Evaluation of land use/land cover changes of Bantneka Watershed, Ethiopia

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Abstract

This study was carried out to examine the trend of land use and land cover changes of Bantenka watershed, Ethiopia through time. It was conducted using satellite image of Landsat5 TM 1986, Landsat7 ETM$^+$ 2000 and Spot 2006. In addition, field observations and focus group discussions were conducted. ERDAS Imagine 9.1 and ArcGIS 9.3 software for satellite image processing, and global positioning system as well as topographical maps of scale 1:50,000 for ground verification were used. The result of the study revealed that annual cereal crop, mixed and woodland showed a negative rate of change. However, perennial crop land and settlement land were increased by 5.83 and 1.41 ha/year respectively from 1986-2006. It implies that perennial crop land and settlement land were the major driving forces for the change of watershed biodiversity and other land resources.

Key words: Land use and land cover change, watershed

1. Introduction

Land use and land cover (LU/LC) change is a major issue of global environment change (Prakasam, 2010). The terms "land use" and "land cover" are often confused. Land use change is defined as the alteration of land use due to human intervention for various purposes, such as for agriculture, settlement, transportation, infrastructure and manufacturing, park recreation uses, mining and fishery. In contrast, land cover change refers to the conversion of land cover from one category of land cover to another and/ or the modifications of conditions within a category (Meyer and Turner, 1992).

There are many studies conducted in Ethiopia on LU/LC changes. Most of these studies were conducted in the Northern highland (Woldeamlak, 2002; Amare, 2007; Munro et al., 2008; Abate, 2011; Amare et al., 2011; Temesgen et al., 2014). Most of the studies reported the expansion of cultivated land at the expense of forest land, and cultivated lands were stretched into sloppy areas due to the shortage of land. As a result of these, land degradation in the form of soil erosion is a common problem in northern highland of Ethiopia. Similarly, there are a number of studies indicated LU/LC changes towards cultivated land aggravated land degradation (Gete and Hurni, 2001; Belay, 2002; Woldeamlak, 2002; Temesgen and Tesfahun, 2014). While, studies conducted in the Southern part of Ethiopia is very much limited. The southern region particularly Gedeo zone is known by its agro-forestry system (Tadesse, 2002; Abiyot et al, 2013). A study by Bogale (2007) using satellite imageries of 1986 and 2006 in Gedeo Zone showed that natural forests were declined from 1.1 % in 1986 to 0.6 % in 2006. Additional studies (Tadesse, 2002; Abiyot et al, 2013) showed that indigenous multipurpose trees such as *Cordial Africana, Fiscus sur, Millettia ferruginea, Prunus africanus* and *Vernonia amygdalina* are being over exploiting in the study area. Land under little vegetative cover is subject to high surface runoff and low water retention. The increase of runoff causes sheet erosion to intensity and rills and gullies to widen and deepen (Woldeamlak, 2003). As a result of these, currently LU/LC change is a very sensitive issue in the area. Therefore, this study aims to examine the trend of LU/LC changes of Bantinaka watershed, Southern Ethiopia by using two decade satellite images.

2. Materials and Methods

2.1 Study area

The study was carried out in Bantneka watershed, Southern Ethiopia which is found in the Eastern Escarpment of the rift valley. Specifically, it is located between the coordinates of $6°23'$ - $6°25'$ N latitude and $38°18'$ -$38°22'$ E longitude. Its altitude ranges between 1750-2200m above sea level, and covers about 574hectars of land. The watershed has an average 1300mm rainfall and 21^0C temperature. The main soil type includes Dystric Nitosols, Eutric Nitols and Luvic phaeozems. The traditional soil classification shows that the Bantneka watershed comprises brown soil (90%), red soil (5%) and black soil (5%). The area is characterized by undulating topography and coffee with enset form of agroforestry land use systems (Tadesse, 2002; Bogale, 2007; Abiyot et al., 2013). Main cultivated crops including maize, bean and root crops, and perennial crops including coffee, enset and fruit like banana, avocado and mango are some of the agricultural crops in the study watershed.

2.2 Data sources

The study was employed using three different years of satellite imagery (Landsat5 TM 1986, Landsat7 ETM$^+$ 2000 and Spot 2006). 30m resolution of Landsat5 TM 1986 and Landsat7 ETM$^+$ 2000, and 5m resolution of Spot 2006 images were used. Thus, re sampling of Landsat5 TM 1986 and Landsat7 ETM$^+$ 2000 into 5m were

undertaken. Topographic map of 1:50,000 scale and Global Positioning System (GPS) for ground verification were used. In addition, field observations and three focus group discussions having 12 members were also conducted.

2.3 Image classification methods

Image preprocessing including band ratio, radiometric correction, Tasseled Cap and post classification comparisons were undertaken to correct the surface features reflectance characteristics. In classifying the images, supervised image classifications techniques were applied. A total of 45 ground control points (9 ground control points for each LU/LC class) were taken during field work. The LU/LC classes include annual cereal crop land, mixed land, perennial crop land, woodland and settlement land (Table 1). Among different algorithms of supervised classification, maximum likelihood image classification was utilized. Then, the LU/LC maps were produced from Landsat5 TM 1986, Landsat7 ETM$^+$ 2000 and Spot 2006.

Table 1: Descriptions of land use/ land cover classes (adapted from FAO, 2000)

LU/LC class	Characteristics
Annual cereal crop land	Areas of land that is ploughed and/or prepared for raising crops. It includes annual crops such as maize, barley, bean, and root crops.
Mixed land	Areas of large indigenous trees with coffee and Enset crop lands.
Perennial crop land	Coffee and Enset are the dominant which includes fruit trees such as, Avocado, Mango, Banana, Pineapple and others
Woodland	A closed-to-open canopy community, typically consisting of a single tree canopy layer likes Eucalypts and Cordial Africana.
Settlement land	Small rural communities and other manmade structures, market areas, roads, schools and local office.

2.4 Data analysis

ERDAS imagine 9.1 and Arc GIS 9.3 Software were employed for satellite image processing and LU/LC change analysis. The rate of change was calculated for each LU/LC classes as Rate of change (ha/year) = (R-P)/Y

Where: R = Recent area of LU/LC in ha, P = Previous area of LU/LC in ha, Y = interval between X and Y in years.

3. Results and Discussion

The analysis of the three satellite image data indicated that there was an expansion of perennial cropland and settlement land by 5.83ha/year and 1.41 ha/year respectively from 1986-2006. While, wood land, mixed land and cereal cropland were reduced by 2.98, 2.35 and 1.9 ha/year respectively on the same period (Table 2). The result of this finding is different from a study conducted by Temesgen et al. (2014) in Dera District, Ethiopia, Gessesse and Kleman (2007) in South Central Rift Valley, Ethiopia, Woldeamlak (2002) in Chemoga Watershed, Ethiopia, and Gete and Hurni (2001) in Dembecha area, who showed that there has been agricultural land size expansion at the expense of natural vegetation cover lands and marginal areas without any appropriate conservation measures. But, this result is due to the area's agroforestry system (Tadesse, 2002; SLUF 2006; Bogale, 2007; Abiyot et al, 2013). The traditional agroforestry system is an exemplary land-use system in the region (Tadesse, 2002; SLUF, 2006). It has been practiced in almost all parts of the study area for their livelihood. Bannana, coffee, avocado, mango, orange and other spice tree with indigenous multipurpose trees such as *Cordial Africana, Fiscus sur, Millettia ferruginea, Prunus africanus* and *Vernonia amygdalina* are some of the attribute of agroforestry land use in the study area. However, currently due to the human and natural induced factors the above indigenous multipurpose trees which have a great potential for biodiversity conservation are being over exploited in the study area (Tadesse, 2002; Bogale, 2007; Abiyot et al, 2013).

Table 2: LU/LC changes of the study area (1986, 2000 and 2006)

| LU/LC class	1986		2000		2006		Rate of change (ha/year)		
	Area (ha)	(%)	Area (ha)	(%)	Area (ha)	(%)	1986-2006	2000-2006	1986-2006
Cereal crop land	148.95	25.96	194.94	33.97	110.86	19.32	+3.28	-14.01	-1.90
Mixed land	198.76	34.64	82.29	14.34	151.79	26.45	-8.32	+11.58	-2.35
Perennial crop land	40.46	7.05	175.13	30.53	156.99	27.36	+9.62	-3.02	+5.83
Woodland	154.17	26.87	66.28	11.55	94.59	16.48	-6.28	+4.72	-2.98
Settlement land	31.44	5.48	55.07	9.59	59.66	10.39	+1.69	+0.76	+1.41
Total	573.78	100	573.71	100	573.71	100			
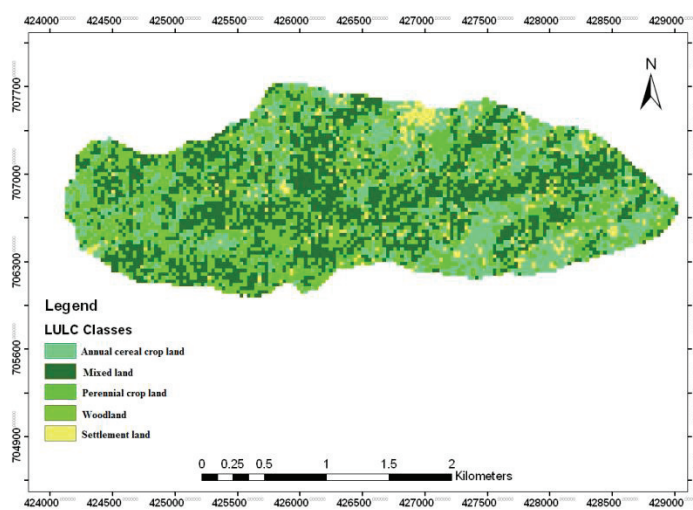
Figure 1: LU/LC map of 1986
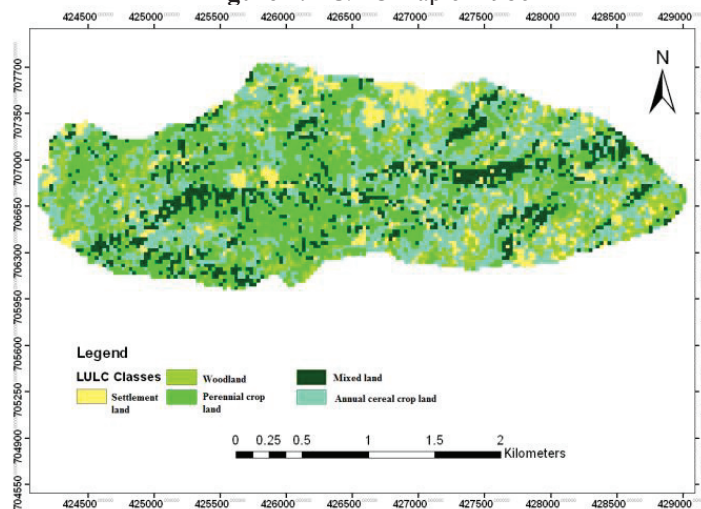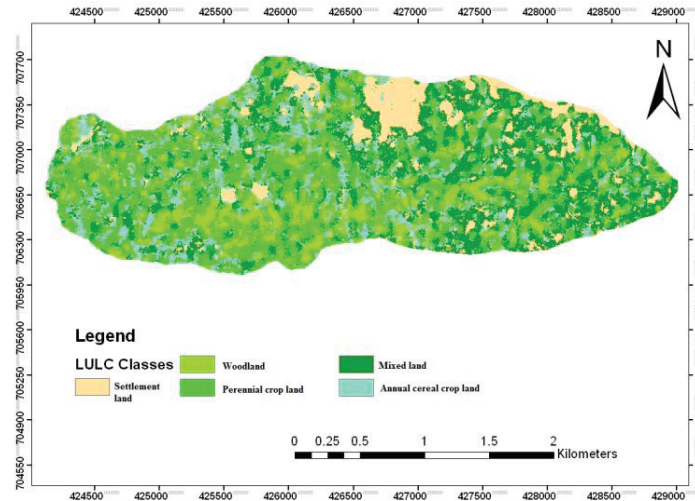

Figure 2: LU/LC map of 2000

Figure 3: LU/LC map of 2006

4. Conclusion

The analysis of two decades satellite image result reveled that annual cereal crop, mixed and woodland were declining at rate of 1.9, 2.35 and 2.98 ha/year respectively from 1986-2006. However, perennial crop land and settlement land were increasing. Simply, these imply that population dynamics is a major agent for these conversion. Thus, appropriate land use system is recommended to maintain the huge potential of the area for biodiversity conservation.

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