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Land use and land cover change in Ameleke Watershed, South Ethiopia

Gebrekidan Worku[1], Amare Bantider (Ph.D)[2] and Habtamu Temesgen[3]
1.Debretabor University, Department of Natural Resource Management
kidanw1@gmail.com
2.Center for Food Security Studies, College of Development Studies, Addis Abeba University, Ethiopia
amare_zerfe@yahoo.com
3.Dilla University, Department of Land Resource Management
habte023@yahoo.com

Abstract
This study investigated the land use and land cover change at Ameleke watershed, middle catchment of Gidabo River, South Ethiopia that occurred from 1986-2006. Landsat TM of 1986, Landsat ETM+ of 2000 and SPOT of 2006 were used to produce land use and land cover maps of the watershed. A pixel-based supervised image classification through decision rule of maximum likelihood classifier algorithm was used to map land use and land covers on ERDAS Imagine 8.6. For land use and land cover maps of 1986, 2000 and 2006, error matrixes were produced and have an accuracy assessment of 80%, 85% and 85.71% respectively. Focused group discussions and key informant interviews were also used for land use and land cover reconstruction. The result showed from 1986 up to 2006, cropland and mixed cover increased from 23.33% to 31% and 7.26 to 15.68% of the watershed respectively. In contrast grass lands and shrub lands decreased from 25.9% to 14.96% and 30.3% and 24.25% of the watershed respectively in 1986 to 2006. There was also an increasing trend on agroforestry while there was a decreasing trend on riverine forests. This study recommends further assessment and monitoring of spatial and temporal based land use and land cover change at homestead level having high resolution satellite images.
Keywords: land use and land cover change, Ameleke watershed

Introduction

Land use and land cover change is a phenomena starting from ancient time. However, rapid and extensive land cover change was the major element of global environmental changes of the past three centuries. Globally cropland showed fivefold increase from 1770 up to 1990 and pastureland also increased by above six fold from 1700 to 1990. In contrast forest cover was decreased from 5000-6200 million hectares in 1700 to 4300- 5300 million hectares in 1990 (Lambin et al 2003). More rapidly than the aforementioned periods, more woody vegetation cover was converted to cropland between1950 and 1980 (MEA, 2005). But direction of land use and land cover change is not similar for all parts of the world. In the last two decades, the area of temperate forest was increasing by almost 3 million hectares, while the tropical forest was decreasing by 12 million hectares per year (MEA, 2005). In contrary, in Eastern and Western Africa only reduced and fragmented forestlands were left (Gutman et al 2004).

In Ethiopia, there are several studies on land use and land cover change that showed the different facets of change. Gete and Hurni (2001) in Dembecha area of Gojjam, Belay (2002) in Derekolli catchment of South Wello, Amare (2007) in Eastern Escarpment of Wello, Nyssen et al (2008) in Wag zone of Amhara Region, Northern Ethiopia, studied land use and land cover dynamics. Gessesse and Kleman (2007) in Southern part of Ethiopia (Central rift valley), Berhan Gessesse (2010) in western part of Ethiopia and Diress et al (2010) in North eastern Afar range lands have also studied LULCC. Most of these studies found cropland has expanded at the expense of woody vegetation cover. But from 1984- 2003, area of forest and shrub land was increased while area of agricultural land was decreased in Simen Mountains National Park, North western Ethiopia (Menale et al 2011). So that region-specific information of changes in LULCC is essential for land resource management. Though LULCC research is undergoing at different places and at different scale, still a lot more studies are needed to cover the country.

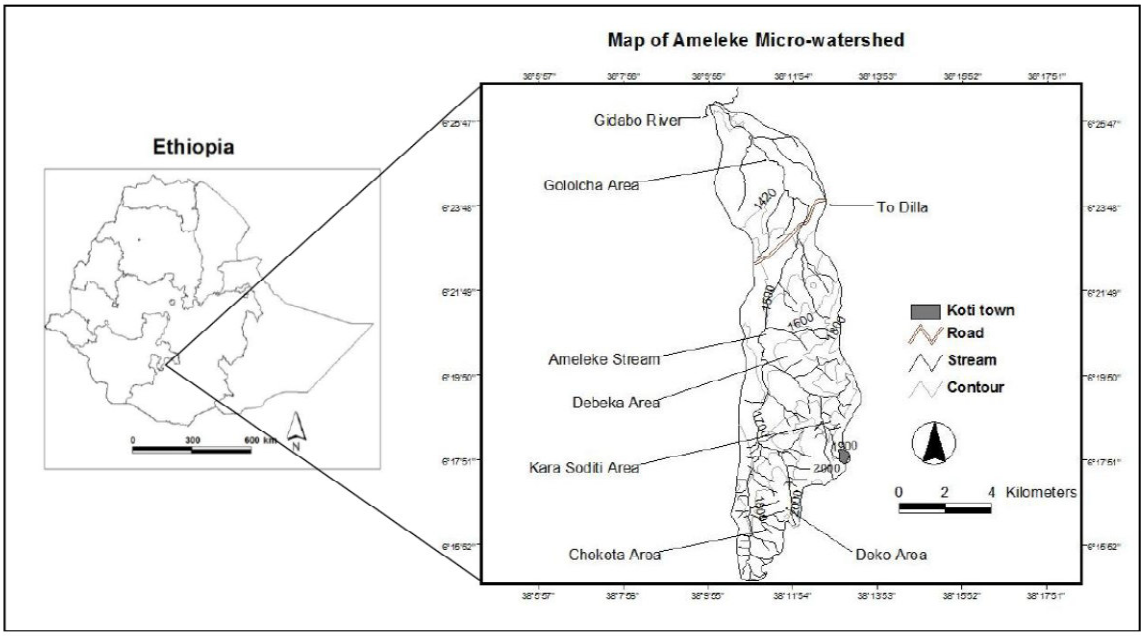
The present study investigates the land use and land cover dynamics in Ameleke watershed in middle catchment of Gidabo River, South Ethiopia. This watershed is inhabited by the Gedeo Guji Oromo ethnic groups. The Gedeo community change the natural forest and grassland to agroforestry while in Guji Oromos' land charcoal production, expansion of croplands and overgrazing on grass lands and shrub lands are the major land use problems. Cultivation and grazing of marginal lands has also a desperate effect on the resources of the watershed. In association with this problem, this study tried to document the spatial and temporal land use and land cover dynamics of Ameleke watershed.

Description of Study Area

Ameleke watershed is located between 6°15'N to 6°26'N latitude and 38°10'E to 38°12'E longitude. The watershed has an area of 69. 69 km. sq. Ameleke watershed is one of the tributary of Gidabo River. The mean

monthly temperature of this watershed ranges from 23.2 ^{0}C in July to 30.2 ^{0}C in January. Regarding rainfall, mean annual rainfall ranges from 800 to 1400 mm in the upper part of the watershed while it is 105.5 mm in the lower stream of the watershed. The rain has bimodal pattern where March to June and September to November are rainy seasons. The rainfall variability is very high. Seasonally *Bega* has high rainfall variability than *Belg* and *kiremt*. In Ameleke watershed altitude ranges from 1200 to 2000 masl. The upper stream of the watershed coffee, *Enset*, maize and teff are major crops where as in the lower and middle stream of the watershed livestock production is the main stay of the community.

Figure 1 Map of Ameleke watershed



Methods and Procedures

To achieve the study, topographic map was scanned in Tag Image Format (TIFF), then geo-referenced using nearest neighbor resampling technique. From this geo referenced map, the watershed was cut out following the contour lines. Then satellite images of Landsat TM for the date 21 January 1986, Landsat ETM+ for the date 5 February, 2000 and SPOT for the date 4 February, 2006 were acquired from Ethiopia Mapping Authority. Landsat TM 1986 and Landsat ETM+ 2000 images have 30m pixels resolution while SPOT 2006 image has 5m pixels resolution.WGS_1984_UTM_Zone_37N projection was used to geo reference and to geo rectify the images. The method used to classify both Landsat and SPOT images was pixel based supervised classification through decision rule of maximum likelihood classifier algorithm on ERDAS Imagine 8.6. For this method, training areas were taken. Accuracy of land use and land cover classification was tested. Error matrix was produced for 1986, 2000 and 2006 land use and land cover maps with an accuracy assessment of 80 %, 85.0% and 85.71 % respectively. The overall accuracy and Kappa (K) statistics of 1986, 2000 and 2006 land use and land cover maps was 0.76, 0.82 and 0.83 respectively.

Besides to the land use and land cover maps of the watershed, ground truthing data was collected by guided and transect walks and GPS. Focused group discussions and key informant interviews were used for land use and cover reconstruction. Participants included are Gedeo and Guji Oromo ethnic groups those having different economic status, age and sex group.

Result and Discussion

Qualitative trend

Reconstruction of land use and land cover changes was done by using focused group discussion and interview data. Before 40 and 50 years ago there were natural forest lands and large communal grass lands in Ameleke watershed. The forests in Deko and Karasoditi area are largely taken away by the settlers nearby these kebeles for fuel and traditional timber. On the other hand natural forests of the upper stream of the watershed are modified to agroforestry type of land use by Gedeo. Natural forests cover in Debeka and Gololocha Kebeles (middle and lower stream of the watershed) declined owing to charcoal production and crop land expansion. The grass land of the upper stream of the watershed was changed into crop land. The grass land in Debeka and Gololocha sub catchments was largely communal. But this communal grass land is changed in to semi private grass land and in to crop land.

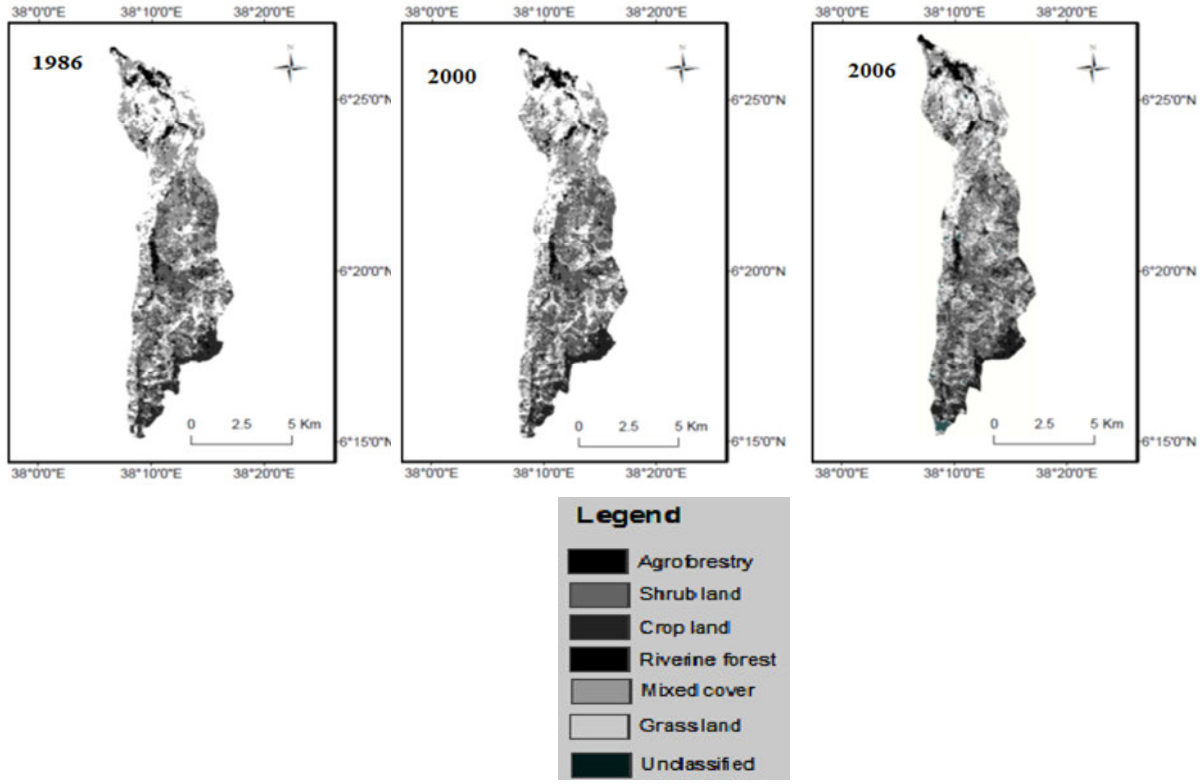
Land Use and Land Cover Mapping

By using field survey data and satellite images of Landsat TM 1986, Landsat ETM+2000 and SPOT 2006, cropland, grass land, shrub land, mixed land cover, agroforestry and riverine forest were identified. These land use and land covers have spatial pattern and subject to change over time.

Table 1 Description of land use and land cover classes found in Ameleke watershed

Agroforestry	Those land uses where big trees like *Birbira(Milita ferruginea), Korch (Erythrina brucei) Wanza(Cordia africana), Warka (Ficus vasta), and sholla (Ficus sycomours*) and others are found with crops like maize, coffee, enset *(Ensete Ventricosum), Sicuardinich (Ipomea bapatase), Godera (Colocasia esculenta)* and *Boyna (Dioscorea abyssinica).*
Crop land	Areas of land that is ploughed and/or prepared for cultivation of annual crops.
Grass land	Grass land refers to those land units that are used for livestock grazing, including privately and communally owned grazing areas. The land is basically covered by grass and herbaceous species.
Mixed cover	Lands on which trees, grass and herbaceous species, crops and shrubs are mixed at a place at different proportions.
Shrub land	Communities of vegetation dominated by short woody, self supporting, multi stemmed plants.
Riverine forests	Trees grown following the course of streams.

Figure 4.5 Land use and land cover maps of 1986, 2000, 2006 in Ameleke watershed



Quantitative trend

There are different extents of land use and land cover changes in Ameleke watershed. On some land use and land cover types there is an increase while in contrary there is a decrease on other land use and land cover types. Cropland, grass land, mixed cover and shrub land are land use and land cover types on which relatively significant change is take place.

Table 2 Change in area of land uses and land covers from 1986-2006

Land use and land cover types	Area in ha			Area in percentage			Land use and land cover change in ha		
	1986	2000	2006	1986	2000	2006	1986 to 2000	2000 to 2006	1986 to 2006
Agroforestry	433	492	529	6.2	7.0	7.6	+59	+37	+97
Crop land	1626	2052	2156	23.33	29.4	31.0	+426	+104	+530
Grass land	1807	1601	1043	25.9	22.97	14.96	-206	-558	-764
Mixed cover	506	829	1093	7.26	11.89	15.68	+323	+264	+587
Riverine forests	485	399	377	6.95	5.72	5.4	-86	-22	-108
Shrub land	2112	1596	1690	30.3	22.9	24.25	-516	+94	-422
Unclassified	--	--	81	--	--	1.16	--	--	--
Total area	**6969**	**6969**	**6969**	**100**	**100**	**100**			

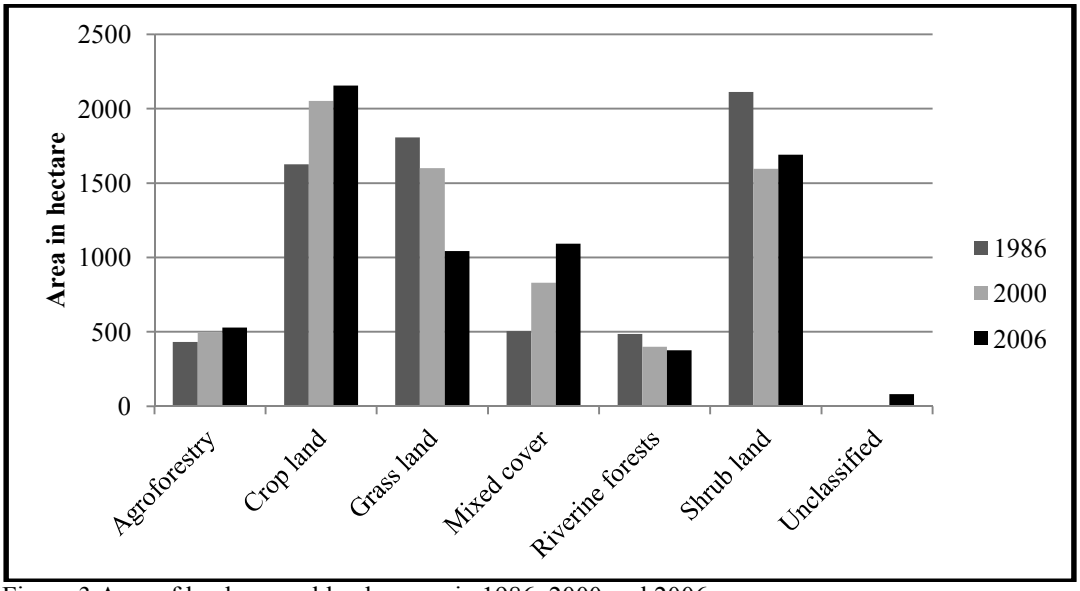


Figure 3 Area of land use and land covers in 1986, 2000 and 2006

Change in Cropland

Cropland is among the land use types that showed considerable increase in area. It increased from 23.33% in 1986 to 31.0% in 2006. The result of this study is consistent with tropical region and in many parts of Ethiopia. In tropical region, cropland was among the land use and land cover types characterized by rapid change in 1990s (Lambin et al, 2003). In Dembecha area of Gojam, cropland increased from 1957 to 1982 (Gete and Hurni, 2001). In contrast to the study of Ameleke watershed, the area of cultivation was almost unchanged from 1958-1986 in Kalu district, South Wello (Kebrom and Hedlund, (2000). In Ameleke watershed cropland is expanded mainly at the expense of shrub lands and grass lands. From 1986- 2000, shrub lands and grass lands were changed into croplands in the upper and middle streams of the watershed and after 2000 cropland expansion continued on the shrub lands and grass lands of the lower stream of the watershed. After 2000, expansion of cropland also triggers shrinkage of riverine forests. Similar cropland change direction is documented by Woldeamelak (2002), Northern Ethiopia in Chemoga watershed and Belay (2002) in Derecolli catchment, South Wello.

Change in Grass Land

Contrary to croplands, there is a significant negative grass land use and land cover change. It occupied 25.9% in 1986 but declined to 14.96% in 2006. It concedes with the land use dynamics of Afar rangelands, Ethiopia. In Afar range lands, there was a reduction of 88% of grass land from 1972 to 2007 (Diress et al, 2010). Grass lands in the upper stream are changed to cropland and mixed cover while in the lower stream of the watershed there is expansion of shrub lands on grass lands.

Change in Mixed cover

These are land use and land cover classes from where there is no single spectral class is recorded. In Ameleke watershed crop land is found within grass lands and shrub lands that resulted encroachment of mixed covers on

grass lands and shrub lands. Mixed cover was 7.26 % in 1986 while it increased in to 15.68% of the watershed in 2006. In the upper stream of the watershed, former grass lands and shrub lands are changed in to mixed covers where crop lands are coming into on grass lands and shrub lands. Beside to this, mixed covers is also expanding on grass lands and shrub lands in the lower and middle stream of the watershed. Concurrent to this, area of mixed land cover was constantly increasing in the Eastern Escarpment of Wello from 1986 to 2001(Amare, 2007).

Change in Shrub land

In Ameleke watershed there is a net decrease on area of shrub land. It was 30.3% and 24.25% of the watershed in 1986 and 2006 respectively. But there was an increase of shrub land from 2000 to 2006 on the grass land of the lower stream of the watershed. This finding concurs with the study of Belay (2002) in Derecolli catchment, South Wello where there was a thinning of shrub land cover from 1957 to 2000. In contrast to the shrub land change of Ameleke watershed, an increase of shrub land cover was found in Afar range lands from 1972 to 2007 (Diress et al 2010). In Ameleke watershed, shrub lands are changed in to cropland and mixed cover. In the upper and middle stream of the watershed, large area of shrub land is changed into cropland and mixed cover. Similar shrub land change direction was identified in Northern Ethiopian highlands, Bela-Welleh catchment (Nyssen et al, 2008); Kalu district, South Wello (Kebrom and Hedlund, 2000).

Change in Riverine forests

There is also a change in riverine forests cover but it is subtle. Riverine forests were 6.95% and 5.4% of the watershed in 1986 and 2006 respectively. This concedes with many studies in tropical region and in Ethiopia. Forest cover decline was among the rapid land cover changes of the last decade in tropical region (Lambin et al, 2003). In Ethiopia, similar results were analysed by Gete and Hurni, (2001) and Woldeamlak (2002) in North western part of Ethiopia; Gessesse and Kleman (2007) in the central rift valley region of Ethiopia; Berhan, (2010) in Western part of Ethiopia. In Ameleke watershed, forest cover has modified into agroforestry in the upper stream and to some extent changed into cropland in the middle stream of the watershed.

Change in Agroforestry

Unique to many tropical regions and many parts of Ethiopia, agroforestry is increasing in Ameleke watershed. Agroforestry was distinctively found in upper stream of the watershed. But it is intruding into the middle stream. Tree covers are thinning and converted in to agro forestry land and grass lands and croplands were modified in to agroforestry land use type in the upper stream of the watershed. Very similar to this study, the farmers of Sumatra, Indonesia plant trees and many monoculture coffee gardens after deforestation takes place in this area. They gradually transformed the natural landscape into mixed systems with shade trees (Verbist, et al 2005). The agroforestry system was established on unmanaged pastures in 1989 and 1990 in Sarapiquõ region of Costa Rica (Tornquist et al 1999). Similar result was also explored by Bogale (2007) in Gedeo Zone.

Conclusion

This paper has demonstrated that the recent advancements in remote sensing image analysis is powerful tool for assessing land use and land cover changes at watershed levels. The study is carried out in Ameleke watershed using satellite images in conjunction with focused group discussion, interview and field observations. In Ameleke watershed there is spatial and temporal land cover and land use change. In upper stream of Ameleke watershed, agroforestry and cropland are the major types of land use and land cover types. While grass land and shrub land are found to be the dominant land cover type in the middle and lower stream of the watershed. In Ameleke watershed generally an increase on crop land, mixed cover and agroforestry while a decrease on grass land, shrub land and riverine forsts was observed from 1980s to 2006. An increase on mixed cover is a way for a change of shrub lands and grass lands in to crop land. But in other parts of Ethiopia, expansion of crop land reached its upper limit and started to slowed down since 1980s (Kebrom, 2000; Gete and Hurni, 2001; Belay, 2002). In contrary to what is happening in Ameleke watershed, wood lands and shrub lands started to increase in other parts of the country (Woldeamelak, 2002, Nyssen et al, 2008).

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