Assessment of land use and land cover change in Finote Birihan kebele, Amhara region, Ethiopia

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Abstract- A small scale changes in land use and land cover (LULC) in different part of the planet has a substantial contribution for the regional or global LULC changes. The combined effect of these changes could also result a global impact on the natural as well as the human environment. To make informed planning and management decisions in addressing these adverse impacts, in-deep knowledge and information on the local scale changes require an immediate attention. This study aimed to investigate the extent and magnitude of LULC changes in Finote Birihan kebele, Ethiopia from 1986 to 2018 using Geographic information system (GIS) and remote sensing approaches. It is found that in the current study area, agriculture land and built-up area has increased by about 37 and 497%, respectively at the expense of grassland (55%), forest land (33%) and shrub lands (32%).

Keywords: LULC change, Finote Birihane, Geographic information system, Natural environment, Remote sensing

I. INTRODUCTION

Land use and land cover (LULC) change is a worldwide challenge influencing local to global environment [1]–[5]. Human beings had been degraded and changed the land and its resources in a variety of ways for their existence (Vitousek et al. 1997; Lambin et al. 2003). Changes in land-use and land-cover in most cases may pose a big threat on the ecosystem and its fragile components [2], [4], [6], [7].

Changes in land use from forest to agriculture have become a major problem in developing countries including Ethiopia owing to rapid population growth and its subsequent resource scarcity [3].

Like other regions of Ethiopia, in recent decades Finote Birihan kebele ("Kebele" is the lowest administrative unit in Ethiopia) underwent rapid LULC changes, which have aggravated the process of land degradation. In order to balance the associated trade-off between satisfying immediate human needs and maintaining other ecosystem function, quantitative knowledge and evidences about ecosystem responses to land use is required [7]. In addition, sustainable management of natural resources also requires a frequent study and monitoring of LULC changes at different spatial and temporal scales [8]. In this case, use of Geographical information System (GIS) in couple with remote sensing techniques is proved to be effective in assessing and monitoring LULC changes (Bewket 2003; Erener et al. 2012; Mallupattu and Sreenivasula Reddy 2013; Rawat et al. 2013).

Thus, the objective of this study is to analyze the spatial and temporal dynamics of LULC from 1986 to 2018 in Finote Birihane kebele and to generate LULC maps of these two years using GIS and remote sensing techniques.

II. MATERIALS AND METHODS

2.1. Study area

The study was done in Finote Birihan kebele, located between 10°52'46.67"N latitude and 38°16'10.63"E Longitude in the north-western highlands of Ethiopia Amhara regional state Enebse Sar Mider Woreda (Fig. 1). The study area has a total population of 4,186 (2,007 male and 2,179 female), 858 households based on the data obtained from 2007 census of Ethiopian central Statistics Agency. The major livelihood of the community in this kebele is mixed subsistence rain feed farming system (rearing of animals and crop production).

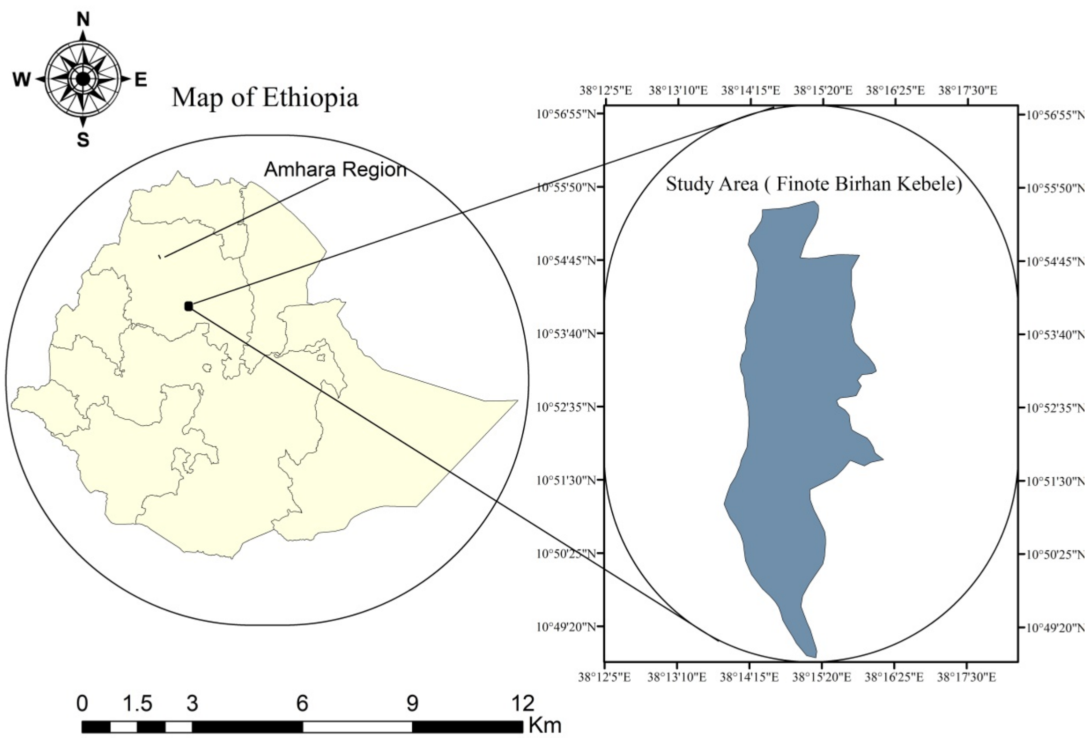

Figure 1. Location map of the study area.

2.2. Method of data collection and analysis

For change detection over the 32 years of study periods, temporal satellite images of the year 1986 (Landsat 5ETM) and 2018 (Landsat 8OLI) were acquired from the United States Geological Survey (USGS) website (http://glovis.usgs.gov), where only cloud-free images were considered to maximize the classification accuracy. In order to get cloud-free images with similar phonological properties and make the classification process more efficient, images of drier period of the year (December, January and February) were considered.

The overall flow chart of satellite image analysis depicted in Fig. 2. For this study, Arc GIS 10.2 and ENVI 5.3 software were employed for processing and analysis. The classification process for the current study consisted of pre-processing (geo-referencing, radiometric calibration, layer-stacking) and post-image processing phases. To make uniformity among spatial data, all images/spatial data were geo-referenced into similar map projection of World Geodetic system (WGS 1984); Universal Traverse Mercator (UTM) zone 37 north. For this study supervised classification method with maximum likelihood classifier was applied. The study area was classified into five classes (forest lands, grasslands, cultivated lands, built-up area and shrub lands) based on prior knowledge and supportive ancillary data, (Table 1). The accuracy of the classification maps was computed using confusion matrix and kappa statistics.

Table 1. Description of LULC categories in the study area

No.	Land cover type	Description
1	Agriculture lands	Areas mostly used for annual and perennial crop cultivation.
2	Forest lands	Areas covered by trees both natural and planted.
3	Grasslands	Area with some scattered trees and commonly used for grazing.
4	Built-up areas	Land area mainly covered with towns.
5	Shrub lands	Areas mostly covered by shrubs, bushes, and grass under it.

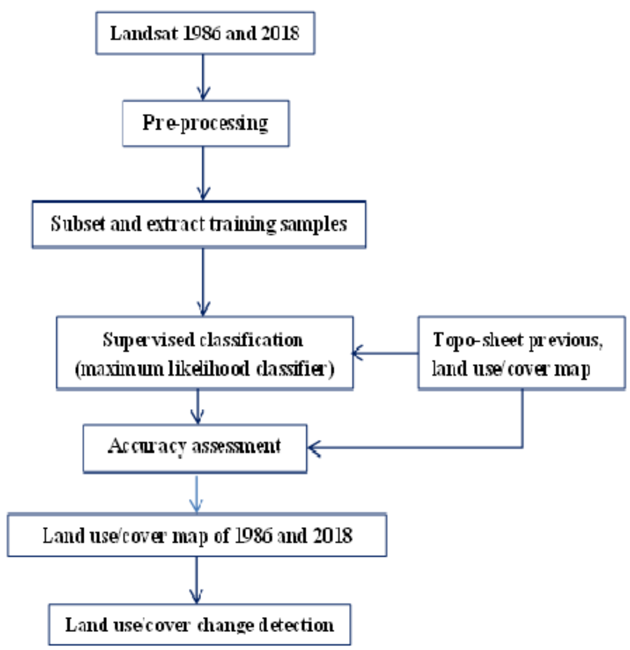

Figure 2. The overall flow chart of satellite image analysis of this study.

In order to determine the quantity of conversions from a particular land cover to other land cover category and their corresponding area over the study periods, cross tabulation analysis on a pixel-by-pixel (30 x30m) basis was conducted [12]. Finally, classified maps for different years are then computed change rate and percentage using the Eqs. 1 and 2 [13].

$$P = \frac{A2-A1}{A1} * 100 \quad (1)$$

$$Q(\%) = \frac{A2-A1}{A1} * \frac{1}{T2-T1} * 100 \quad (2)$$

Where: Q= rate of change, P= percentage of change of a specific land use class, A1= area of the previous land use class, A2= area of the recent land use class and T= time (years) interval between the two periods.

III. RESULTS AND DISCUSSION

3.1. Accuracy Assessment

The most common way to present map classification accuracy outputs is using confusion matrix/error matrix [9]. For this study, 140 pixels were randomly selected from the classified images and the reference data collected on the real ground. The overall map classification accuracy was 88 and 86% for the year 1986, and 2018 associated with a kappa coefficient value of 0.84 and 0.81, respectively.

3.2. Land use and land cover change detection

The results of the Geographic Information System (GIS) and Remote sensing data analysis were illustrated in Figures and Tables. Figures 3 and 4 illustrate the spatial distribution of the five land use and land cover categories in the year 1986 and 2018, respectively. Table 2 and 3 reveals quantitatively the areal extent of each land use categories in terms of pixels and percentage in the year 1986 and 2018 as well as the rate and percentage of change among the five LULC categories within the period of 32 years (1986- 2018).

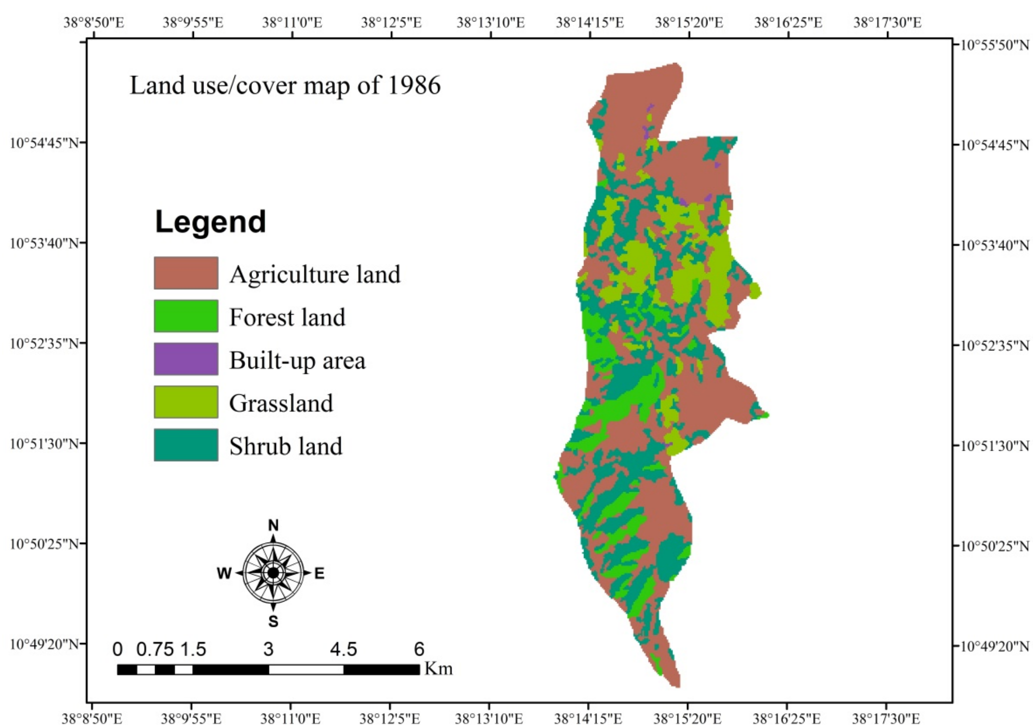

Figure 3. Land use and land cover map of Finote Birhan kebele in 1986.

During the 32 years period of study, the coverage of agricultural land and built-up area drastically increased with a dramatic loss of forest land, grassland and shrub lands. For instance, Built-up area coverage increased in 496% (585 pixels) in 2018 from 0.3 pixels with an annual rate of 15.5% (Table 2). Agriculture land coverage increased in 36.5% from 14,850 pixels in 1986 to 20,264 pixels in 2018 with an annual rate of 1.1% (Table 2). On the contrary, forest land decreased 32.7% from 3,320 to 2,242 pixels, grassland decreased in 55.1% from 3,925 to 1,764 pixels and shrub land decreased in 31.6% from 8403 to 30604 pixels with an annual rate of -1.0, -1.7 and -1.0%, respectively with in the entire period of study (1986 to 2018) (Table 2).

Table 2. Extent, rate and percentage of change in the five LULC categories during 1986 to 2018

	1986		2018		1986-2018	
LULC categories	Area (pixel)	Area (%)	Area (pixel)	Area (%)	Change rate (%)	Change (%)
Agricultural land	14850	48.5	20264	66.2	1.1	36.5
Forest land	3330	10.9	2242	7.3	-1.0	-32.7
Built-up Area	98	0.3	585	1.9	15.5	496.9
Grassland	3925	12.8	1764	5.8	-1.7	-55.1
Shrub land	8403	27.5	5749	18.8	-1.0	-31.6
Class Total	30606	100	30604	100.0		

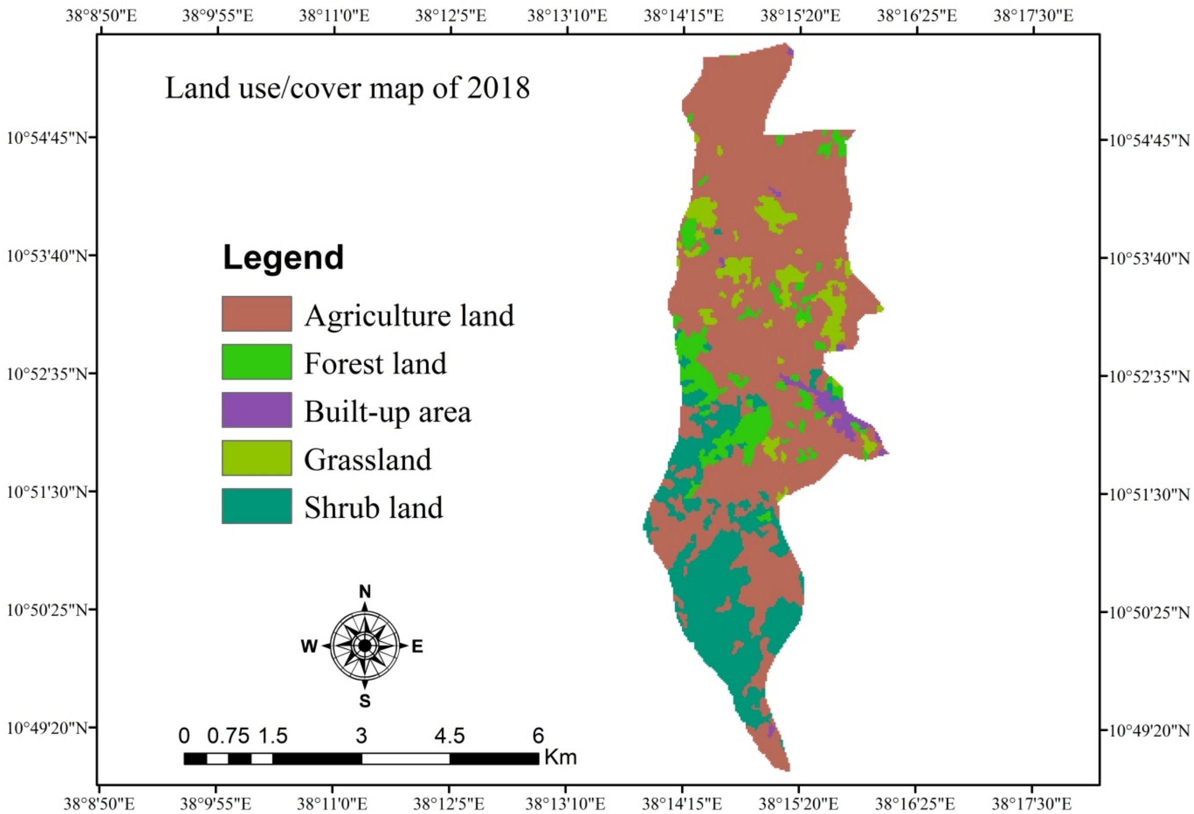

Figure 4. Land use and land cover map of Finote Birhane kebele in 2018.

The change detection matrix (Table 2 and 3) for the time period between 1986 and 2018 shows the transition in the five land cover categories. Out of the 14850 pixels that were covered with Agriculture area in 1986, 4.6, 3.3, 1.6, and 10.4% was transformed to forest land, built-up area, grassland and shrub land, respectively the rest 80% was still agriculture land in 2018(Table 1 and 2). In the same time, out of the 3330 pixels which were covered with forest land in 1986, (53.4%) and (20.9%) mainly converted into shrub land and agriculture land, respectively in 2018 while 25.4% is still unchanged (Table 1 and 2). In the same fashion, from the 3925 pixels of area covered with grassland and 8403 pixels which were under shrub land in 1986, about 66.2% of grassland and 58.8% shrub land have been converted to agriculture land in 2018 (Tables 2 and 3). The area of other land cover classes replaced by built-up and agriculture was small.

Table 3. Land use and land cover change matrix showing land encroachment (%) of the study area

Year	1986					
	LULC categories	Agricultural	Forest	Built-up	Grassland	Shrub land
	Agricultural land	80.0	20.9	100	66.2	58.8
	Forest land	4.6	25.4	0	2.1	8.4
2018	Built-up Area	3.3	0.2	0	0.8	1.0
	Grassland	1.6	0.1	0	30.6	4.1
	Shrub land	10.4	53.4	0	0.3	27.7

Class Total	100	100	100	100	100

IV. CONCLUSION

The study conducted in Finote Birihan Kebele using satellite imageries in the period 1986 to 2018. The result reveals that the study area has experienced a pronounced LULC changes within the 32 years period. Based on the analysis results, agriculture land and built-up area accounted the lion share of the LULC dynamics interims of area coverage and percentage, respectively. The area under agriculture and built-up area have increased by 5,414 pixels (36.5%) and 497% (484 pixels), respectively at the expense of grassland, forest land and shrub land. Within the same period of study grassland, forest land and shrub land coverage has reduced by 55 (2,161 Pixels), 33 (1,088 pixels) and 32% (2,654 pixels) accordingly. Therefore, this study illustrates the capability of GIS and remote sensing techniques in monitoring and detection of spatio-temporal changes in LULC which is otherwise not possible to attempt through conventional mapping techniques in less time, cost and with better accuracy.

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