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Dynamics of Land Use/Land Cover Change in Debis Watershed, West Shewa Zone, Ethiopia

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Abstract
Background: To implement sustainable natural resource management at local and national levels, up-to-date and area specific land use/land cover change information is required. However, dynamics of land use/land cover change in *Debis* watershed was not analyzed previously. Therefore, this study was designed to analysis the rate and pattern of land use/ land cover change in Debis watershed. To address the aforementioned research purpose, the period between 1984 and 2017 was considered. The results of the study reveals continuous expansion of cultivated land, urban built-up area and bare land with the increasing rate of 386ha/year, 33ha/year and 27 ha/year respectively. On the other hand, forestland, bush/shrub land and grassland showed reduction with the rate of 34 ha/year, 114ha/year and 297 ha/year respectively for the study period (1984 to 2017) in the watershed. Outrageous expansion of cultivated land, bare land and built-up area at the expense of bush/shrub land, forestland and grassland were observed in Debis Watershed. This implies that there was loss of vegetation because of expansion of cultivated land and settlement. In other words, Poor natural resources management in general and poor land use planning and management were practiced. This study recommends applying appropriate land management practices to reverse the undesirable land use/land cover change in the study area.
Keywords: Change, Debis Watershed, Ethiopia, GIS&RS, Land use/land cover

Background

Land use /land cover change (LULCC) a phenomenon starting from ancient time is a locally pervasive and globally significant ecological trend and has become an event of paramount importance to the study of global environmental change (Geist and Lambin 2001). In the last three centuries, there is rapid and extensive LULCC as part of global environmental changes (Lambin *et al,* 2003; Gutman *et al*. 2004; WRI 2005). Global assessment of LULCC showed that cropland increased fivefold from year 1770 up to 1990 and pastureland increased more than six fold from 1700 to 1990 (WRI, 2005). These increases of cropland and pastureland occurred at the expense of forest, bush land, shrub land and grassland. In fact, the direction and speed of LULCC are not similar for all parts of the world. Being a less developed society, the observed changes of the land is swifter in Africa than in other continents (Ashenafi 2008). Land use and rapid alteration of land cover have great implications for the very existence of human as dependents of natural biophysical systems for survival (Kwabena 2007).

There are reasonable numbers of studies conducted in Ethiopia on land use/land cover change. Most of these studies reported the expansion of cultivated land at the expense of grass and forestland. In other words, cultivated lands were reported to be stretched into slope areas due to the shortage of land underpinned by the growth of human population. For instance, Temesgen *et al.* (2017) reported a significant increase in cultivated land at the expense of shrub lands and forests between 1985 and 2015 in Andassa watershed, Blue Nile Basin, Ethiopia. Similarly, Amare (2016) reported a considerable increase in cultivated land at the expense of wet and bush land in Infraz watershed northwestern, Ethiopia. Eyayu *et al.* (2010) reported a 90 % increase in cultivated land between 1957 and 2003 at Tara Gedam, northwestern highlands of Ethiopia. In addition, Solomon *et al*. (2013) reported that between 1957 and 2001, the total forest cover decreased in Birr watershed (from 27 % to 13%) as well as in Upper-Didesa watershed (from 90 to 45 % cover) in Blue Nine basin. 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. Similarly Berhan(2010) reported that area of forest cover reduce by 80.15% in Dendi district ,Oromiya regional state Ethiopia from year 1973 to 2005.

Debis watershed, which can represent a large part of the Ethiopian highland, in terms of topography, climate, vegetation and socioeconomic conditions, is headwater of Blue Nile basin Ethiopia. However, its land use/land cover change was not analyzed by any previously conducted studies in the study area and land use policy makers and managers less understand its dynamics. Hence, this study analyzed the dynamics of land use/land cover change in the study area and provided specific recommendations to reverse the undesired condition. In a nutshell, this study intends to analyze the dynamics of land use/land cover change in Debis watershed which underpins sustainable natural resources management in general and sustainable land use management in particular for the watershed and Blue Nile basin in the years to come.

MATERIALS AND METHODS

Description of study area

The Debis watershed is located in West-Shewa Zone, Oromia Regional State, Ethiopia. It is located between 8°47' N - 9°21'North latitude and 37° 32' E -38° 3' East longitude (Figure.1).

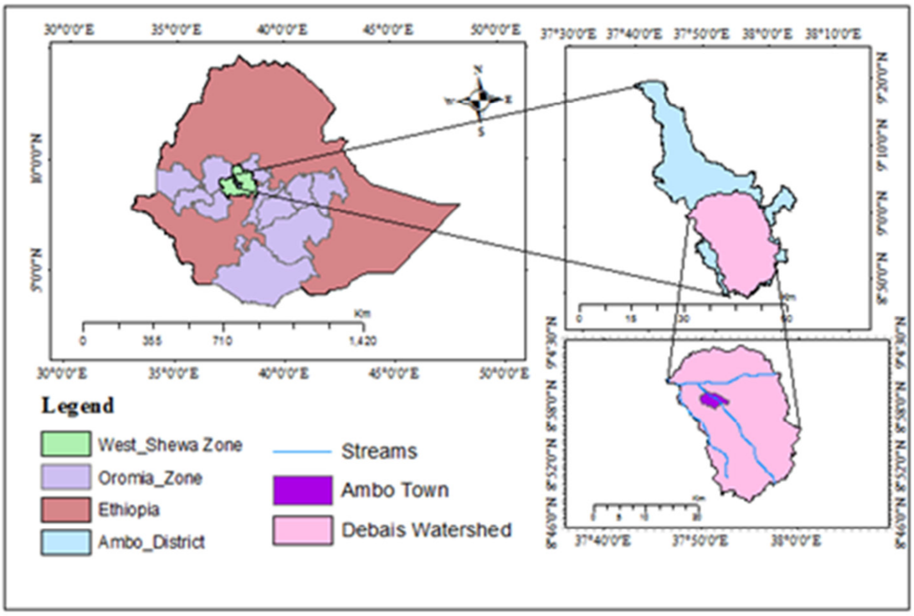

Figure 1. Location map of study area

Debis watershed has a mean annual temperature ranging between 23-25°C and a mean annual rainfall of 1300-1700mm (NMSA 2015). The altitudinal range of the agro-climatic zones in the watershed fall between 1875 and 3,202masl. It covers an area of 45,414.4ha. *Eutric cambisols*, *Eutric nitisols, pellic vertisols* ,*chromic vertisols* ,*Chromic luvisols* and *Orthic luvisols* area the dominate soil class found in the watershed(FAO 1997). The major indigenous natural vegetation types include *Juniperus procera*, *Arundinaria alpina, Ricinus communis, Morus alba, Olea europea subsp. cuspidata, Hagenia abyssinica, Dombeya torrida, Euphorbia abyssinica, Embelia schimperi, Erythrina abyssinica, Combretum molle and Ensete ventricosum (*WSZARDO 2016). An introduced vegetation type that is widely planted by farmers is *Eucalyptus* spp the traditional mixed crop–livestock agriculture is the single most important economic activity.

Data sources and methods of analysis

Three period of satellite, images were used to conduct this study (Tabel1). Digital map on shape file of scale of 1:50,000 from Ethiopia Mapping Authority were used as supporting spatial data for delineating the boundary of the study watershed. Moreover, Global positioning system (GPS) points during fieldwork or observation were used in the collection of Ground Control Points (GCP) as the support for the image classification. More than 300 sample-training sites have been used in each year(1984, 2000 and 2017) from ancillary data like high-resolution Google imagery and for 2017 directly from field. In addition, field observation and three focus group discussion, six key informant interviews within the farming household have been conducted to get additional information.

Table 1. Satellite image used for LU/LC change analysis and their characteristics

Satellite image	Sensor	path/row	Acquisition date	Resolution (m)	source
Landsat8	OLI-TIRS	169p54r	17/Feb/17	30*30	USGS
Landsat7	ETM^+	169 p54r	19/JAN/2000	30*30	GLCF
Landsat4-5	TM	169p54r	09/JAN/1984	60*60	GLCF

Data analysis

Based on information from local communities, characteristics of Landsat images, ancillary data like Google Earth and field observation six land use/land cover class (Table 2) were used for image classification, land use/land cover change analysis and to prepared map with the help of Arc GIS 10.1 and ERDAS imagine 9.1 software.

Table 2: Description of land use/land cover categories considered in image classification

LULCC	Description
Forest	Areas covered with dense trees, which include both *Eucalyptus* and coniferous trees, and riveren trees
Cultivated land	Areas used for rain fed crop production and scattered rural settlements usually associated with cultivated lands
urban Built-up area	Areas occupied by urban residential houses, buildings and industrial uses.
Bush/shrub land	Land covered by shrubs and bushes and sometimes with scattered small trees mixed with grasses.
Bare land	Areas with no or very little vegetation cover and characterized with shallow and rocky surface along the flooding area of the local stream valleys, over gentle and steep mountain slopes.
Grassland	Land predominately covered with grasses, forbs, grassy areas used for communal grazing.

Image Pre-Processing and Classification

Before doing change detection, image pre-processing like layer staking, geo-metric correction (the raw data were geo-referenced by Arc GIS software version 10.1. It was registered to the UTM projection, map zone 37, and datum of WGS84), radiometric correction(to improve visible interpretability of an image by increasing apparent distinction between the features in the scene, digital enhancement level like histogram equalization, nose/haze reduction was carried out by the help of radiometric tools/option of ERDAS imagine software) was applied.

Image classification was undertaken using hybrid classification methods involving both unsupervised and supervised techniques among different classification algorithms. Maximum likelihood was used for supervised classification by taking ground control points for six major land use land cover class .These LULC types were identified with the help of visual interpretation elements and the different reflection characteristics of the feature in the satellite images of 1984, 2000 and 2017.

Accuracy Assessment

Accuracy classification assessment was carried out to verify to what extent the produced classification is compatible with what actually exists on the ground (Congalton 1991). Therefore, accuracy assessment was performed through standard methods (Congalton 1991). In principle, all the output maps have to meet the minimum 85% accuracy (Anderson *et al*.1976). Table 3 shows result of accuracy assessment established in three periods of classified images in study area.

Table 3. Accuracy assessment for the classified image

Reference year	Overall accuracy	Overall kappa coefficient
1984	85.19%	0.82
2000	92.58%	0.8968
2017	92.19%	0.8703

The changes over 33 years were analyzed and the rate of change for each land use/ land cover type was calculated. Besides, various types of summary statistics were documented, in the mean time, the rate of land use/ land cover change for the three periods from 1984 to 2000, 2000 to 2017 and from 1984 to 2017 could be computed using the following simple formula (Abate 2011).

$\text{Rate of change (ha/year)} = (\mathrm{A} - \mathrm{B})/\mathrm{C}$ --------------------Equation 1

Where, A = Recent area of the land use and land cover in ha

B = Previous area of the land use and land cover in ha

C = Time interval between A and B in years

Overall change matrix was constructed to understand or observe the magnitude of change between different land uses

The whole procedure followed is summarized in the chart below(Figure2)

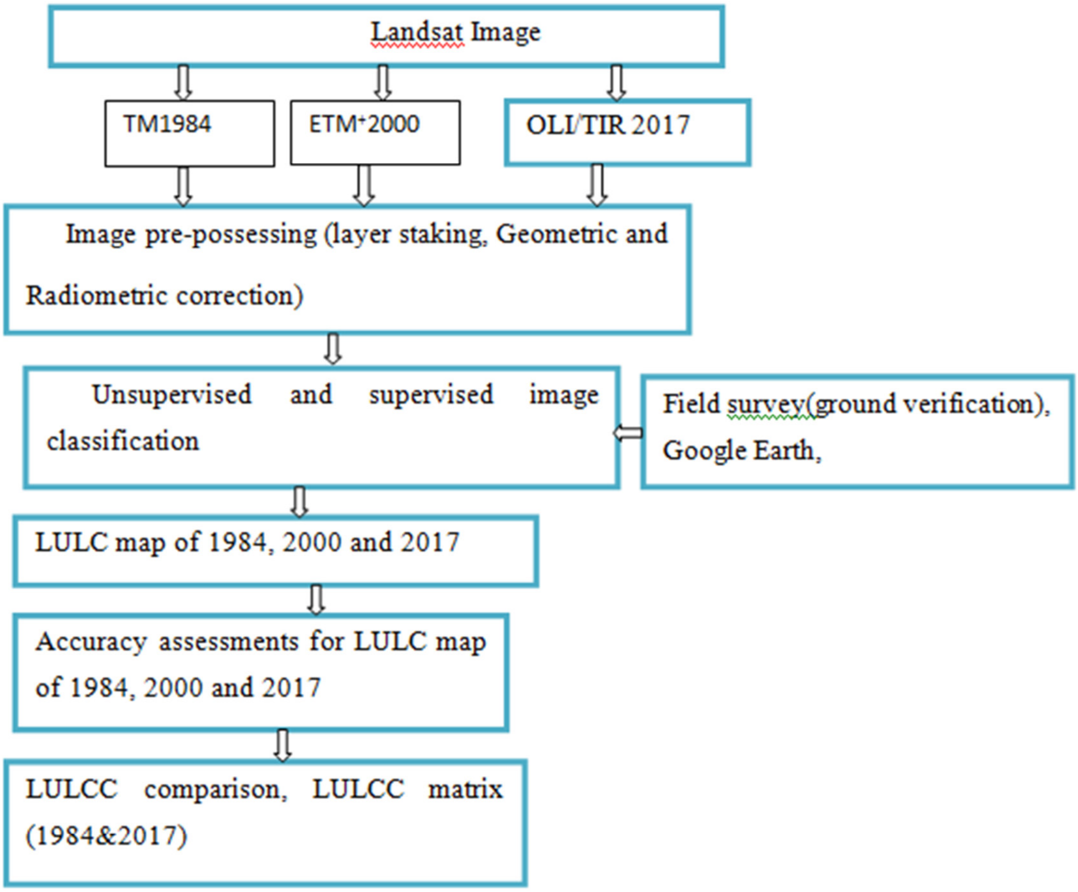

Figure2: Flow chart showing LULC change analysis

RESULTS AND DISCUTIONS

As the result reveals in study area there is a significant land use/land cover change in the last 33 years (1984 to 2917). For a clear and informative comparison of the land use/land cover change, area values for in three periods 1984-2000, 2000-2017 and from 1984-2017 were summarized in (Table 4) below. The three thematic maps (Figure 3) also illustrate the change in land use/land cover of study area.

According to the result grassland were the major land use land cover that occupies large areas (22065 ha) in 1984 while bare land cover small areas (575.6 ha). However, in year 2000 and 2017, cultivated land covers the largest area 16 887.7ha and 21902.3ha respectively. On the other hand, built up area covers smallest area throughout study period (Table 4 and Figure 3)

Table 4. LU/LC changes of study area (1984, 2000, and 2017)

LU/LC class	1984	2000	2017	Rate of Change in ha/year		
	Area(ha)	Area(ha)	Area(ha)	1984 -2000	2000 - 2017	1984 - 2017
Grass land	22065.0	15128.4	12267.1	-433.5	-168.3	-296.9
Forest land	5320.6	4002.7	4189.8	-82.4	11.0	-34.3
Cultivated land	9168.9	16 887.7	21902.3	482.4	295.0	385.9
Urban Built-up	80.6	308.6	963.7	14.3	38.5	26.8
Bush/Shrub	8203.7	7945.4	4428.3	-16.1	-206.9	-114.4
Bare land	575.6	1141.7	1663.2	35.4	30.7	33.0
Total	45414.4	45414.4	45414.4			

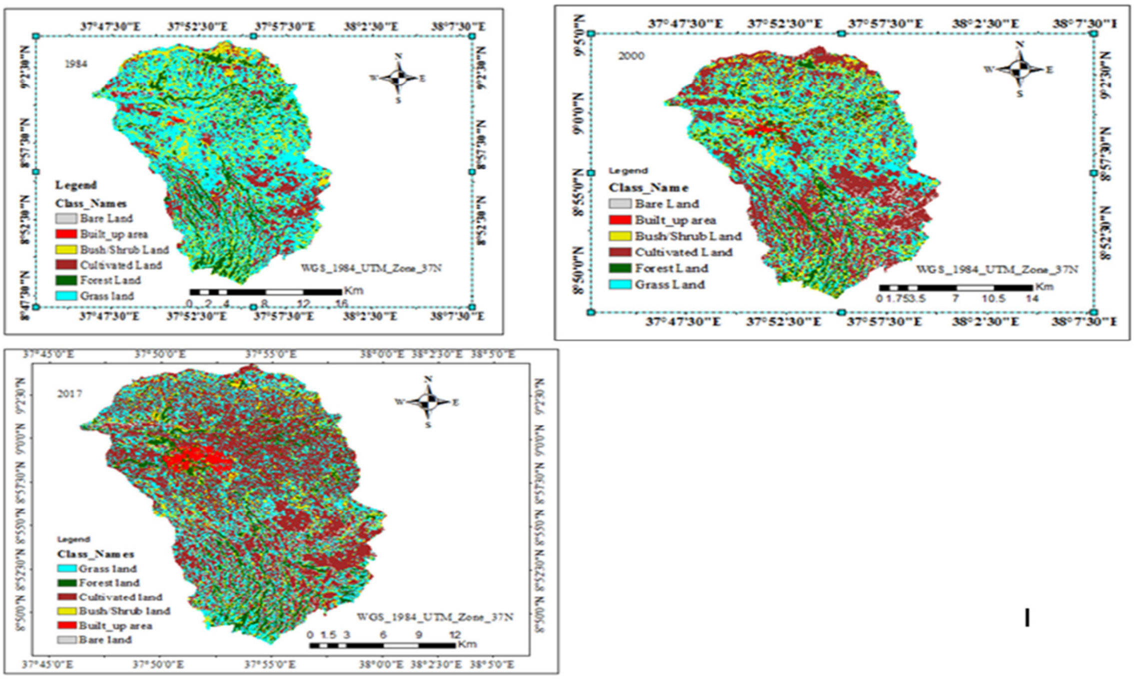

Figure3: Land use/land cover map of Debis watershed 1984, 2000 and 2017 period respectively

There was an expansion of cultivated land, bare land and urban Built-up with the rate of 385.9, 33 and 26.8 ha/year respectively from the year of 1984 to 2017. This finding agrees with the contention of Amare (2013) who contended that farmland and settlement area expanded in Gilgel Abay watershed for the time period between 1957 to 2008.

In this period (1984 to 2017), the largest decrement was shown in grassland, which reduced by 296.9 ha /year followed by bush/shrub land and natural forest, which decline by 114.4 ha/year and 34.3 ha/year respectively. This figure indicates that during study period there was degradation of vegetation. In line with this Lewoye (2014) reported that area of grazing land decreases in West Guna Mountain**,** northwestern Ethiopia with 15.1% from 1973 to 2014. In contrast to this finding Nurelegn and Amare(2014) reported there was increment of grazing land from 1973 to 1995 in Ribb watershed, northwestern Ethiopia. As Amanuyel and Mulugata (2014) reported, there was continues reduction (40 ha/year) on area of bush land in Naddo Ashendo watershed. The result of this finding is different from a study conducted by Eyayu *et al.* (2010) in Tera Gedam North Ethiopia and adjacent ecosystem from 1980 to 2003 and Nurelegn and Amare (2014) in Ribb watershed, Northwestern,Ethiopia from 1995 to 2011 who showed that there is an expansion of shrub and bush lands because of recent conservation activity.

The major contributor for this expansion of cultivated land was grassland (Table 5).This was affirmed during field observation and intensive focus group discussion because of increment of population number extra land was required for cultivation and settlement which causes grass and bush/shrub land converted to cultivated land and settlement. There is increment area coverage of cultivated land and settlement from 1957 -2005 by 21.99% at expense of bush/shrub and grassland in Gumara watershed of Lake Tana basin Ethiopia (Mesfin *et al*. 2016).

There are many studies conducted in highland of Ethiopia on LU/LC change which reported that there is an expansion of cultivated land at the expense of forest land (Woldamlake 2002; Abate 2011). According to the results of this study, there is overall loss of forest from year 1984 to 2017. However, as seen in (Table 4) from year of 2000 to 2017 area of forest increase with rate of 11 ha/year. As confirmed from intensive focus group discussion and key informant interview, the cause for the expansion of forest area is attributed to the expansion of *Eucalyptus* plantation. Solomon *et a*l. (2013) assert that expansion of *Eucalyptus* plantation in Birr and Gilgel Abbay watershed from 1957 to 2000 with 9% and 18% respectively underpin the increase in forest cover in the aforementioned study areas. From year 2000 to 2017 the major contributor was bush/shrub land this was asserted during intensive key informant interview because of recent conservation activities implemented in the area bush/shrub land was converted to forest areas.

Expansion of Ambo Town (urban built area) was observed during field observation, which indicates population growth cause grassland and bush /shrub to be converted to Built up area (Table 5). Population number of town increase from 19,325 to 48.171 from year of 1984 to 2007(http://www.citypopulation.de/Ethiopia.html) this figure indicts in the area there is high population growth. According to the result 553 ha and 246.6ha grassland and bush/shrub land of area have been converted to urban built-up areas from year of 1984 to 2017.

This indicates the major contributor for this expansion is these two-land classes. Similar to the aforementioned finding Wakjira *etal. (*2016) claim that there is continuous increment of urban built-up area and cultivated land underpinned by increment in human population in Gilgel Giba catchment. Scholars of land use/land cover also contend that the reduction in areas covered with natural ecosystem and conversion of other land use/land cover into urban built-up area are highly attributable to rapid increase in human population in different parts of Ethiopia. For instance, Woldeamlak and Solomon (2013) assert that expansion of Gish Abay town, Blue-Nile basin, Ethiopia between 1957 and 2001 was underpinned by natural human population increment and in-migration. Another case in point is Mary etal (2013) who affirms that dramatic increment of urban features in Mekelle city, Ethiopia from 1985 to 2010 was due to high rural "push" in the study area.

Table 5. Land use land cover change matrix from 1984 to 2017

Change from1984/to	Land use land cover class to 2017					
	Grassland	Forestland	Cultivated	Built -up	Bush/Shrub	Bare land
Grass land	6696.1	1141.2	11040.2	553.0	1833.6	801.0
Forest land	1019.4	2104.3	1275.1	26.5	801.6	93.7
Cultivated	2248.0	65.2	5743.4	59.0	546.4	507.0
Built-up	0.1	7.1	0.0	72.9	0.5	0.0
Bush/shrub	2189.4	866.5	3506.0	246.4	1206.2	189.2
Bare land	114.0	5.5	337.6	6.0	40.1	72.4

Conclusion

Analysis of three decade satellite images reveals that in *Debais* watershed there is an expansion of bare land ,cultivated land and bare land with the rate of 33 ha/year, 386 ha/year and 27 ha/year respectively at the expense of forest land , bush/shrub land and grass land. Area of forestland, bush/shrub land and grassland reduces with rate of 34ha/year, 114ha/year and 297 ha/year respectively. This indicates that in study area there is continues degradation of vegetation unless conservation activities are implemented.

Authors' contributions

The research project idea was conceived by Mr. Abebe Senamaw. He actively participated in the design of the study, carried out the data collection, and undertook the GIS and Remote sensing-based data analysis. More importantly, he conducted the full write-up of the research report and organized the manuscript for publication. Mr. Mesfin Megistu participated in the design of the study, carried out the data collection, and full write-up of the research report and edition of the manuscript for publication. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

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