

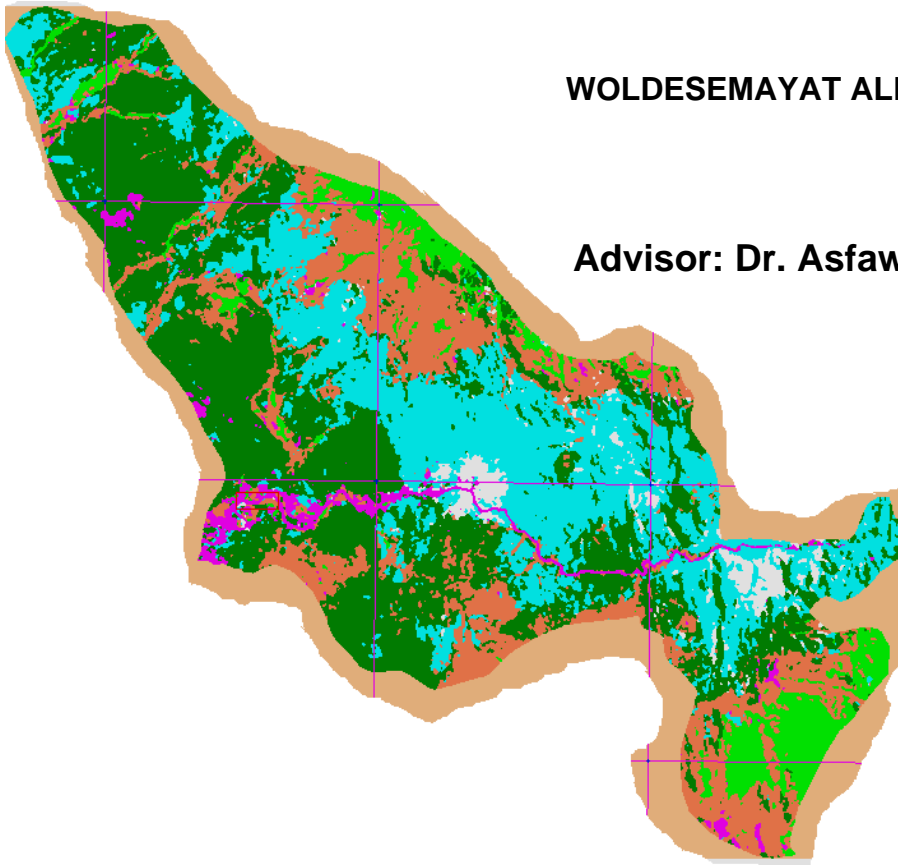


**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES**

**LAND USE/LAND COVER CHANGES ENVIRONMENTAL ANALYSIS AND
IMPLICATION FOR SUSTAINABLE AGRICULTURE
DEVELOPMENT IN GAMBELLA WOREDA, GAMBELLA REGION SOUTH
WESTERN ETHIOPIA**

WOLDESEMAYAT ALEMU

Advisor: Dr. Asfawosen Asrat



JUNE, 2007

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**A THESIS PRESENTED TO THE SCHOOL OF GRADUATE STUDIES
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BY

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**Land Use/Land Cover Changes Environmental Analysis and Implication for
Sustainable Agriculture Development In Gambella Wored, Gambella
Region, South Western Ethiopia**

**By
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Table of Contents

Acknowledgements.....	IV
LIST OF TABLES.....	VII
LIST OF FIGURES.....	VIII
List of Abbreviations.....	IX
ABSTRACT.....	X
CHAPTER ONE.....	1
1. INTRODUCTION.....	1
1.1 Background.....	1
1.2 Objective of the study.....	2
1.3.2 Sampling Procedure and the questionnaire survey.....	4
1.3 Data analysis techniques.....	5
1.6 Review of the previous study.....	5
CHAPTER TWO.....	7
2. Description of the study area.....	7
2.1 Location.....	7
2.2 Climate.....	7
2.3 Topography.....	10
CHAPTER THREE.....	11
3. Review of the Literature.....	11
3.1 Land use and land cover types in Ethiopia.....	11
3.2 Cover changes and Land Degradation.....	11
3.3 Land use and population change.....	12
3.4 Sustainable Development.....	13
3.5 Growth and Development.....	14
3.6 Sustainable Agriculture.....	15
CHAPTER FOUR.....	16
4. Distribution and pattern of changes in land cover of the study area.....	16
4.1 Land Use and Land Cover Change.....	16
4.2 Land Distribution between 1990 And 2006 The Study Area.....	17
4.3 Pattern of Changes in Land Use And Land Cover.....	23
4.4 Factors influencing change in Land use land cover.....	25
4.5 Farmers Perception of environmental Problems.....	26
4.5.1 Farmers' Perception of Resource Degradation.....	26
4.8 Farmers' perception on Agricultural problems.....	29
4.9 Indigenous methods of Maintaining soil Fertility.....	31
CHAPTER FIVE.....	32

5 LU/LC mapping and change detection using RS and GIS techniques	32
5.1 Land use and land cover mapping of 1987 and 2000 periods.....	32
5.1.1 Land use land cover map of the 1987	32
5.1.2 Land use and land cover of the year 2000.....	33
5.1.1 Discussion on each LU/LC identified from images and their accuracy of mapping	34
5.2 Change detection analysis on each LU/LC	35
CHAPTER SIX.....	39
6 Methods and procedures used to model the existing environmental	39
CHAPTER SEVEN	51
7. Conclusion and Recommendation	<u>49</u>
7.1 Conclusion	<u>50</u>
7.2 Recommendation	51

LIST OF TABLES

Table 4.1 The status of land use/cover in Gambella woreda and the study PAS in 2006.	15
Table 4.2 Land use distribution between 1990 and 2006 in the study area at PA level.	17
Table 4.3 Land use land cover changes between 1990 and 2006 in the study PAS.	18
Table 4.4 Major land use changes between 1990 and 2006 in the study area in percent	19
Table 4.5 Land use changes between 1990 and 2006 in the study Area in hectares.....	20
Table 4.6 The current state of soil erosion as perceived by Farmers of the study Area.....	26
Table 4.7 The present state of forest Resources as perceived by the study population.....	21
Table 4.8 Major agriculture production problems perceived by the formers of the study area.....	29

LIST OF FIGURES

Figure 2.1 Study Area.....	7
Figure 2.2 Monthly Mean Rainfall & Temperature of Gambella	8
Figure 6.1 Method and Procedures used to model un sustainable development process of the study area to change sustainable development condition	40
Figure 6.2 Classification of Environmental and Resource Depletion	41
Figure 6.3 The schematic model of land use/land cover change at the study area towards un sustainability	42
Figure 6.3.1 The process and objectives of modeling environmental problems	43
Figure 6.4 The schematic model of land use/land change at the study area towards sustainability	44
Figure 6.5 The schematic model of land use/land change of unsustainable development of the study area to change to sustainable development condition	
Figure 6.6 Geo-environmental system modeling of land use/cover changes due to interaction ,interconaction and interdependence of human action.....	

List of Abbreviations

ESRI	Environmental Systems Research Institute
FAO	Food and Agricultural Organization
LUPRD	land use planning and Regulatory Department
MOARC	Ministry of Agriculture and Rural cooperative
GRPSC	Gambella Region People state council
GRARDB	Gambella Region Agriculture and Rular cooperative Bureau.
GWAO	Gambella wored agriculture office peasant Association.
PA	Peasant Association
UNDP	United Nations Development Program
BPSD	Basic principles of Sustainable development
LULS	Land use/Land cover

ABSTRACT

The study area is located in Gambela Woreda of Gambela region (south western Ethiopia), about 777 km from Addis Ababa. It is characterized by steep slop to the east and lowland plain area to the western direction of the region. Gambela region can be broadly classified into three agro-climatic zones, namely; moist and dry wina dega, moist kola and dry kolla or berha, but this research study focus mainly on moist Kolla agro-climate zone of Gambela Woreda.

The main objectives of this study have been to investigate the magnitude and extent of land cover changes due to the expansion of cultivated land and to see indigenous resources management practices in the study area. The data for the study was acquired from the field survey using structured questionnaires, group discussion, field observation and from the official un (published) documents. The method of analysis involves the computation of quantitative indices. Such as parentage, mean, coefficient of variation and standard deviation.

The qualitative results have show that the average holding size in the area is 0.75 hectare with minor disparities between the Woreda and PAs. The findings also indicated fragmentation is greater among the indigenous farmers, since they live near the riverbank area. The research also indicated land cover/land use change in the last 16 years (1990 to 2006). Barren land and cultivated land area have increased at the rate of 4.9 and 3 percent per annum.

Moreover, traditional soil management practices are less employed by the study population to counter the depletion of soil nutrients. The study suggested that deforestation and soil erosion problems need to be given due attention urgently to maintain the stability and resilience of the agro-ecosystem. In addition, integrating agriculture with other income generating non farm activities are also

important to raise the living condition of the people and to combat burning of natural forest for the purpose of hunting of wild animal and honey bee production throughout the dry season in all sites of the study area.

CHAPTER ONE

1. INTRODUCTION

1.1 Background

The use of land in unsustainable way affects land resources such as soil, mineral, water, plant, animal, the atmosphere and man himself. Increasing land degradation, deforestation, desertification and erosion are caused by poverty, population pressure and misuse and mismanagement of land resources.

The magnitudes of land cover changes threaten the stability and resilience of the eco system through global warming; green house gases, climatic change and disruption of nutrient recycling (Joanne, 1996). The process of environmental degradation in developing countries can be regarded both as a result and a cause of underdevelopment on one hand. The socio-economic situation in rural areas of the third world often forces people to use their environment in an inappropriate way and thus induces land degradation. On the other hand degradation reduces the productive potential of the land and thus leads to decreasing yield, crop failures and consequently to poverty and underdevelopment.

Disturbance often creates an imbalance in the distribution of resources, which may affect species composition through shift in resource availability. This, in turn may create condition, favoring invasions of non-native species and deletion of native species.

Williamson (1996) and Suthest (2000, noted that climate change brings change in pattern of production and trade in agricultural commodities thus the

opportunities to contaminate in new range will also increase. Ghorden (1998) wrote that human activities that modify ecosystems cause most of the problems.

Sustainable development indicators can provide crucial guidance for decision-making in a variety of ways. They can translate physical and social science knowledge into manageable units of information that can facilitate the decision making process. They can be useful to measure and calibrate progress towards sustainable development goals.

1.2 Objective of the study

The general objective of the research is to identify and analyze agricultural land use conflicts, changes, cropping pattern and indigenous resources management practices of the local people.

1.2.1 Specific objectives

1. To examine the land cover changes between agriculture land and forest land.
2. To come up with defined land cover changes between 1990 to 2006.
3. To investigate the perception, knowledge and attitude of local communities about sustainable use of resources.
4. To model the existing environmental problems associated with the land cover changes.

1.3 Data Sources and Method of acquisitions

1.3.1 Source of Data

For the fulfillment of the above stated objectives, data from primary and secondary sources have been employed.

A. Primary Source of Data

Necessary discussions and consultations were conducted with relevant organization at the site such as the regional bureau of agriculture (RBOA), Gambella Woreda Agriculture Office and Bonga Refugee area and other dwellers in the catchment's area. Further more field observation work were carried out to identify land cover types such us forest, wood land, bush and shrub, Savanna grass land, cultivated land and bare land of the study area.

To evaluate land cover change, production constraints and indigenous resources management practices of farmers of the study area, various models were used. Horni & Messe (1980) model was used to determine the magnitude of land cover change. In addition, percentages, mean and coefficient of variation have been used to analyze land use types.

B. Secondary Source of Data

The secondary sources were included socio-economic, demographic, vegetation, physiographic, soil, hydrologic and farming systems data are exextracted from the secondary data sources of Baro-Acobo river Basin study and Gambela region land use planning study, were used to investigate the magnitude and extent of land cover changes.

1.3.2 Sampling Procedure and the questionnaire survey

The first stage in sampling process involved the selection of primary sample units; in this case, three peasant associations were randomly selected from three-area location. The selected peasant association was Eley (south), Uchoy (west), and the refugee center of Bonga town to the east of Gambela town as a research site.

The second stage involved preparation of a list of household heads from each of the selected PAs (peasant associations). Because of the limited fund, time and resources, 100 households (25 from Elay, 25 from Uchoy and 50 from Bong refugee area) which make-up about 10 percent of the households of the selected PA. The distribution of the sample units was based on area location and proportion of the samples units by systematic selection.

1.3.3 GIS & REMOTE SENSING

The majority of the data collected for the purpose of this study came from two earlier studies of the Baro- Akobo basin: the study by Selkozprom export in 1990 and Gambella Region land use planning studies in 2004. These data were reviewed and analyzed to identify, locate and priorities impact on land cover change in the study area.

A comprehensive geographic information system (GIS) is one of the tools used by this study to integrate different sources of data by means of satellite image interpretation of 1987 and 2000 with tabular data. The distribution of resources and development plans can be better understood and presented by means of GIS.

Data integrated in the GIS of this study have also been collected from the woody Biomass Inventory and strategic planning project and form the analysis performed during the initial phase of BARO-AKOBO Master plan.

1.4 Data analysis techniques

To achieve the stated objectives and to test research questions, various methods of data analysis are employed. One of the objectives of this study was to identify land cover changes of the study area; the variables that were considered for computation include forest land, wood land, grass land and cultivated land cover changes observed between 1990 and 2006 land use activities at Gambella Woreda.

1.5 Significance of the study

The result of the study expected to contribute the following.

1. It is expected to provide information on land cover change or deforestation level in the area.
2. It may help to provide information to assess the existing environmental problems associated with land cover change in the study area: and to propose and recommend mitigation measures to combat deforestation due to expansion of cultivated land and fuel wood collection etc.
3. It could initiate further similar research on Biodiversity loss in the area.

1.6 Review of the previous study

A preliminary review of background literature and previous studies related to forest resource of the study area has been undertaken and data were collected to analyze their inputs for current study.

Among the reviewed documents, the one that have relevant to land use/land cover is Baro-Akobo Master plan and Resources Development of Gambella Plain. It was conducted from 1985 to 1990. its major Objectives was to identify potential area for irrigated agriculture. This study incorporated detailed land cover study with the aim of compilation of the Gambella Plain Vegetation

cover map with identification of more than 10 major classes land use units, from these major land use classes six were identified to be found in the current study area.

CHAPTER TWO

2. Description of the study area

2.1 Location

Gambella peoples national regional state is located in south western Ethiopia between the geographical coordinate $6^{\circ}28'38''$ to $8^{\circ}34'$ North latitude and 33° to $35^{\circ} 11''$ N East Longitude, which covers an area of about $34,063 \text{ km}^2$ and about 780 km from Addis Ababa. The region is bounded to the North, North East and East by Oromya National Regional State, to the south and southeast by the southern Nations and Nationalities people's Regional state and to the southwest, west and Northwest by the Sudan Republic.

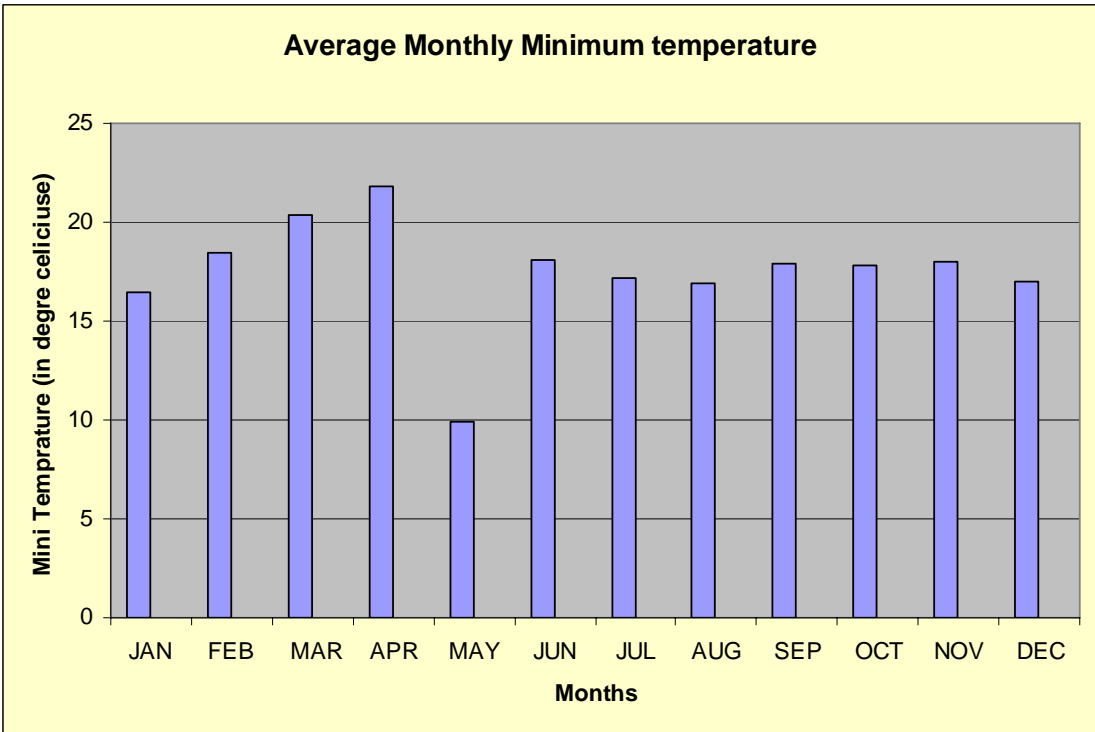
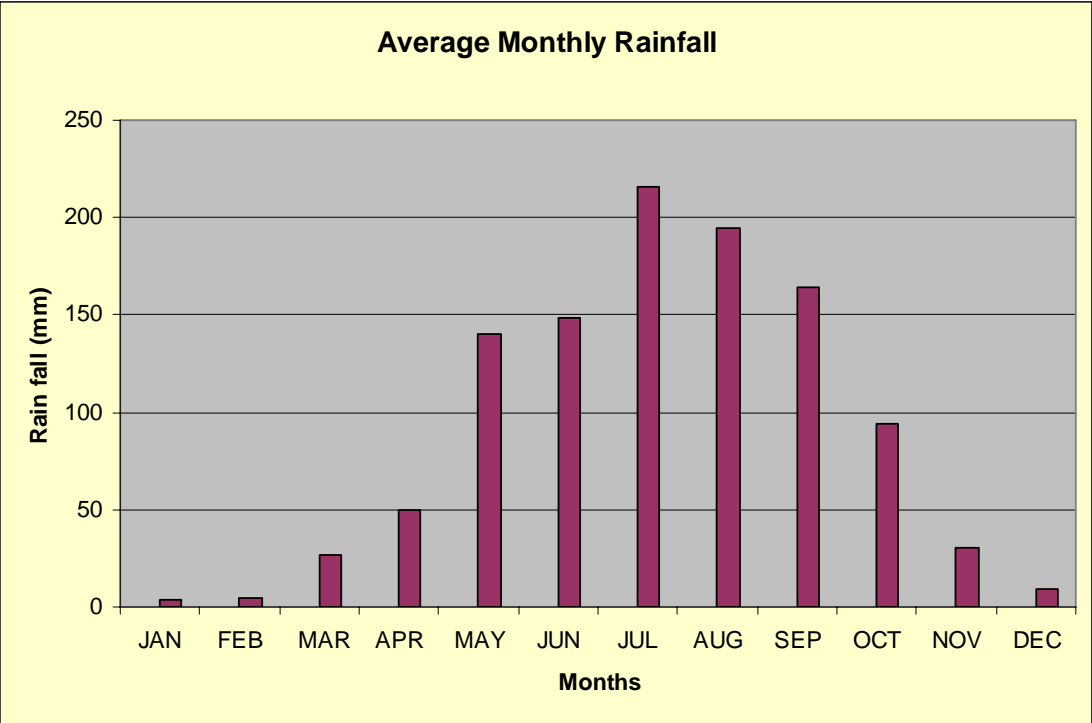
2.2 Climate

The climate of the region comes under the influence of the tropical monsoon from the Indian Ocean, characterized with high rainfall in the wet period from May to October and a dry period from November to April. The mean annual temperature of the region varies from 17.5°C to 28.3°C and annual monthly temperature varies throughout the year from 27°C to 33°C . The absolute maximum temperature occurs in mid march and is about 47°C and the absolute minimum temperature occurs in December and is about 10.4°C .

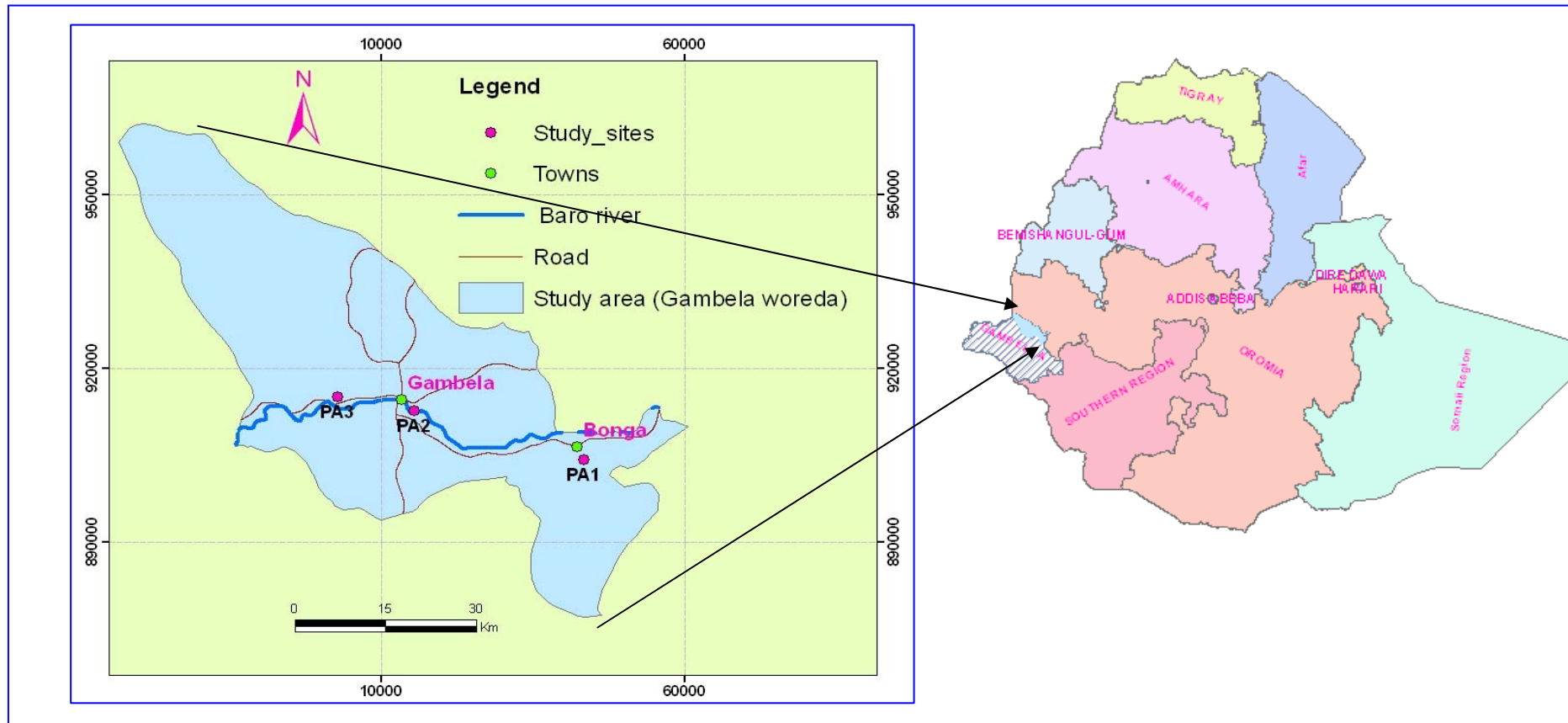
The annual rainfall of the Region in the middle altitudes varies from 900-1500mm, At higher attitudes, it ranges from 1,900-2000mm, at lower altitudes it varies from 900-1000mm. The annual evapo-transpiration in Gambella region reaches about 1612 mm and the maximum value occurs in March and is about 212 mm.(GRARDB)

Source:- Gambella People's Regional state land use/ land allotment study (2004)

- Meteorology data collected from 1970 to 1985



The Map of Gambela Woreda and the study area.



2.3 Topography

Topography is an integral part of the land surface. It influences soil formation, drainage, run off, erosion, exposure and accessibility etc. The topography of the study area is in the lower piedmont Gambella Woreda, between 500 to 1000 masl and the flood plain of below 500m contours. The plain is gently inclined Westwards and prone to inundation and water logging during the wet season from June to September.

2.4 Population of the study Area

There are about five different native ethnic groups living in the Gambella area. These are the Anguala, Nuer, Mejenger, Komo and OPUO. In addition other people come to the region as a result of the settlement program of the previous regime and by their own will. Refugees from Sudan also live in Gambella region in three main camps, These are Bonga, Pungindo and Dimma camps, how ever, this study focuses mainly on Bonga refugee settlement site of the Uduk people of southern Sudan.

CHAPTER THREE

3. Review of Literature

3.1 Land use and land cover types in Ethiopia

The first nation wide land use and land cover types survey of Ethiopia, from the resource inventory tradition point of view was conducted in the late 1970 and early 1980s (Berhanu,1989). Among the major classes of land use types comprised: unutilizable land (18.8%), cultivated land 14.7%), woody vegetation/forestland /bush land (11.6%) and un productive land (3.7%). Grazing and browsing land accounted for 51.2% of the area of the country. It has also suggested that 85% of the country's territory can be used for agricultural activities (UNDP/FAO, 1986: 94).

3.2 Cover changes and Land Degradation

Breitehnbach, (1961) by observing the general climate situation, altitude and types of plants that existed during his observation had estimated the country's original climate forest at 37% of the total area of the country. In addition he has also estimated the early 1960 forest coverage of the country to about 8% (plus 50% open wood land ,deciduous wood land ,and evergreen wood land combined).

According to Akolg (1990:3), the gross satellite imagery interpretation data of the late 1970s published in 1986/ makes the forest area of the country 4, 512, 000 ha (3.6 of the country). "The Ethiopia Forestry Action program "estimate the current forest coverage of the country are about 2.3%

(MONROEP,1994). As regards the causes of deforestation in the developing countries empirical studies of Allen and Bornes (1985) and Matter (1987) have identified population pressure to be the major cause.” Other factors like catastrophic changes in climate, fire and landslide hazards (particularly in the mountain ecosystems) were also identified as factors of deforestation.

Population pressure (in seeking land for cultivation, grazing, fire wood, timber) is the major causes of deforestation (Bercherifa, 1990:373). Other factors identified by case studies are fire outbreaks, a sudden change from shifting cultivation to permanent cultivation on the hills or mountain slopes, traditional methods of honey production, timber production, the introduction of large scale commercial farming and large scale resettlement scheme (Gebru, (1982; Kebrom, 1984: Tafesse, 1990; Ubrig and Abdue, 1990; Ublig 1990; Legess, 1992; Pank harst, 1992).

A number of scientific studies have documented the multifaceted consequence of deforestation. Besides loss of the so called direct benefits, Admasu and Tamire (1974),in we lazok and Orymalukwe (1977); Grainger (1982), Troech,et al (1986); Goude (1986) and Assefa (1995) signify the direct link between deforestation and soil fertility decline, disturbance of hydrologic regime, disturbance of wild life, an expansion of desertification.

3.3 Land use and population change

Several writers argue that population distribution and change are the most important variable that explain the pattern and dynamics of land use and land cover. For instance, Bekure (1983:26) has argued that in Ethiopia the distribution of high percentage of crop land correlated with high population density zones of the country. Other several micro and empherical investigation

in the high land of Ethiopia (LUPR/FAO; 1984; Getachew, 1991: Hillman, 1990:280-281:

Muluneh, 1994; Gizachew, 1994:23, Assefa; 1995, and Guymbo 1990) have disclosed that an increase in population density results in a conversion forest land to marginal land. This increment, they argue also leads to the reduction of farm size, intensification of land fragmentation and decline of fallow periods. The cumulative effect, particularly in the absence of improved agricultural and degradation or resources. Other agricultural land use studies have also revealed the presence of strong association between land fragmentation and population increase (Fassill, 1980; Alemneh, 1987, Tadesse 1989; Yohannes, 1989). Hurni and Messerli (1981) have argued that the accelerated population increase with 2.5 to 3.0% was directly responsible for the relentless expansion of cultivation land into marginal lands of the mountain area.

3.4 Sustainable Development

The objectives of development have undergone various transformations in the past. The concept (concern) for development shifted to the satisfaction of human needs and aspirations with emphasis on social objectives of in generational distribution of income. At present, development objectives focusing on the protection of the environment have gained prominence. Thus achieving the greatest improvements in living standards subject to constraints of sustainability is considered as and appropriate objective.

Much of the interrelationships can be generalized if the three approaches, i.e, the economic, environmental and socio- cultural, are considered with focus on one of them with out completely over looking the other approaches (Munasinghe, 1993). Thus in brief, the economic approach to sustainability is based on the concept of maximization of benefits that could be generated,

while at least maintaining the stock of assets, in line with the neoclassical concepts of economic efficiency applied to the use of scarce resources.

The environmental approach focuses on the stability of the biological and physical systems, on the protection the biological diversity of the ecosystems, and on the resiliency and dynamic ability of systems to adapt to change. The socio- cultural approach to sustainability focuses mainly on the maintainace and stability of social and cultural systems with special emphasis on reducing the conflict arising with in intra generational distribution of income as well as inter-generational equity (Joanne 1996).

3.5 Growth and Development

If sustainable development is to be achieved, the most quoted definition of sustainable development is found in Brundt land commission Report (WCEB.1987). Sustainable development is a process of change in which the exploitation of resources, the direction of investment, the orientation of technological development and institutional changes are all in harmony/ health/, and enhance both current and future potential to meet human needs and aspirations.

The major objective of growth and development is the satisfaction of human needs and an aspiration for long term sustainability. Thus sustainable development requires that society meets human needs (a) by increasing productivity potential and (b) by conserving equitable opportunities for all the future generations. Thus, sustainability as a dynamic concept involves intertemporal trade- off with primary focus on improving the productive performance of a system without depleting the natural resource based upon which the performance depends (Pandey and ,Hadnker, 1995).

3.6 Sustainable Agriculture

Agriculture plays a pivotal role in the context of sustainable land use. The sector is being carried on the both increase production to achieve food security and improve it stewardship of the land resources. In addition, agriculture supports social and economic development of the rural life styles.

If practiced in sustainable manner, it contributes to the conservation of the countryside and related natural resources. Agriculture and the state of rural development are associated with most land resource issues. Increasing land degradation, desertification and deforestation is caused by poverty, population pressure, land allocation, inappropriate farming and grazing practices.

Demographic condition, both it distribution, size and even the economic cultural orientation, has an impact on the land cover types in the study area. Population of the study areas is very poor. They are not self-sufficient in crop production to support their family needs. They do hunting of wild animals and honey production by traditional methods of burning natural forest during dry seasons to meet the growing food requirement, during hunger period of the year.

CHAPTER FOUR

4. Distribution and pattern of changes in land cover of the study area.

4.1 Land Use and Land Cover Change

Land use pattern refers to the proportions of areas under major kinds of land uses in the area. Land cover/land use pattern is greatly influenced by both natural and demographic factors. The amount and distribution of rainfall, temperature, altitude and terrain are significant natural attributes in which farming activity and vegetation cover of an area are manifested. Further, the distribution, size and cultural orientation and practices of population has also a considerable impact on the cover of land.

The land use/cover in the study area are differentiated into six types: These are cultivated land, forest,woody vegetation, the Savanna grass land, the Savanna bush and shrub land, and barren-land. Before dealing with the major land use and land cover pattern in the study area, it seems relevant to state the current patterns in Gambela woreda. Gambella woreda has a total area of 3621000 ha /hectares/of which crop land, forest cover and barren land (rock mountain,wet land and town) accounts for 1.1,10 and 0.7 percent, respectively, while the wood land shares 49 percent followed by the Savanna grass land 33.2 percent.

While comparing the land use pattern of the surveyed PAs with the woreda total area, the woodland accounts for 47 percent of the area the same function followed by savanna grassland 35 percent. Likewise, cultivated land, forest cover and barren land share 1.5%, 2and 0.5 percent, respectively (Table 4.1)

Table 4.1 The status of land use /cover in Gambella woreda and the study PAs in 2006

Land use Type	Gambella Woreda Area in hectares		The study area hectares		The over all total change In percent
	ha	%	ha	%	%
Cultivated land	39831	1.1	988	1.5	2.5
Forest land	362,100	10.0	1299.1	2	0.35
Wood land	1774290	49	30592.6	47	1.7
Savanna grass land	1165962	33.2	22732	35	1.9
Bush and shrub	217260	6	9518.3	14	4.2
Barren land	25347	0.7	161.9	0.5	0.63
Total area	3621000	100	64865	100	

Source: Unpublished official document of Gambella woreda agriculture office and field survey in 2006

4.2 Land Use Distribution between 1990 and 2006 the study area

To identify the recent land use/land cover pattern, and to assess its spatial and temporal changes, data for the years 1990 and 2006 were employed. The data for 1990 taken from Baro Akobo river Basin master plan study and the land use /land cover data for the year 2006 was obtained from field survey using structure questionnaire and supported by Gambella region land use planning and allotment of land units study (2004).

During data interpretation some problems were encountered in differentiating grass land from bush and shrub land due to close similarities .This was solved partly by the detailed knowledge of the study area and the use of field survey.

As indicated in Table 4.2, the overall pattern of the study area shows that wood land is the dominant land use category, accounting for 53 percent of the total area for 1990, followed by savanna grass land which accounts for 33.6 percent. The third land use type is bush and shrub land and accounting for 8.8 percent of the total area, and followed by forest land, which accounts for about 3.4 percent of the total area. Cultivated land shares 1 percent of the total area and the bare land accounts for 0.2 percent for 1990.

The area covered by cultivated land in the PAs increased to 1.5 percent in 2006. The proportions of area under shrub land and grassland in 2006 were 14 and 35 percent of the total area, respectively, while the area under wood land forest cover dropped to 47 and 2 percent, respectively (table.4.2).

In 2006 at PA level cultivated land increased by the proportion of 2.3, 0.8, and 1.2 percent, respectively in Bonga, Eley and Uchoy. Similarly, wood land occupies the largest position, which is 49 percent in Eley, 49 percent in Uchoy, but it ranks third in Bonga (45 percent), out of the total area of 30592.6 hectares under woody vegetation cover.

Table 4.2 Land use distribution between 1990 and 2006 in the study area at the PA level

Land –use type	Bonga				Eley				Uchoy				Overall Total			
	1990		2006		1990		2006		1990		2006		1990		2006	
	Area ha	%	Area ha	%	Area ha	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Cultivated land	413.8	1.59	595	2.3	125	0.6	152.4	0.8	180	0.9	241	1.2	669.4	1	987.8	1.5
Forest land	1293.2	5	517.3	2	762	4	381	2	1202.5	6	621	3	3257.7	3.4	1299	2
Wood land	13190.8	51	11639	45	9525	50	9334.5	49	10220.4	51	9819.2	49	33327	53	30592.6	47
Bush and shrub land	2302	8.9	4138.3	16	1905	10	2280	12	1322.64	6.6	2404.8	12	5729.8	8.8	9088.3	14
Pasture/ grazing land	8612.8	33.3	9130	35	6637.25	35	6858	36	6493	33.5	6553.5	35	21793.2	33.6	22732	35
Bare land	52.6	0.2	98.9	0.7	28	0.14	38	0.19	100	0.5	25	0.96	90.6	0.2	161.9	0.5
Total	25864	100	25864	100	19050	100	19050	100	20040	100	20040	100	64854	100	64854	100

Source: Field survey in the study area and secondary data source of woreda agriculture office

Table 4-3 Major land-use change between 1990 and 2006 in the study Area (%)

Land use/ land cover classes	Bonga		Eley		Uchoy		Total changes in3PAS	
	Total change	Change/year	Total change	Change/year	Total Change	Change per year	Total Changes in the study area	Change Per year
Cultivated land	43.7	2.7	21.9	1.37	34	2.1	48	3
Forest land	-59.9	3.7	-46	3	-41	3	-58	2.4
Wood land	-11.8	0.7	-2	0.125	-3.92	0.2	-18.2	-1.1
Bush land	79	4.9	19.7	1.2	71	4.4	58.5	18.8
Grass land	7	0.4	2.87	0.18	16.8	1	3.8	0.5
Bare land	89.3	15	35.7	2.2	39.5	2.5	78.7	3.4

Source: Computed from Table 4.2

- Changes were calculated in reference to the base year (1990).

Table 4.4 Land use change between 1990 and 2006 in study Area (PAS)

No	Land-use/Land cover type	Total area b/n 1990 to 2006 in the study PAS				Land-use change b/n 1990 to 2006 in the study		Land use charge per year	
		1990		2006		Study area			
		Area (ha)	%	Area(ha)	%	Area(ha)	%	Area(ha)	%
1	Cultivated Land	669.4	1	987.8	1.5	+318.5	48	+20	3
2	Forest Land	3257.7	3.4	1299	2	-1957.46	-58	-54.8	3.6
3	Wood Land	33327	53	30592.6	47	-2734.44	-8.2	-178.32	0.54
4	Bush and Shrub land	5729.87	8.8	9082.3	14	+3352.3	58.5	+233.2	3.7
5	Grass Land	21793.2	33.6	22732	35	+838.25	3.8	+52.44	0.24
6	Bare Land	90.6	0.2	161.9	0.5	71	78.7	+4.4	4.9
	Total	64854	100	64854	100				

Source: Data derived from table 4-2

Table 4.5 Land-use /land cover between 1990 and 2006 in the study area (PA) hectares

Land use Type	Bonga area				Eley				Uchoy				Change in the study PAS (1990-2006)			
	Total change in ha	Change in percent	Change per annum		Total change in ha	Change in percent	Change per year		Total change 1990-2006		Change per year		Total change		Change per year	
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area(ha)	%	Area(ha)	%
Cultivated land in (ha)	181.08	3.6	11.31	3.7	27.4	2.5	1.71	2.5	61	2.56	3.81	2.56	318.5	48	2.	3.7
Forest Land	-774	15.8	3.74	15.8	381	34.82	23.8	34.8	581.5	24.42	36.34	24.24	-1957	-58	-54.8	10
Wood Land	1551.8	31.7	97.4	31.7	109.5	10	6.84	6.84	400	16.80	25	16.80	-2734.44	-8.2	-178.32	32
Pasture /grazing	1827	37.36	114	37.36	375	34.28	23.43	34.28	1082	45.5	67.62	45.5	838.25	3.8	52.44	9.8
Bush and Shrub land	517	10.57	32.3	10.4	191	17.46	11.94	11.94	241	10.12	15	10.12	3352.3	58.75	233.2	43
Barren Land	47	0.2	2.9	1	10	0.91	0.62	0.91	15	0.63	0.93	0.63	71	78.7	4.4	0.8
Total Area	4890	100	307	100		100	68.34		2380.5	100	149	100	8764.3		542	100

Source: computed from Table 4.2 between 1990 and 2006

As noted in table 4.3 the rapid expansion of cultivated land in Bonga 43.7 percent (181 hectares) of land of the total area, compared to the other two sample PAs is probably due to high population pressure of Southern Sudan refugees who settled in the area, This are increase at a rate of 11.3 hectares per annum for the period between 1990 and 2006.

4.3 Pattern of Changes in Land Use And Land Cover

Some assert that changes in land use/cover patterns are the reflection of the dynamics in socio-economic development and changes in the local environment (Solomon, 1992 and Boscrup 1965). Table 4.3 indicates spatial-temporal changes in the land use/land cover (1990 to 2006) of the study PAs. As noted in the Table 4.3 the significant changes that had occurred in land use/cover categories could be seen in two different ways: i.e, those that showed increasing trends, and those with a decreasing triend, during the period considered. Therefore, the most dramatic change at aggregate level has been the increasing in bare land 78.7% and Grass land 3.8%, cultivated land 48%, and bush and shrub land 58.5%. The forest and wood land use class, exhibited a decreasing trend in general.

This shows that with in 16 years period around 71 hectares (4.4 hectares per annum) of new land areas had been out of production. Where as, the expansion of bush shrub land, grassland and cultivated land is about 58.5%. (233 hectares), 38% (53.1 hectares) and 48% (20 hectares) respectively for the period of 16 years. On the other hand, wood land and forest land revealed the reverse pattern. The area occupied by forest land and wood land show a drop of about 957.5 ha and 2734.4 hectares respectively. In the period probably at the cost of the expansion of bare land, bush and shrub, grass land and crop land. In the considered period the area under forest and wood land

cover progressively declined due to the expansion of bare land and cultivated land. The forest clearing was estimated at 54 hectares per annum.

In the study area the trend of deforestation has remarkable variation for the period between (1990 to 2006). For instance, the largest change in barren land was observed in Bonga refugee center, where it increased from 0.2 percent in 1990 to 0.7 percent in 2006. This shows a change of 15 percent per annum, While the change was 2.2 and 2.5 percent in Eley and Uchoy, respectively. The main reason for the increase in barren land in Bonga as compared to the other two sample PAs could be ascribed to the impact of southern Sudan refugees (uduk) who settled near Bonga town.

The rate of decline of wood /forest land was considerably high in Bonga area which shows a drop of (1551 ha) or (31.7%) as compared to the rest of study area (PAs). At Eley 109.2 hectares or (10%) and Uchoy 400 hectares or (16.8%) land was deforested (table 4.5).This is mainly due to the expansion of crop land to marginal areas of along the river banks by the refugees and the clearing of wood for fuel wood collection ,charcoal making as a source of energy for household cooking and for construction. But in Eley and Uchy peasant Association where only the local people the (Anywa) have settled the rate of deforestation is very low as compared to Bonga site. This could be explained by the expansion of cultivated land by the indigenous people (the Anywa) was limited along the river bank area only and mostly they are not involved in charcoal making process.The consumption of fuel wood is also lower as compared to the Uduk in the refugee center.

It can be inferred from Table 4.5 that the highest degree of expansion of cultivated land was observed in Bonga area 181 hectare, within 16 years, Which exhibited on average annual increment of 11.3 hectares per in contrast

to there Uchoy (3heactars) and Eley (3.6 heactars). Field observation reveals intensive charcoal making, fuel wood collection, and the growing demand for agriculture land which resulted in extensive deforestation of the study PAs.

4.4 Factors influencing change in Land use land cover.

The most notable factors of land use changes are natural and socio-economic conditions. Natural factors, such as climate and terrain are the main factors that appear to have influenced land use/cover change of the study area. Altitude, temperature and rainfall can define the type of vegetation cover and crop grown. On the other hand, excess rainfall in the hill sides of Bonga resulted in the excessive erosion on the cultivated land and barren land.

Socio-economic development: the fragmentation of land holding of local farmers and the resettlement near the river banks which are exposed to seasonal flooding and erosion, as well as shifting cultivation system practices in the study areas are the main socio- economic influences of land cover change. Demographic conditions - its distribution, size and cultural orientation of population pressure - has a tremendous impact on the change of the current land use/cover in the study area.

Under rapid population growth to meet the growing food requirement an increase in food crop production is inevitable and this has been achieved by expanding cultivated land into forest and woodland areas. As a result of the increasing population pressure in Bonga PA, the wood land and forest land available for farming is squeezed from 1299.2 hectares or 6 percent in 1990 to 517.3 hectares (2 percents) in 2006. In addition, population pressure further resulted in additional demand for domestic fuel, cash income and construction poles particularly in the refugee center of Bonga area, heace the expansion of more and more forest and woodland areas into arable land and bare land.

Further more, the shifting cultivation near the river bank without the use of improved conservation practices may further accelerate soil degradation and changes of the cultivated land to barren land form time to time as the population pressure increased.

4.5 Farmers Perception of environmental Problems

4.5.1 Farmers' Perception of Resource Degradation

Degradation has been associated with destruction of natural forest, overgrazing, denudation of hill slopes, and the increasingly intensive use of land for crops in the absence of conservation measures. In the study area, as a result of the increasing population pressure, misuse, mismanagement of land resource and marginal lands were brought under cultivation in response to shortage of farm land near the river bank area.

The final out come of the competition among land uses has further aggravated the extent of environmental degradation. In addition, this supplementary land has been obtained by extending cultivation to steep- slopes and river-bank area. Such land has marginal value for crop farming and is sensitive to ecological degradation. In order to identify the most prominent agricultural and environmental problems and traditional conservation practices in the study area, households were asked to indicate the current state of natural resources and the magnitude of the problems. In addition group discussions were also made with the community elders to enrich the data.

Soil erosion is generally taken as a strong indication of adverse human impact on environment. Several eroded areas can no longer be used for any productive agriculture. Farmers are aware that soil erosion, in various forms, is taking place on their farms as well as in the surrounding areas. They have

identified the major characteristics of the severely eroded and slightly eroded fields. The soil properties identified by the respondents to characterize the fertile (dark soil) and infertile soil (stony soil) groups respectively, were found to coincide very well with the characteristics of the slightly and severely eroded soils.

Thus, these responses show that the farmers well perceived some environmental problems like soil erosion appear in their surrounding. Hence as indicated in Table 4.6, over 55 percent of the sample population reported that the soil in their locality is highly eroded while 25 percent indicated that this is not the case. At the peasant association levels, soil erosion was reportedly severe in Bonga (68 percent), followed by Eley, (48 percent).

In contrast 36 percent of the study population in Uchoy responded that erosion is not as such problematic in the area (PA).

Table 4.6 The current state of soil erosion as perceived by farmers of the study Area as interviewed in Field survey 2006.

Type of erosion rate	Bonga		Eley		Uchoy		Overall	
	N=50		N=25		N=25		N=100	
	No	%	No	%	No	%	No	%
Slightly eroded	10	20	7	28	8	32	25	25
Moderately eroded	6	12	6	24	8	32	20	30
Severely eroded	34	68	12	48	9	36	55	55
Total	50	100	25	100	25	100	100	100

Source: Field survey of 2006 at the study area as interviewed the farmers.

N=sample size No=Number of respondent

The data shown in Table 4.7 suggests that 71% (percent) of the sample population reported that the forest of their locality had already been depleted, while (11% percent) of them felt that the forest resource was depleting.

At the PA level, the highest forest resource depletion was observed in Bonga (88% percent) followed by Eley and 64% and 44% of Uchoy .In contrast, (26 percents) of Uchoy farmers responded that the forest resource in their locality is not exposed to depletion as such. On the other hand, the forest resource in Bonga area is getting exhausted. This PA is probably the most degraded part of the study area due to high population pressure of southern Sudan refugee (Uduk).,

Discussion with the elders and knowledgeable men in Bonga revealed that recently fuel wood consumption of Sudan refugee (Uduk) and the expansion of cultivated land may be responsible for the depletion of forest resource. The discussion further revealed that forest fire hazard during the dry season is also a prominent cause for the degeneration of forest resource in the study area.

Table 4.7 The present state of forest Resources as perceived by the study population sample interviewed.

Deforestation rate at present state	Bonga No=50		Eley N=25		Uchoy N=25		Over all No=100	
	No	%	No	%	No	%	No	%
Depleting	2	4	3	12	6	26	11	11
Depleted	4	8	6	24	8	32	18	18
Very depleted	44	88	16	64	11	44	71	71
Total	50	100	50	100	25	100	100	100

Source: field survey of the study area, as interviewed the farmers 2006

4.7 Farming System of the study area

In the region as well as in the study area, agriculture is dominated by subsistence farming systems with no use of modern agriculture inputs and in Gambella region is owned by each farm household head and they have fully controlling right over the use of land including natural vegetation grown in the area. There are no restriction on movement and use of land for cropping as well as grazing except along the river bank.

In order to sustain the existing agricultural endeavors and to alleviate the main problem, farm communities of the study area need to have an integrated approach the exercise must include social, environmental, economical and other natural resources including forest management to solve major environmental problems.

The rural population of the study area depends on crop and livestock husbandry. Crop production is mainly rain-fed. However, two harvests per year are possible through rain fed farming in the main season and riverside cultivation at the end of wet season along the river banks of Baro.

In general, the type of farming system pertinent to the study area includes riverside cultivation, arable farming and shifting cultivation. In addition livestock rearing, poultry farming, bee keeping, fishing and hunting are also peculiar practices of the farmer of the study area.

4.8 Farmers' perception on Agricultural problems

Informants further told that there are faces four most significant problems related to agricultural production. These include rain fall variability (37 percent) and decline in soil fertility (29 percent). The prevalence of weeds; insect pest and disease problem (15 percent) were the highest agricultural problem perceived by people in the study area. In a similar study that was conducted by Berhanu (1986) resource depletion, adverse weather conditions, wide

spread prevalence of Human, animal and plant diseases are important production problems in rural Area of Ethiopia.

As shown in Table 4.8 the perception of agricultural production problems exhibited spatial variation through the study areas. For example in Bonga the most prominent problem perceived by the majority of the farmers were rain fall variability (44 percent) and decline in soil fertility 36 percent. On the other hand, crop diseases, weed damage and insect pest (6 percent), was perceived to be the highest agrarian production problems in the study population areas of Bonga, Elay and Uchoy. Thus, the prevalence of crop disease, weed and insect pest, animal disease, rain fall variability, flooding in the raining season and decline in soil fertility were the most widely perceived agriculture production problems (Table 4.8)

Table 4.8 Major agricultural production problems perceived by the farmers of the study Area.

Major agriculture production problems	Bonga N=50		Eley N=25		Uchoy N=25		Over all N=66	
	No	%	No	%	No	%	No	%
Rainfall variability	22	44	8	32.98	7	28%	37	37%
Decline in soil fertility	18	36	4	16.96	7	28%	29	29%
Crop disease, weed and insect pest	3	6	7	20%	5	20%	15	15
flooding	3	6	3	12%	2	8%	8	8
Livestock disease	4	8	3	12%	4	10%	11	11
Total	50	100	25	100	25	100	100	100

Source: field survey in 2006 at study area.

4.9 Indigenous methods of Maintaining soil Fertility

As far as the agricultural ecology of the study area is concerned, the increase in population pressure has led to the encroachment of crop land on to the forest land. The imbalance between crop land and forest land, in turn, leads to soil erosion and subsequent as environmental degradation. To combat this problem traditional practices of improving soil fertility are not common through the study area (PAs) Since the study area is low land, maintainace of soil fertility is practically less pronounced as people have access to more potentially productive agricultural land by clearing natural forest.

CHAPTER FIVE

5 LU/LC mapping and change detection using RS and GIS techniques

5.1 Land use and land cover mapping of 1987 and 2000 periods

In this research mapping of land use land covers of the area comprises six major categories namely, which is a general classification that includes the Forest, Woodland, Shrubland, Pastureland, Bare land and Agriculture land. The LU/LC map of the area has been developed from the satellite images following the different principles and procedures of image analysis.

5.1.1 Land use land cover map of the 1987

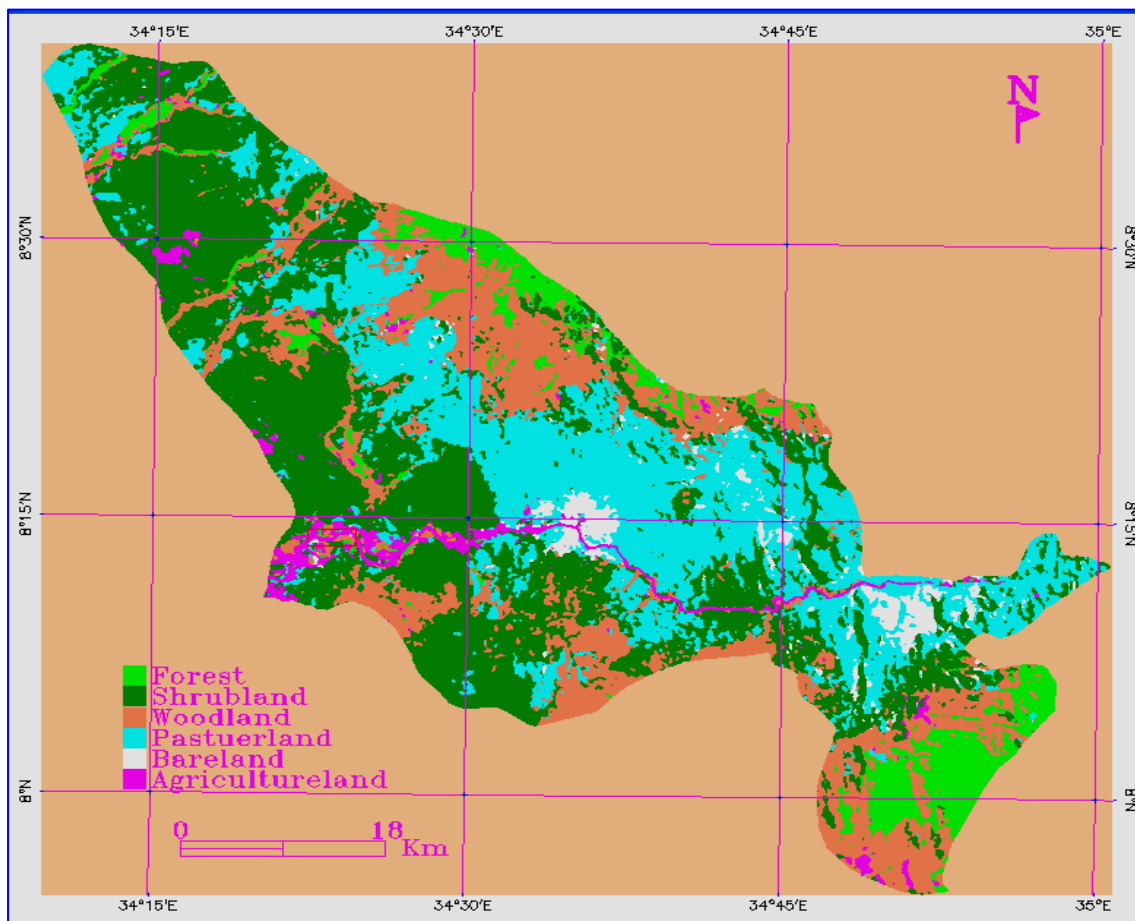


Fig- LU/LC map of the year 1987

5.1.2 Land use and land cover of the year 2000

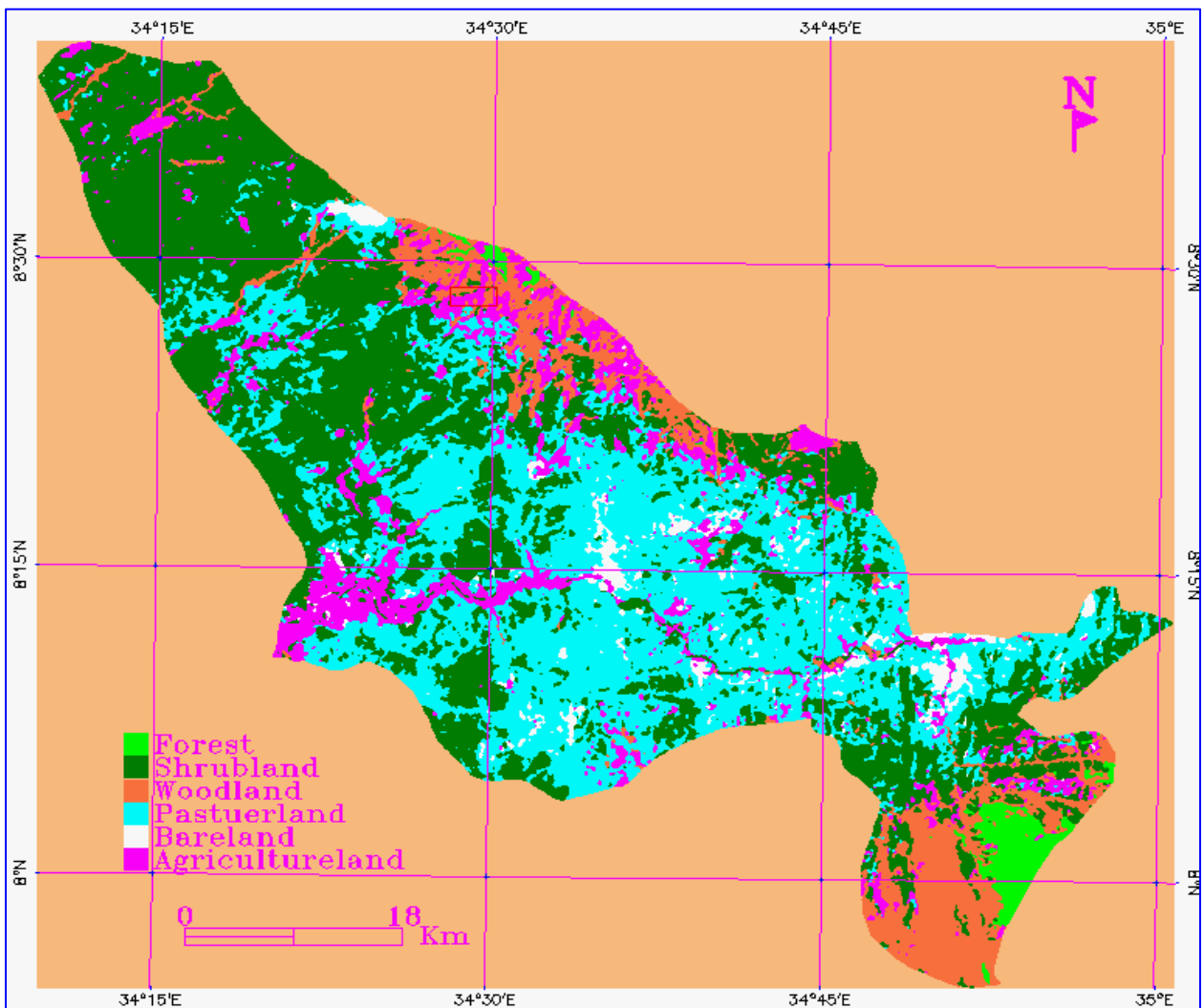


Fig- LU/LC map of 2000

5.1.1 Discussion on each LU/LC identified from images and their accuracy of mapping

A) Forest: This land cover includes big trees, which have closed canopy of both natural and artificial forests. Image classification of the various time series results the Forests have been classified with an over all accuracy of 90.17, 95.59 and 70.38 percent for the year 1987 and 2000 respectively.

B) Shrub land: This land cover includes short trees and bushes, which have an opened canopy and contain grass under the canopy. Image classification of the various time series results the Shrub lands have been classified with an over all accuracy of 95.59, 92.39 and 91.84 percent for the years 1973, 1986 and 2000 respectively.

C) Pasture land: This land cover includes grass lands, grazing areas dominantly covered with grasses. There might have also sparse vegetation with it. Grasslands have been classified with an over all accuracy of 84.31, 97.45 and 69.9 percent for the year 1973, 1986 and 2000 respectively. Relatively the 2000 image classification shows poor classification of grasslands because of its similarity with that of the bush land.

D) Bare land: This land Cover class represents areas that are covered by either rock outcrop or bare-soil or rocky and rugged topography areas. The area has very limited bare land, which covers less than five percent of the study area. The bare land have been classified with an over all accuracy of 93.25, 95 and 98.48 for the year 1987 and 2000 respectively. The classification accuracy of this category is relatively high.

E) Agriculture land: Agriculture is not a common practice in the study area . However there are some limited agricultural activities observed following the

Baro river. This is still based on flooded irrigation using the river Baro and covers very small portion. This land cover includes areas which are continuously cultivated. They are always covered by crops and appear green in the image. This land use is very common following rivers, but seasonal peasant agricultural activities are very limited and insignificant to be accounted in this study.

Generally, the accuracy of assessment for all LU/LC mapping was 95.8% and 91.2 % for the year 1987 and 2000, respectively. In principle, it is clear that the number of LU/LC classes for all period should not be the same and equal since there is a change. New classes may be created and old ones may disappear. But for change detection purpose the new and old classes would be merged during the change detection analysis and therefore only those permanent ones are presented here in the analysis of this research.

5.2 Change detection analysis on each LU/LC

The change detection tables presented below are change matrices that depict the magnitude and direction of change i.e. what are changed to what. The column of the table represents the initial stage 1987 and the row represents the final stage 2000. The diagonal values of the table depict the unchanged values, which are found in both times images. Unlike the diagonal values the class change tells the total changed image areas of each LU/LC of the initial stages. Whereas the class total value of the column indicates the initial stage image total area of each LU/LC classes the row total represents the final stage area of LU/LC classes. The Image difference is the total net change of the two time images. The negative image difference indicates a certain LU/LC is in a state of decrease and the positive indicates increment.

Table 5.1 LU/LC Change of 1987-2000 (km²)

	Forest	Shrub Land	Woodland	Pasture Land	Bare land	Agriculture Land	Row Total	Class Total
Forest	50.66	0.08	2.06	0.03	0	0.45	53.28	53.28
Shrub land	18.17	655.54	179.89	271.84	11.35	23.66	1160.45	1162.55
Woodland	109.39	12.95	149.2	5.26	0.56	6.57	283.92	284.36
Pasture land	5.46	373.26	147.62	412.72	44.9	8.47	992.43	993.08
Bare land	0.29	17.2	4.25	33.88	19.23	1.58	76.43	79.52
Agriculture land	32.22	59.97	99.78	40.95	3.76	39.05	275.73	276.3
Class Total	216.78	1119.84	583.49	765.13	76.82	79.91	0	0
Class Changes	166.12	464.3	434.29	352.41	60.59	40.85	0	0
Image Difference	-163.5	42.7	-299.13	227.95	3.29	196.4	0	0

From one image, a map can be generated showing different land uses and land covers at the moment the image was captured. When generating such a map periodically, a set of maps will be obtained which reveal the dynamics of the ecosystem and the spatial relationship between elements at different time scale using remote sensing satellite images. Changes and relationships between the elements can be explored and modeled (Toyra and Pietroniro, 2005). The land use and cover status was identified through the classification of land sat imagery acquired in January 1987 and 2000 in ENVI 4.2 software.

Landsat images acquired on January 28, 1986 were selected as the historical image and used for change detection against the January 27, 2000 images. In this study only two phase of change detection were done; one is in between 1973 and 1986 and the other is between 1987 and 2000. The changes of land use and cover categories were assessed and change detection maps for each and every land use category were prepared in ENVI 4.2 Software. The generalized spatial distribution and change statistics of land use changes in the study area are presented in the following tables.

Table 5.2 LU/LC Change of 1987-2000 (%)

	Forest	Shrub land	Woodland	Pasture land	Bare land	Agriculture land	Row Total	Class Total
Unclassified	0	0	0	0	0	0	0	0
Forest	23.368	0.007	0.354	0.004	0.002	0.558	99.997	100
Shrub and	8.381	58.538	30.831	35.528	14.222	29.611	99.82	100
Woodland	50.462	1.157	25.571	0.687	0.699	8.219	99.848	100
Pasture land	2.518	33.332	25.299	53.941	56.252	10.595	99.934	100
Bare land	0.135	1.536	0.729	4.428	24.094	1.971	99.88	100
Agriculture land	14.861	5.355	17.101	5.352	4.716	48.875	99.794	100
Class Total	100	100	100	100	100	100	0	0
Class Changes	76.632	41.462	74.429	46.059	75.906	51.125	0	0
Image Difference	-75.422	3.813	-51.266	29.792	4.126	245.783	0	0

In summery, the LU/LC changes in all the land use types are not static; there is a significant LU/LC change observed in the area. The automated digital LU/LC change between the time periods of 1986 and 2000 is presented in the table above both in percent and area base.

This result directly indicates that almost 163.5 km² area of the forest in 1987 has gone away in 13 years gap which is about 75.422%. The other land use which has decreased was woodland estimated at about -299.13 km² area (-51.266%) in 13 years period. In principle the LU/LC decreased in a certain time has to go to other LU/LC and results increment of other LU/LC. Therefore, on the contrary shrub land, pasture land and agriculture land have increased at the expense of the other LU/LC which have decreased.

Table 5.3 LU/LC dynamics (1987-2000)

LU/LC classes	1987			2000			Rate of Change over 13 years
	Km ²	%	ha	Km ²	%	ha	
Forest	216.778	7.58	216777.8	53.2807	1.86	53280.7	-5.72
Shrub land	1,119.84	39.2	1119844	1,162.55	40.7	1162545	1.5
Woodland	583.489	20.4	583498.2	284.3564	9.94	284356.4	-10.46
Pasture land	765.134	26.8	765134.2	993.0831	34.7	993083.1	7.9
Bare land	79.8176	2.78	79817.6	76.5243	2.68	76524.3	-0.1
Agriculture land	79.9068	2.79	79906.8	276.3038	9.62	276303.8	6.83

The Remote sensing technique for mapping LU/LC of the area tells that there is no as such very big environmental threat to the area concerning the vegetation cover status of the land. As the land use land cover of the area describes, about 60% of the area is still covered with vegetation.

Even though there is no huge bare land and bad land in the study area which is considered as a big environmental threat, the trend shows that there is still a slight expansion of agriculture and a slight thinning of forest cover in the area. So an immediate attention has to be given to make sustainable utilization of the existing resources and to safeguard the environment. Lastly, this study concluded that the area has moderate vegetation cover and this has to be properly managed in a sustainable way.

CHAPTER SIX

6 Methods and procedures used to model unsustainable development process of the study area to change towards sustainable development conditions.

6.1 Environmental Problems associated with land cover changes

The methods and procedures discussed as follows. Field mapping on 1:50000 scale topographic sheet and ground woody vegetation survey and field observation in the study area were carried out 1) to identify the anthropogenic effect on woody vegetation cover 2) to see the status of vegetation after some disturbances such as fire hazard and abandoning cultivation and 3) to use the generated data as a ground truth for further land use and land cover classification.

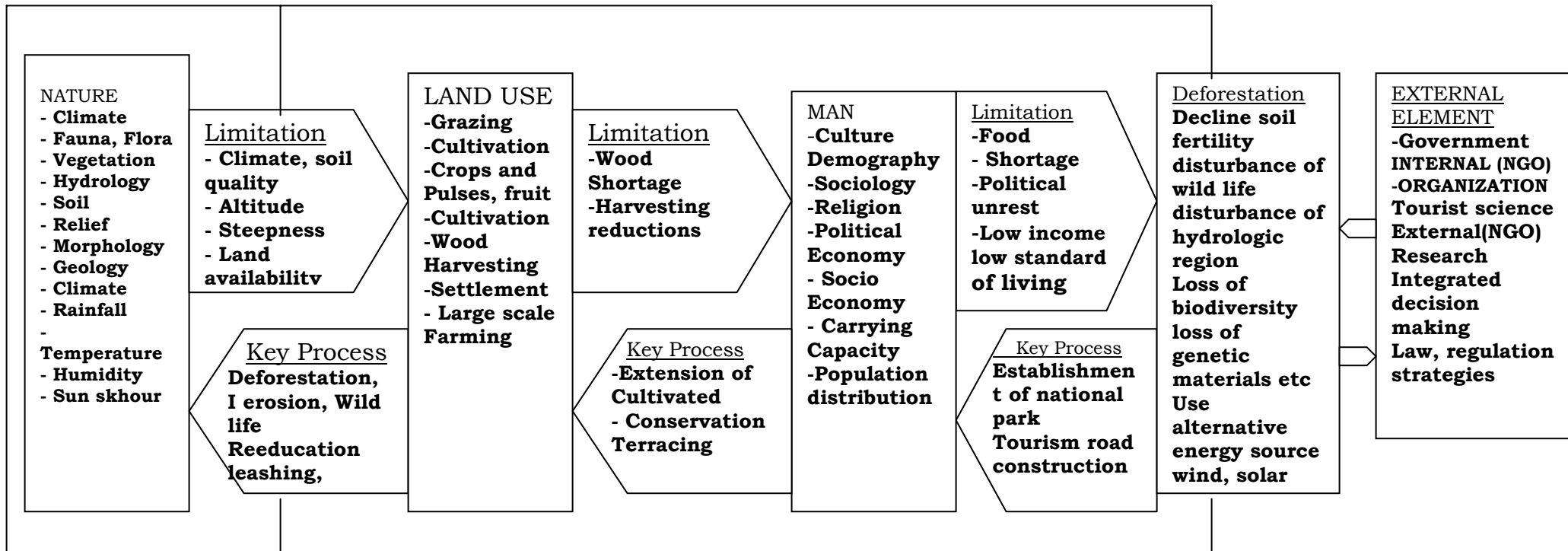
In an attempt to guide a scientific research with the objective of understanding the function of modeling and the low land ecosystems, geologists and rural development researchers have developed several models and conceptual frameworks (Hurri and Messerli, 1980).

An urban growth model for the application of conservation equations Presented by Forrester is another example of environmental modeling .Forrester model assumed that events in urban area do not alter the environment outside the city. This modal urban system is structured on the basis of three sub systems a) business b) housing, and c) population (1980:50). On the other hand the selection of Hurri and Messerli model is more advantages to understand rural environmental modeling as shown below.

The present study, in general has employed the model developed by Hurri Messerli, B. (1980:50). This model indicates the interrelationships among MAN, LAND USE, AND NATURE (Fig 6.1). The scheme shows interactions among the three subsystems in two opposite directions. Relation reading from left to right illustrates the limiting factors of one subsystem on the other. For example, climate, relief and soil quality constitute the NATURE subsystem which limit agricultural activities (the land use subsystem). This in turn influences the MAN subsystems where for example human existence is affected due to harvest reduction (losses) that would result either in migration or innovation of conservation measures. Such linear relationship would extend to EXTERNAL subsystems in the form of trade reduction or political unrest. The other relation is read from right to left. This direction of relationship, according to Hurri the application of resource conservation should be practiced to the entire geo-ecosystem. Hence planning and management of resource should seriously consider these interactive subsystems.

In this study the two subsystems /NATURAL AND MAN/ were treated mainly with the aim of explaining the land use dynamics (change) by paying attention to the description of pattern, as well as dynamics and conflicts of land use and land cover changes in the study Area. Attempts are also made to quantify the relationships among variables. The required data for the study were derived from field investigation and secondary data sources such as Baro- Akobo master plan study and Gambela region land use and land allotment plan (1990 and 2004).

Figure: 6.1 The scheme of the land cover change of Geo ecosystem modeling, showing the relationships among the attributes of the subsystems NATURE, LAND USE and environmental degradation



6.2 LAND USE/LAND COVR CHANGES OF ENVIRONMENTAL MODELING TOWARDS SUSTAINABILITY

In general the increasingly wide acceptance of a new concept of sustainable development is development which protects the environment, and development which advance social justice and an economically sustainable system must be able to produce goods and services in continuing basis: (see figure 6.2)

Therefore an environmentally sustainable system must maintain a stable resource base, avoiding over-exploitation of renewable resource systems or environmental sink functions. This includes maintenance of biodiversity, atmospheric stability and other ecosystems function, but the result of this research study in general shows that there is high resource depletion of natural forest, soil fertility and wildlife reduction of the study area (see table 4.2 & 4.4).

Thus from this environmental system analysis out put it may be easier to identify unsustainable development than sustainable development and this identification of unsustainable development can motivate us to take necessary policy action and sustainable development modeling to change unsustainable development processes of the study area towards sustainable environmental management processes.(see figure 6.3)

A qualitative understanding of the problem of land use - land cover change is the modeling stage which makes easy the understanding of the relation of variables in the system. This is accomplished by obtaining functional relationships between the variables so that for a given alternative and set of input values, the outputs are specified. There are a variety of forms for these relationships, such as maps, graphs or tabulated numbers. (see figure 6.3.1).

One important function of modeling is to assist the system analyst and decision maker to obtain a clearer understanding of interactions between the different elements of the system.

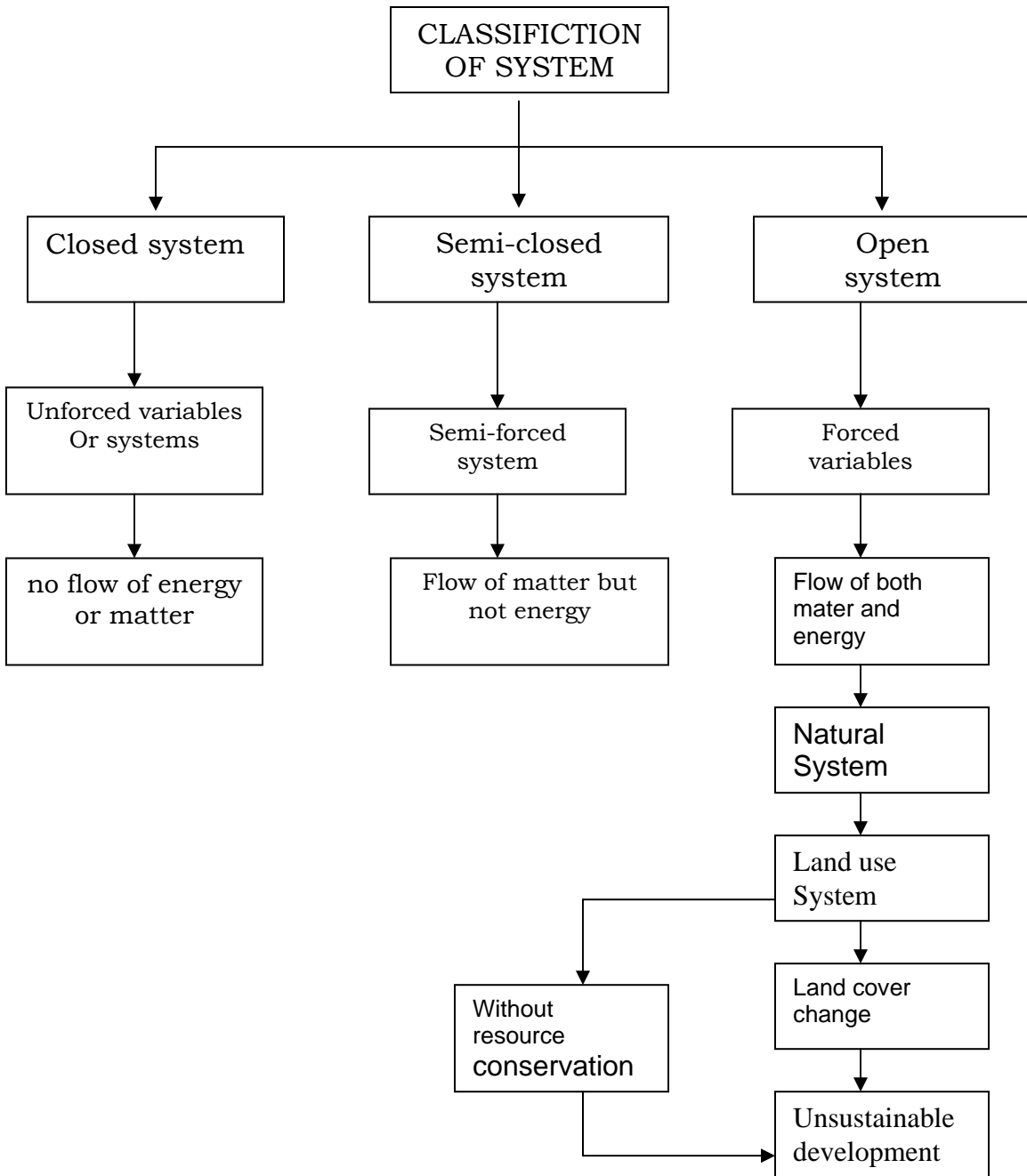
The goal of modeling is to relate output variables to input variables, so that the consequences of the imposition of alternative policies may be predicated.

An important part of the modeling process, once the problem has been structured, is to identify possible continuity and rate of change relationships. Namely, the flow rate of a variable into and out of any part of the system is related to the rate of change of the level of the variable.

The interaction and interconnection of different human activities determine the transfer of materials between the environment and the consumers (Figure 6.6), illustrates the flow of materials between the environment and consumers. The environment provides natural Products such as water air, mineral, agriculture and animal products. This resources are used by consumers, but this use has not been without limit or in a distractive manner and their should be conservation measure to create natural balance in the system, which we call them sustainable development Processes (Figure 6.5).

In put Variables are those factors that are imposed upon the system. This would include population Projections, Climatic conditions and other Socio-economic factors. Out put Variables, also known as dependent endogenous, or state variables, describe the performance Properties of the system. In these instances a population density may be insensitive to changes in land use system (Figure 6.7).

Figure 6.2 Classification of Environmental System & Resources Depletion



6.3 Sustainable development as objective of environmental management

Sustainable development is a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are all in harmony and enhance both current and future potential to human needs and aspirations (WXED 1987). This is essentially an economist's approach to the concept of sustainable development. It is the level of welfare that is to be sustained or perpetuated through economic, institutional and technological change (see figure 6.4).

In other words sustainable development focuses on the physical or resource base of an economy. In this definition, sustainable development requires that the level of environmental capital increases or is at least kept at the same level. This implies no reduction of aggregate resource stocks, maintenance of the quality and quantity of regeneration systems and compliance with constraints set by the resilience of ecosystem (opschoor 1987).

In general, regenerative and assimilative capacities of the environment are treated as natural capital and failure to maintain these capacities is considered capital consumption and therefore unsustainable. This requires that harvest rates of renewable resources should not exceed regeneration rates (sustainable yield) and that waste emission rates should not exceed the natural assimilative capacities of ecosystems into which wastes are emitted.

Fig 6.3 The schematic model of land use land cover change at the study area towards unsustainability

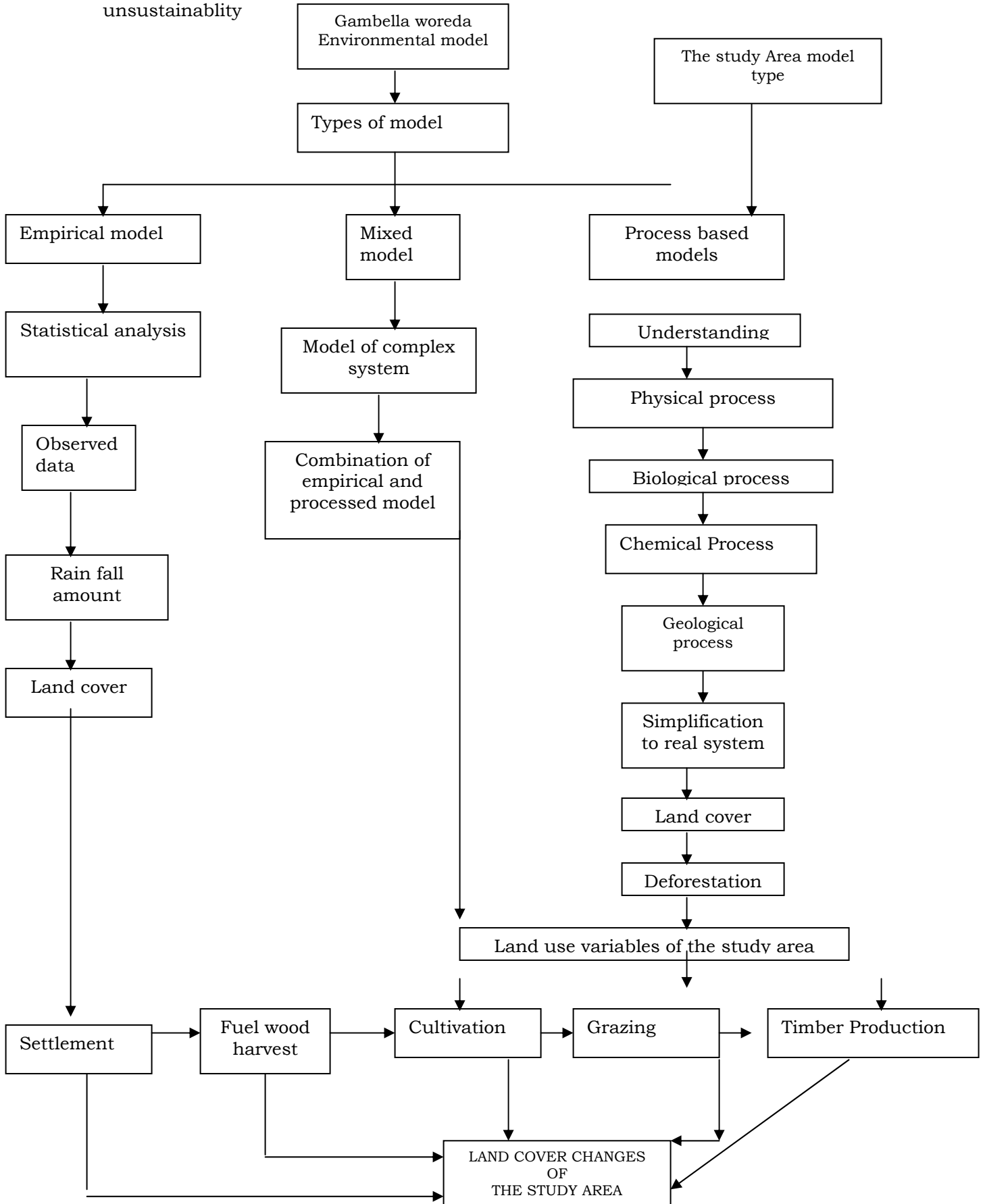


Figure 6.3.1 The process & objectives of modeling environmental problems

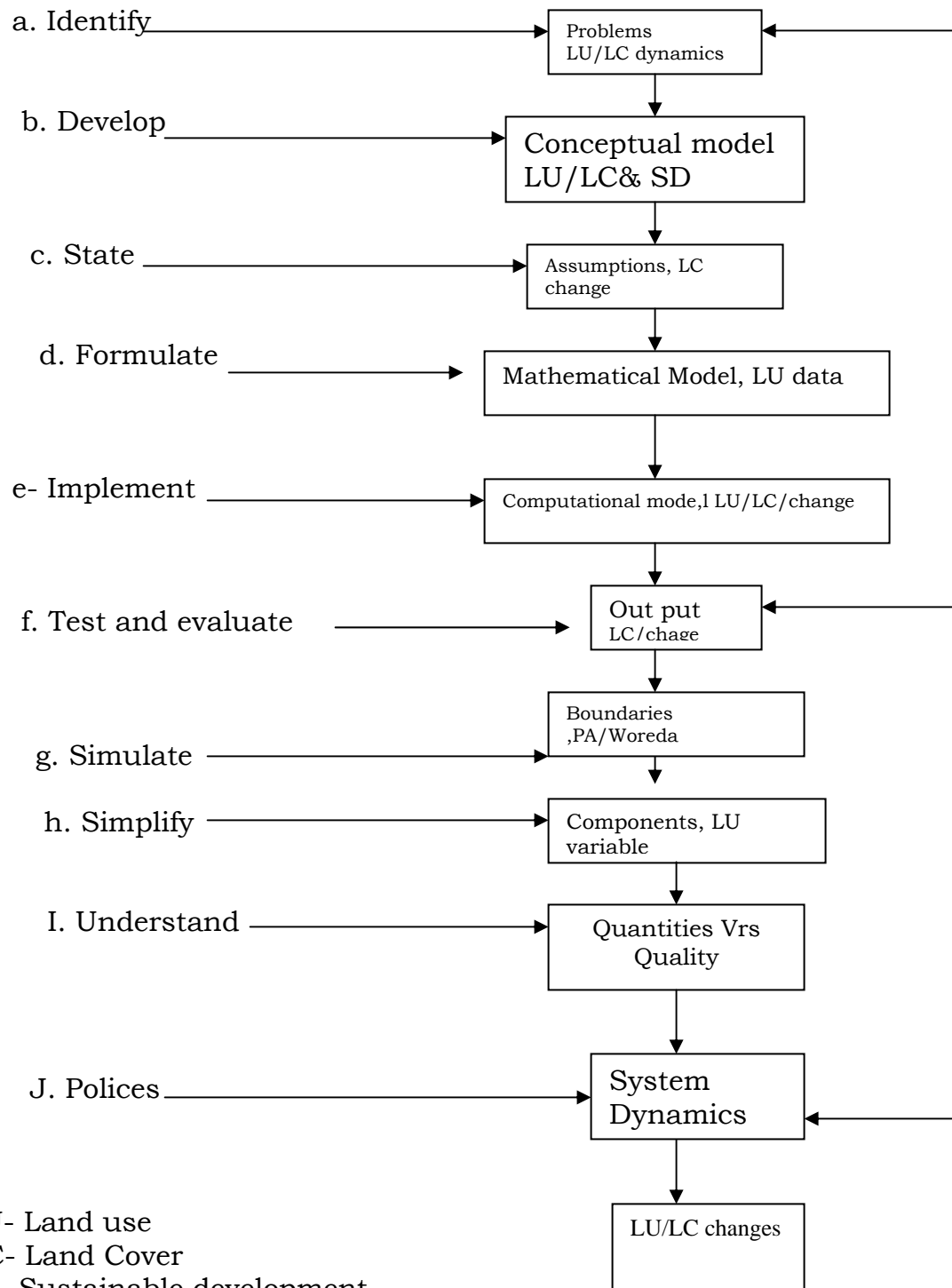


Fig 6.4 The schematic model of land use land cover change at the study area and towards sustainable development

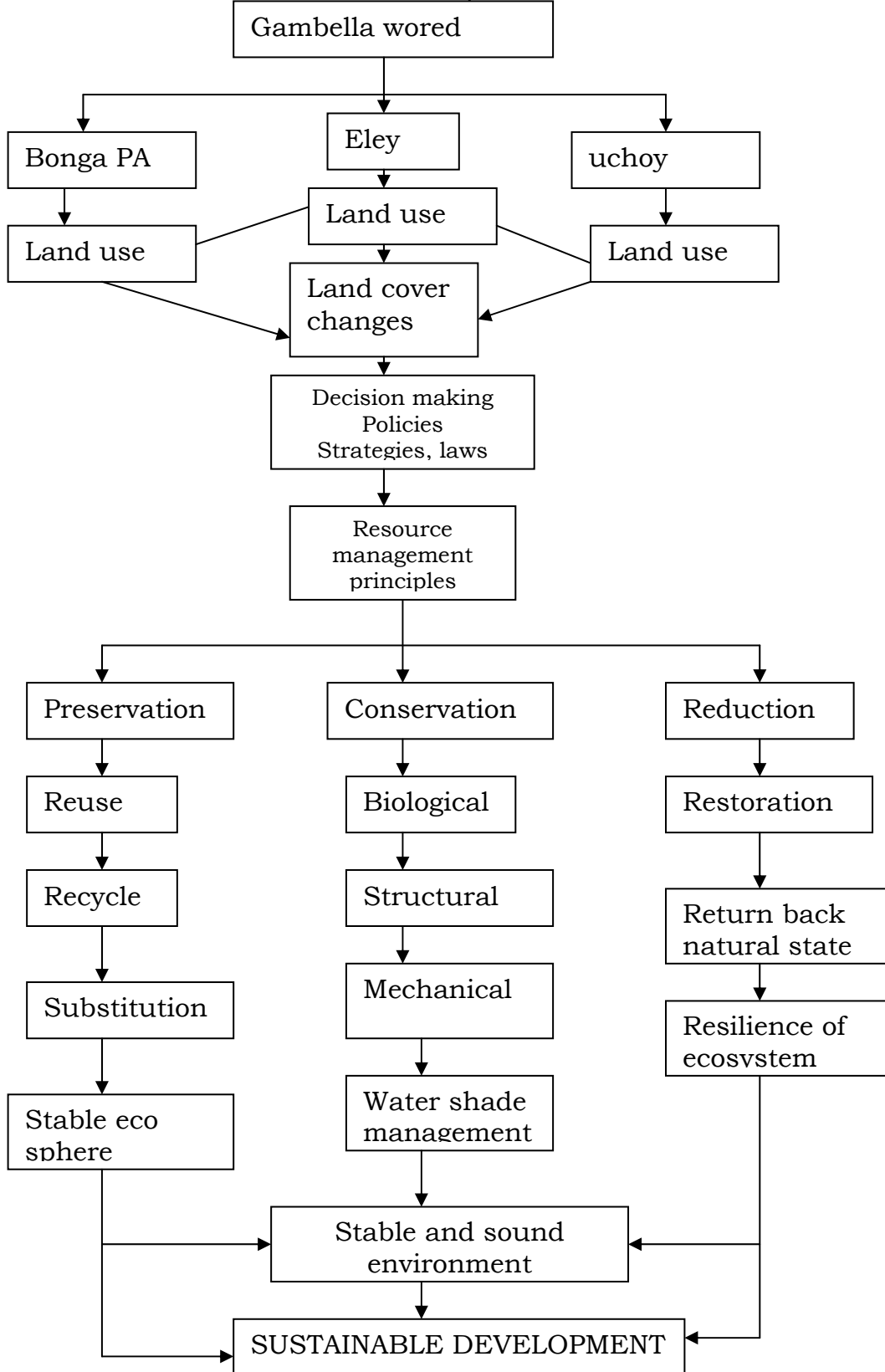


Fig-6-5 The schematic model of land use land cover change and unsustainable development of the study area towards sustainable development

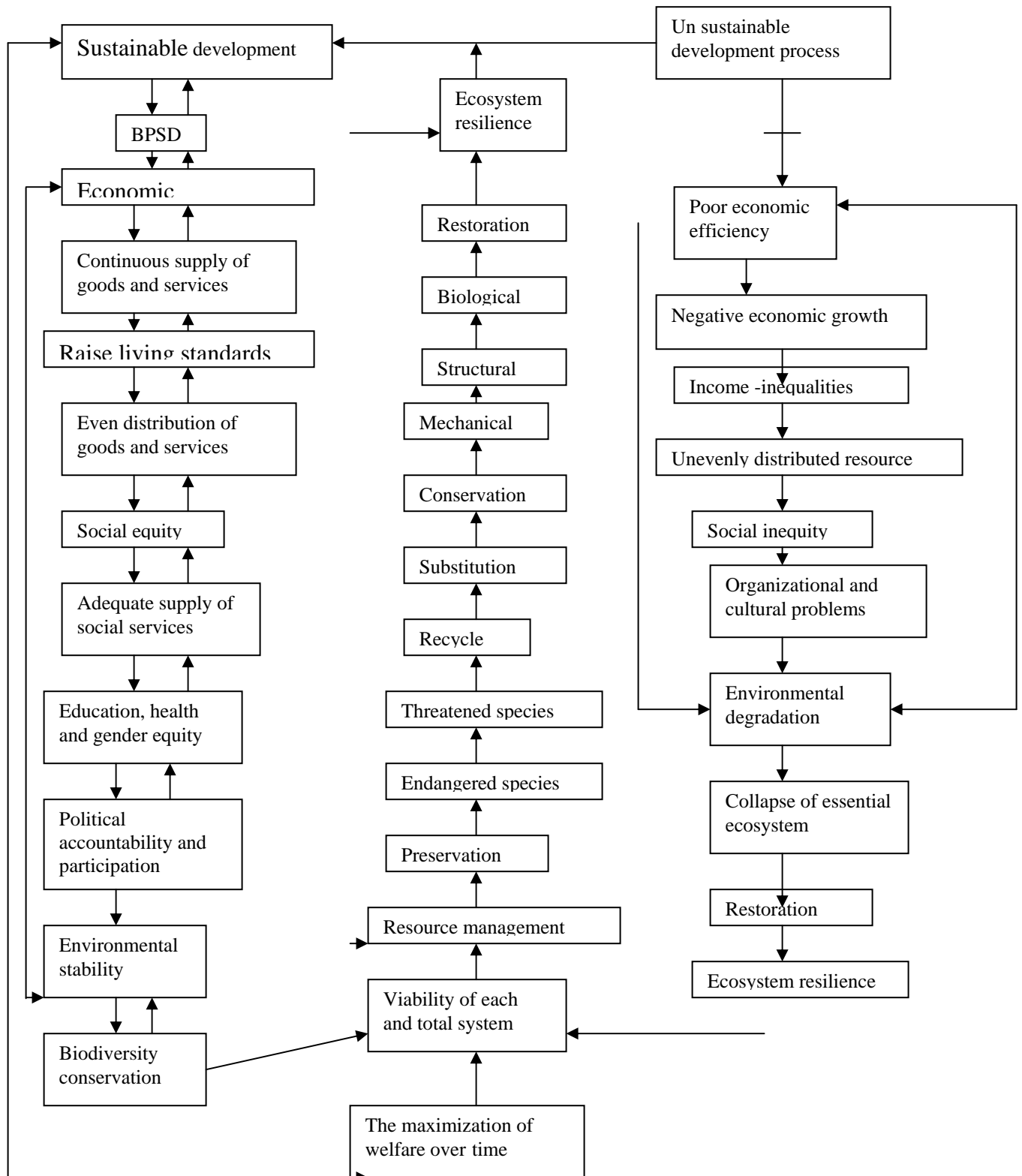
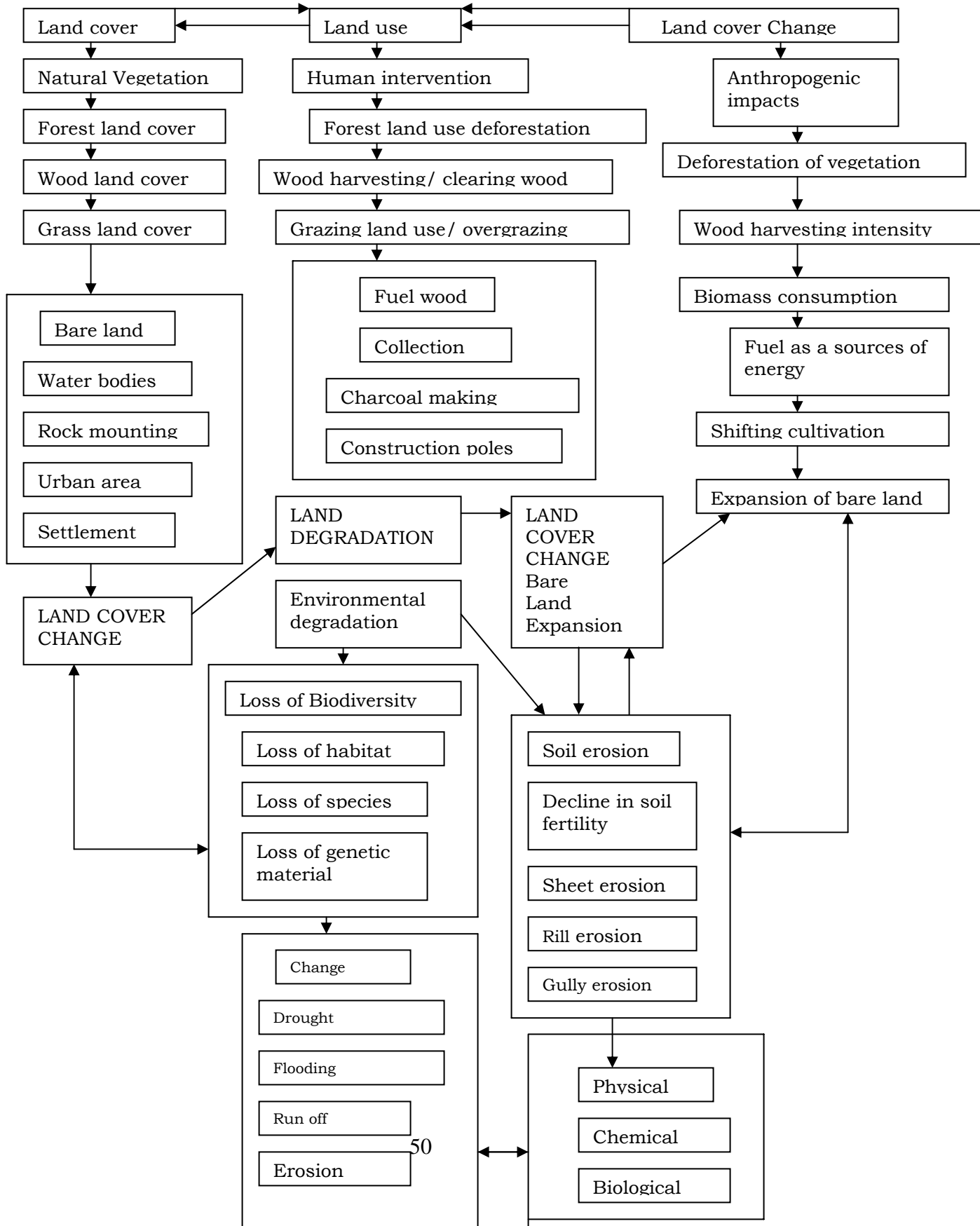


Fig 6.6 Geo-Environmental system model of Land use/cover changes due to interaction, interconnection and interdependence of human action.



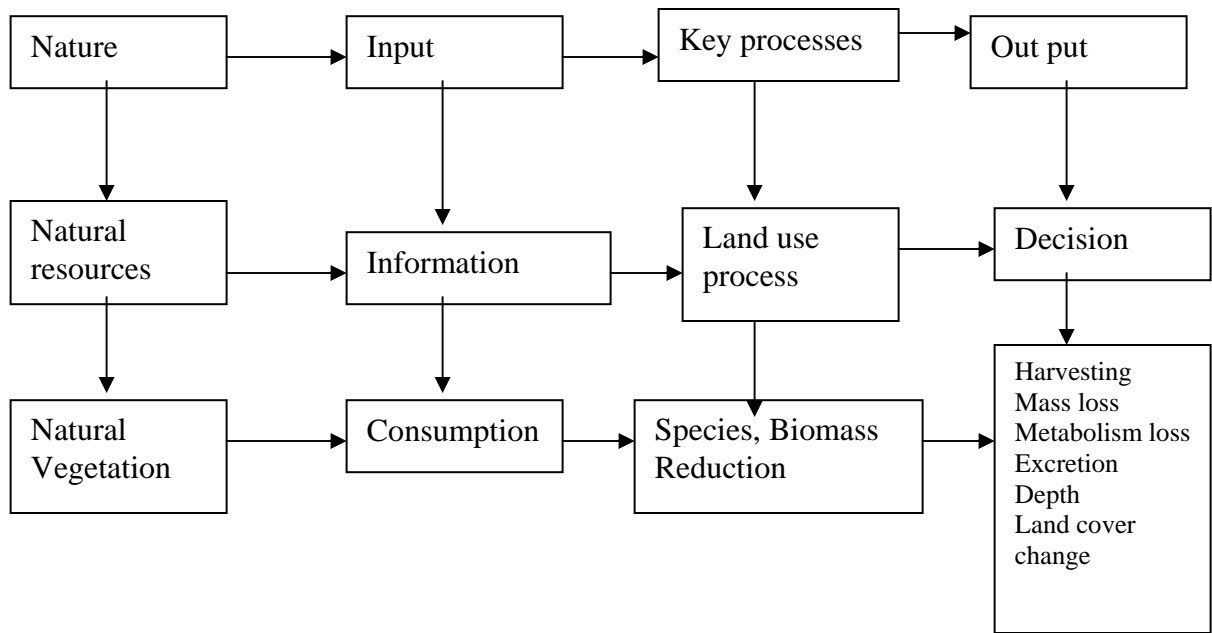


Figure 6.7 Input and out put flows model affecting the total mass of a vegetation cover

CHAPTER SEVEN

7. CONCLUSION AND RECOMMENDATIONS

7.1 CONCLUSION

This study is aimed at identifying the magnitude and the extent of land cover change in agriculture land use, indigenous resource management and the perception of farmers on the dynamics of land use in three random, selected PAs in Gambella woreda. The main rationale for selecting the three peasant Associations (PAs) are: first, agricultural land use conflicts are prevalent phenomena and second, the selected PAs belong to three different locations which is helpful for a comparative analysis of land use competition and resource management level between southern Sudan refugees at Bonga area (Uduk) and the indigenous peoples' (Angwa) at Elay and Uchoy peasant associations.

Assessment of the land use conflicts of the survey population lead to several conclusions. High population density of Bonga PA is the major defining feature as compared to local people of Angwa at Uchoy and Eley PAs of the study area.

At PA level population density varies from 70 persons in Bonga to 40 and 25 persons per square Kilometer in Uchoy and Eley PA, relatively this ration is quite high when compared to densities of 46.2 persons at national level and 15 persons per square kilometer at regional level. Due to misuse and inappropriate management of natural vegetation cover, there are severe devastation of the natural resources base.

The overall land use/cover change of the study area/Bonga, Eley and Uchey/ shown in (table 4.2 & 4.4), indicates that bare land, bush land, agriculture land and Pasture land was increased by 4.9,3.7,3 and 0.22 Percent per annum and the decrease in forest and wood land was -3.6 and -0.54 Percent per annum within 16 years (1990 to 2006).

When we consider the land use competition between agriculture land and forest/wood land cover, one can observe a considerable change in the last 16 years 1990 to 2006 (Table 4.2).

The total land cover change forest land and wood land was considerable high in the study site which shows a drop of 58 and -8.2 Percent, respectively. This is probably due to the expansion of crop land and clearing of forest for construction Poles and charcoal making.

The land use/cover Pattern of Gambela worda Shown in Table 4-1 (2006) indicates that wood land and grass land is the dominate land use classes account 82.2 Percent of the total area while the remaining land use types share 17.8 Percent.

Where as the land use/cover Pattern of Gambela region as shown in appendix-3 the dominate land use classes are wood land and grass land account 75 Percent of the total area while the remaining land use types share 25 percent.

As discussed in chapter four the land use/cover types of the study area of three PAS as shown in Table 4.2 (2006) wood land and grass land is the dominate land use classes account 82 percent of the total area and the remaining land use types share 28 percent.

As we have discussed in the above statement the land use/cover types Gambella region, wordeda and the study area is relatively similar land cover units i.e. the dominant land use category is wood land, followed by grass land, bush land, forest land, agriculture land and bare land. Although the scale of these studies did not allow the identification of homogeneous land cover.

- Both refugees and the local people's have very low perception and knowledge on forest recourses conservation methods.
- Natural forest is the major sources of energy for rural household of the study area.

- People of the study area have no experience about alternative energy use for different daily activities.
- Population pressure in seeking land for cultivation, grazing, fuel wood harvest, timber production and large scale settlement/is the major cause of deforestation

7.2 Recommendations

From empirical study data on the basis of the experience gained through the pursuit of this study area and primary data from field survey result, the following issues requires immediate actions as well as further research.

1. From this study, it can be concluded that recently in the study area, there was a land cover change in due to land use competition between cultivated land and wood land, grazing land and livestock production, fuel wood collection and wood land regeneration etc. The increasing need for fuel wood charcoal, construction pole and the expansion of cultivated land adversely affect the natural vegetation cover. Thus by controlling the expansion of cultivated land ,illegal cutting of trees ,burning natural forest and charcoal making with out limit, due attention should be given to the reduction of Biodiversity loss and the environmental degradation in the study area as well as in the region.
2. Environmental education program should be given to the community continually to protect the forest from frequent fire incidence and loss of biodiversity.
3. A way to reduce deforestation problem in the study area is to promote the establishment of plantation project, especial fuel wood plantation.
4. Promotion and use of more efficient energy supply which are renewable and continuous sources of energy such as wind, biogas and solar energy etc.

5. Water and soil conservation measures on the target area to stabilize ecologically.
6. Environmental rehabilitation program is the key component within the food security plan by improving the natural resource base.
7. Planting indigenous tree species to balance environmentally degraded area of the study site to achieve sustainable development of environmentally, socially and economically equitable processes.
8. Sustainability should focus mainly on the maintenance and stability of natural social and cultural systems, on reducing the conflict arising with in intera-generational distribution of resource as well as intr-generational equity.

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APPENDICES-I

QUESTIONNAIRE USED IN THE HOUSEHOLD SURVEY

A - AREA IDENTIFICATIONS

1. Name of the peasant Associations _____
2. Total Area in hectare(s) _____ ha
3. Cultivated land in hectares _____ ha
4. Forest/wood land in hectares _____ ha
5. Pasture/grazing/land in hectares _____ ha
6. Bare land in hectares _____ ha
7. Altitude (meter) _____ ha
8. Agro-climatic zone _____ m

B. HOUSEHOLD BACKGROUND

9. Number of the Household Head _____ Total Population _____ the PA.

Number of family size _____ occupation _____

10. Marital status

10.1 Married _____ 10.3 Single _____

10.2 Polygamous _____ 10.4 Divorced _____

11. In which activities do they engage in the place of reception? Put (✓) in the space provided

Activities	Household head	Children	Wife
Farming	✓		
Weeding			
Charcoal making			
Fuel wood collection			
Daily labour			
Harvesting			
Hunting			

C- LAND-USE AND LAND-HOLDING

12. Mention the major land use types under your possession.(in time put in hector (ha) or in any other local units.

Land cover Type	Years	
	1990	2004
1. Cultivated land		
2. Pasture /grazing land		
3. Forest/wood land		
4. Bare land		
5. Total holdings		

13. What was the average form size for each of the following crops in 1990 and 2004 harvest year (timed)

Maize _____ Sorghum _____ Sesame _____
 Ground nut _____ Root crops _____ Fruit & Vegetable _____

14. Which crop type was dominant in terms of area occupied for the last fifteen years?

Maize _____ Sorghum _____ Sesame _____ Millet _____

15. Based on question number 14, why did it became more dominant (reasons)?

1. Low labour requirement _____
2. High market value _____
3. Security food through out the year _____
4. Productivity _____

16. Which types of crop and/or activity (ies) dwindled in terms of areas occupied for the last fifteen years?

Maize _____ Sorghum _____ Sesam _____

Ground nut _____ Millet _____ Forest _____ grazing land _____

17. Based on question 16, why did it lose its importance (reason)?

1. Unable to stand against natural hazards _____

2. Low market value _____

3. Low Productivity _____

4. Absence of grazing ground _____

5. Attack by pest and disease _____

18. How many farm plots (parcels) do you possess?

1. Less than 2 _____ 3. 4-5 _____

2. 3 - 4 _____ 4. More than 5 _____

D.RESOURCE USE AND MANAGEMENT PRACTICES

19. The slope of your farms (put a tick) (✓)

1. Slightly sloppy _____ 3. Valley bottom _____

2. Hill top _____ 4. Table land _____

20. The colour of the soil on this farm ?

1. Dark _____ 3.Red _____

2. Brown _____ 4. Others (specify)

21. Do you face shortage of labour during farming activity?

1. Yes _____ 2. No _____ 3. Seldom _____

22. How do you frequently solve labour shortage problem?

1. By hiring laborers _____

2. Give the farm for share -croppers _____

3. Perform labour exchange arrangement _____

23. What is the state of vegetation cover in your Kebele?

1. Stable _____ 2. Depleted (deforested)

 3. Depleting _____ 4. Severely depleted _____

24. If your response to question 23 is depleted, can you state the main causes?

1. Over grazing _____
 2. Unfavorable Climatic condition _____
 3. Clearing the forest _____
 4. Timber cutting _____
 5. Other (specify) _____

25. What is the soil erosion status on your farm?

1. Slightly eroded _____ 3. Poorly eroded _____
 2. Moderately recoded _____ 4. Severely eroded _____

26. If your answer to question 25 is severely eroded, which indigenous practices do you employ to maintain the fertility of the soil erosion?

1. Earth terraces _____ 3. Infer cropping _____
 2. Agro –forestry _____ 4. Crop rotation _____

27. What is the most important climate problem in your village ? put atick (✓)

1. Drought _____ 2. Flood _____ 3. Windstorm

28. What are the main agricultural and environmental problems in your Kebele?

1. Decline of soil Fertility _____
 2. Rainfall variability _____

3. Damage by pest and disease _____

4. Multiplication of weeds _____

5. Other (specify) _____

E-CROP MANAGEMENT PRACTICES

29. Farm implements used for land preparation?

1. Clearing the cultivated field _____

2. Cultivating /Plowing /prope _____

3. Harvesting purpose _____

30. In your cereal field, which type of fertilizer do you frequently use in large proportion?

1. Manure _____

2. Chemical fertilizers

3. Green manure _____ Fallow

31. To which crop type do you apply manure /Chemical fertilizer/ in large proportion?

1. Maize _____

2. Sorghum _____

3. Millet

4. Sesame _____ 5. Ground nut _____

32. Do you inter crop Maize with other crops?

1. Yes _____ 2. No _____ 3. Others

33. What crop do you inter crop with Maize and Sorghum

1. Soybean _____ 2. Millet _____ 3. Pumpkin

34. When do you harvest Maize plant

1. After Maturity _____
2. Before Maturity _____
3. Depends on need _____
4. No specific period _____

F- PRODUCTION OF CROPS AND LIVESTOCK

35. State the yield in quintals (for crops) and in number (for live stock)

Crop type	Quantity (in Quintals)			
	1990		2004	
	Area(ha)	Yield(qt)	Area(ha)	Yield(qt)
Maize				
Sorghum				
Root Crops				

Sesame				
Ground nut				
Millet				
Total Yield				

LIVESTOCK POPULATION (NUMBER)

Live stock type	Number	
	1990	2004
Cow		
Oxen		
Sheep		
Goat		
Equines		
Polluter		
Total		

36. How did the agricultural production for the last 15 years?

1. Reduced _____

3. Constant _____

2. Increased _____

4. Difficult to determine

37. If your answer to question number 36 is reduced, what mechanisms do you adopt to raise the productivity of your farm land?

1. Selection of good seed varieties _____

2. The use of modern inputs _____

3. The use of indigenous resource management practices _____

4. Engage in wage labour /craft activates _____

5. Other (Specify) _____

38. What is the source of your cash income? (Circle the number).

1. Crop yield

3. Fire wood collection

2. Livestock sale

4. Charcoal making

5. Apiculture

APPENDICES

APPEDIX 2: Crops Grown in the study Areas and their Yield.

<u>Study Areas</u>	<u>Crop</u>	<u>Area</u>	<u>Yield</u>
	<u>Common Name</u>	<u>in ha</u>	<u>in quintal</u>
Bonga	Maize	150	1650
	Sorghum	128	1024
	Sesam	25	100
	Groundnut	10	110
	Mango	200	20000
	Banana	60	6000
	Yam	22	2200
<hr/>			
Eley	Maize	90	900
	Sorghum	46	330
	Sesam	30	60
	Groundnut	47	470
	Mango	44	4400
	Banana	31	3100
<hr/>			
UCHOY	Maize	144	1584
	Sorghum	72	578
	Sesam	96	386
	Groundnut	48	480
	Mango D	73	7300
	Banana	48	4800
	Yam	24	2400

Source: Field Survey 2006.

Appendix 3. Land cover types of Gambella Region

No	Land cover types	1990		2006	
		Area ha	Percent %	Area ha	Percent %
1	Forest land	545040	16	556,000.00	12
2	Wood land	1803250	50	1,522,516.00	45
3	Bush and Shrub	34065	10	737,000.00	22
4	Grass land	1021950	30	1,220.00	28
5	Wet land	12700	0.4	19,638.00	0.6
6	Urban Area	2300	0.04	3114.00	0.09
7	Cultivated land	4769100	1.4	114527.40	3.4
	Total Area		100	3406500	100

Source: Gambella Region land use planning study 2004 and Baro- Akobo integrated Master plant study 1990.

Appendix 4 Accuracy assesement of LU/LC mapping

LU/LC mapping accuracy for 1987

	Ground Truth (Percent)						Agricultural	Total
	Forest	Scrubland	Woodland	Pastuerland	Bare land			
Unclassified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Forest	30.08	0.00	0.00	0.00	0.00	0.00	8.07	
Shrubland	10.59	98.89	7.43	47.70	3.42	0.22	49.81	
Woodland	40.47	0.00	34.46	0.00	0.00	0.20	16.45	
Pastuerland	7.75	0.78	43.82	50.79	21.37	0.40	12.31	
Bareland	0.00	0.00	0.00	0.33	71.79	0.77	0.43	
Agriculturela	11.11	0.33	14.29	1.19	3.42	98.41	12.93	
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

LU/LC mapping accuracy for 2000

Ground Truth (Percent)							
Class	Forest	Shrubland	Woodland	Pastureland	Bare land	Agricultural	Total
Unclassified	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest	88.34	0.00	0.42	0.00	0.00	10.44	24.54
Scrubland	0.53	89.44	0.69	8.58	5.30	6.73	40.34
Woodland	10.44	6.54	98.12	1.79	0.00	19.74	23.12
Pastureland	0.00	4.01	0.00	89.63	0.00	2.99	6.68
Bare land	0.00	0.01	0.00	0.00	94.70	1.18	0.57
Agricultural	0.69	0.00	0.77	0.00	0.00	58.92	4.75
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Appendix 5: THE DESCRIPTION OF THE MAJOR LAND COVER TYPES IN THE STUDY AREA.

- 1. Forest:** is land which consist of a multi-storied tree community with a tree crown cover of 50 or more. It is described by major type and degree of disturbance. In general there is no forest cover in the study area. The forest land is devastated for cultivation purposes it is disturbed at different degrees, which are substitute by secondary forest.
 - 2. Wood land:** Consist of a single storey tree cover with fairly even height and crown density under lain by grass species.
 - 3. Bush land:** is land mainly consists of multi stemmed bush type vegetation with 2-6 m in height.
 - 4. Shrub land:** is a land area covered mainly with multi-stemmed shrub types vegetation which are less than 2m in height.
- According to the field survey in the study area all the above four types of land cover treated under wood land cover for the seek of understanding land use/cover types.

The wood land cover types may all be defined as open and dense wood land cover.

- 5. Cultivation:** Land which is being cultivated cultivate land is commonly cultivated during only part of the year, for the rest of the year grasses may be allowed to grew and the land may be almost indistinguishable from grass land.
- 6. Grass land:** is the land is continuously/permanently covered by grasses. This land cover type also had some difficulties to distinguishing it. The minor problem was to distinguish it from cultivated land.
- 7. Wet land:** Land that is covered by water bodies.
- 8. Bare land:** Land that has no apparent vegetation cover. It is either in the form of exposed rocker or exposed soil. Both the wetland and exposed rock treated as a bare land in this study.
- 9. Urban:** This referees to land under settlement including village, town and city.

Catchments management and Reforestation

Although the study area is by no means the worst example of soil loss, nevertheless land degradation occurs in various forms throughout the region including the study area water caused soil erosion of chemical, physical and biological degradation.

Soil erosion reduced plant productivity by decreasing soil depth, there by reducing the capacity of sites to store water for plant use, and by selectively removing clays and the fine material that absorb soil nutrients essential to plant processes.

The catchments management programme proposed consists of two approaches:

1. Withdrawing seriously effected soils and steep land from agriculture use and.

2. Undertaking soil conservation practices.

The main soil conservation practices proposed include:

- Development of grass strips in undertaking land planted to annual crops.
- Construction bunds in rolling terrain in annual crops.
- Terracing in steeper terrain

DECLARATION

I, the undersigned, declare that this thesis is my work and that all sources of materials used for the thesis have been duly acknowledged.

Woldesemayat Alemu _____

Addis Ababa

June,2007