressure on land. But that was not the case hence there is little or no off-farm employment with which people may supplement their income from agriculture as a result the population almost entirely depends on the land resources of the area. As a result the population continues to degrade the natural resources and change the land cover.

4.4. Population pressure as a major cause for land use/cover changes in 1936, 1965, 1986 and 1994.

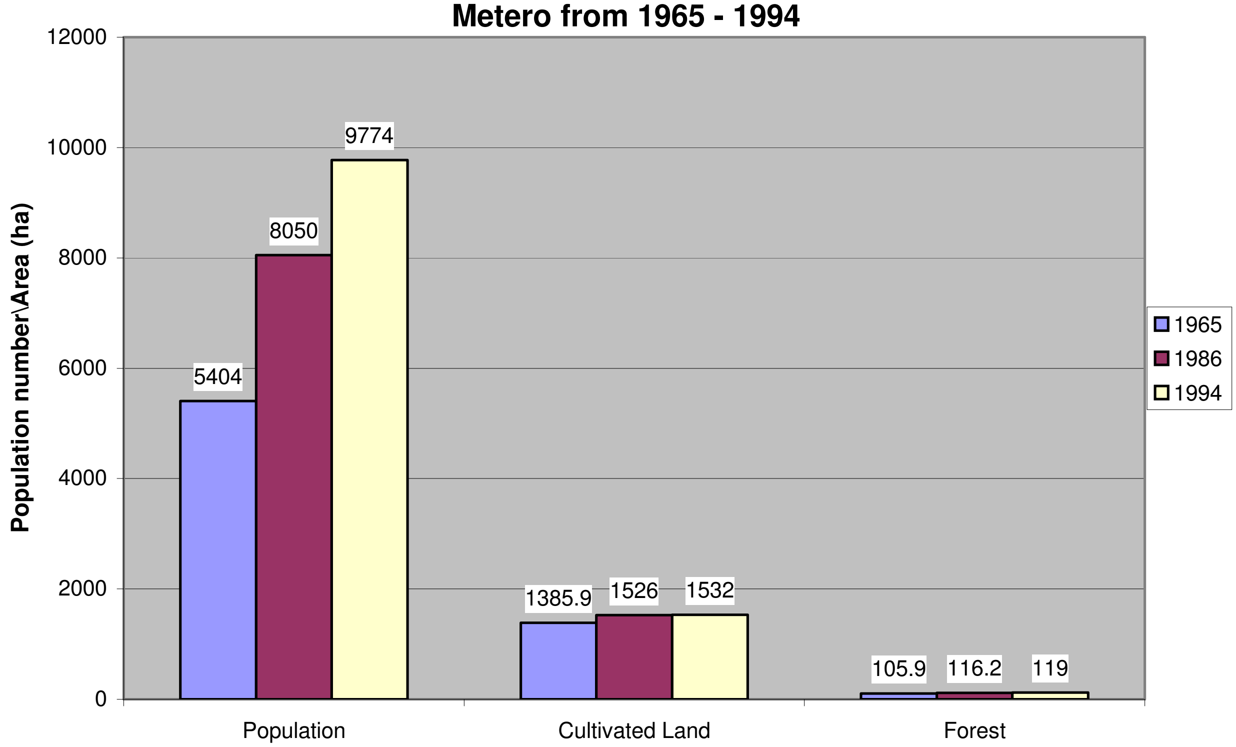
Many geographers' sociologists, ecologists land use planners such as Hurni H (1989), Markos Ezra (1997), Yeraswork Admasse (2000), Belay Tegene (2000), Gete Zeleke (2000), etc, stated on their studies that the northern Ethiopian high lands that have been a center of civilization for thousands of years are currently exposed to high population pressure. Consequently they are now devoid of natural vegetation, heavily degraded and frequently affected by drought and famine.

In fact, as indicated in the literature review, rapid population growth by itself need not be a problem if it were supported and guided with appropriate land use policy. Otherwise it is a huge threat to the environment as observed in many parts of the Ethiopian highlands. For instance the 1972/73 and 1984/85 famines, which took the lives of many hundreds of thousands of people and livestock in north-eastern Ethiopia was partly attributed to several hundred years of population pressure and poor land management systems. (Hurni H. 1996 and Recnberg R. 1998 cited on Gete Zeleke 2000).

Population pressure is believed to be one of the causes of the observed land use changes. In order to analyze the changes in population using GIS method interpretation was done from the respective aerial photographs of 1965, 1986 and 1994 for the whole study as well as for small sample areas (Gora and Boru Sellassie) based on aerial photos of 1936 and 1994. (See the details form the methodology part).

The aerial photographs of 1965, 1986 and 1994 showed that the total number of households increased by 18.5% between 1995 and 1986 (within 21 years) and by 35.67% between 1986 and 1994. (Table 18 & Fig 25).

Fig.25 Population and major land use/ Land cover changes in Boru-Metero from 1965 - 1994

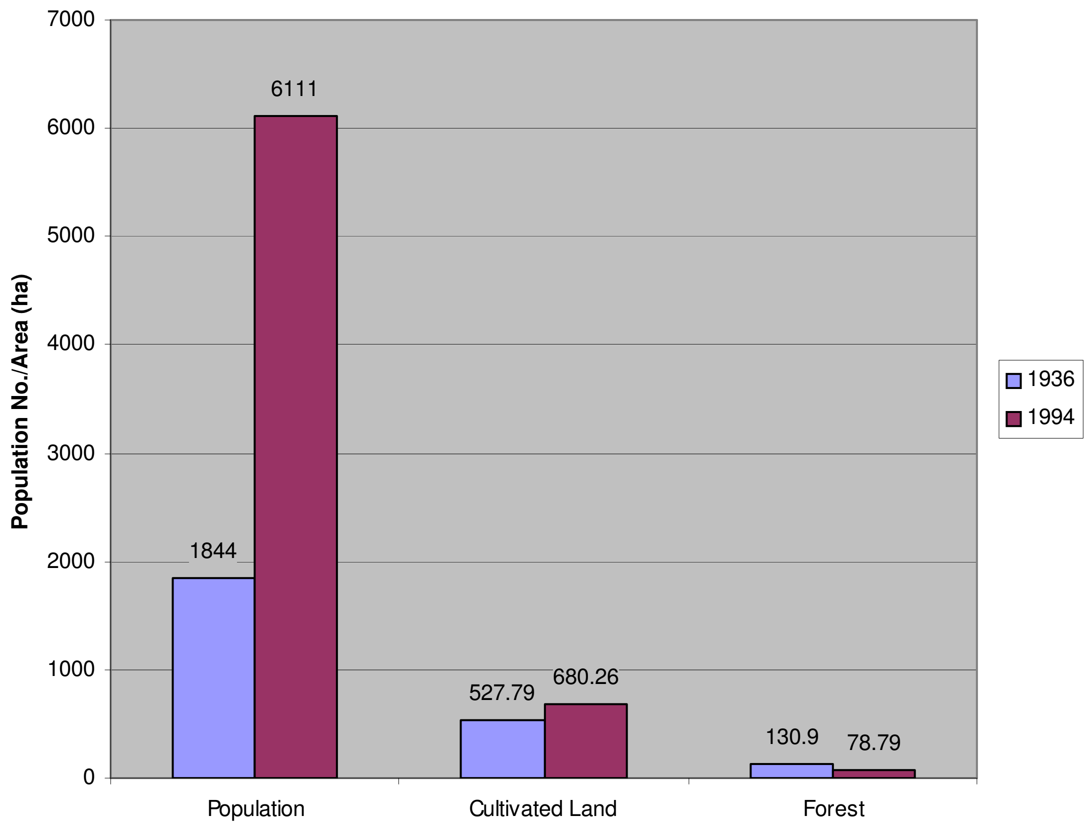


Comparison was done between major land use/land cover types (cultivated and forest lands) and population number. Population size which was 5404 in 1965 and increased to 8050 in 1986 and to 9774 in 1994. And it shows an addition of 48.96% from 1965 to 1986 and 21.42% from 1986 to 1994. (Table18 and Fig.25).

When we relate this population growth to the cultivated land, the change was significant with the addition of only 140.1 ha of cultivated land between 1965 and 1986 and 6 ha between 1986 and 1994 (Table18). The increase in cultivated land could not keep pace with the rapid population growth as land suitable for farming has already been brought under cultivation. There was a slight increase in forested land observed because of the new forest plantation and tree farming in the area.

Interpretation of the 1936 and 1994 aerial photos for the sampled areas of *Boru Sellassie* with (513ha of land) and *Gora* areas (717ha) and the result shows, households increased from 382 in 1936 and to 778 in 1994 of *Boru Sellassie* area. (Fig.21and22). The interpretation of households between 1936 and 1994 in *Boru Sellassie* shows population of 1528 in 1936 and increased in to 3501 in 1994. The change was only 33 people per year, which indicate high population in 1936 because *Boru Sellassie* area has been a known market center until the Italian occupation. *Gora* area was settled by only a household of about 79 in 1936 and increased to 580 in 1994, and population was counted as 316 and 2610 in 1936 and 1994 respectively. (Table18 and Fig 23, 24 and 26).

Fig.26 Population and magor land use/ Land cover changes of Boru Sellase and Gora area in 1936 and 1994



The results of analysis show that a population increase of 1973 was accompanied by a cropland increase of only 70ha.There was very little forest cover around *Boru Sellassie* area in 1936 but there was an area of 23.69ha of mixed forest in 1994.

Gora area is different from *Boru Sellassie* where its natural vegetation cover was higher in 1936 with 130.9 ha of the indigenous tree species (Juniperus Procera) on its ridges. This natural forest decreased to about 55.1ha in 1994. But cultivated land was still higher in 1936, which was 267.35 ha and increased to 350.31ha in 1994. (Table17). A combined analysis between major land use/land cover of cultivated land, forestland and population size of *Boru-Sellassie* and *Gora* areas show that, an increase of population from 1844 in 1936 to 6111 in 1994. About 4267 additional people were counted until 1994 in both areas. But forest cover declined from 130.9ha in 1936 (a recorded of *Gora* area) to 55.1ha in 1994. Regarding cropland, the change was shown as 527.79ha in 1936 and increased to 680.26ha in 1994. This shows an additional land of about 152.47ha was recorded in 1994 to support an added population of 4267. (Fig.26).

CHAPTER FIVE

5. Conclusions and Recommendations

5.1. Conclusions

The land use/and land cover change, land degradation and population pressure analysis carried out for *Boru-Metero* area of South *Wello* at a scale of 1:12500 based on aerial photographs of 1936, 1965, 1986 and 1994 clearly indicates a considerable change in land cover and population.

The result shows that the natural forest cover in the area declined from 3.43 percent in 1965 to 2.74 percent and 2.5percent in 1986 and 1994 respectively. While woodland increased from 4.36 percent in 1965 to 8.17 percent in 1986, primarily because of the modification of the forest cover to wooded lands. But woodland also declined to 3.3 percent in 1994. Grassland cover of the area shows decrease from 10.28percent in 1965 to 5.12percent in 1986. The abrupt change of grassland in the area from 1965 to1986 may be the result of land tenure change between the stated years with subsequent expansion of cropland to marginal lands and grass lands. The second reason may also be the aforestation and enclosure programs done in the 1980's.

The interesting change was the increasing of tree (Eucalyptus) farming since 1965. It was only 1.63 percent coverage in 1965 and increased to 4.71 percent in 1986 and 4.63 percent in 1994. The tree farm coverage grew to about 95.02 ha in 1986 and 92.62 ha in 1994 which was only 50.38 ha in 1965. The increasing of eucalyptus farming in the study area as investigated in the field work, is not only on marginal lands but also on private farm lands and around homesteads as the financial benefit obtained was much larger than obtained from other crops grown on a piece of land.

The expansion of eucalyptus plantation with the dwindling natural forests has resulted in an expansion of a mixed type of forest (Eucalyptus and Juniperoud procera) near *Boru Sellassie* between1965 and 1986. As a result mixed forest cover was observed as 1.02 percent coverage in 1986 and 1.26 percent in 1994. The total area of mixed forest cover increased by 3.9 percent between 1986 and 1994. The expansion of mixed forests is attributed to the extensive aforestation and enclosure of hillsides in the 1970's and 1980's around *Kundi, Tengego, Metero, Gora* and *Gelanna* ridges in the area.

The major change of vegetation cover of the area took place between 1965 and 1986 where the 1965 forest cover was reduced by about 20percent. Bushes and shrub land cover also declined from 12.15 percent in 1965 to 9.11 percent in 1986 and slightly increased to 9.52 percent in 1994.

From the point of view of environmental protection the increasing of vegetation cover (indigenous) since 1980's is positive development. But the increased plantation and farming of eucalyptus trees has a negative effect in the area. As it is indicated on chapter three, the sample informants have reported the drying of springs, the disappearance of doctylion (Serdo Sar) and declining of crop production near plantations.

During the periods, cultivation of land extended to marginal areas. As indicated on (table 16) cropland coverage was 44.86 percent in 1965 but increased to 49.44 percent in 1986 and 49.62percent in

1994. Most of the expansion of cropland occurred between 1965 and 1986, (an increase of 10.11 percent).

The analysis of land use and land cover change in a sample area of about 513ha based on the 1936 and 1994 aerial photography showed that cropland cover increased from 50.83 percent in 1936 to 64.25 percent in 1994. The change of cropland has a similar trend as observed from 1965 to 1994, contrary to general expectations where the increment was only 1.18 ha/yr. The most interesting coverage change observed as stated above was around *Kundi* ridge of *Borusellassie* where no vegetation cover was observed in the ridge in 1936, but forested land was observed with mixed type of plantation in 1986 and 1994.

Another sample area used to analyze the 1936 with the 1994 aerial photographs was the *Gora* area of the study different in its vegetation cover from *Boru Sellassie.* The area taken for comparison was about 717 ha for both years of investigation. Significantly natural forest cover (Juniperous procera) declined from 18.22 percent in 1936 to 7.7 percent in 1994. About 57.91 percent of natural forest was destroyed between 1936 and 1994. Regarding cropland the change was from 37.22 percent in 1936 to 48.91 percent in 1994, which is 1.5 ha of additional cropland every year. The expansion of cultivated land since the stated year was at the expense of grasslands, woodlands and natural forests. Due to expansion of cropland to the steep slopes, land has greatly deteriorated largely by accelerated erosion.

The increase in forest cover in some parts of the study area does not imply the control of erosion in the whole study. The general loss of the indigenous vegetation cover and its possible implication of ecological disturbances of the area led to problem of land degradation and may also lead to further degradation of the environment in the future. We can conclude from these two sample study areas that the past studies done regarding vegetation cover in Wello area where some of them said, as there is an increase today, and others wrote as there is high deforestation than before depends on the local area under study. If the area was under some plantation and enclosure of hillsides in the 1980's, obviously the areas vegetation cover will be more than the coverage before and areas, which do not have such activities, were highly affected than before.

Land use and land cover changes are caused by a number of natural as well as artificial factors. But the effect of human activities is immediate and often radical, while the natural factors effect is a prolonged one. Analysis of the aerial photographs showed that the rural population of *Boru-Metero* in 1965, 1986 and 1994 years was found as 5404, 8050, and 9774 respectively, which was an estimated for the area of about 3088ha of land. This means that an additional population of 2646 between 1965 and1986; and 1724 between 1986 and 1994. But cropland increased from 1386.9ha in 1965 to only 1526 ha in 1986 and 1532 ha in 1994. The increased cropland was only 140.10ha from 1965 to 1986 and only 6 ha between 1986 and 1994.

Owing to land scarcity due to demographic pressure, farmers of the area were forced to use continuous cropping system by abandoning even seasonal fallowing and shifting cultivation. At *wereda* level of the study, the whole cropping system is based on continuous, which is the only coping strategy that farmers adopt to provide food for their family.

The population concentration analyzed from the stated aerial photos show a population density of 175 persons/km^2 in 1965, 216 persons/km^2 in 1986 and 317 persons /km^2 in 1994. The current population density of the *kebeles* (06 and 07) of the study area shows 415 and 289 persons/km^2 respectively. The result of agricultural density shows that, 389.93 persons/km^2 in 1965, 572.52persons/km2 and 637.99 persons/km^2 of cultivated land in 1986and 1994 respectively. Such huge concentration of rural population has no other alternatives except to use all the resources of the land and land degradation due to population pressure is severe in the area.

The views of the relationship between population growth and land degradation, the study follows the Malthusian views. Having alternative means of income reduces the overall dependence on agriculture, which in turn diminishes pressure on land and thus reduces the impact of population on land. But for the area under study, there is little or no off-farm employment with which people may supplement their income from agriculture. Nor can farmers invest in inputs such as fertilizers, selected seeds, etc. to increase the productivity of the smallholdings they cultivate. Thus, unlike to the Boserupian view mentioned in the literature the population in the study area depends almost entirely on the land they cultivate. Due to this, environmental and natural resource degradation induced by population pressure has one of the most frequently cited factors of land degradation in the area.

5.2 Recommendations

The following recommendations are made to enhance the future development of the area.

__ the area's land use/land cover changes observed and analyzed and the land degradation process attributed to them have been caused largely due to population pressure in the area. Therefore, careful management of the existing biophysical, socio-economic, government policies and institutional conditions have to be investigated before applying any development activities in the area.

__ farmers of the area lack motivation and awareness regarding forest protection and planting natural vegetation due to the influence of tenure insecurity. This may be the case that most farmers tend to plant trees in their homestead rather than far away lands. This needs proper land management on participatory basis with stable and appropriate land and tree tenure system that can integrate the increasing of tree farming with the indigenous tree plantation.

__ the population growth in the rural area of the region in general and the study area in particular is alarming where the land available for additional people is very small. The pressure of population on the already disturbed land has to be urgently controlled based on appropriate economic and social policies such as literacy campaigns, family planning, etc. in order to ease the stress on the natural resources.

__ the wood lots, boundary plantations, tree farms based on eucalyptus species represent a very attractive land use as stated before for the production of poles and fuel wood as a cash crop and hence need to be encouraged. But the appropriateness to the biophysical measure of reducing soil erosion is questioned. Since eucalyptus plantation does not permit rich undergrowth. The recent introduction of tree allotments on degraded mountain slopes seems to be successful in some regions. Although it does not provide private land ownership, it does guarantee of long term use right for the land.

__ last but not least, the application of GIS technology to the study of land use/land cover changes and land degradation on such local area found to be a helpful tool for managing and analyzing different attribute data and understanding the changes easily. Therefore, land use planners, geographers, foresters, soil scientists, etc, have to make more use of it in their research works.

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Questionnaire results of 65 sample farmers of the study area

I. Land ownership, production and scarcity of land and their copying strategies to food shortage.

1. Farm land situation:

   a. Land Ownerships

Farmer having		Land less	
Farm land	%	Farmers	%
60	92.31	5	5.69

   b. Size of farm land owned:

	Less than 0.25 ha	0.25-0.5 ha	0.5-0.75ha.	>1 ha
№:	2	4	54	-
%:	3.33	6.67	90	-

   c. Location of their farmland:

	Plain	Sloppy land
№:	42	23
%:	64.62	35.38

   d. Regarding farm land soil fertility:

	Fertile Land	Mixed type	Infertile land
№:	55	9	1
%:	84.62	13.83	1,54

   e. Land holding situation of the sampled farmers:

	Land is more than enough	Just enough	Too small
№:	0	25	40
%:	0	38.46	61.54

2. Land fragmentation:

   a. Grazing Land situation:

	Become Scarce	Just enough
№:	48	17
%:	73.85	26.15

b. Reason of scarcity of grazing land:

	Human Population Increase	Live stock increment	Both
№:	57	5	3
%:	87.69	7.69	4.62

3.Crop Production:

a. Annual Crop production to feed their family:

	1 - 5	6 - 10	>10 (Quintals)
№:	38	27	0
%:	58.46	41.54	0

b. Annual food security of the farmers produced on their farmland:

	Enough for 1 year	only for half a year	for 3 months only
№:	23	31	11
%:	35.38	47.69	16.92

4. Plantation and aferestation programs in the study area:

a) The reason of creasing Plantation:

	Scarcity of farmland	Increasing financial out put from it
№:	0	65
%:	0	100

b) The use of plantation trees in the study area

	Recovered the vegetation cover of the area	Not yet recommended
№:	60	5
% :	93.31	7.69

c. Competition of afforestation program with farm and grazing land:

	Yes there is	No there isn't
№:	18	47
%:	27.69	72.31

3. Copying strategies of the problem of grazing land and food security by the respondents

    a. Grazing land situation:

	Abandoning gov. forests	Reduce live stock population
№:	22	42
%:	33.85	64.62

    b. Food shortage

	Plantation Eucalyptus trees and selling fuel wood and poles	working as daily laborers	Small scale Trading
№:	38	1	19
%:	58.46	1.83	29.23

	By food for work	Others
№:	7	___
%:	10.77	___

II.Source of water and energy of the sampled respondents.

1.Source of drinking water

a)	Spring	Stream /River	Well	Pond/Lake	Pipe
№:	51	25	20	2	20
%:	78.46	38.46	30.76	3.08	30.77

b. Source of drinking water dried within the past 10 years.

	Yes	No
№:	15	47
% :	24.20	75.80

2.Energy resource of the farmers

a.

	Fuel wood	Crop residue	Cow dung	Charcoal	Electricity
№:	63	30	59	1	2
%;	96.92	46.15	90.77	1.54	3.08

b. Source of fuel wood

	Homestead Plantation	Natural Forest	Community forest	Purchased from market	From farm trees
№:	62	2	15	1	45
%:	95.38	3.08	23.08	1.54	69.22

c. Is there Scarcity of fuel wood?

	Yes	No
№:	25	40
%:	38.46	61.54

d. Reason for scarcity of fuel wood

	All fuel wood and poles are cutting for selling	Due to farm land expansion	Drought problem
№:	25	17	23
%:	38.46	26.15	35.96

e. Generally is land cover in the area is increasing?

	Yes	No
№:	45	16
%:	73.77	26.23

f. Is homestead plantation increasing than farm plot trees?

	Yes	No
№:	55	10
%:	87.62	15.38

g. What environmental problems do you face in year locality?

	Drought	Soil erosion & land sliding	drying springs and wells
№:	57	64	54
%:	87.69	98.46	83.31

h. What do you suggest the solution of environmental problem in your locality?

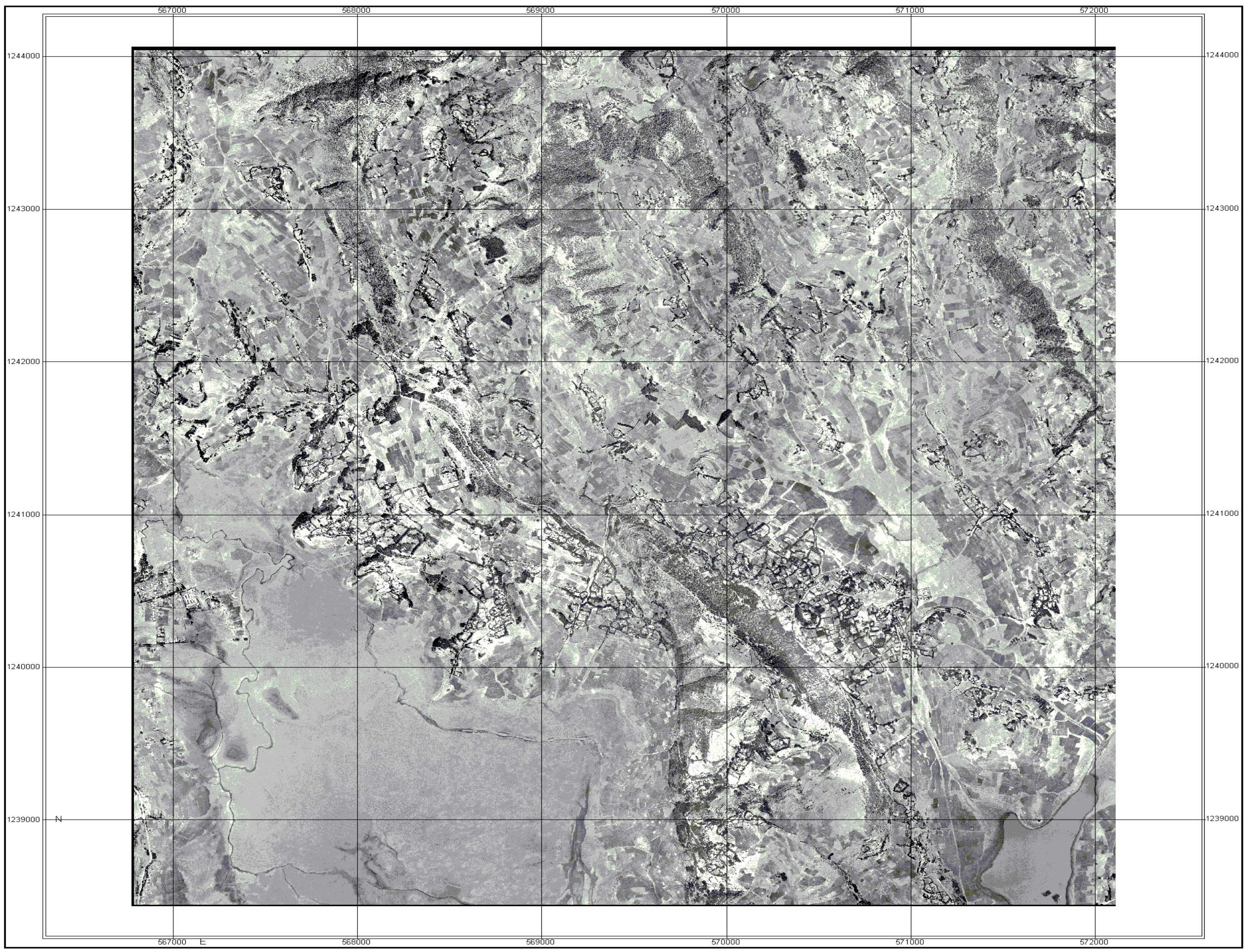
	Intensive awareness about the problems	Increasing aforestation	Prohibitions of cutting trees
№:	47	46	36
%:	72.31	70.77	53.38

Source: Interview of 65 sample farmers of *Beru Metero* South *Wello*.

Appendex-2

2. Original Aerial photographs of the study area.

ORTHOPHOTO MAP OF BORU-METERO, SOUTH WELLO, 1994



N

Grid: UTM Zone 37
Projection: Transverse Mercator
Unit of measurment: Meter

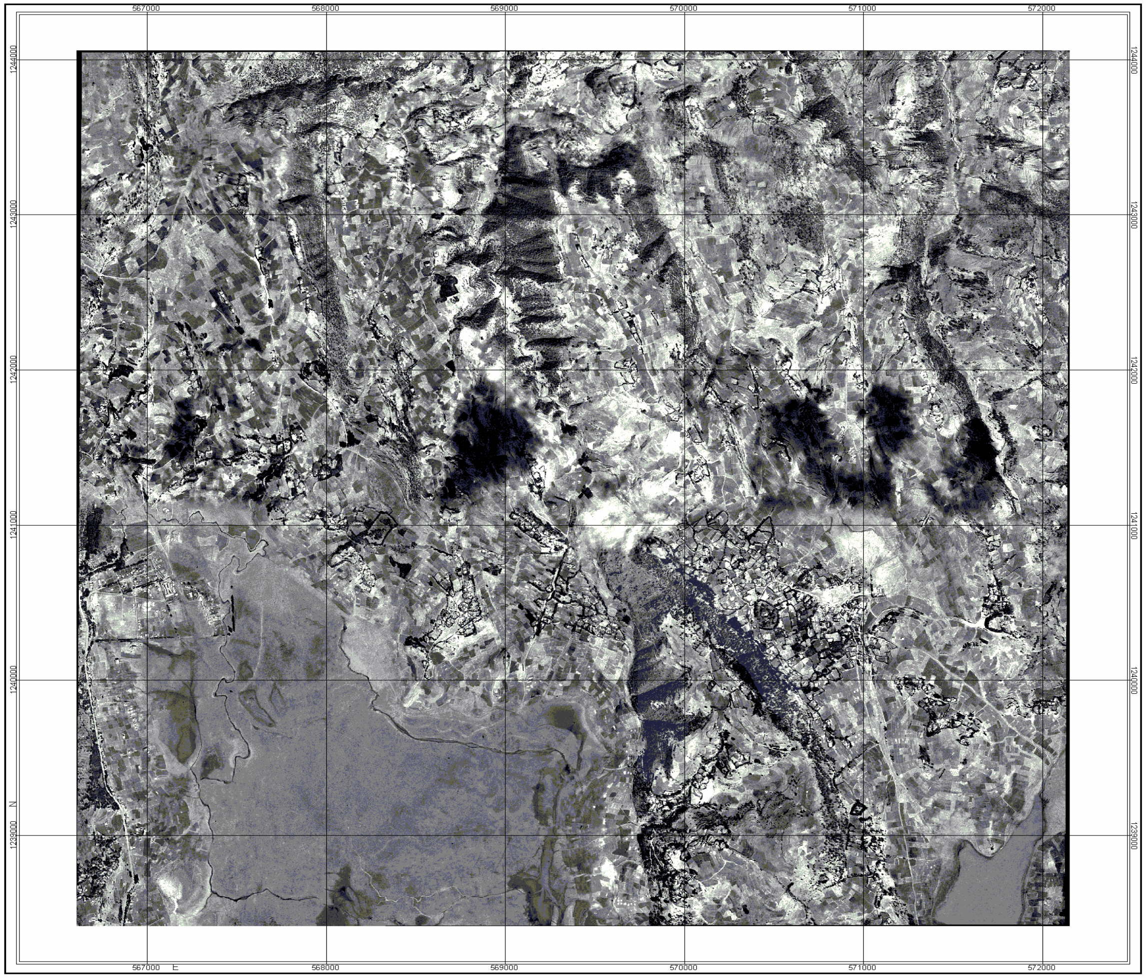
Prepared by: Girmay Kassa, 2003

Source: Aerial Photograph of 1994, EMA

Scale 1:12500

1 0 1 Kilometers

ORTHOPHOTO MAP OF BORU-METERO, SOUTH WELLO, 1986



N

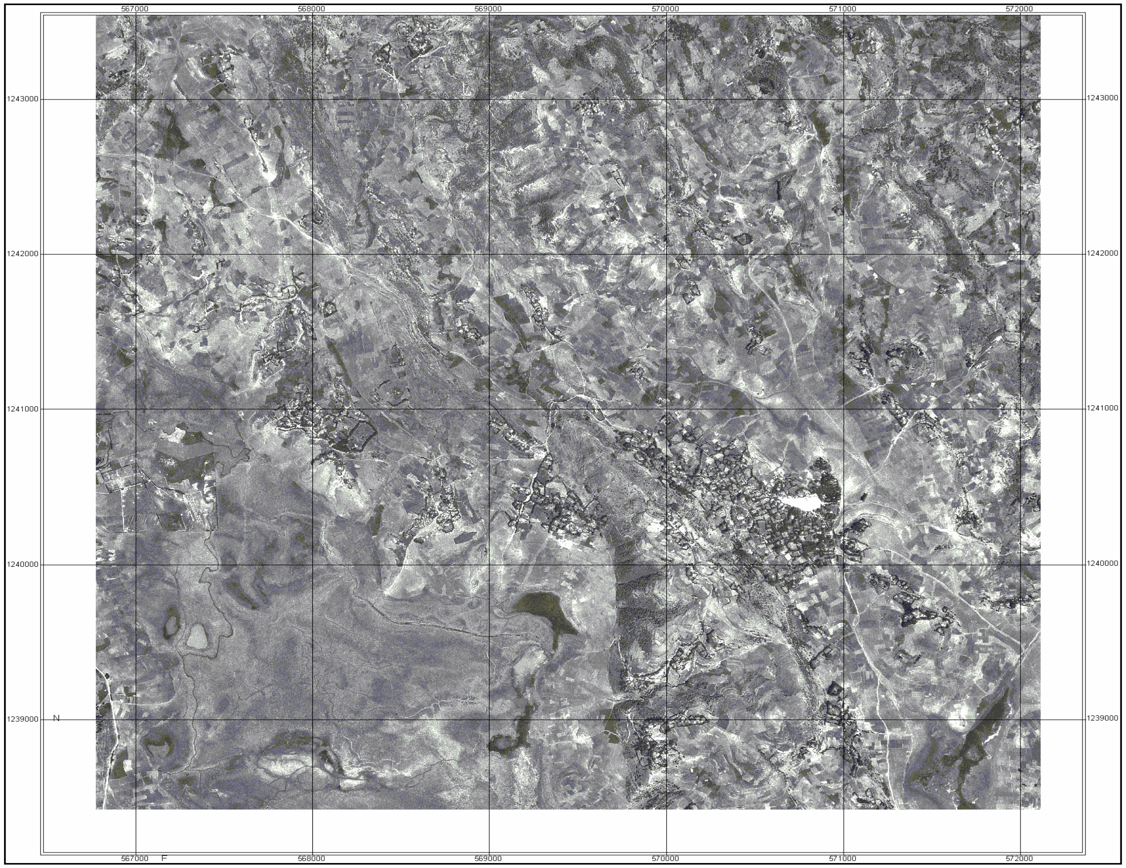
Grid: UTM Zone 37
Projection: Transverse Mercator
Unit of Measurment: Meter

Scale 1:12500
1 0 1 Kilometers

Source: Aerial photograph of 1986, EMA

Prepared by Girmay Kassa, 2003

ORTHOPHOTO MAP OF BORU-METERO AREA, SOUTH WELLO, 1965



Source: Aerial photograph of 1965, EMA

Prepared by: Girmay Kassa, 2003

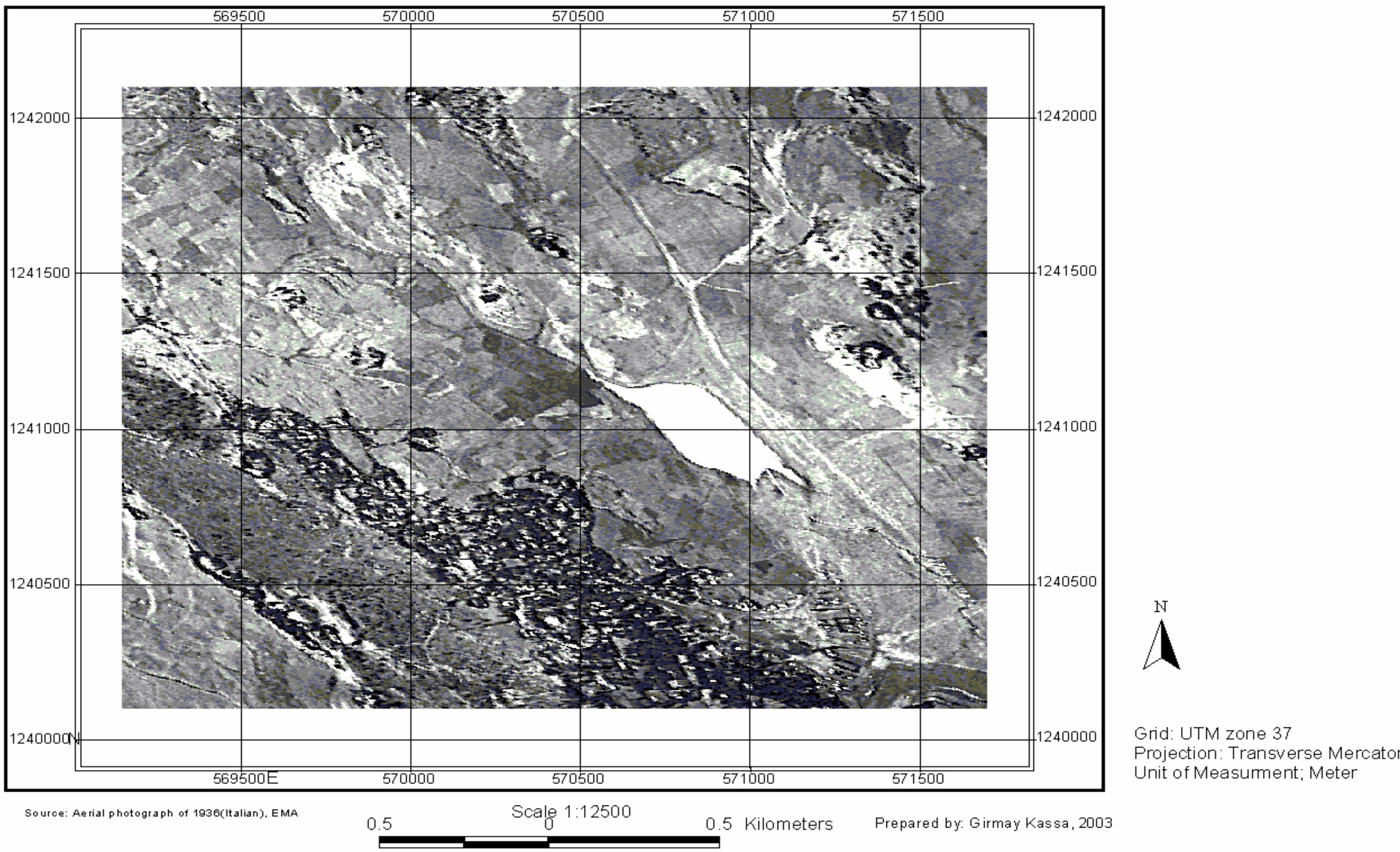
Scale 1:12500

1 0 1 Kilometers

N

Grid: UTM Zone 37
Projection: Transverse Mercator
Unit of Measurment: Meter

ORTHOPHOTO MAP OF BORU SELASSIE, SOUTH WELLO, 1936



ORTHOPHOTO MAP OF GORA AREA, SOUTH WELLO, 1936