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An Analysis On Land Use/Land Cover Change Using Remote Sensing And GIS - A Case Study In Amjaye District, South Gondar, Ethiopia

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Abstract: *The dynamics of land use and land cover (LULC) has a human age and is one of the phenomena that intertwines socio-economic and environmental problems in Ethiopia. Amjaye district is one of the highland districts of Ethiopia. A few decades ago, the indicated study area was covered by natural plantations. But, today, like another part of Ethiopia, it is experiencing complex dynamics of LULC. The objective of this research was to evaluate the LULC dynamics observed between 2000 and 2017. This was achieved through the collection of qualitative and quantitative data using the Geographic Information System (GIS) and the Remote Sensing (RS) technique. The use of Google Earth was also used to validate the results of data detected remotely. According to the result, four main dynamics of the LULC classes of the study area were identified. Of these LULC classes, only agricultural land had shown continuous and progressive expansion mainly at the expense of grassland areas, plantations, and urbanized areas. The 84.1% of Agricultural land of the watershed in 2000 expanded to 89% and in 2017 while the 8.7%, and 7% grass, and plantation of the watershed in 2000 degraded and increased to 3.7% and 7.2% in 2017 respectively. As a result, land units that had been used for Plantation and Grassland before 2000 were identified under the Built-up area after 2017. In the end, this study came with a recommendation of an intervention of the concerned body to stop the rapid degradation of Plantation on the watershed.*

Key Words: *Amjaye District; GIS; RS; Land use; Land cover; South Gondar; Ethiopia.*

I. Introduction

Around the world, the change in land use and land cover (LULC) is as old as that of humans (Halefom A., et al., 2018; Turner et al., 1993). But, the current exchange rate is not the same as in the beginning. There has been a dramatic increase in the exchange rate in recent centuries (Lambin and Geist, 2006). Most of the changes registered in LULC were the result of the practices carried out to meet the immediate needs of the human being (Turner et al., 1995; Brandon and Bottomley, 1998; Serneels and Lambin, 2001; Sherbinin, 2002). These rapid LULC changes exert detrimental and adverse impacts on the environment and livelihood. For example, Kalnay and Cai (2003) assumed LULC as the most important factor in climate change. Lambin and Giest (2003) have also described its negative impact on the socio-economic of the rural population. Meyer and Turner (1994) described its impact on physical resources like water, soil, and land quality. LULC change can also affect global and local biodiversity (Chapin et al., 2000). In Ethiopia, LULC changes were registered at the local level that adds up to the changes at the national level. Most of these changes were from the natural forest to agricultural land and was due to human intervention (Tolosa, A.T., 2018; Woldeamlak, 2002; Daniel, 2008). Specifically, a few decades ago, the highlands of the country to which the Amjaye district belongs were covered with plantations that had provided a good opportunity to increase economic sources such as livestock and crop production and to reduce soil erosion (Asirat Teshome Tolosa et al. 2019; Tolosa, AT, 2019; Motuma, 2006). But, over time, the state of the natural forest degrades. Therefore, this research aimed to assess the nature and tendency of changes in land use and watershed coverage over the past two decades.

II. Materials and methods

2.1 Area description

For the present study, the Amjaye district was selected. The study was conducted in South Gonder, Farta wereda, particularly Amjaye district. The area is situated between Longitudes 410732.99 m- 421339.73m E and Latitudes 1306382.14 - 1317632.79 m N (Fig.1). The total area covered is approximately 5109.8ha. The altitude of SMNP ranges from 2049 to 2987 m.

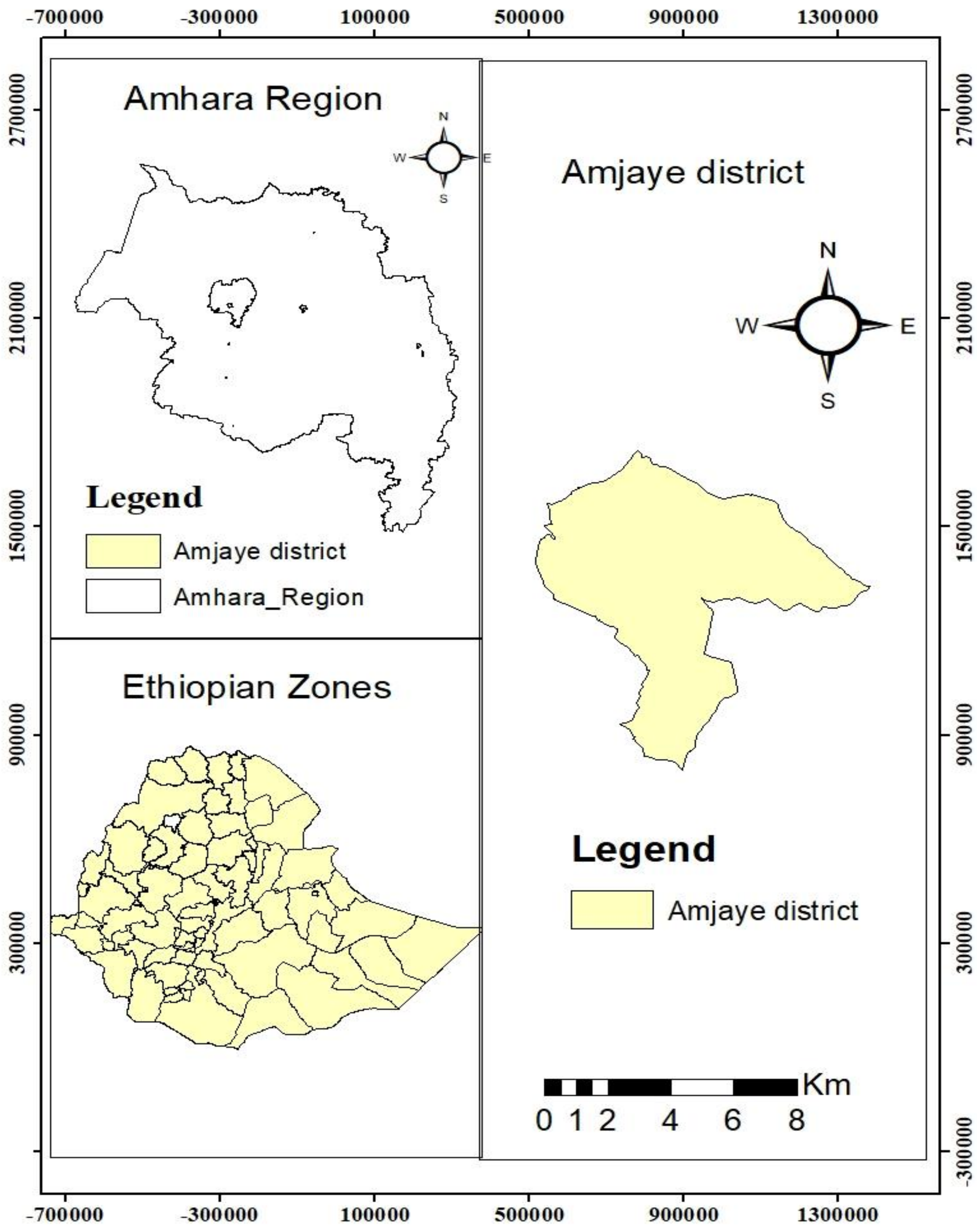


Fig. 1 Location of the study area

2.2 Methodologies

The major source of LULC data was mainly multi-temporal satellite images and topographic maps. Three dates of remotely-sensed land sat images acquired in the dry season (Table 1) were collected from different sources. These images procured were processed using image processer ERDAS IMAGINE 2014 software and Arc view GIS 10.3 software.

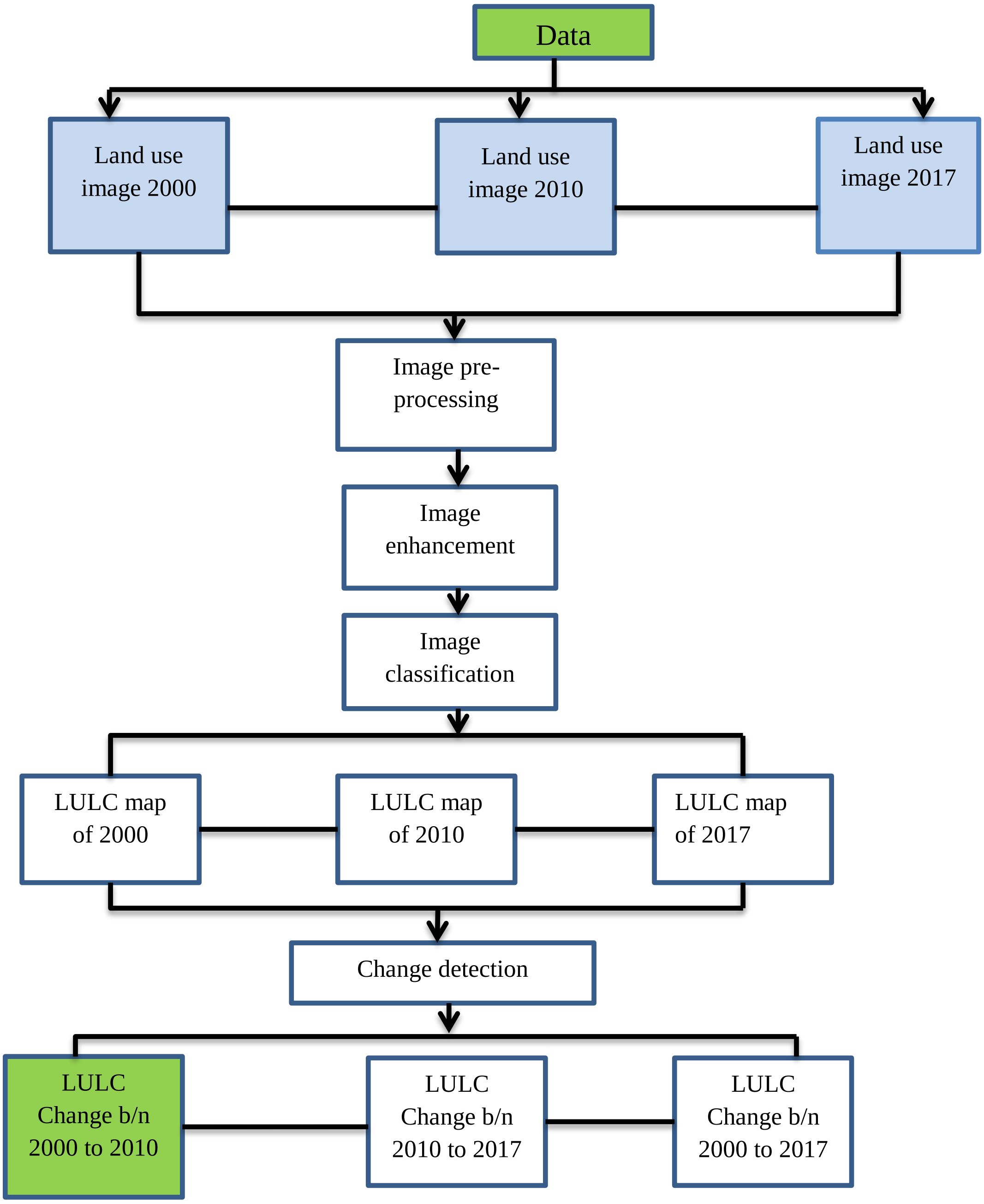


Figure 2: Flow chart showing the general methodology of land use/land cover evaluation

Table 1 Satellite images Used

s.no.	Image	Resolution (m)	Sensor	Path	Row	Source
1.	Landsat7	30 × 30	TM	169	52	http://earthexplore.usgs.gov
2.	Landsat7	30 × 30	TM	169	52	http://earthexplore.usgs.gov
3.	Landsat7	30 × 30	TM	169	52	http://earthexplore.usgs.gov

2.2.1 Pre-classification processing

The satellite images were geometrically corrected in reference to the geo-referenced topographic map and re-projected to the WGS 1984-Universal Transversal Mercator (UTM), zone 37N. In this study, As the study area was small, the higher order of transformation was not required.

Image pre-processing

Pre-processing of satellite images before the detection of changes is a very vital procedure and has a unique aim of building a more direct association between the biophysical phenomena on the ground and the acquired data (Coopin et al. 2004). Data were pre-processed in ERDAS imagine for geo-referencing, mosaicking and sub-setting of the image on the basis of Area of Interest (AOI). The main objective of image classification is to place all pixels in an image into LU/LC classes in order to draw out useful thematic information (Boakye et al. 2008). Image classification was done in order to assign different spectral signatures from the LANDSAT datasets to different LULC. Land cover classes are typically mapped from digital remotely sensed data through the process of supervised digital image classification (Campbell, 1987; Thomas, Benning, & Ching, 1987). The overall objective of the image classification procedure is to automatically categorize all pixels in an image into land cover classes or themes as shown in Figure 2. The area was classified into four main classes: Build-up area, Plantation, Agricultural land, and grassland. The description of these land cover classes is presented in Table 2.

Table 2 Description of considered land covers classes

Land cover types	**Description**
Built-up area	Includes construction activities including villages and some governmental buildings
Plantation	This category comprised of planted junipers, eucalyptus trees, Acacia and natural forest or areas covered by trees planted around homesteads and some public institution areas.
Agricultural land	Areas cultivated with annual crops, vegetables, or fruit.
Pastureland	Land areas of exposed soil surface as influenced by human impacts and/or natural causes. It contains sparse vegetation with very low plant cover value as a result of overgrazing, woodcutting, etc.

2.2.2 Classification

Several studies (Abrams et al., 1996; Congalton, 1991), stated the importance of developing a classification system which suits to the study area and to the objective of the study. Therefore, the hybrid (unsupervised and supervised) classification system was used to classify all satellite images with ERDAS IMAGINE 2014 software. The maximum likelihood classification was applied for image classification after selecting 50, 51, 40 and 70 training areas on TM 1986, ETM 2000 & ETM+2009 land-sat images, respectively. Training sites were identified based on the information obtained from Google earth.

2.3 Data analysis

The summary statistics such as an area of land cover in each image and conversion matrixes were automatically generated from the ERDAS 2014 software. The change of land cover from the base date of an image during the stay until the next date of the image was automatically generated by overlaying classified land cover maps over the next classified land cover map. The estimated conversion of one land cover class to other land cover classes was compared with the total estimation of land cover conversion of respective pairs of years for each land cover. The rate of land cover change was calculated for the three periods from 2000 – 2010, 2010 – 2017 and 2000 – 2017 using following formula Rate of land cover changes (% yr-1) = [(B-A)/At]×100 (1) where A= previous land covers area (ha); B= recent land cover area (ha); t= number of years between A and B.

III. Result and discussion

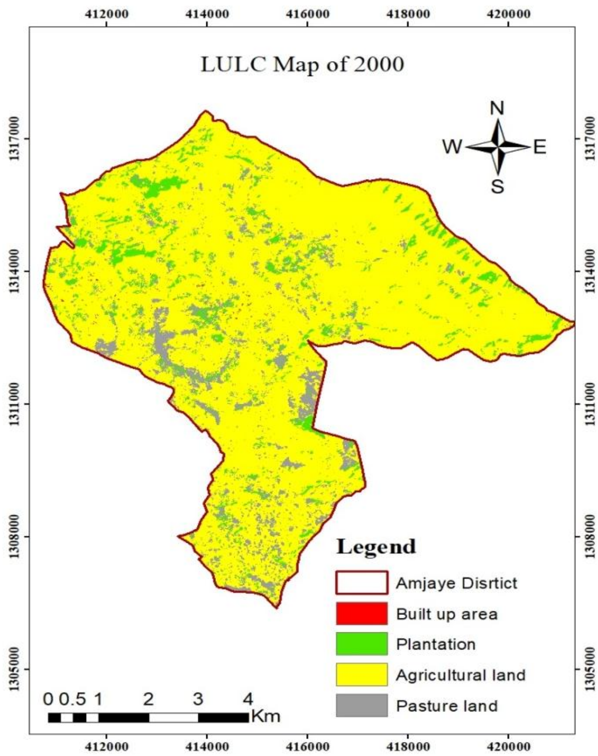
3.1 State of land cover

In Amjaye district four major land cover classes were identified in each date of a satellite image. The land cover classes and coverage in each date of an image are given below (Table 3):

Table 3 Coverage of each land cover classes in each date of the image

Class	Land cover in each year of image					
	2000		2010		2017	
	Area		Area		Area	
	(ha)	%	(ha)	%	(ha)	%
Built-up area	0	0	5.3	0.1	7.7	0.2
Plantation	359.2	7.0	256.7	5.0	368.5	7.2
Agricultural land	4299.3	84.1	4524.0	88.5	4545.7	89.0
Grass land	446.1	8.7	329.2	6.4	187.9	3.7

The rows in Table 3 show temporal variations of land cover classes and the columns show the spatial variation of land cover classes. About 84.1% of Amjaye district was under cultivated by the year 2000, while the remaining 15.7 % was covered by the other land cover classes. Later on, cultivated land dominates the other land cover classes. For example, cultivated land in 2010 has increased by about 4.4% in 10 years gap. In reverse of this, the fragmented natural plantation decreased by 2%. In the successive period i.e. 2000-2010, cultivated land has shown an increase of about 4.9% while grassland dropped about 5%. In the last date of the satellite image, in 2017, the classification referred that about 89% of the study area was under cultivated land.



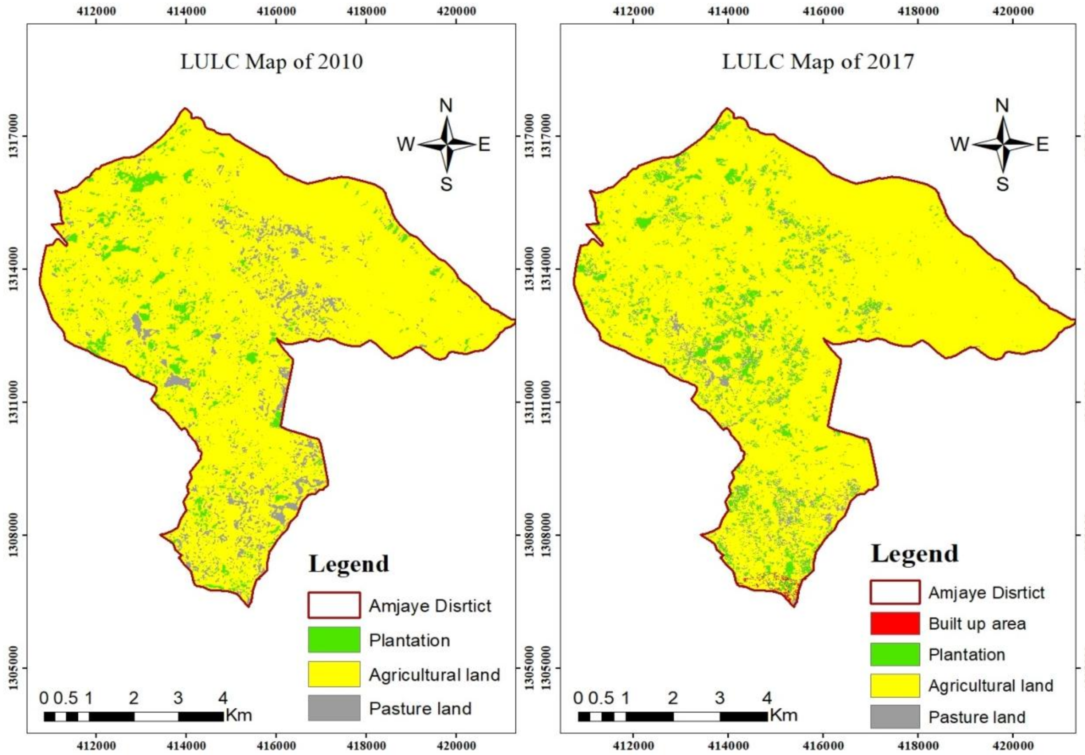


Fig. 3 Land cover map of 2000, 2010 and 2017

The result of this study has revealed the conversion of one land cover class to other land cover classes in the Amjaye district (fig.3). In areas like highlands that were under high population, it was unthinkable to expect and find a land cover that remains stable in time respect. But, what should be mattered was the direction of the change. Starting from 2000 to 2017 and even onward, a dominant one-way LULC conversion was seen in the Amjaye district. That was from grass and natural forests to cultivated lands. The transitions of different LULC to cultivated land were in two types. The first one was the deliberate and direct conversion of many LULC classes to cultivated land. For example, natural forests and grasslands were directly converted to cultivated land. The second type of conversion to cultivated land was a step by step conversion. For instance, the continuous natural forest was converted to fragmented natural forest and then to woodlands and shrublands and finally converted to cultivated land. Such step by step conversion of the LULC classes to cultivated land may be related to the extraction of forestry-related uses like extraction of fuelwood and construction woods. In this style of conversion, the intention farmers were not converting into cultivated land.

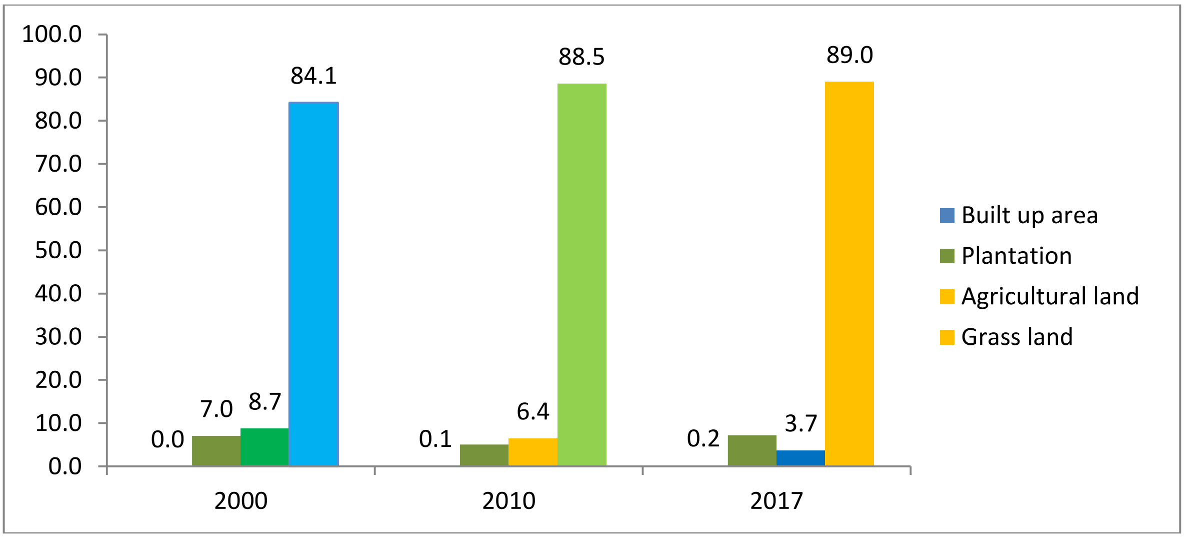


Figure 4 Areal coverage of Land use land covers changes

3.2 Rate of land covers change

The rate of land cover change was not mono-directional that was some of the land cover classes were expanding through time while others were shrinking from time to time. The detail is displayed in Fig.4.

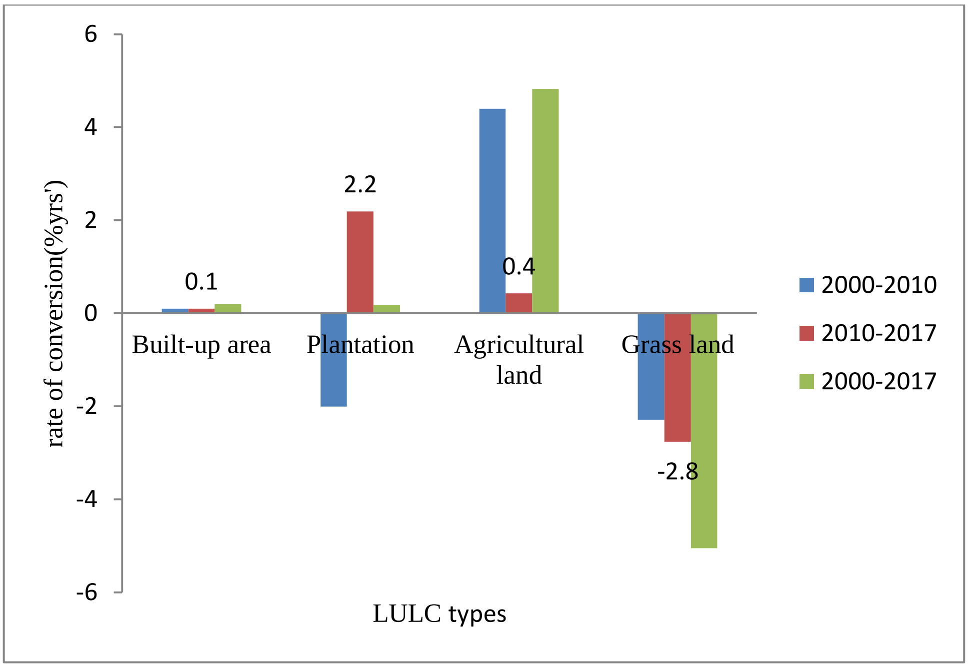


Fig. 5 Rate of each land cover change in each period

The up warded bars indicated expansion rate while the inverted one indicates the shrinking rate, it is a relative expression of each land cover as compared to its originals. The above figure shows continuous progress in the rate of cultivated land expansion. It increased from 0.1% in 2000 – 2010 to 0.2% in the last period considered (2010–2017). In reverse to this, grass and plantation lands have shown continuous shrinking in the last 17 years. The degrees of shrinking these land cover classes have shown an increase from the earlier period up to the latest period. The rapid expansion of cultivated land at the expense of grazing and plantation lands implies the increase of the local community's interest in producing annual crops instead of livestock production. Efrem et al. (2009) and Kebede (1998) indicated that the change of the local community's economic source in the highland of Ethiopia from pastoralists to permanently settled crop-producing practices in the 1960s. From this time onward, farmers shifted their source of the economy toward producing annual crops. To increase crop production, farmers have been increasing the size of cultivated land. Of course, this could have been achieved by intensifying agricultural practices on the existing cultivated land. The other cause of the rapid conversion of other LULC to cultivated land was the reduction of land productivity.

As a result of climate change and continuous soil erosion, the productivity of land can decline from time to time. To compensate for the reduction of yield, farmers believed increasing the size of cultivated land for annual crop production as the right solution achieved by clearing the natural vegetation which would have been important in International Soil and Water Conservation Research, mitigating climate change and soil erosion had it been used sustainably. In addition, according to (Cohen, 1987) the rapid population increases the migration of people from the central high lands found to be causes for the expansion of cultivated land.

According to Meyer and Turner (1994), the rapid loss of vegetated land covers has influenced to human life directly and indirectly. Lands with good vegetation cover could not susceptible to gullying. This could be related to the capability of the vegetation in intercepting falling raindrops. In addition, the roots are important in inhabiting the channeling of land flowing water. Therefore, the expansions of cultivated land can worsen gully erosion.

IV. Conclusions

The study area was identified with four main dynamic classes of land cover during the period (2000 - 2017). The change of LULC in the Amjaye district during the last two decades was dominated by a unidirectional transition. The dominant transition of LULC was mainly from pastures and forest land to cultivated land. The expansion rate of cultivated land in the study area has shown a progressive increase until the end of 2017. However, this could not be expected after 2017 due to the shortage of other LULCs that can be converted into cultivated land. Conversions from wooded land to cultivated land in the Amjaye district were step by step and straightforward. The conversion of lands with vegetation to cultivated lands was attributed to the factors that changed the local community from the livestock rearing system to the crop production system and the rapid increase in population. The consequences of the rapid degradation of vegetation in the area were the severe expansion of streams and streams that contribute a large part in the decline in agricultural production. In addition, respondents agreed that displaced land in the district has an impact on Lake Tana. Finally, this study urges an intervention of the agency involved in the search for sustainable land use management by reversing the common direction of the LULC change seen in the area.

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