Evaluating The Land Use And Land Cover Dynamics In Borena *Woreda* South Wollo Highlands, Ethiopia

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Abstract

This paper describes the land use and land cover dynamics in Borena Woreda of South Wollo Highlands of Ethiopia and implications by using the DPSIR framework(Driving Forces-Pressures-State-Impact-Response) in a Geographical Information System (GIS) context. The integration of satellite remote sensing and GIS was an effective approach for analyzing the direction, rate, and spatial pattern of land use change. Three land use and land cover maps were produced by analyzing remotely sensed images of Landsat satellite imageries at three time points (1972,1985,and 2003) . The result shows five major land use and land cover types. These include forest, shrub or bush, grassland, agricultural land and bare land. Between (1972 to 1985), there was a dramatic expansion of agricultural land followed by bare land while, shrub land, forest land and grass land showed reduction in coverage. The period between 1985 to 2003,saw similar changes in agricultural land, bare land, shrub land and forest land cover but grass land showed a slight expansion in coverage due to the conversion of forest and shrub land to grass land. The major driving forces for these changes were natural factors such as steep slope, drought and Climate change. The human driving forces for these changes steep slopes, drought and climate change. The human driving factors include population growth and density, over-use of land, farm size, land tenure status and land use. These factors exert pressure and impacts on land use. Implications include biodiversity loss central ownership of natural resources , the breakdown of traditional structure and consequent difficulties in the use o fallow lands, open access to grass lands, inability to protect and manage land resources , inappropriate development strategies and la ck of land use planning.

Key words: land use/land cover dynamics, DPSIR model, remote sensing, Ethiopia.

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Introduction

Land use and land cover pattern of a region is an outcome of natural and socio – economic factors and their utilization by man in time and space (Zubair, 2006). Driving forces which also referred as factors can be categorized as natural and human induced were recognized in the study area. The natural factors in the study area include high intensity of rainfall and steep relief (Lakew et al, 2000) and soil types as well as Climate change are also driving forces for land use/land cover change. Among the straightforward identified human causative factors includes Population growth and density, over intensification of land use, Farm size, Land tenure status and Lake of Policies on land use.

A change in land use and land cover is increasingly rapid, and can have adverse impacts and implications at local, regional and global environments (Brandon, 1998). As rightly noted by Reid et al. (2000), land use and land cover is an endlessly changing process taking place on the surface of the earth. Furthermore, Richards (1990) argues that the modern world has been facing massive changes in its land use patterns in the past few centuries. Williams (1990) clearly stated that in the last few decades' conversion of grassland, woodland and forest into cropland and pasture has risen dramatically in the tropics.

It is taken as a serious problem in changing the environment. The change is due to human activities and/or natural processes (Meyer and Turner, 1994). Moreover, this change could be the result of complicated interactions of socio economic and biophysical situation like economic diversification, technological advancement, demographic pressure and many other related conditions (Reid *et al*., 2000).

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, northwest Ethiopia (Gete, 2000).

Kebrom and Hedlund (2000) reported increases in open areas settlements at the expense of shrublands and forests between 1958 and 1986 in the Kalu area, north central Ethiopia. On the other hand, deforestation trend was reduced through appropriate interventions by promoting planting of local tree species in the Chemoga Watershed, Blue Nile basin, Ethiopia (Woldeamlak,2003) between 1957 and 1998.Similarly, Aklilu (2006) concluded that in the Beressa watershed (central Ethiopia), there were substantial land use changes in the area during the second half of the 20th century. The most important changes were destruction of the natural vegetation, increased plantations and expansion of grazing land. Cropland increased slightly in the 43 years period. Moreover, Bezuayehu and Geert (2008) reported that the decline of natural forests and grazing lands due to conversion to croplands between 1957 and 2001. In this respective period, crop lands increased from 403km^2 in 1957 to 607 km^2 in 2001- a net increase of 51% in Fincha' watershed. In addition, in Chirokella Micro-watershed of South Eastern Ethiopia, the dense forest cover decreased by over 80%, the moderately forest land was completely transformed into other land use and land cover systems, cultivated and settlement lands increased by 62.8% and bushes and degraded land cover categories showed increasing patterns of 49.9% and 100%, respectively between 1966 and 1996 (Mohammed and Tassew, 2009).

Such local-level dynamics is very important in determining the status of land and ecosystem health. Hence, information on land use and land cover and possibilities for their optimal use is essential for the selection, planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population (Moshen, 1999). Studies of rates, extents, patterns, causes and implications of land use and land cover dynamics at local level can help to design appropriate land management practices, strategies and policies. But evaluation of land use and land cover dynamics at this level is rare in

Ethiopia in general and the highlands of Wollo in particular.

The specific objectives of this study are to evaluate the extent and rate of land use and land cover dynamics over time and to assess the cause and effect relationships between interacting components of social, economic, and environmental systems with land use/land cover change and implications of these changes in Borena Woreda of South Wollo Administrative zone which is located in the Highlands of Ethiopia.

Description of The Study Area: The study is carried out in Borena *Woreda* which is located in the north-central highlands of Ethiopia (Figure 1). The area is located within South Wollo administrative zone of the Amhara Regional State. It lies between $10^0$34'N to $10^0$53'N and $38^0$28' E to $38^0$54'E. The *Woreda* covers a total area of 937km^2 and is inhabited by about 158,920 people (CSA, 2008). It is characterized by diverse topographic conditions consisting of four agro-climatic zones ranging from 1000 to 4000 meters above sea level by Ministry of Natural Resources Development and Environmental Protection- Watershed Development and Land Use Department (MONRDEP-WDLUD, 1995). These are *Kolla* (Tropical) refers to lowlands between 500 and 1,500 meters, *Woina Dega* (Subtropical) refers to highlands between 1,500 and 2,300 meters, *Dega* (Temperate) refers to highlands between 2,300 and 3,200 meters and *Wurch* (Alpine) refers to highlands between 3,200 and 3,700meters. A mountainous and highly dissected terrain with steep slopes characterizes the upstream part of streams whereas undulating topography and relatively gentile slopes characterized the downstream part of streams in the Woreda.

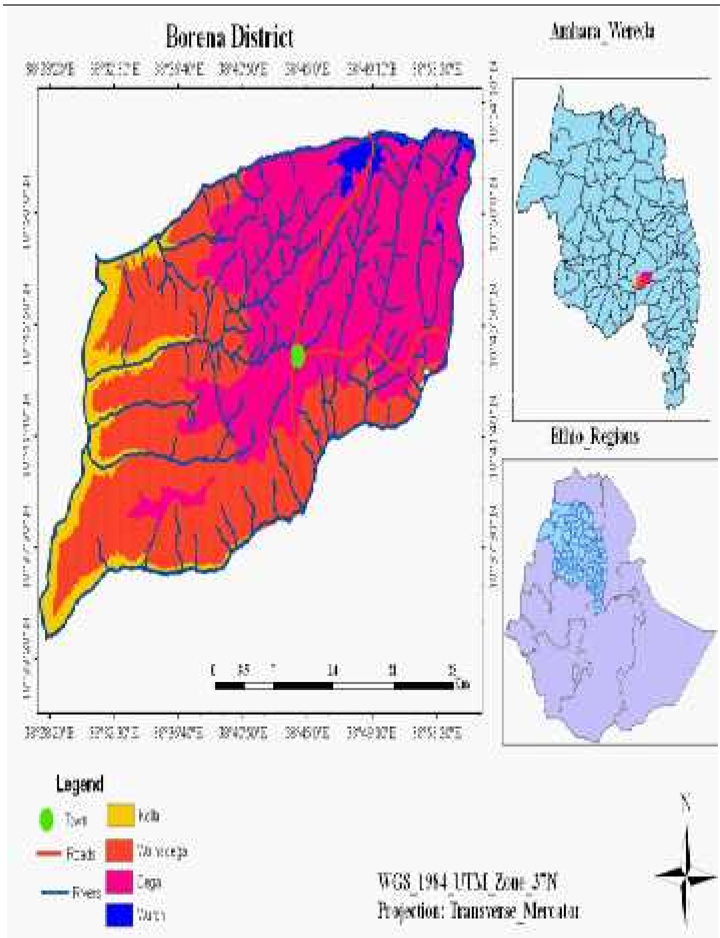

Figure 1: Location map of Borena woreda

The total annual rainfall varies from 889 to 1500 mm per year. The highest rainfall falls during summer, which starts in June and ends in September and short rainy season is in spring which consists of March, April and May. The mean annual temperature of the region varies from 14^0c to 19^0c. The absolute maximum temperature occurs from March to May and the absolute minimum temperature occurs in December, July and August. The upper North Western part of the *Woreda* is known for its minimum temperature which results in the prevalence of *Wurch* type of climate while the South Western part of the *Woreda*, has the highest temperature, characterized by *kolla* climate.

Materials and Methods

The Description of DPSIR model for Land use and Land Cover Evaluation

Land use and land cover data play important roles in evaluating landscape state, change, pressures, and potential management responses. The DPSIR model assumes cause-effect relationships between interacting components of social, economic, and environmental systems, which are

Driving forces of land use/land cove change

Pressures on the land use/land cover

State of the land due to the changing situations

Impacts on population, economy, ecosystems and/or environment

Response of the society.

The DPSIR model (Figure 2) shows how human activity (also known as a driver or driving force) exerts pressure on the land resources and, as a result, changes the state of the environment or land. The state of the environment or land can have impacts on people's health, ecosystems, and natural resources. These impacts can result in responses in the form of management approaches, policies, or actions that alter the driving forces, pressures, and, ultimately, the state of the environment. Changes in impacts over time can result in people modifying their response to those impacts (European Environment Agency, 2003).

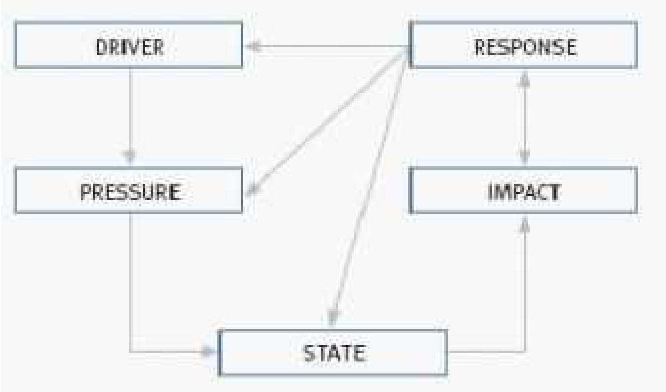

Figure 2: DPSIR model (**Source**: Adapted from Smeets and Weterings, 1999.)

Table 1: Description of DPSIR indicators

Indicator type	Description of indicator type
Driving force (driver)	Describes social, demographic, and economic developments. Primary driving forces are population growth and changes in people's needs and activities. These change lifestyles and overall levels of production and consumption, which in turn exert pressures on the land.
Pressure	Tracks people's use of natural resources and land, and production of waste and emissions (for example, greenhouse gases and particulates into the air). These pressures can change environmental conditions.
State	Describes the quantity and quality of the environment and natural resources (for example, water quality, air quality, or land cover).
Impact	Describes the effects that land use/land cover changes have on environmental or human health (for example, land productivity decline).
Response	Describes responses by government, organizations, or the community to prevent, compensate, ameliorate, or adapt to changes in the environment (for example, the introduction of regulations such as national environmental standards and legislative initiatives to protect native vegetation and biodiversity).

Source: Adapted from European Environment Agency, 2003.

According to Lillesand et al. (2006), change detection involves the use of multi- temporal datasets to discriminate areas of land cover change between dates of imaging. Thus, the materials used to create spatio-temporal database needed for this study were three set of landsat satellite imageries. To analyze and quantify the spatial-temporal LU/LC dynamics the GIS and remote sensing technologies were used. This is because of the fact that Remote Sensing (RS) and Geographic Information System (GIS) are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of Earth system function, patterning, and changes at local, regional and global scales over time and space; such data also provide an important link between rigorous, localized ecological research and regional, national and international conservation and management of biological diversity (Wilkie and Finn, 1996).

To meet the objectives of the research multi-temporal satellite imagery and global positioning system as well as topographical maps of scale 1:50,000 for ground verification has been used as it is summarized in (Table 2).

Table 2: Materials and their sources used in the study

No	Image	Sensor	Resolution or Scale	Date of acquisition	Source
1	Landsat1	MSS	57x79m	12/12/1972	GLCF
2	Landsat5	TM	30x30m	1/1/1985	GLCF
3	Landsat7	ETM +	30 x30m	12/2/2003	GLCF
4	Top Sheet		1:50,000		EMA

GIS and remote sensing method allow spatial monitoring and analyses where the knowledge of the stakeholders can be integrated. As a result to analyze and quantify the spatial-temporal Land Use and Land Cover dynamics the GIS and Remote sensing technologies was used.

Data from Landsat imageries was processed by ERDAS EMAGINE 9.1 software and spatial analysis, interpolation and other calculations by ArcGIS 9.3.1. For change detection the ENVI 4.3 software was utilized and MS office Visio 2007 was used to create Charts and graphs. Supervised digital image classification technique was employed, complemented with field surveys that provided on-the-ground information about the types of land use and land-cover classes.

The Supervised Classification method for Land Use and Land Cover dynamics analysis with spatio-temporal changes were monitored by analyzing multi- temporal remotely sensed images of three dates of Landsat satellite imageries. A blend of steps/procedures was developed to interpret, analyze, map and quantify the available data sets (Figure 3).

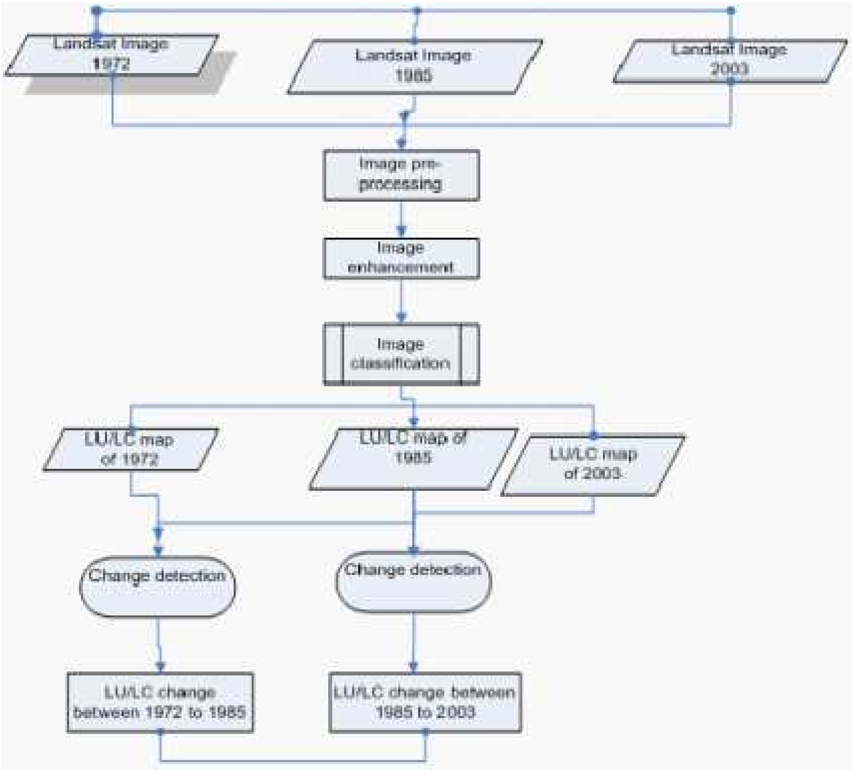

Figure 3: Flow chart showing the general methodology of land use/land cover evaluation.

Local geodetic datum of Adindan, reference ellipsoid of Clark1880(Modified) and projection type of UTM Zone 37 North are the spatial reference coordinate systems applied to rectify and resample both the three imageries using ArcGIS 9.3.1software. For the land cover classification 30 (10 from agricultural land, 10 from forest cover and 10 from shrub land) ground control points were collected by global positioning system (GPS) and assisted with toposheet map of 1:50,000 scale as base map to register the geo-database environment to facilitate further analysis. Finally, three land use and land cover maps with RMS error of less than 0.85 where produced. In the mean time, Geo-database was created and all spatial datasets were stored within a produced corresponding to the three reference years and temporal changes in land use and land cover were determined. The author also used Focus Group Discussion to obtain qualitative information from a predetermined and limited number of people sharing a common feature. The focus group interviews and observation were conducted in six villages in the study area to obtain additional information on the long year experience of land use and land cover practices of the *Woreda*. This informal in-depth interview and intensive discussion were done with 12 of the elder household heads of which 3 of them where female. This is due to their long year land use system of the people in the study area.

The investigated households for this study were selected based on multistage sampling technique. Firstly, the existing households were stratified spatially into *Dega, Woinadega and Qolla* agro-climatic zones. Then, the sample households were proportionally selected from each agro-climatic zone based on systematic sampling technique. Hence, 80 sample households were selected for this study. Given the relative homogeneity of the subsistence farms in the three agro-climatic zones in terms of physical environmental factors and resource endowments, the sample size of each agro-climatic zone would be reasonably representative of the population it stood for. Moreover, knowledgeable key informants were included into the study through purposive sampling technique.

Results and Discussion

Dynamics in Land use and land cover types in the Study Woreda**.** Using the application of image classification methods, five major land use and land cover types were identified in Borena *Woreda.* These include forest, shrub or bush, grass, agricultural and bare land, based on the characteristics of Landsat satellite images of the year 1972, 1985 and 2003.

Table 3: shows description of each land use land cover type in the study area.

Land use and Land cover classes	Description of each land use class
Crop Land	Areas allotted to rain fed crop cultivation both annuals and perennials, mostly of cereals in subsistence farming and the scattered rural settlements included within the cultivated fields.
Forests	Areas covered by trees forming closed or nearly closed canopies; forest; plantation forest; dense (50-80% crown cover) predominant species like Juniperus procera.
Shrub land	Land covered by small trees, bushes, and shrubs, in some cases mixed with grasses; less dense than forests
Grass land	These are lands where small grasses are the predominant natural vegetation. It also includes land with scattered or patches of trees and it is used for grazing and browsing
Bare Land	Which are parts of the land surface which is mainly covered by bare soil and exposed rock.

Land cover mapping

The major land use and land cover types shown by the maps of 1972, 1985 and 2003 include cultivated land, grassland, shrub or bush land, forest, and bare land.

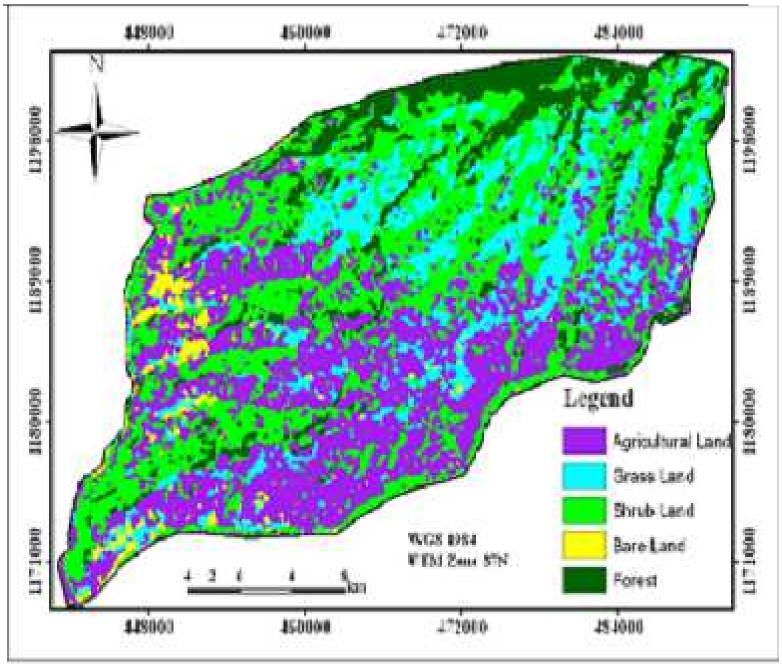

Figure 4: Land use and land cover map of Borena *Woreda* in 1972

As indicated in (Figures 4 and 5), the greatest share of land use and land cover from all classes is shrub land, which covers an area of 36,239 ha, contributes 35% of the total area. Agricultural land and grass land cover an aerial size of 32,750 ha (31 %) and 16,535 ha (16 %) respectively whereas the aerial coverage of forest and bare land was 13,599 ha (13%) and 4790 ha (5%) of the total area of the *Woreda*. This shows that 64% of the total area of the district was covered by shrub , forest and grass land in 1972 and the remaining 36% was covered by agricultural and bare land, which indicates that much of the area was covered by green vegetation in 1972.

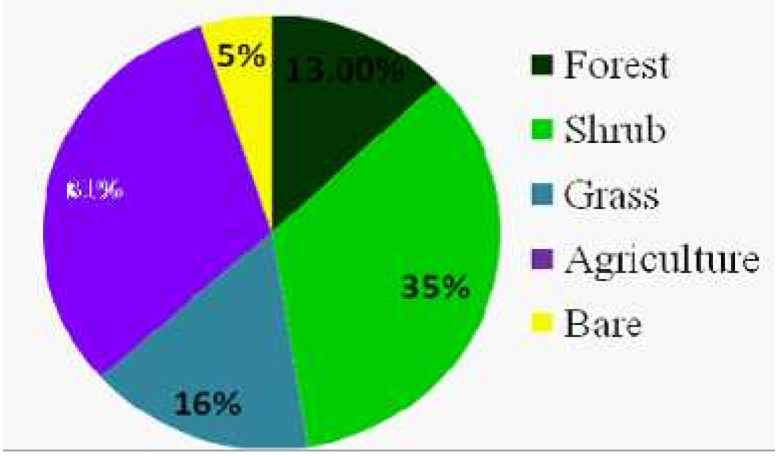

Figure 5: Aerial coverage and percentage of land use and land cover types in 1972.

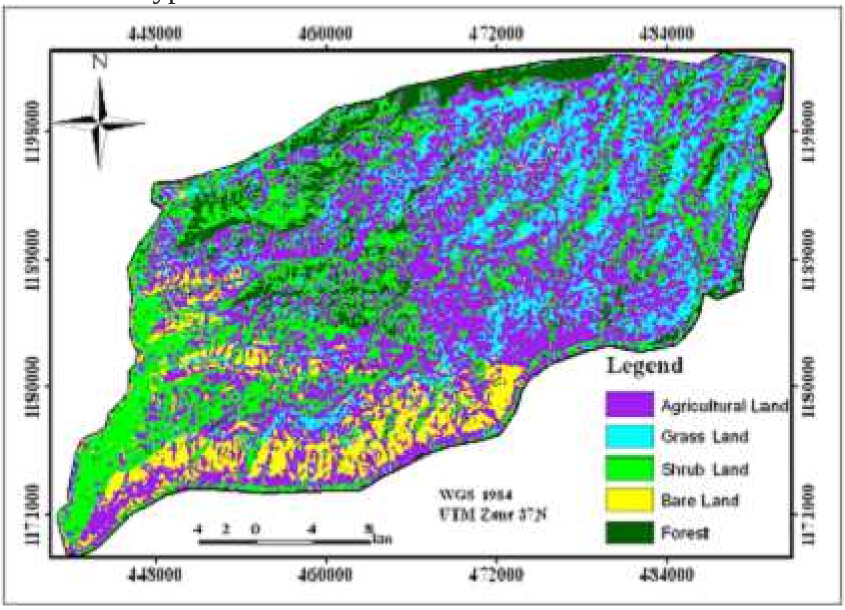

Figure 6: Land use and land cover map of the Woreda in 1985.

As indicated in (Figures 6 and 7) the greatest share of land use/land cover from all classes is cultivated land, which covers an area of 45,735 ha (44 %). Shrub or bush land and grass land covered an aerial size of 25020ha (24 %) and 15,580 ha (15 %) respectively. The least aerial coverage was forest and bare land, which accounts for only 9,795 ha (10 %) and 8,117 ha (8%) respectively from the total area of the *Woreda*. The fast growth of agriculture up to 44% was due to the conversion of forest, shrub and grass land to agricultural land because of rapid population growth in the study area as explained by Central statistical Agency of Ethiopia in 1994 and 2008. In addition to this there was expansion of bare land from 5% in 1972 to 8% in 1985 because of severity of drought in Wollo area in between these years.

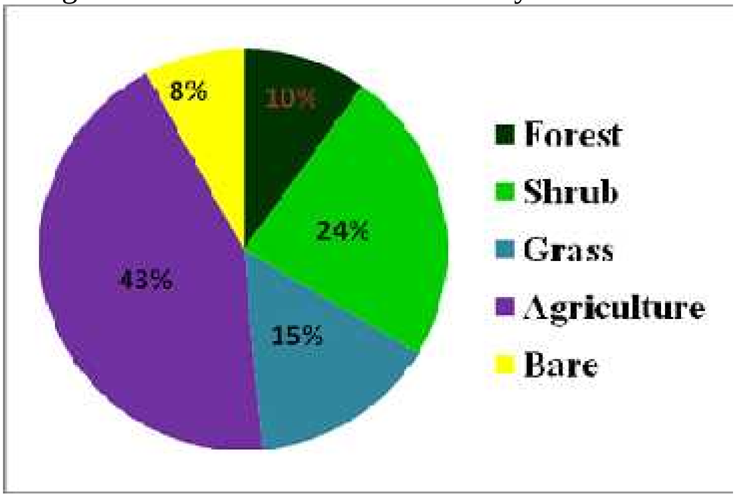

Figure 7: Aerial coverage and percentage of land use and land cover types in 1985.

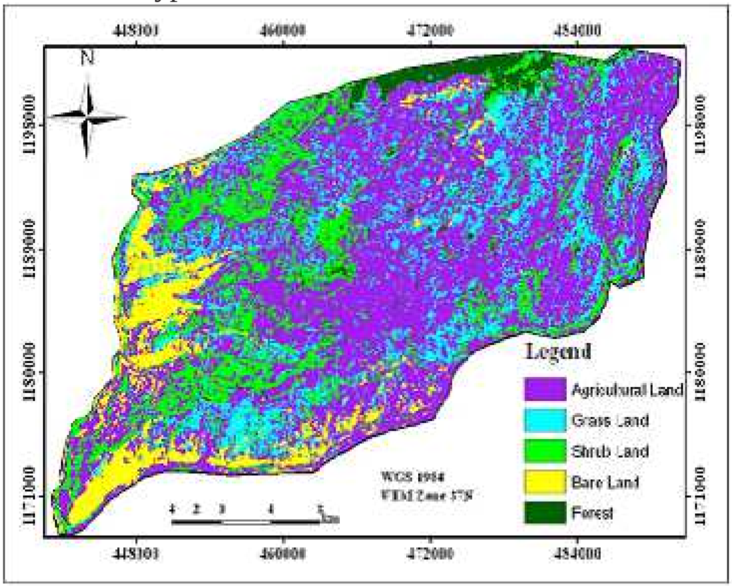

Figure 8: Land Use and Land Cover Map of the Woreda in 2003.

As indicated in (Figure 8 and 9) the greatest share of land use and land cover from all classes is cultivated land, which covers 51,842 ha (49 %) which is almost half of the total area of the *Woreda*. Shrub or bush land and grass land covers were 18,186 ha (17 %) and 19,604 ha (19 %) respectively. The forest and bare land respectively covered 6,087 ha (6%) and 9,076 ha (9%) from the total size of the *Woreda*. Still agriculture covered the largest area in 2003 which depicts conversion of other land cover classes to cultivated land.

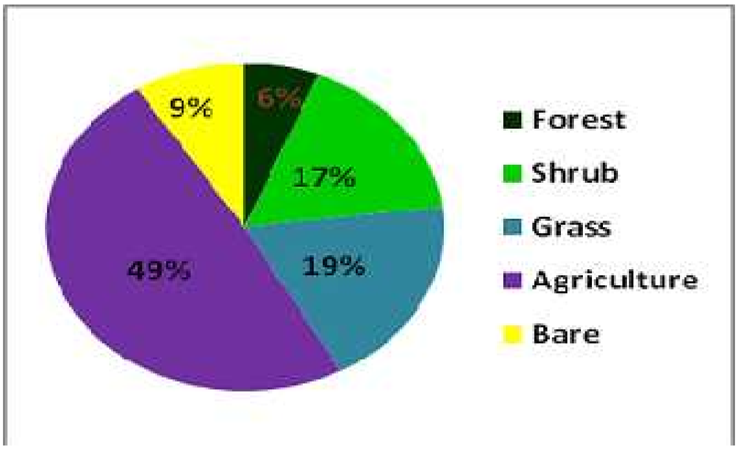

Figure 9: Aerial coverage and percentage of land use and land cover types in 2003.

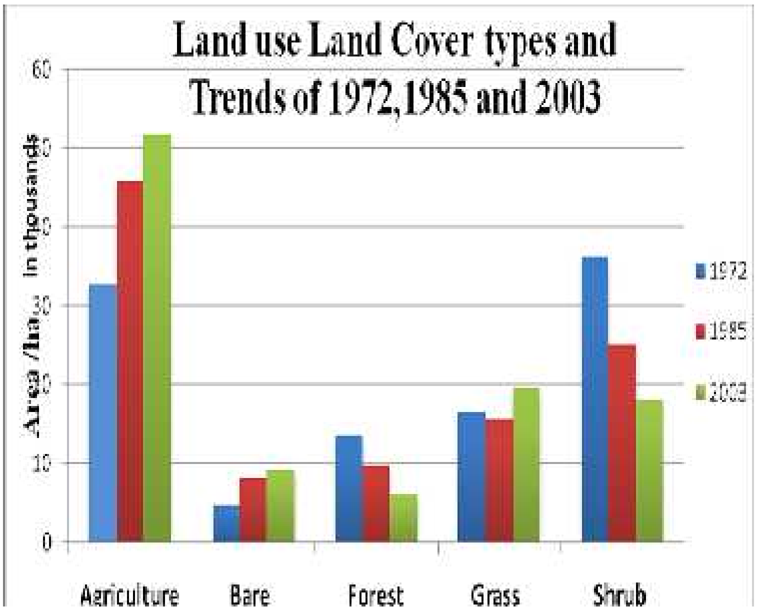

Figure 10: Land use land cover classes of the three periods (1972, 1985 and 2003).

The extent of Land use and Land covers change in the *Woreda*

An important aspect of change detection is to determine what is actually changing to what i.e. which land use class is changing to the other. This information will also serve as a vital tool in management decisions. This process involves a pixel to pixel comparison of the study year images through overlay analysis. The land use land cover change matrix depicts the direction of change and the land use type that remains as it is at the end of the day. For the land use land cover change matrix shown in (Table 4 and 5) the columns represent the older land cover categories and the rows represent the newer categories.

Table 4: Land use land cover change matrix between 1972 to 1985

	Land use land cover type of 1972	Agricultural land	Forest	Bare Land	Shrub Land	Grass Land	Class Total
Land use land cover type of 1985	Agricultural land	**27953**	1221	0	11432	5205	45811
	Forest	0	**7665**	0	2130	0	9795
	Bare Land	4797	0	**4747**	11	3359	8117
	Shrub land	0	4562	0	**20458**	0	25020
	Grass Land	0	151	43	5352	**7971**	15517
	Class Total	32750	13599	4790	36239	16535	0

As shown in (Figure 11) between (1972 to 1985), there was a dramatic expansion of agricultural land followed by bare land but shrub land, forest land and grass land showed a reduction in aerial coverage.

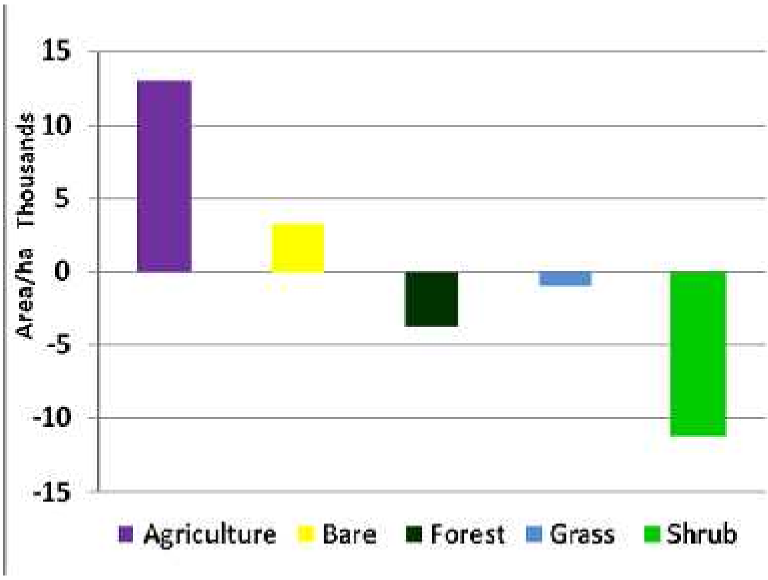

Figure 11: Land Use/Land Cover change between 1972 to 1985.

On the other hand in between 1985 to 2003, the same is true for agricultural land, bare land, shrub land and forest land but grass land shows a slight expansion in the aerial coverage due to the conversion of forest and shrub land to grass land and it is clearly shown in (Figure 12).

Table 5: Land use land cover change matrix from 1985 to 2003 of Borena *Woreda*

Land use land cover type of 2003 0032 003	Land use land cover type of 1985						
		Agricultural land	Forest	Bare Land	Shrub land	Grass Land	Class Total
	Agricultural Land	**40711**	2688	0	7896	547	51842
	Forest	0	**5399**	0	688	0	6087
	Bare Land	2500	0	**6576**	0	0	9076
	Shrub Land	1017	1247	141	**15082**	699	18186
	Grass Land	1507	461	1400	1354	**14882**	19604
	Class Total	45735	9795	8117	25020	15580	0

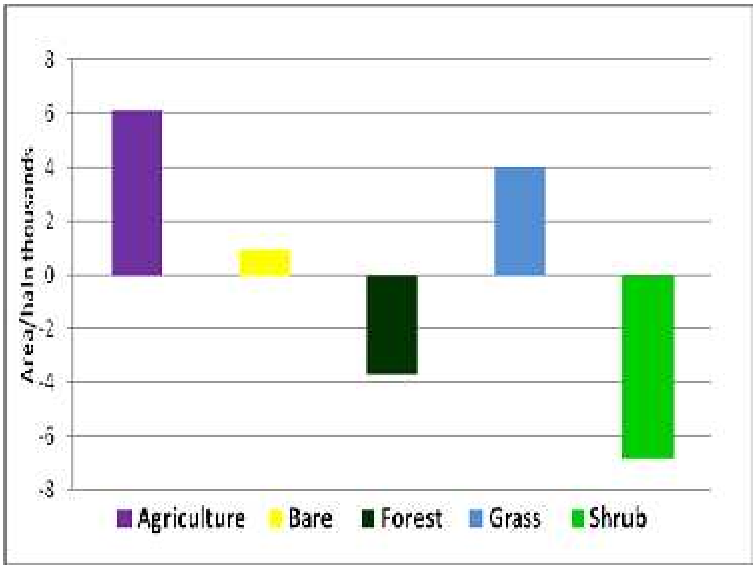

Figure 12: Land Use and Land Cover change between 1985 to 2003 in the Borena *Woreda*

Accuracy Assessment

To assess the classification accuracy, confusion matrix was used. Confusion matrix indicates the nature of the classification error and used in many other research works, as it is shown in (Table 6) the overall accuracy and kappa coefficient is 86.11% and 0.8312 respectively. This shows 86.11% of the land use land cover classes are correctly classified.

Table 6: Confusion matrix of 2003 land use land cover classification.

Land Use Type	Bare Land	Forest	Shrub Land	Grass Land	Agriculture
Bare Land	95.9	0.08	2.05	4	6.24
Forest	0	94.91	5.96	0.69	0
Shrub Land	0.57	2.31	80.43	8.09	6.55
Grass Land	1.4	2.57	8.11	80.22	8.12
Agriculture	3.58	0.13	3.45	7	79.09
Total	100	100	100	100	100

Overall Accuracy = 86.11% with a Kappa Coefficient of = 0.8312

Rate of land use and land cover changes in the study Woreda .The rate of change was calculated for each land use and land cover using the following formula:

Rate of change (ha/year) = (A-B)/C Where A = Recent area of land use/ cover in ha.

B = Previous area of land use/ cover in ha. C = Time interval between A and B in years

Table 7: Land use land cover classes and rate of change in between 1972 to 2003.

Land use land cover	Years			Rate of change					
	1972	1985	2003	1972 to1985 (ha/yr)	% ◆	1985 to 2003 (ha/yr)	% ◆	1972 to 2003 (ha/yr)	% ◆
Agricultural land	32750	45735	51842	998.85	3.1	339.28	1.57	50.66	0.88
Forest	13599	9795	6087	-292.62	-0.91	-206	-0.95	14.32	0.25
Bare Land	4790	8117	9076	255.92	0.79	53.28	0.25	6o.63	1.06
Shrub land	36239	25020	18186	-863	-2.67	-379.67	-1.76	16.06	0.28
Grassland	16535	15580	19604	-73.46	-0.23	223.56	1.03	37.94	0.65
Total*	103913	104247	104795	2483.85		1201.79		179.61	

◆ Rate of change in percent is calculated as change in between the two study years per total change of these years divided by the time interval times 100.
*Note. Steam beds are not included in the classification due to resolution problem of the image (30meter) that is why some hectares vary in the total area.

Between 1972 to 1985 agricultural land increased with a rate of 927.5 ha/year and further increased in 2003 with accelerated rate of change 339 ha/ year. The expansion of agricultural land was by the outflow of bush/shrub land, forest land and grass land as it is explained in the change matrix of (Table 7 and 8). From (1972 to 1985) 1221, 11432 and 5205 ha of forest, shrub and grass land had been changed to agricultural land respectively. While between 1985 to 2003, 2688, 7896 and 547 ha of forest, shrub and grass land had been changed to agricultural land respectively. This shows that there was a dramatic expansion of agricultural land within the specified time period because of population pressure and poor land administration. The expansion of agricultural land between 1972 and 2003 in the *Woreda* in general, could be directly related to rapid population growth.

On the contrary, shrub or bush land and forest land had decreased from 1972 to 1985 with
863 and 293 ha/year rate of change and further decreased in 2003 with rate of 380 and 206ha/year. The change was induced by the transfer of shrub and forest land to agricultural land in between 1972 to 1985 and to grass land and agricultural land in between 1985 to 2003 and even to bare land, rural and urban settlements. The massive reduction of vegetation particularly in between 1972 to 1985 was because of lack of administration especially during the transition period and land re distribution of the Derg regime.

Similarly, grass land was reduced in size in between 1972 to 1985 with rate of 73 ha/year. But it increases in between 1985 to 2003 with a rate of 223 ha/year. This is because of the degraded forest and shrub lands especially during the drought years and the transition period were changed to grass lands. Whereas bare land was continuously increased between 1972 to 1985 with a rate of 256 ha/year and then further increased with a rate of 53 ha/year, the rate of expansion is very high between 1972 to 1985 because of severity of drought in 1985 in Wollo area which killed thousands of animal and human life and a huge of loss of vegetation biomass. And now 9% of the study area is covered by bare land particularly areas which are found at the south western part of the *Woreda* around the Blue Nile River gorge.

Assessment of DPSIR indicators in relation to Land use and Land cover in the study area

Indicators are variables, parameters, or measures which provide evidence of a condition in change of quality, or change in state of something valued (Dumanski and Pieri, 1996). Land quality indicators, for instance, include statistics that report on the condition and quality of the land resource itself. They may also reflect the cause-effect relationships that may result in changes in land use and land cover, and on the responses to these changes by society. Indicators should allow the determination and analysis of the cause-effect relationships involved and identifies trends of land use and land cover change in order to take remedial action. Land use change is therefore often modeled as a function of a selection of socio-economic and biophysical variables that act as the so-called 'driving forces' of land use change (Turner II *et al.* 1993).Accordingly the land use/land cove indicators in the study area is modeled as follows(Figure 13).

Driving forces of land use and land cover change in the study *Woreda*. The total population of the study area was 125,126 in 1994 (CSA, 1994) and it increased to 158,920 in 2007 (CSA, 2008) with the rate of 1.84% ($r=1/n L_n$ (p_t/p_o) which implies it will double within 38 years ($DT=Ln2/r$). Thus population growth was certainly the most driving force in the observed land use and land cover dynamics. This is because the demand for land for cultivation and settlement and forests for fuel and construction purposes was greater. As population pressure is often considered to be an important driver of deforestation (Pahari and Marai 1999). In economic models of land use change demand and supply functions are the driving forces of land use change. There has been little adjustment of family size since children are considered an asset in the struggle for survival, as well as a security in old age. Environmental consequences of population growth thus have been a reduction in fallow periods and soil exhaustion, cultivation of shallow soils and steep slopes followed by accelerating erosion, over-exploitation of forest and range areas, and consequent denudation and erosion, and worsening prospects for future agricultural growth.

The system of land tenure in Ethiopia in general and in the study area in particular is uncertain about farmers' security of rights to the land which in turn led for short-term needs than long-term yield which resulted in ecological damage, inappropriate or over use and poor land management practices that accelerate land use and land cover change. Agricultural growth is still based on area expansion, and intensification through new technology, cash inputs, or adjustments in farming systems is slow. The failure of agricultural growth to keep pace with population growth when the nonfarm sector can only absorb a fraction of the added labor force has resulted in decreased per capita resources of land and livestock. Livestock grazing in high densities and with static grazing patterns may alter floristic composition, reduce biodiversity, increase soil compaction and in extreme cases eliminate vegetation cover altogether (White, Tunstall and Henniger, 2002).

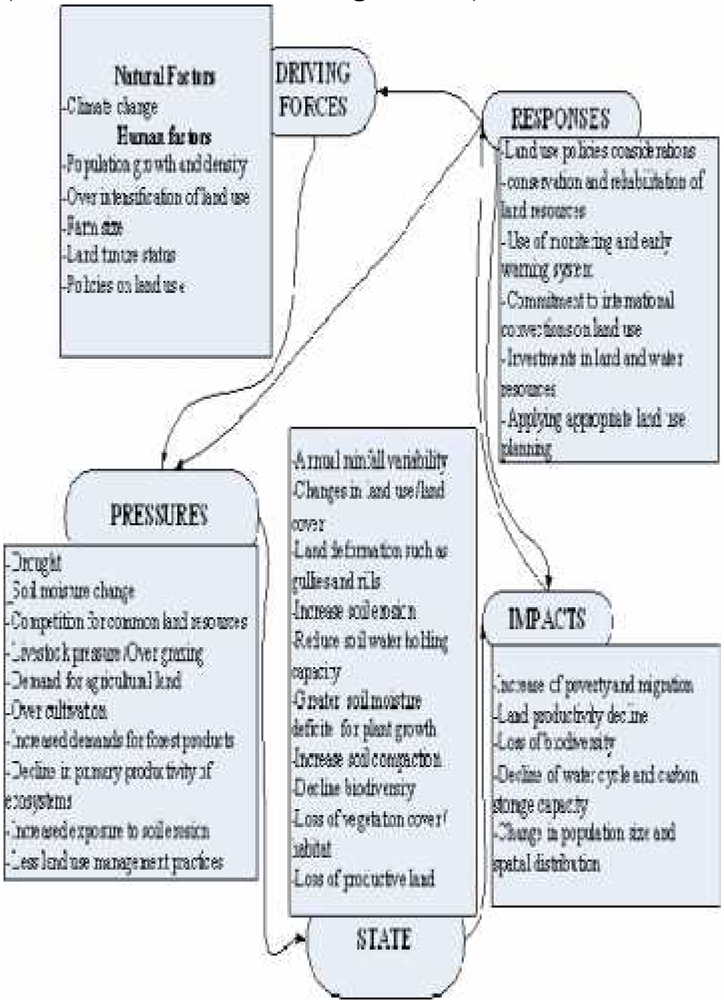

Figure 13: Major types of DPSIR indicators with their description in the study area (adapted from FAO, 2004)

Pressures on the land use and land cover in the study *Woreda*

Causes are the direct agents that promote change resulting in a given state of land use and land cover. Causes are the direct pressures exerted on land resources under which the onset of degradation or deterioration processes occur. These pressures are, in turn, caused by driving forces of a variety of origins (i.e. economic, social, political, etc.), which can be understood as indirect causes of land use and land cover change. The problem of land degradation in Ethiopia stems largely from poor land-use practices and population pressure (especially in the highlands) (UNCCD, 2008). The pressures in the study area include drought, soil moisture change, competition for common land resources, livestock pressure/over grazing, demand for agricultural land, over cultivation, increased demands for forest products, decline in primary productivity of ecosystems, Increased exposure to soil erosion and less land use management practices (Figure 13). Inappropriate farming practices, overgrazing, deforestation and the use of crop residues and dung for fuel in rural households are among the main causes. Very high population pressure, particularly in the highland farming areas has led to scarcity in arable land in the study area. Combined with increasing land degradation and recurrent droughts, this has contributed to declining crop productivity. Increased human and livestock populations have led to agricultural encroachment on to marginal areas, significantly reducing the already dwindling forest and woodland resources of the highlands.

States of the land due to the land use and land cover changing situations in the study *Woreda*

The important current conditions observed in the study area includes annual rainfall variability, land deformation such as gullies and rills, increase soil erosion, reduce soil water holding capacity, greater soil moisture deficit for plant growth, increase soil compaction, decline biodiversity, loss of vegetation cover/habitat and loss of productive land.

Impacts of land use and land cover change on population, economy, ecosystems and/or environment in the study *Woreda*

According to FAO (2004) Impacts in the - Land Degradation Assessment in Dry lands (LADA framework) refer to land use and land cover changes on the different aspects of people's livelihoods imposed by the state of land degradation and its causes. Examples of impacts of land degradation which is caused by land use/land cover changes in the study area, increase of poverty and migration, land productivity decline, loss of biodiversity, decline of water cycle and carbon storage capacity of the land, change in population size and spatial distribution (figure 13). One of the immediate impacts of the thinning and destruction of the shrub land is shortage of fuel wood and construction materials for the farming community. This condition forces farmers not only to travel very long distances to collect wood, but also to increasingly burn crop residues and organic manure for cooking and heating. The latter has momentous consequences for the fertility and productivity of the cropland as the action lead to depletion of the organic matter in the cultivated soils. The shortage of land has compelled farmers to practice continuous cropping and completely abandon even seasonal fallowing. Such continuous cultivation in a situation where little organic matter returns to the soils leads to severe soil erosion and land degradation (Belay, 2002).

The decrease of land quality which in turn brings a decrease in land productivity and has an effect on the livelihoods of people in terms of food insecurity, poverty and migration. The reduction of habitat for living species, both, macro and micro flora and fauna and the likely increase on Greenhouse Gases (GHG) emissions, for example, the increase in carbon emissions through the oxidizing of organic matter induced by tillage. The ecosystem functions and landscape processes such as water and nutrient cycles, which in turn affect water availability and primary productivity of ecosystems and their services to populations as well as the decline in land productivity are directly related to land use and land cover change.

Response of the stakeholders to reduce the effects of Land use and land cover change in the study Woreda.

Responses are understood in the LADA framework as the direct or indirect actions taken by land users and managers to the impacts on their livelihood caused by the state of land degradation, the pressures on the land causing such state, and the driving forces causing such pressures. Such responses may manifest themselves as possible remediation actions. The experience of land users themselves, who run informal "experiments" with nature through their responses in their particular lands, accrue knowledge and experience (i.e. "indigenous" or traditional knowledge) about remediation actions. The response of stakeholders for the changing land use/land cover is very limited. The inconvenience for such week responses include-the needs of the local people for cultivation, grazing land, hunting, and forest products. The activities have suffered from several effort, the major ones have been (a) a lack of tenure security for the farmers; (b) political instability; (c) repeated famines (d) paid (food) labour-both on communal land and on land cultivated by individual farmers-to alleviate the famines; (e) farmers not involved in planning and implementation of the work on their land; (f) the soil conservation extension not integrated into the agricultural extension; and (g) ineffective agricultural extension.
Therefore, there is a need for land use policies considerations, conservation and rehabilitation of land resources, use of monitoring and early warning system, commitment to international convections on land use, investments in land and water resources and applying appropriate land use planning (Figure 13).

Conclusions

Land use and land cover assessments generally involve the use of detailed spatial biophysical and socio-economic field data and rigorous statistical and GIS analytic techniques. The method used in this study was analysis of remotely sensed (captured) images with GIS, integrated with descriptive socio-economic analysis of DPSIR model indicators. These enabled the researcher to characterize land use and land cover dynamics in the study watershed.

This study shows that substantial land use and land cover change occurred in Borena *Woreda* over the 32 years from 1972 to 2003. Five major land use and land cover types were found. These include forest, shrub or bush, grass land, agricultural land, and bare land. From 1972 to 1985 there was a dramatic increase in agricultural land, moderate increase in bare land, and decreases in shrub land, forest land and grass land. Between 1985 and 2003, a similar trend for agricultural land, bare land, shrub land and forest land prevailed, but grass land showed a slight expansion in the aerial coverage due to the conversion of forest and shrub land to grass land.

Both natural and human induced driving forces of LU/LC change were recognized in the study area. The natural factors include high intensity of rainfall, steep relief, and soil types. Climate change is also found to be a critical driving force for land use and land cover changes in the area. Among the human causative factors, population growth and density, over-use of the land, expansion of farm size, land tenure insecurity, and lack of appropriate policies on land use played the greatest role in the area. The implications were biodiversity loss and soil erosion, and land degradation.

This study clearly demonstrates the following policy implications:

Changes in land use and land cover affect land-based ecosystems and biodiversity unless proper conservation measures are taken by stakeholders.

Changes in land use and land cover affect soil quality and soil intactness (the ability of soils to withstand erosion), have effects on water quality in rivers, lakes, and increase the risk of flooding. Therefore, climate change adaptation measures should be taken.

There has been insufficient government attention to land degradation, agricultural development and peasant farming, and family planning.

There is a lack of economic incentives for producers and marketing difficulties caused by public interference;

There is insufficient adaptation of recommendations to the large agro-ecological variability over time and deficiencies in proven technology, extension, input distribution, and credit;

Inefficiencies arise from institutional weaknesses, particularly over-emphasis of the public sector and central decision making; there is a need to promote privatizing and local initiatives;

Ownership of natural resources is over-centralized and traditional structures are breaking down with consequent difficulties in the form of insecurity in individual use of fallow lands; open access to grasslands; and inability to protect and manage public forests and parks.

Development strategies are inappropriate and land use planning is lacking.

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References

Aklilu Amsalu .2006.Long-term dynamics in land resource use and the driving forces in the Beressa watershed, highlands of Ethiopia. Journal of Environmental Management 83 (2007):448–459

Belay Tegene. 2002. Land-cover/land-use changes in the Derekolli catchment of south Wello zone of Amhara region, Ethiopia. Eastern Africa Social Science Research Review.

Bezuayehu T, and Geert,S. 2008. Hydropower-induced land use change in Fincha'a watershed, western Ethiopia: analysis and impacts. Mountain Research and Development. Vol28 No.1:72-80

Brandon R. B. 1998.Mapping rural land use and land cover change in Carroll county, Arkansas: utilizing multi-tempora landsat thematic mapper satellite imagery.University of Arkansas. Retrieved 11st,April 2009 from the WorldWide Webe, http: //www.coloradoedu/research/cires/banff/pubpaper

Central Statistical Authority (CSA), 1994. Ethiopia: Population and Housing Census Abstract, CSA, AA.

Central Statistical Authority (CSA), 2008. Ethiopia: Population and Housing Census Abstract, CSA, AA.

Dumanski, J, and Pieri, C. (1996) Application of the pressure-state-response framework for the land quality indicators (LQI) programme. In: Land quality indicators and their use in sustainable agriculture and rural development. Proceedings of a workshop, 25-26 January. FAO, Rome. http://www.fao.org/docrep/W4745E/w4745e09.htm

European Environment Agency. 2003. Environmental Indicators: Typology and use in reporting, internal working paper. Copenhagen: European Environment Agency.

FAO, 2004. Methodological Framework for Land Degradation Assessment in Drylands (LADA),FAo, Land and Water Development Division. Rome

Gete Zeleke. 2000. Landscape dynamics and soil erosion process modeling in the North- Western Ethiopian Highlands. African Studies Series A16. University of Berne, Berne, Switzerland. Geographica Bernesia.

Kebrom T.and L.Hedlund.2000. Land cover changes between 1958 and 1986 in Kalu district, Southern Wello, Ethiopia. Mountain Research and Development 20(1): 42-51.

Lakew Desta;Menale Kasie;Benin.S. and Pender.J.2000. Land degradation and strategies for sustainable development in the Ethiopian highlands: Amhara Region. Socio-economic and Policy research Working paper 32. ILRI,Nairobi,Kenya.122pp.

Lillesand, T.M. et al., .2006. Remote sensing and Image Interpretation. Newyork, John Wiley and Sons, Inc.

Meyer, W.B., and Turnnor II, B.C 1994. Change in Land Use and Land Cover: A Global perspective. Camprage, Cambridge University Press: 1-10.

Ministry of Natural Resources Development and Environmental Protection- Watershed Development and Land Use Department (MONRDEP-WDLUD, 1995).Guidelines for Development Agents on Soil Conservation in Ethiopia, Switzerland.

Mohammed Assen and Tassew Nigussie.2009. Land use/cover changes between 1966 and 1996 in Chirokella micro watershed, Southern Ethiopia. East African Journal of Sciences. Vol.3 (1) PP 1-8

Moshen A. 1999. Environmental Land Use Change Detection and Assessment Using

Multi – temporal Satellite Imagery. Zanjan University.

Pahari, K. and Marai, S. 1999. Modelling for prediction of global deforestation based on the growth of human population. ISPRS Journal of Photogrammetry & Remote Sensing 54, 317-324.

Reid, R.S. et al. 2000. Land use and land cover dynamics in response to in climatic, biological and socio political forces: The case of southern Ethiopia. Journal of Landscape Ecology, 15:339-355

Richards, J. 1990. "Land Transformation" (ed) in Turnnor II, B.C and et al. The Earth as transformed by human action: A global and regional changes in the biosphere over the past 300 years. Cambridge University press: 164-178.

Smeets, E, and Weterings, R. 1999. Environmental Indicators: Typology and overview. Retrieved from http://reports.eea.europa.eu/TEC25/en/tech_25_text.pdf (1 June 2007).

Turner II, B. L., Ross, R. H., and Skole, D. L. 1993.Relating land use and global land cover change. IGDP report no. 24; HDP report no. 5.

UNCCD ,2008. Ethiopia. Increasing finance for sustainable land management, Rome, Italy

White, R.P., Tunstall, D. and Henniger, N.,(2002). An ecosystem approach to drylands: Building support for new development policies. Information Policy Brief. World Resources Institute.

Williams M. 1990. "Forests". ed in Turnnor II, B.C and et al. The Earth as transformed by human action: A global and regional changes in the biosphere over the past 300 years. Cambridge University press:179-223

Wilkie, D.S., and Finn, J.T. 1996. Remote Sensing Imagery for Natural Resources Monitoring. Columbia University Press, New York.

Woldeamlak Bewket.2003. Land degradation and farmers' acceptance and adoption of conservation technologies in the digil watershed, Northwestern highlands of Ethiopia. Social Science Research Report Series-no.29, OSSREA. Addis Ababa, Ethiopia.

Zubair A.O.2006.Change detection in land use and land cover Using remote sensing data and GIS: A case study of Ilorin and its environs in Kwara State.Msc thesis. University of Ibadan, Ibadan.