

Full Length Research Paper

The study of land use and land cover (LULC) dynamics and the perception of local people in Aykoleba, Northern Ethiopia

Mehari Mariye¹, Melesse Maryo^{2*} and Jianhua Li¹

¹College of Environmental Science and Engineering, Tongji University, Shanghai, People's Republic of China.

²Ethiopian Biodiversity Institute, Addis Ababa, Ethiopia.

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It is believed that since the advent of agriculture, changes in land use and land cover (LULC) have happened. However, rates, extents and intensities of LULC changes have become more aggravated at all levels. The current study aims to examine the dynamics and perceptions of LULC change in the last four decades (1973-2013) in Aykoleba, Ethiopia using a combination of remote sensing data and the ground truth data. Focus group discussions were employed to obtain data on the status of land degradation. Remote sensing data were obtained using Landsat imageries of MSS (1973), Landsat TM, 1986 and 2000, and Landsat ETM+ (2013) with 30 m spatial resolution. ArcGIS10.2 and ERDAS Imagine13.1 were used to generate LULC classes. Accordingly, four LULC classes were identified, of which forest and bare LULC have been augmented by 8.8 and 54.9%, respectively. The escalation in forest cover is associated with plantation of eucalyptus near the home gardens, farmlands, and degraded areas. Nevertheless, open bush and grassland, and cultivated and settlement land cover classes were lessened by 27.4 and 37.8%, respectively although increase in bare land is related to abandonment of the cultivated land in hilly and sloppy areas, and overgrazing, among other factors. The local community perceived that population pressure is a top driver of LULC change in the study area. Overgrazing and lack of appropriate land use policy are also significant causes of change. Thus, the establishment of land use plan and appropriate population policy is recommended in Ethiopia.

Key words: Analysis, dynamics, Ethiopia, land cover, land use.

INTRODUCTION

Land-use refers to means in which land has been utilized by humans and their territory, commonly highlighting the

functional nature of land for economic activities (Rawat and Kumar, 2015). Lambin et al. (2003) also discussed

*Corresponding author. E-mail: melesseidevid@gmail.com.

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land use as the aim for which human beings exploit the land cover whereas Rawat and Kumar (2015) viewed a land cover as the physical attribute of the earth's surface. Land cover refers to social, cultural, and economic feature that entails human beings as they influence, outline, and create the environment (Wood and Porro, 2000). According to Quentin et al. (2006), any biological, physical or chemical changes related to land management are referred to as land use change. It is believed that changes in land use and land cover (LULC) occurred since the start of agriculture but the prevailing rates and intensities of LULC modifications are far larger than ever in the history of human beings, triggered by unmatched alterations in the ecosystems and environmental processes at different geographic scales. The topic of LULC change has developed a hot research agenda on international environmental dynamics and understanding the effects of surface processes on climate (Sagan et al., 2014). Dinka (2012) explained LULC change (LULCC) as the alteration of environment by human beings, which influence climate, biogeochemical cycles, ecological circumstances, and geomorphology. Such changes are associated with deforestation, agricultural expansion, and urban expansion, among others (Liu et al., 2007). Both natural and anthropogenic land cover dynamics affect biodiversity and the ecosystem services (Haque and Basak, 2017), cease socio-cultural practices, and improve natural disasters such as flooding (Mac et al., 2004).

Land degradation in developing countries, mainly sourced from the LULC is characterized by the current agricultural land expansion and production system (Mekuria, 2005; Barana et al., 2016), which can be revealed by intensified surface runoff as well as decline in yield. Many countries of low economy have rich natural resources and depend upon them, and have contributed to environmental out migration (IPBES, 2019). According to Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services/IPBES (2018), battling land degradation in Africa and restoring the degraded land is an urgent priority to protecting the biodiversity and ecosystem services.

IPBES (2018) also indicated the expansion of agriculture into native vegetation, climate change; indefensible forestry practices, urban growth, and infrastructural development are principal direct drivers of land degradation and related biodiversity loss. The rate and intensity of the dynamics of land use modification in Ethiopian agricultural land areas has increased significantly during the last decades at the expense of natural vegetation (Kiros, 2008), and gave rise to severe degradation of the natural environment, the downturn and ultimate extinction of species and the loss of ecosystem services (IPBES, 2018). Deforestation and the consequent land degradation are global threats, and so

are they in Ethiopia (Adugnaw, 2014). Land degradation is common in heavily populated highlands of Ethiopia (Aklilu et al., 2007). It is undesirable outcome of obstinate deforestation, physical and biological soil deterioration, and overgrazing of the agricultural land use types (Hurni, 1993), which consecutively caused low agricultural produce and poverty (Pender and Birhanu, 2007).

Various studies in Ethiopia depicted that increased dynamics of LULC was associated mainly with the high population pressure and the complex landscape where there is a heavy rainfall in the highlands of the country (Helden, 1987; Aklilu et al., 2007; Tadesse et al., 2017; Fikire et al., 2021), which has led to an escalation in the susceptibility of vegetation cover, land degradation and the reduction of biological resources. This in turn caused the environmental decline (Barana et al., 2016), and hostile influences the livelihood poverty (Hagos, 2014; Mohammed et al., 2017). IPBES (2018) depicted seriousness of the problem in its report that climate change and land degradation are liable to force 50 to 700 million individuals to migrate by 2050. Wubie et al. (2016) also discussed that land degradation; desertification and biodiversity loss are effects of LULC change in Ethiopia. Traditional poor agricultural systems mingled with weak policies and institutional environments along with other socioeconomic problems have given rise to LULC changes in Ethiopia (Zelege and Hurni, 2001). Therefore, the connection between LULC change and its causal factors remain multifaceted and dynamic (Mather and Needle, 2000).

The aforementioned facts demand both national and international attention on regular tracking of the changes using the latest data on LULC with the purpose to evaluate complex causes and effects in order to plan future tendencies better at different scales (Prenzel, 2004). Change analysis and detection of features of earth's surface allow someone to comprehend the natural phenomena (Butt et al., 2015). LULC change detection is of a vital importance to realize the landscape dynamic and sustainable land use management (Rawat and Kumar, 2015). Gathering remotely sensed data permits synoptic study of the earth-system function, patterning, and changes at diverse scales over time. Such data also offer an authoritative link between localized ecological research, and conservation of biodiversity (Haque and Basak, 2017).

The assessment of the study area and development of a management plan demand appropriate quantification of the present and past LULC parameters as changes perceived to help in realizing both anthropogenic and natural processes. Accordingly, the present study area, Aykolba, was chosen for the change detection since it is exposed to land degradation, deforestation, and overgrazing among others. Therefore, the major aim of the study was to investigate LULC dynamics and

perceptions of LULC change over the last four decades (1973-2013) in Aykoleba.

The study seeks to answer the following research questions:

- (a) What are LULC categories and patterns of land use dynamics over the last 4 decades (from 1973 to 2013) in Aykoleba?
- (b) Is there a shift in LULC categories through spatial comparison of the LULC maps produced?
- (c) How do local communities perceive LULC dynamics of the study area?

MATERIALS AND METHODS

The study area

Aykoleba is located in Wogera *Woreda* (district) of Amhara Regional State, Ethiopia (Figure 1), which covers an area of 14, 424 ha. The study area lies between the geographic coordinates of 14°10'52"N to 14°36'85" N latitude, and 35°63'04" E to 36°30' 84"E longitudes. The climate of Aykoleba falls within the *Woyna Dega* (mid land) to *Dega* (high land) and the altitudinal range of 1800 and 3080 m above sea level (asl) (WWAB, 2017). The average annual mean temperature is 15.5°C whereas the annual rainfall ranges between 500 and 1600 mm with an average of 900 mm Ethiopian Meteorological Services (EMS, 2013). The *Woreda* has a total population of 244,928 (124653 males and 120275 females) with an average population density of 134.5 persons/km² but the total population of the study area was 3,736 Central Statistical Agency (CSA, 2007). The soil types common to the study area include vertisols and cambisols though cambisol covers > 50% of the study area (FAO, 1986). Livelihoods of the majority of the population rely on mixed crop and livestock production systems Wogera *Woreda* Agricultural Bureau (WWAB, 2017).

Methods of data collection and analysis

The primary and secondary data were collected from diverse sources. For the LULC analysis, freely accessible time series Landsat satellite images were used (earthexplorer.usgs.gov). In order to examine LULC dynamics, Landsat imageries of MSS (1973), Landsat TM of 1986 and 2000, and Landsat ETM⁺(2013) with 30 m spatial resolution were employed for Aykoleba (Stefanov et al., 2001). ASTER, DEM, and topographic map of the study area (1:50000) were collected from the Geospatial Information Institute of Ethiopia. Images were Ortho rectified into Universal Transfer Mercator (UTM) zone 37N, WGS 1984. Image processing and GIS data analysis were performed using remote sensing and GIS software, including ERDAS Imagine 13.1 and ArcGIS 10.2, respectively. Initially, images were transformed into UTM and Geo-referenced to a datum to which Ethiopia has been chosen by WGS-84. The demarcated study area was digitized in Arc GIS 10.2 to superimpose the view on spatial databases produced from the photographs and the satellite image.

The identification and classification of LULC types on the aerial photographs were presumed by visual interpretation with mirror stereoscope whereas post-classification change detection was

used for the period of 1973 to 2013 following Singh (1989). The overall research procedure for the LULC change analysis was structured in the schematic diagram (Figure 2). Google earth image, field inventory and ground control point reading were major sources of data to generate the up-to-date land cover map of the study area. The trends and dynamics of LULC change were evaluated using Landsat image that offers a multi-temporal, multi-spectral and multi-resolution range of imagery for the land cover analysis following Oettera et al. (2000) and Yuan et al. (2005).

LULC change detection and NDVI methods were employed to examine the rate of land use change and the level of degradation following previous studies (Amanuel and Mulugeta, 2014). The normalized vegetation index (NDVI) values were extracted from the Landsat satellite images for the study periods to associate the result with supervised classification of land cover classes. The empirical formula for calculating NDVI = Near infrared - Visible red/Visible red + NIR; where NIR is the near infrared band value for a cell. NDVI value ranges from "+1 to -1" Close to '+1' means denser and greener vegetation and close to '0' means less green or other colored vegetation or dry leaf. '0' means no vegetation and '0 to1' represents other land cover types whereas negative values indicate the absence of vegetation that may match with the presence of water bodies (Haque and Basak, 2017).

Socio-economic data were gathered from 130 households selected randomly through household survey from the study area. In order to engage in-depth discussions, key informant interviews, and focus group discussions (FGD) were conducted to collect data regarding the past and present circumstances, including the drivers of LULC change of the study area. The district, administration, and household participants were chosen using a three-stage sample approach that included purposive and random sampling, while the household respondents are being chosen via systematic random sampling following Wubie et al. (2016). As a result, out of 2411 households 40 households were selected from each of the 3 elevation classes namely the lower (1800-1999 m asl), middle (2000-2499 m asl), and the upper (2500-3080 m. asl) classes. Sampling for the socio-economic survey of the study area was done in two phases. The first phase required selecting sample locations, while the second involved selecting individual households from the selected community. Furthermore, the focus group discussions (FGDs) were carried on with 16 participants (4 women and 12 men) to gain supplementary information about the long-term experience of LULC exercise in the study area. The participants for FGDs comprised of 4 farmers, 5 development agents, 4 *Kebele* (the smallest administrative structure in Ethiopia) cabinet members, and 3 community elders who were chosen by the *kebele* administrative bodies and the knowledgeable community representatives. For the in-depth discussion, 9 elderly peoples (age >60 years) were purposefully chosen as they were expected to have better historical information about the trends in LULC change over the past 4 decades. The study sample size was calculated as following Kothari (2004).

$$n = \frac{Z^2 \cdot p \cdot q \cdot N}{e^2 (N - 1) + Z^2 \cdot p \cdot q}$$

where n = denotes the sample size. Z = 95 confidence limit (interval) under normal curve that would be 1.96. P = 0.1 (percentage of the population to be included in the sample that is 10%). q = none occurrence of event = 1-0.1, which means (0.9). N = Total number of household = 2411. e = margin of error or degree of precision (acceptable error term) (0.05).

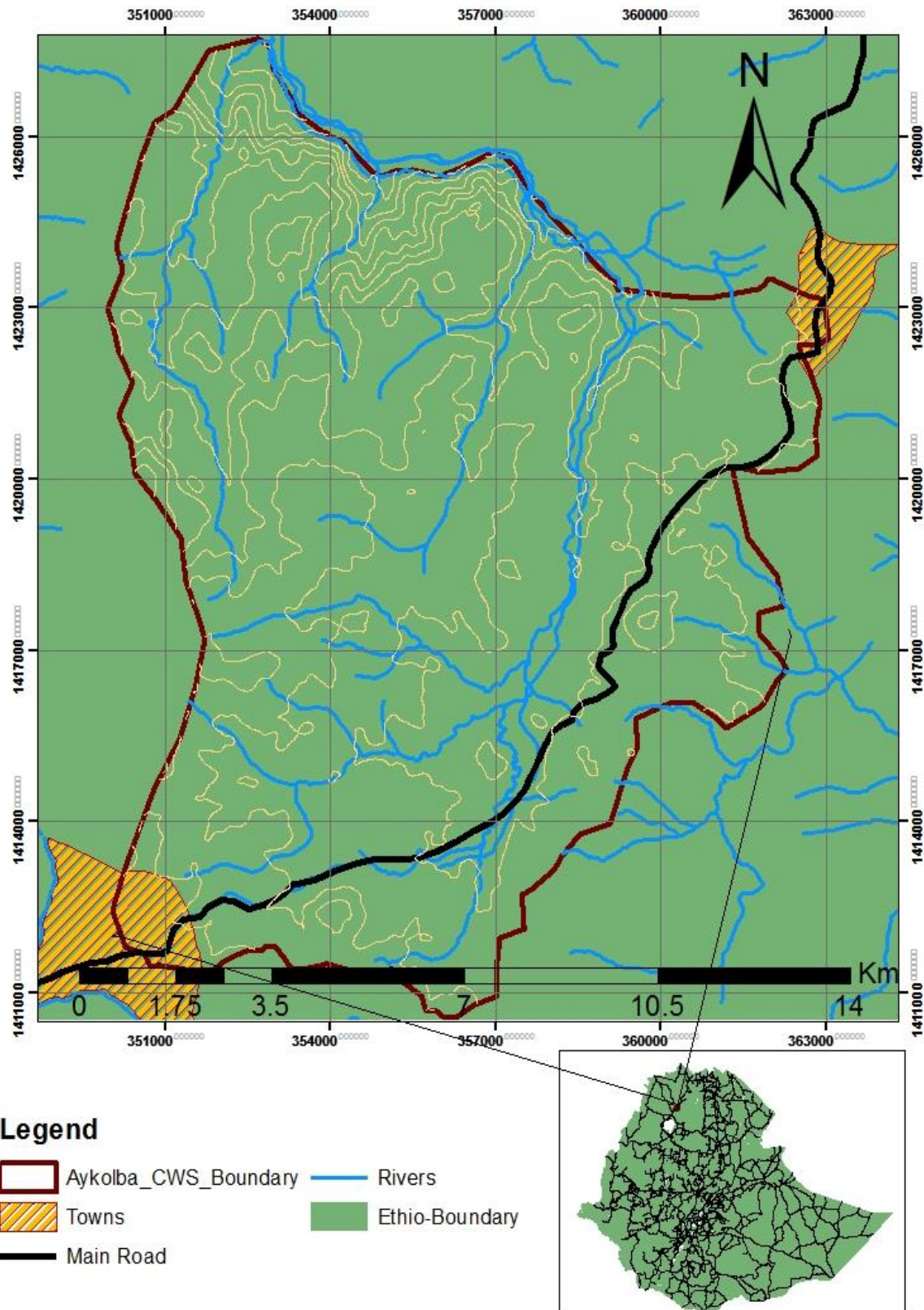


Figure 1. Location map of the study area (Source: WGS 1984, UTM Zone 37N, Projection: Transverse Mercator).

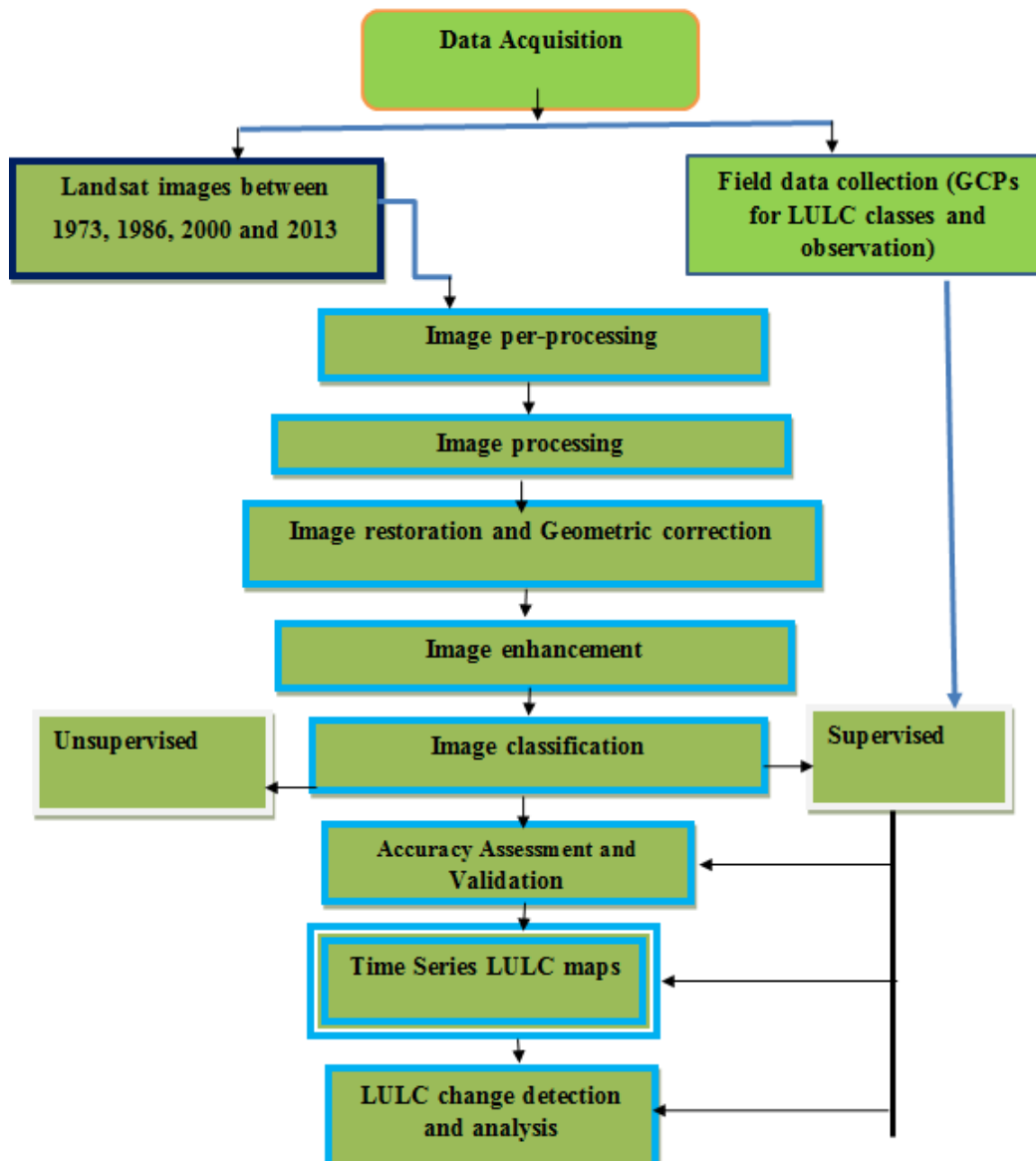


Figure 2. Schematic representation of LULC dynamics and data analysis process.

Accuracy assessment

Accuracy assessment was carried out by matching the classified image with the land cover classes on the topographic maps and the ground control points on the field. For the first comparison, accuracy evaluation based on 1973, 1986 and 2000 classified images were carried out through visual interpretation and the assistance of topographic maps. In this regard, 20 points were spread randomly across the classified image and topographic maps of the particular period. For the classified cover types, 40 random sampling points were set up and visited in the field for the validation of the actual cover type. Conversely, for the 2013 image, the ground truth data accuracy assessment was done by comparing remote sensing generated classification and the reference test

data. Table 1 displays the findings of the confusion matrix generated to analyze the classification's accuracy. Overall accuracy is 89.4%, with a kappa value of 0.854. This means that 89.4% of LULC classes are correctly categorized. Individual class accuracy varies from 100% for cultivated land and settlement to 72% for forestland. The accuracy of the producers varies from 94.4% for degraded/bare land to 76.5% for open bush and grassland, respectively. Overall, kappa statistics of 0.854, indicating that there is 85% better agreement than would be expected by chance alone. According to Pontius (2000), whether the kappa statistics was much less than 0.4, between 0.4 and 0.7, or greater than 0.75, the scientifically acceptable outcome for kappa coefficient is bad, good, or excellent, respectively. Kappa represents an agreement between the classified LULC and the observed land use category. It was

Table 1. Confusion matrix of classification accuracies for Aykoleba.

Classified data	Reference data					User accuracy (%)
	OB&GL	C&SL	FL	DL	Total	
OB&GL	26	2	4	0	32	81.3
C&SL	0	64	0	0	64	100.0
FL	4	3	27	3	37	72.9
DL	4	0	0	51	55	92.7
Total	34	69	31	54	188	-
Producer accuracy (%)	76.5	92.8	87.1	94.4	-	-

Overall accuracy 89.4%; Kappa statistics 0.854. OB&GL= Open bush and grassland, C&SL= Cultivated and Settlement, FL= Forestland, DL= Degraded land.

evaluated following Butt et al. (2015) based on the equation:

$$\text{Kappa} = \frac{P(A) - P(E)}{1 - P(E)} \quad (1)$$

where P (A) represents the number of times the K raters agree, and P (E) represents the number of times the K raters are anticipated to agree by chance. P (A) and P (E) are computed using the following Equations 2 and 3:

$$P(A) = \frac{(CP+UP)}{(TP)} \quad (2)$$

$$P(E) = \frac{(CP+MA)(CP+FA)+(FA+UP)(MP+UP)}{TP+TP} \quad (3)$$

Here, changed pixels (CP) relate to pixels that have been detected to change, whilst unaltered pixels (UP) refers to pixels that have been identified to be unchanged. TP stands for total number of pixels, missed alarms rate (MA), and false alarms rate (FA), respectively. The sum of CP, UP, MA, and FA is TP. The higher the kappa coefficient, the more accurate the segmentation.

Change detection

It refers to the process of identifying alterations in the state of an object or phenomenon by ascertaining it at various times. Remote sensing based change detection employs assessment of a set of temporal images covering time of concern using specific change detection algorithms (ESCAP, 1996). Change detection is significant for monitoring the change of earth's surface features in order to realize interactions between human and his environment to enhance the management and use of natural resources as described by Singh (1989). With the aim of obtaining the information on LULC dynamics in terms of pattern and rate of conversion, post-classification change detection analysis was effected in ERDAS Imagine 13.1 employing classification images of 1973, 1986, 2000 and 2013. Effective use of Satellite Remote Sensing for LULC change detection relies upon appropriate knowledge of landscape topographies, imaging systems and a method engaged in association with the aim of the analysis (Yang and Lo, 2002). The change detection of LULC comprises the interpretation and analysis of multi-temporal and multi-source satellite images to categorize temporal phenomena or changes through a certain retro. There are four conditions of LULC change detection characteristics such as,

detecting the changes that have occurred, classifying the nature of the change, computing the areal extent of the change, and evaluating the spatial pattern of the change as argued by Yismaw et al. (2014). Change detection methods have been grouped generally into image algebra, transformation and classification. Classification categories include post-classification comparison, spectral temporal combined analysis, expectation-maximization algorithm change detection, unsupervised change detection, and hybrid change detection and artificial neural networks (Lu et al, 2007). For detecting LULC changes, this study used post classification compassion, an integrated GIS and remote sensing method, and supervised classification. The major benefit of these techniques is their ability to offer a matrix of change information and minimize adverse impacts from atmospheric and environmental changes across multi-temporal images.

Post classification change detection

It links two individually formed classified LULC maps of two dissimilar dates. Accordingly, it reduces the problem of normalizing for atmospheric and depicts the nature of the variation. The LULC change detection is based on the assumption that the two LULC maps were created appropriately (Jensen, 2002). Post classification analysis encompasses autonomously made spectral classification outcomes from each end of the time interval of interest, followed by a pixel-by-pixel or segment-by-segment evaluation to find changes in cover type. Besides, to algorithms that are employed on the classified images to fix those pixels with a variation between the two dates, statistics can be compiled to express a certain nature of changes between the two images (Lillesand et al., 2004).

RESULTS AND DISCUSSION

LULC categories and patterns of land use dynamics

Four classes of LULC of the study area were identified (Table 2), namely, forestland, open bush and grassland, cultivated land and settlement, and bare land.

However, Table 3 reveals that open bush and grassland cover class of the study periods (1973-1986) and (2000-2013) declined by 76.6% (996 ha) and 102.5% (1332.9 ha),

Table 2. Land use cover classes of Aykoleba and their description.

No.	LULC Classes	Description of land cover type
1	Forest	Areas covered with trees forming a closed canopy or nearly closed canopy (70-100%). This includes the natural forest and plantation forest dominated by eucalyptus tree.
2	Open bush and grassland	Bush land and grassland Areas covered with a mixture of grass and bush/shrubs and areas covered with permanent grass and used as a communal grazing land.
3	Cultivated land and settlement	Areas used for cultivation, including fallow plots and a complex unit, i.e., cultivated land mixed with bushes and trees, and rural and urban homesteads.
4	Bare/Degraded land	Areas with very shallow soils, covered partly with scanty grass, bush/shrub, and exposed rocks. Normally consists of abandoned cultivated land or cultivated degraded soil and with exposed rocks, sometimes with gullies; used as local grazing land.

Table 3. Land cover classification of the year (1973-2013) for Aykoleba.

LULC Classes	Land cover in each year of image							
	1973		1986		2000		2013	
	ha	%	ha	%	ha	%	ha	%
Forest	1725.9	11.9	1071	7.4	2766.4	19.2	2080	14.5
Open bush and grass land	5525.9	38.1	4530.2	31.5	5762.8	40	4429.9	30.7
Cultivated land and settlement	5354.4	37	7706.5	53.5	3658.6	25.4	3842.4	26.6
Bare/Degraded land	1876.6	13	1098.9	7.6	2218.8	15.4	4071.7	28.2
Total	14406.6	100	14406.6	100	14406.6	100	14406	100

respectively but it increased by 88% (233 ha) from 1986 to 2000. Previous researchers (Aklilu et al., 2007) also notified that areas of open bush increased between 1982 and 1998. Forestland cover showed the increasing and decreasing trend during the second to fourth study periods with a net raise in forestland cover when compared with its initial period (1973). There was also an increase in forest LULC of the study area from its level of 7.4% (1071 ha) in 1986 to 19.2% (2766.4 ha) in 2000 (Table 3).

The increment might be associated with soil and water conservation actions taken by the government as one of the natural resources management methods. This was implemented country wide between 1980s and 1990s following the incidences of drought and famine in Ethiopia. The drought-induced famine of 1984/1985 was reported as one of the worst in Africa, in terms of its intensity and coverage (Woldeamlak, 2009). Between 1986 and 2000, the tendency of forest LULC was altered and it was augmented by 121.1% (1695.4 ha) (Table 4).

This could be linked with tree planting assisted by sustainable land management program in Ethiopia aimed at the conservation of soil and water as explained by Barana et al. (2016).

The reduction in forest cover during the first study period (1973 to 1986) is likely associated with the increased need for the cultivated land (Figure 3). This could have been due to a speedy annual population growth in the area by 2.7% (CSA, 2007), which probably required extra agricultural land. Similar, a study from Nigeria shows that the raise in the number of human population living in the forest reserve led many of them to be employed in farming, leading to an increase in farmland at the expense of forestland (Aderale et al., 2020). The land use policy changes, mainly land reform proclamations in the country between 1975 and 1997, and the loss of land productivity due to unsustainably farming have also significantly aided for the decline in the forest cover. Similar findings were reported from Southern

Table 4. Rate of LULC dynamics (1973-2013) in the Aykoleba.

S/N	LULC classes	Rate of LC Change							
		1973 to 1986		1986 to 2000		2000 to 2013		1973 to 2013	
		Area change (ha)	Rate of change (ha/year)	Area change (ha)	Rate of change (ha/year)	Area change (ha)	Rate of change (ha/year)	Area change (ha)	Rate of change (ha/year)
1	Forest	-654.9	-50.4	1695.4	121.1	- 686.4	- 52.8	354.1	8.8
2	Open bush and grass land	-995.7	-76.6	232.6	88	1332.9	-102.5	-1096	- 27.4
3	Cultivated land and settlement	2352.1	180.9	4047.9	-289.1	183.8	14.1	-1512	- 37.8
4	Bare/Degraded land	-777.7	-59.8	1119.9	80	1852.9	142.5	2195.1	54.9

Ethiopia (Barana et al., 2016). In addition, Mengistie et al. (2013) also discussed the disappearance of a Lake due to deforestation in Ethiopia.

LULC dynamics gained from the digital imagery investigation showed that unpredictable change of trends has been observed in forest LULC (Figure 4). Between 1973 and 1986, the cultivated and settlement land cover class gained 180.9% (2352.1 ha) area from other land cover classes and practiced a positive rate of change (Table 4). As discussed by participants of the FGD, during this period, cultivable lands were abundant and the population pressure was low in most places of the study area. This explanation is well associated with pieces of evidence in LULC dynamics acquired from the digital imagery analysis. Between 1986 and 2000, the rate of change was decreased by 289.1% (4048 ha) (Table 4), and it was shrinking from 53.5% (7707 ha) in 1986 to 25.4% (3659 ha) in 2000 (Table 3). This is most likely related to the migration of people to other areas. According to explanations from FGD and informants, a large number of Bete Israel migrated from the study area. This finding is in line with the study conducted by Lambin et al. (2006) who

have revealed that migration caused changes. However, another study in Wallecha Watershed by Barana et al. (2016) indicated that the cultivated land has augmented with a rate of 30.75 ha/year mostly from forests, and shrub and grasslands. Between 1986 and 2013, the cultivated and settlement LULC showed decreasing and increasing trends. But in general there has been 37.8% (1512 ha) loss of this land cover class was recorded over the last 40 years (Table 4). The result of the LULC analysis disclosed that the area coverage of the bare land has been progressively increasing starting from 1986 (7.6%) to 2013 (28.2%). This might have been connected with the cultivation of sloppy areas, unsuitable farming systems as well as climatic factors that at the end yielded degraded land. However, the study on Wallecha Watershed from 1984 to 2000 indicated a trend of successive reduction of a bare land from 4.8 to 3.2% (Barana et al., 2016).

LULC classification

The LULC classification has resulted in four major

LULC classes, namely forest, open bush and grassland, bare land, and cultivated and settlement (Table 3 and Figure 5).

The largest LULC of the existing study is the open bush and grassland covering about 31% of the total land area, followed by Bare or degraded land, which covers 28.2% (Figure 5). This probably shows high land degradation in the study area that may require ecosystem restoration to protect the biodiversity loss and ensure ecosystem functionality. IPBES (2019) showed that presently, land degradation has reduced 23% of the productivity of the global terrestrial area. Thus, local and national sustainability efforts and mainstreaming biodiversity across all productive sectors has to be aligned, as depicted by IPBES report. LULC classification could vary based on the various factors such as altitude of the area, human culture, the distribution of the rainfall, soil types, etc. The study on LULC classifications indicated that the dominant LULC was agroforestry (69%) whereas only 4.9% of the degraded land cover was reported from Gedeo Zone in Ethiopia (Birhane and Melesse, 2015). Similar study from the same country reported that the largest land cover and the degraded land area cover to be

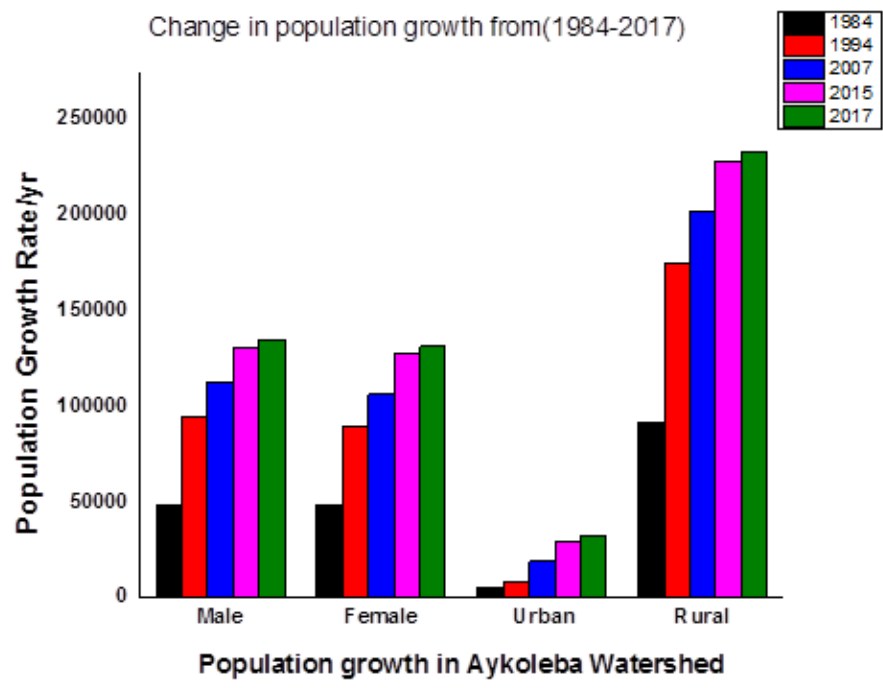


Figure 3. Population growth in Wogera Woreda between (1984-2017). Source: WWAB (2017).

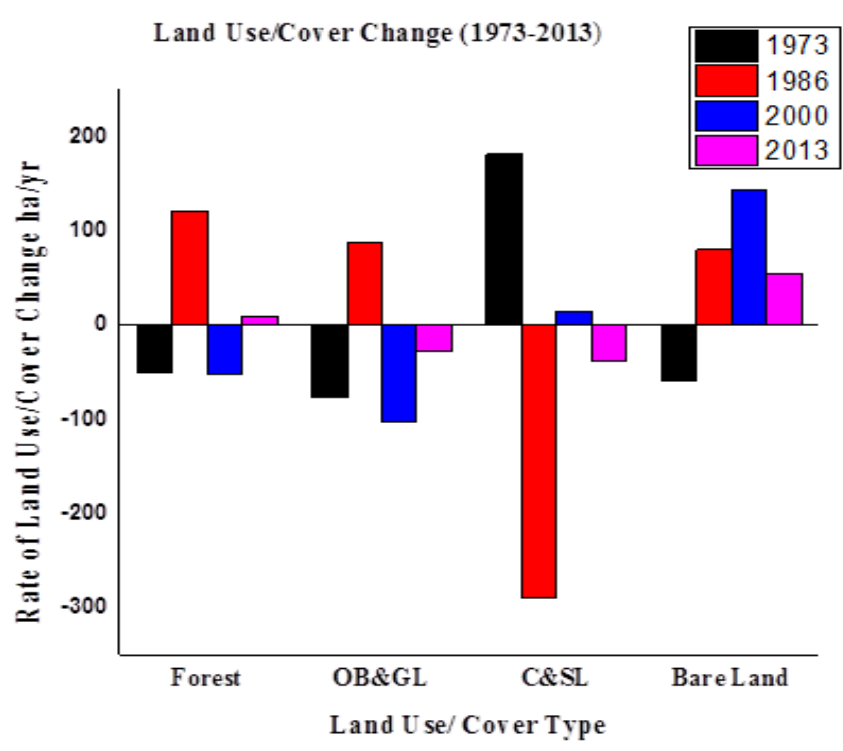


Figure 4. Percent Change in areas of LULC change in Aykoleba (1973-2013). OB = Open Bush, GL= Grazing Land, C = Cultivated land, SL= Settlement Land.

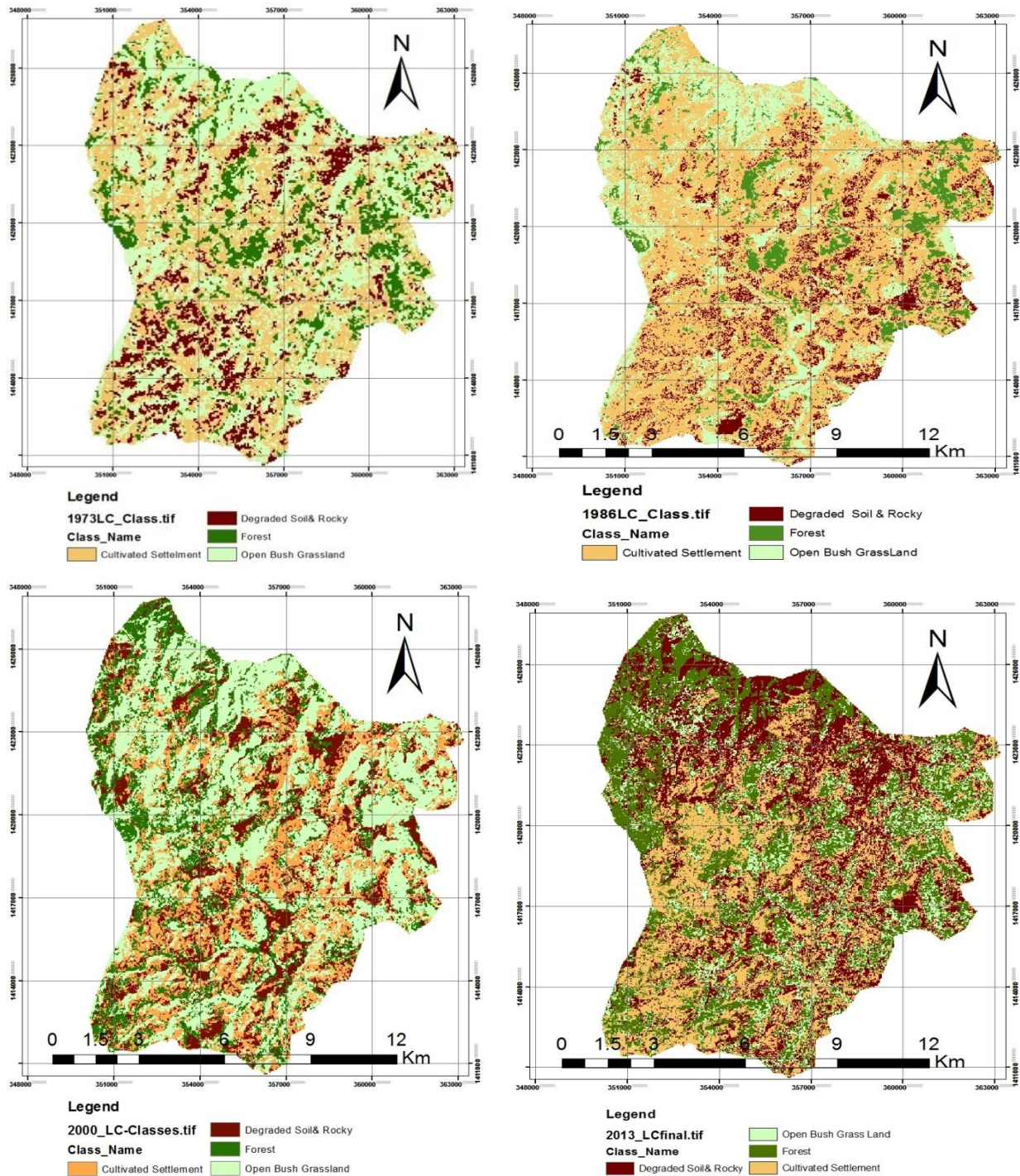


Figure 5. Classified land cover map of Aykoleba (1973-2013).

44.4 and 2.82% from Wallecha Watershed in Ethiopia, respectively (Barana et al., 2016)

The current study used bands 4, 5 or 7 from ETM+ in

combination with 1, 2 or 3 to determine the vegetation condition in the Images. Different color composite red 4, green 3 and blue 2 band combinations were tested for

better visual interpretation (Figures 6 and 7).

Rate and pattern of LULC

Table 4 showed the time-based variations of land cover classes and columns represent the spatial variation of land cover classes realizing the patterns of land use dynamics and its implication supports to plan an appropriate land management in the study area. Accordingly, the finding depicted that the forest and bare land increased by a rate of 8.8% and 54.9 ha/year from 1973 to 2013 whereas open bush and grassland, and cultivated and settlement lands decreased by -27.4 and -37.8 ha/year (Table 4). The increase in bare land depicts that the study area is under critical condition of conservation level. The degradation has increased from 13% in 1973 to 28.2% in 2013 (Table 3). The degradation and land use cover change of the study area is also linked with the demographic factors (population movement and increments) (Table 5). Key informant interviewees also described livestock population pressure, political instability, rainfall variability as important factors of bare land formation. They stated that the political instability during the late 1980's and early 1990's, especially a civil war between the then government (Derge) and the rebellious movement led by EPRDF, which forced the farming community internally displaced; which affected their agricultural activity specifically the crop production system and abandoning crop land to water and soil erosion. Informants maximized that climate change exacerbated by the land resource degradation particularly the soil, water and biodiversity, which was also confirmed by MoARD (2008) too. These factors probably have contributed for a dramatic change in land use and cover of the study area. A study conducted by Mohammed et al. (2017) in southeast lowland of Ethiopia reported that the cultivated land, settlement, bush land and bare land have increased by 13.8, 14.3, 12.6 and 22.3%, respectively from 1986 to 2016 whereas the woodland and grassland have fallen by 33.8 and 24.4% over the same period. A study by Barana et al. (2016) in southern part of Ethiopian showed that tree plantation and cultivated lands have increased by 31.25 and 22.2 ha/year whereas shrubs and grasslands, forest, and degraded land decreased by -35.4, -14.3, and -3.7 ha, respectively, from 1984 to 2000. The increase in forestland cover of the present study is related to the importance of eucalyptus tree for construction and fuel wood needs of the community and its significance for income generation made it become dominant plantation tree. It can be suggested that the current study area has to adopt good practices existing in the same country such as trends in reducing the degraded (Barana et al., 2016) in order to minimize the degraded areas and enhance

the biodiversity and ecosystem services.

Perception on LULC dynamics

Discussants of FGD perceived that the causes for LULC were population pressure (90%), increase of agriculture (80%), the need for fuel wood and construction material (74%), and policy and institutional changes (50.4%) (Table 5). Studies in Ethiopia also showed that deforestation aimed at the expansion of agricultural activities ranging from small to large-scale commercial agricultural systems (Fikire et al., 2021), weak law enforcement (Zelege and Hurni, 2001), and the prevalence of drought (Woldeamlak, 2009) were reported among crucial factors that drive LULC changes in Ethiopia. Informants of the current study claimed that larger population growth has driven urbanization, woodland collection, and great number of livestock that overgrazes agricultural lands.

The change in population size often considered as one of the chief factors affecting land use change (Wubie et al., 2016). Accordingly, about 90% of the respondents reported that swift population growth in the study area has put forth a pressure on the current land resources by raising the demand for food, wood for fuel and construction materials, and resulted in the expansion of croplands to hilly and sloppy areas by encroaching into uncultivated lands, including shrubs and open bush lands (Table 4). In some cases such cultivated fields were left abandoned where soil erosion and others factors have given rise to land degradation in Aykoleba. This causes environmental decline, including biodiversity loss and ecosystem disservice (Barana et al., 2016). Ayalew (2008), Tesfahun and Temesgen (2014), and Habtamu et al. (2018) also discussed that the population dynamics and its associated problems to be major drivers of LULC change. Similarly, a study from Central Malawi reported that population growth, firewood collection, charcoal production, and poverty to be main drivers of LULC changes (Munthali et al., 2019). It was recommended that reducing effects of population pressures on the remaining scarce forest resources should be a priority to be shared by rural developers, family planning advocates, supporters of free trade, and the conservationists (Carr et al., 2006). This in turn requires capacity building at local level to minimize the impact.

The LULC dynamic analysis clearly depicted that areas under cultivation and settlement land have increased in the Aykoleba over the four decades periods (1973-2013). The respondents (80%) showed that expansion of crop production was a key driving force of the LULC dynamics in the study area (Table 5). This is because since 1980s the Ethiopian government has introduced a high yielding rice crop in the area. Consequently, a large portion of the

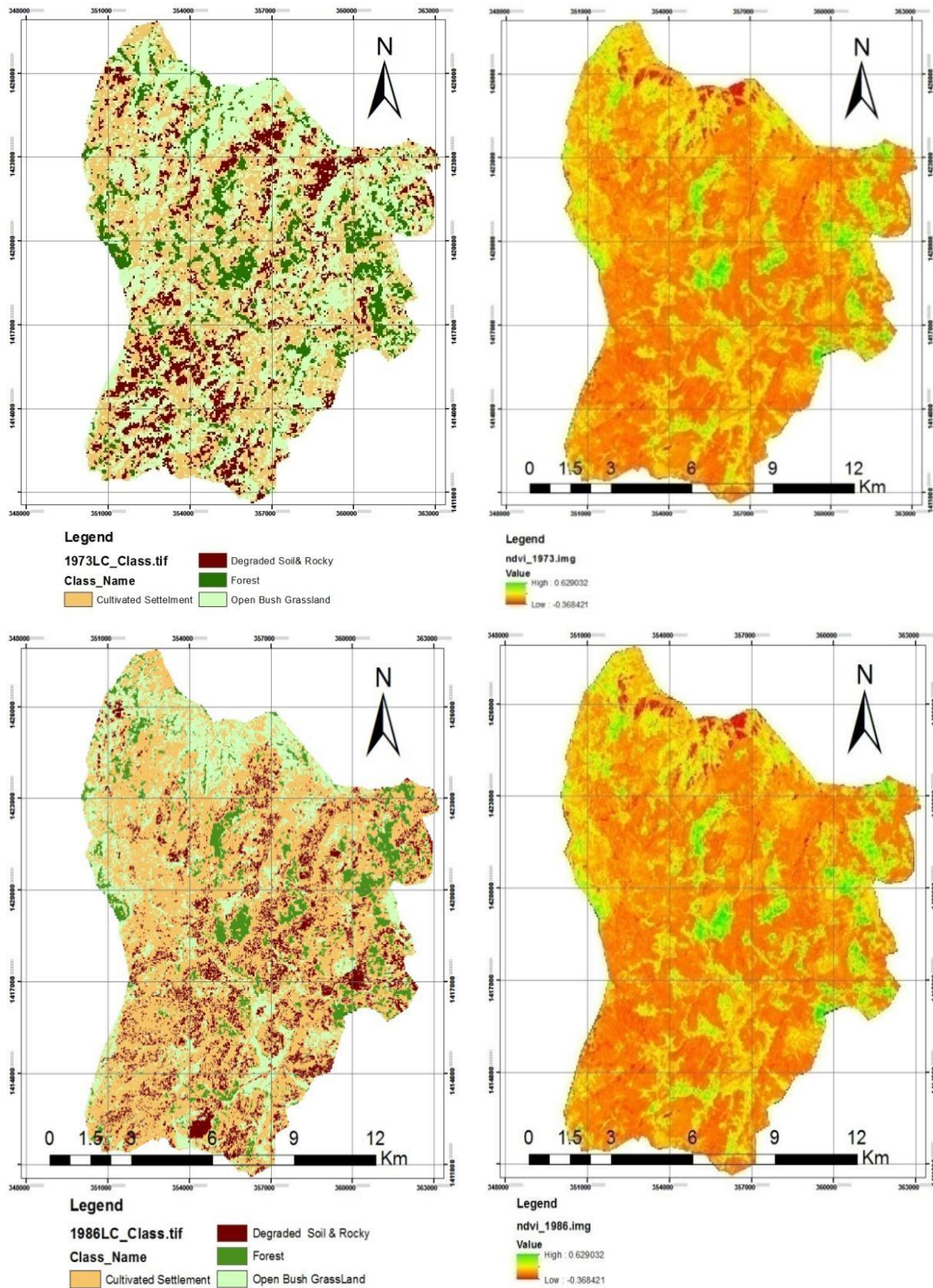


Figure 6. Comparison of LULC class and NDVI analysis (1973-1986).

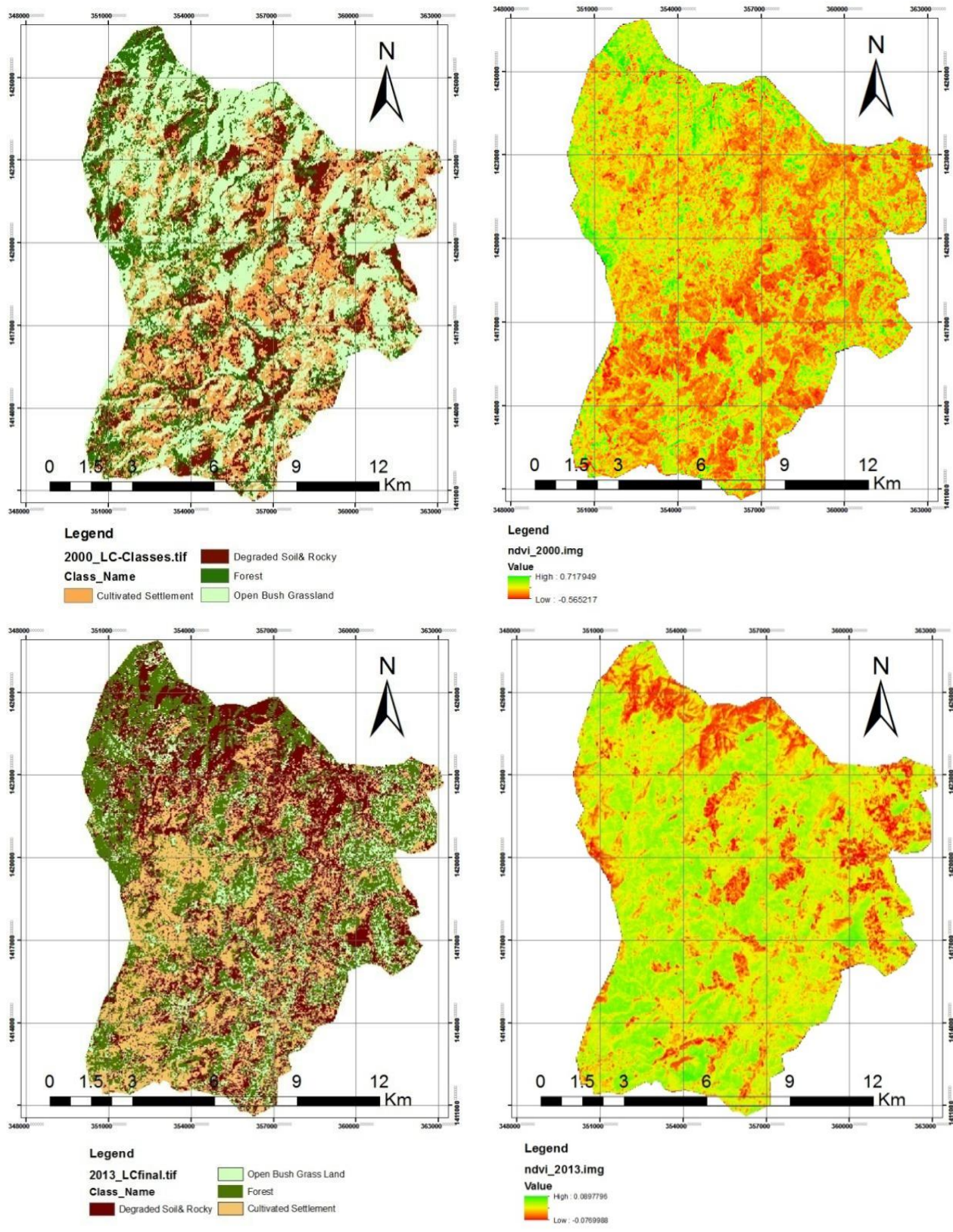


Figure 7. Comparison of LULC covers class and NDVI analysis (2000-2013).

Table 5. Perceptions of local people on the causes of LULC in the Aykoleba.

Causes of LULC	Frequency	%
Population pressure	95	90
Poverty	64	61
Expansion of agriculture	84	80
Policy and institutional problems	53	50.4
Demand for fuel and construction material	78	74

open bush and grassland was converted into cultivated land. Similarly, Barana et al. (2016) discussed that conversion of forests and woodlands into cultivated land is chiefly due to the desire of land for crop production in order to satisfy the food demand to the ever growing human population, which terminated with the loss of land productivity and land degradation. Habtamu et al. (2018) showed that the expansion of cropland in the Borana rangeland has meaningfully contributed to the change of grassland management practice into the cultivated land. The rapid population growth resulted in land fragmentation and small farm size, which in turn caused land use change (Birhane and Melesse, 2015).

Aykoleba is not only providing ecosystem services such as materials for energy demand but also serves as a means of supplementary income generation as confirmed by the respondents 74% (Table 4). The rural poor households relied on firewood sale and charcoal to generate extra income, which has also contributed to obliteration of forest and scrubland. A study by Wubie et al. (2016) reported that increased demand for fuel wood in the absence of alternative sources of energy has led to devastation of forests. Similarly, persistent logging activities in the forest reserve resulted in its loss in Nigeria (Aderole et al., 2020). Deforestation by the local people for different purposes caused land use change in southern part of the country (Mathewos, 2019). In contrast, increasing demand for firewood and house construction material, especially eucalyptus plantation caused increase in forest cover in Koga water shade (Moges et al., 2015), which is also similar to the finding of the present study.

More than 42% of the discussants showed that between 1980s and 1990s, the cultivated land cover has declined. It was noted that portion of cultivated land has been set aside and converted into degraded land. This description well corroborates LULC dynamics obtained from the digital image analysis of 1986-2000 of the cultivated land. This might have happened due to political change events that occurred in Ethiopia, and the land reform, which had seized all rural lands and distributed to the rural poor. Wubie et al. (2016) also reported the land tenure insecurity and policy to be the main driving forces

behind the LULC change in Ethiopia. Furthermore, they have stated that the change in agricultural land policy along with the introduction of rice farming triggered the expansion of agricultural land at the cost of other land use types. Pastoralists in Borana range land of the Southern Ethiopia perceived that government policy is the second major among drivers of LULC changes, preventing the movement of pastoralists was a government rural development strategy that brought a large number of human and livestock population in the area, and caused change in the rangeland conditions (Habtamu et al., 2018).

Conclusion

The current study evaluated the LULC dynamics, and explored drivers of the LULC change in Aykolba, Northern Ethiopia. Over the past 40 years (1973-2013). The study of the LULC dynamics using remote sensing and GIS tools has resulted in four LULC classes. Four LULC classes were identified in this study, namely forest, open bush and grassland, cultivated land and settlement, and Bare land or degraded land. Within the four decades, the forest and bare land showed increasing trend whereas cultivated and settlement land and open bush and grassland classes were declined, which is associated with conversion of the land cover into other land uses types, especially into forest and degraded land. During the four study periods, the trend of LULC change in different classes was varied. The study showed an increase in the forestland and bare land. Large proportion of the study areas is covered by open bush and grassland, which also experienced the greatest dynamics in LULC change where this land use is changed progressively into other classes. The dynamics of population growth, which is directly dependent on natural resources, has become the primary driver of LULC change in the study area. This has led into an increase in cultivated land in order to provide subsistence food for households at the expense of existing natural resources, such as open bush and grassland. The movement of local community due to internal displacement caused

abandoning of the cultivated land in hilly and sloppy areas, and overgrazing shifted the land into bare or degraded land. Accordingly, degraded land became one of the most dominant LULC class in the study area. This in turn has resulted in land degradation. Forestland use depicted increasing trend, which is related to plantation of economically useful trees such as eucalyptus. Eucalyptus also helps households to get wood for construction as well as firewood. They also generate income from eucalyptus sale. In general, increase in bare land in the study area shows a great threat to biodiversity and ecosystem service. Accordingly, the study district particularly, the office for forest and climate change has to work a lot to restore such degraded areas. Furthermore, appropriate land use policy as well as population policy need to be implemented to prevent further land degradation.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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