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Research Paper

Land Cover Change Dynamics and their Driving Forces in the Western Escarpment of the Rift Valley in the Gamo Zone, Southern Ethiopia: Implications for Biodiversity Conservation and Climate Change Mitigation

Temesgen Dingamo [1*], Serekebirhan Takele[2], Sebsebe Demissew[3], Zerihun Woldu[3]

[1]*Biodiversity Research and Conservation Centre, College of Natural Science, Arba Minch University, Arba Minch, Ethiopia*
[2]*Department of Biology, College of Natural and Computational Sciences, Arba Minch University, Arba Minch, Ethiopia*
[3]*Department of Plant Biology and Biodiversity Management, Addis Ababa University, Addis Ababa, Ethiopia*

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Abstract

Land use and land cover (LULC) changes are caused by natural and human alterations of the landscape that could largely affect forest biodiversity and the environment. This study aimed to analyze LULC change dynamics and their driving forces in the western escarpment of the Rift Valley of the Gamo Zone, Southern Ethiopia. Digital satellite images were downloaded from USGS and analyzed using ERDAS Imagine version 14 and Arc GIS 10.2 software. Supervised image classification was used to generate LULC classification, accuracy assessment, and Normalized Difference Vegetation Index (NDVI). Drivers of LULC change were identified and analyzed. Four land classes were identified: forest, farmland, settlement, and water-wetlands. Settlement and farmlands increased by 8% and 6%, respectively within three successive periods (1999-2019). On the other hand, during the same period, forest and water-wetlands decreased in their aerial coverage by 9% and 5%, respectively. The overall accuracy of the study area was 92.86%, 94.22%, and 94.3%, with a kappa value of 0.902, 0.92, and 0.922, respectively. NDVI values ranged between 0.42 to 0.73. Agricultural expansion (31.4%), expansion of settlement (25.7%), and fuelwood collection and charcoal production (22.9%) were the main driving forces that affected the biodiversity of the vegetation in the study area. Integrated land use and a policy on the current situation are deemed necessary to protect biodiversity loss, forest degradation, and climate change.

1. Introduction

Land use and land cover change is a major issue of concern with regard to change in a global environment (Qian et al., 2007). Changes are so pervasive that, when aggregated globally, they significantly affect key aspects of Earth System functioning (Zürich et al., 2005; Lewis, 2006). This directly impacts biodiversity throughout the world (Sala *et al*., 2000); it also contributes to local and regional climate change (Chase et al., 2000; Sintayehu, 2018) as well as to global climate warming (Houghton, 2005). Land use land cover changes are the primary sources of soil degradation (Tolba et al., 1992)and, by altering ecosystem services, affect the ability of biological systems to support human needs (Hooper et al., 2005; Vitousek et al., 2020). Such changes also determine, in part, the vulnerability of places and people to climatic, economic, or socio-political perturbations (Kasperson and Kasperson, 2001).

Land is a major natural resource where economic, social, infrastructure and other human activities are undertaken (Bashir, 2012). Thus, changes in land use that have occurred in the past are currently ongoing and are likely to continue in the future (Moser, 1996; Lambin et

*Corresponding author, e-mail: *temesgendingamo@yahoo.com*

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al., 2003). These changes have beneficial or detrimental impacts, the latter being the principal causes of global concern as they impact human well-being and safety (Zürich et al., 2005; Lewis, 2006). LULC changes are widespread, accelerating, and the trade-offs offset human livelihood (Agarwal et al., 2002). The rapid growth and expansion of urban centers, population pressure, scarcity of land, and changing technologies are among the many drivers of LULC change in the world today (Barros, 2004).

Forest ecosystems occupy a substantial part (31%) of the Earth's land surface (FAO and UNEP, 2020). Tropical forests cover merely 7% of the Earth's land surface and harbor more than half of the world's species (Wilson, 1988). These forests are highly threatened by human activities (Htun et al., 2011). Researchers predicted that clearing half of the world's residual forests would remove 85% of all the species living in them (Jhariya et al., 2012; Kittur et al., 2014; Le et al., 2014). Data from tropical forests alone showed continuous loss of more than one higher plant species per day (FAO and UNEP, 2020), the disappearance of 20 ha of forests, and destruction of more than 1800 populations per hour (Singh, 2002) and loss of species populations at a rate of 3-8% times more than the rate of species extinction due to natural and biotic disturbances as well as habitat alterations (Bargali et al., 1993; Costanza et al., 1997; Karki et al., 2018). Poverty, population pressure, agricultural expansion, and intensification and development of infrastructure have been regarded as major threats to biodiversity in the tropics (Davidar et al., 2010; Jhariya et al., 2012; Padalia et al., 2018; Manral et al., 2020; Karki et al., 2021).

In Africa, 27.4% of the land, or almost 500 million ha, is practically degraded. Of this, 14% of the land degradation is a result of vegetation removal, 13% is overexploitation, 49.5% is overgrazing, and 24% is agricultural practices (Mucova et al., 2018; UNECA, 2011). Moreover, about 72% (Burkina Faso), 72% (Ethiopia), 63% (Lesotho), 60% (Mali), 40% (Sudan), 45% (Chad), 29% (Morocco), 28% (Zimbabwe), 27% (Namibia), 26% (Tanzania), 22% (Botswana), 19% (Malawi), 9% (Angola), 9% (Zambia), 6% (Mozambique) of the population live on degraded lands (FAO, 2011; UNEP, 2011).

Earlier, EFAP (1994) noted that high forests might have covered close to 40% of Ethiopia and that about 16% of the land area was covered by high forests in the early 1950s. In the early 1980s, the high forest cover of Ethiopia declined to 3.6% and further declined to 2.7% in 1989 (FAO, 2001). The recent estimate of the land cover of Ethiopia that could qualify as 'forests', which includes high forests, woodlands, plantations, and bamboo forests, adds up to 15.7% (FAO, 2016).

Remote Sensing and Geographic Information Systems have proved to be very important in assessing and analyzing land use and land cover changes (Lambin, 2001; Ayele et al., 2018). Satellite-based Remote Sensing, under its ability to provide synoptic information on land use and land cover at a particular time and location, has revolutionized the study of land use and land cover change (Attri et al., 2015; Tewabe and Fentahun, 2020).

The Normalized Difference Vegetation Index (NDVI) is the most important tool for the detection of land/environmental degradation and deforestation (FAO, 2010; Eckert et al., 2015). This vegetation index is an indicator of vegetation health, otherwise degradation of ecosystem plants, or a decrease in NDVI value (Bellone et al., 2009; Grover and Singh, 2015; Rugel et al., 2017). The value range of an NDVI is -1 to 1. Negative values of NDVI (values approaching -1) correspond to water. Values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow (Othman et al., 2018; Ridwan et al., 2018).

Land cover change occurs naturally in a progressive manner but could sometimes be rapid and abrupt due to anthropogenic activities (Lambin et al., 2003; Ramankutty et al., 2006). Vegetation cover change is a process in which the diversity and density of individual species that make up the natural vegetation structure are altered due to natural and human-induced pressure (Zewdie, 2002; Lu and Liu, 2014). Inadequate studies that were carried out in the different regions in Ethiopia indicated land use/ cover changes as critical threats to natural forest changes (Zewdie, 2002; Garedew et al., 2009; Gashaw et al., 2014). There is a dearth of LULC change detection studies in the study area. Therefore, the present study aims to evaluate and analyze LULC change dynamics, driving forces, and its implications for biodiversity conservation in the western escarpment of the Rift Valley of Gamo Zone, Southern Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area

Ethiopia is located in the Horn of Africa, and its latitude and longitude is 3′ and 14.8″ latitude 33′ and 48′ longitude. The study was carried out in the western escarpment of the Rift Valley of the Gamo Zone, Southern Ethiopia (Figure 1). Topographically, the study area consists of plains and hillsides of the Gamo Mountain ridge between 6°05´N to 6°12´N and 37°33´E to 37°39´E. The area's elevation ranges from 1168 m to 2535 m a.s.l, and the slope of the forest ranges between 0 to 32 degrees.

➢ **Vegetation Cover**

According to Friis et al., (2010), the study area is characterized by complex vegetation types such as *Combretum-Terminalia* woodland vegetation, *Acacia-Commiphora* woodland vegetation, and dry evergreen Montana forest. The most common tree species in the study area are *Terminalia brownii*, *Combretum molle*, *Ziziphus mucronata*, *Pappea capensis*, *Cadaba farinosa*, *Vachellia and Senegalia species*, *Balanites aegyptiaca*, *Commiphora habessinica*, *Rhus natalensis*, *Olea europaea*, *Psydrax schimperiana*, *Acokanthera schimperi*, and so on.

➢ **Climate**

The study area has a bimodal rainfall type. The maximum and minimum mean annual rainfall during 1999-2019 was 1141.1 mm and 491.8 mm, respectively. The maximum and minimum mean annual temperature during the same period was 33.6^{0}C and 15^{0}C, respectively (Figure 2) (National Meteorology Agency, 2019).

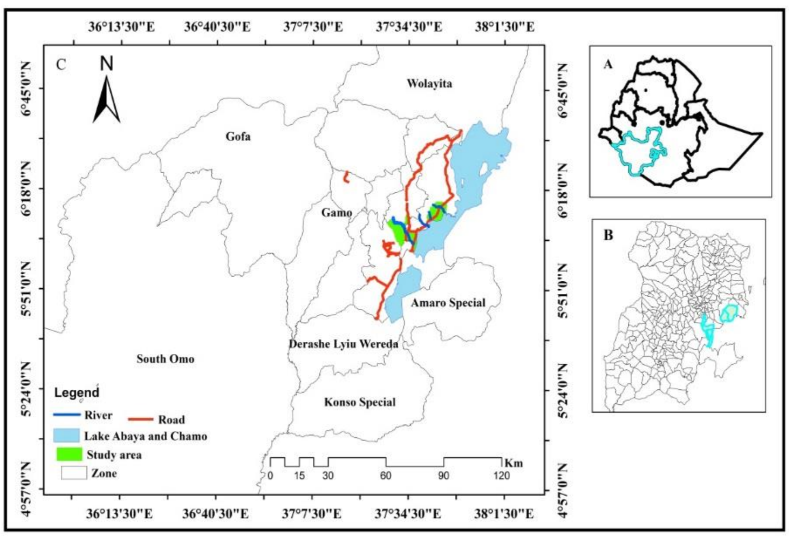

Figure 1. A. Ethio-Region, B._ Gamo Zone, C_ study area (surrounded woreda, Lake Abaya and Chamo, rivers and roads all and dry weathered)

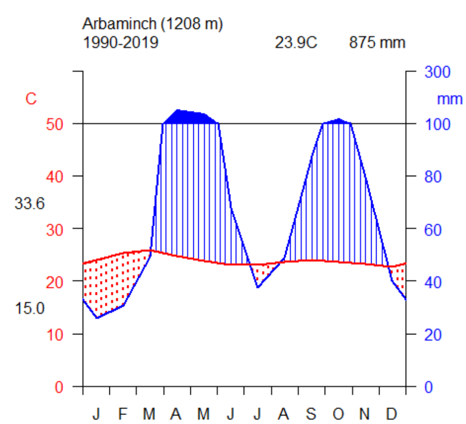

Figure 2 Annual maximum and minimum temperature in ℃ and rainfall in mm (1990-2019)

2.2. Data Types and Sources

Primary and secondary data were used for the study. Ground control points (GCP) for ground truth were collected as primary data using a handheld Global Positioning System (GPS). The secondary data, which were acquired from the United States Geological Survey online imagery portals (http://glovis.usgs.gov), include Landsat Thematic Mapper (TM) for the year 1999, ETM^+ for the year 2009, and Landsat 8 Operational Land Imager (OLI) images for the year 2019. Other Geospatial data include shapefiles and topographic maps collected from the Central Statistical Agency (CSA) and Ethiopian Mapping Agency (EMA) (Table 1).

2.3. Land use change assessment (1999–2019)

Digital satellite images were processed, classified, and analysed using ERDAS Imagine (14). Computations of the area and changes in land use categories were made using Arc GIS 10.2 analytical tools. Pre-processing of satellite images was done to create a more faithful representation of the original scene. Intensive pre-processing such as geo-referencing, layer-stacking, resolution merge, and subsets were carried out to Ortho-rectify the satellite images into UTM coordinates (WGS, 1984) and to remove disturbances such as haze, noise, steep slope effect, and radiometric variation between acquisition dates. A stacked satellite image of the study area was extracted by clipping the Area of Interest (AOI) layer of the Gamo shape file in ERDAS 14 software.

The satellite image was classified using the supervised image classification technique, which employed pixel-based supervised image classifications with the maximum likelihood classification algorithm (Clevers, 2009) to produce LULC maps of the study area. Appropriate band combinations were obtained, and the signatures were used for the supervised classification. Land cover change detection for the study area was monitored at three intervals: 1999-2009, 2009-2019, and 1999-2019. The supervised classification produced four land classes: forest lands, farmlands, settlements, and water-wetlands (Table2).

Table 1: Remote sensing data of the study

Acquisition data	Sensors	Path and Row	Spatial Resolution in m	Number of bands	Format	Source
01/05/1999	TM	169, 56	30	7	TIFF	USGS
01/05/2009	ETM^+	169,56	30	8	TIFF	USGS
01/05/2019	OLI	169,56	30	11	TIFF	USGS

Table 2: Characteristics of land cover classes

Class name	Description
Farmlands	Areas used for crop cultivation (Maze, teff, Banana, Mango, etc.).
Dense forest, scattered forest and woodland	This habitat is dominated by trees characterized by a multi-storeyed nature with a crown cover of almost 10-50%
Settlement	Different settlements (villages) associated with buildings
Water-wetland	Areas covered with water, which may support both aquatic and wetland species

2.4. Accuracy analysis

Since image classification without accuracy assessment is incomplete (Lillesand et al., 2000), accuracy assessment for the images was carried out. The accuracy of the classification was assessed using producers, users, and overall methods of accuracy assessment. The overall accuracy and kappa statistics were calculated based on the GCP collected from the identified land-use types. Kappa statistic was calculated using equation 1:

Kappa = (Observed Agreement-Expected Agreement)/1-Expected Agreement…………(1)

2.5. Land-use and land-cover change detection

The LULC maps of three years showing periods with a range of ten years between (1999, 2009, and 2019) were generated from the satellite imageries using supervised maximum likelihood classification. To analyse the land cover, structural changes in the study area between the periods 1999-2009, 2009-2019, and 1999-2019 were measured for each LULC type and shown in hectares and percentages. Change detection was calculated by:

$$R = Q2 - Q1/t \quad \text{.................................} \ (2)$$

Where, R = Rate of Change, Q_2 = Recent year forest cover in ha; Q_1 = Initial Year forest cover in ha and t = Interval year between Initial year and Recent year

2.6. Vegetation index

Normalized Difference Vegetation Index (NDVI) is one of the indicators commonly used to detect vegetation cover. NDVI values were calculated on composite images using bands 3 (Red) and 4 (Near Infrared) for Landsat 7, and band 4 (Red) comes with band 5 (Near Infrared) for Landsat 8. NDVI, which measures the degree of greenness, correlates with vegetation crown density which in turn correlates with chlorophyll content, and its value is between -1 to 1. NDVI is calculated as:

$$\mathrm{NDVI} = \frac{\mathrm{NIR-R}}{\mathrm{NIR+R}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where: NDVI = Normalized Difference Vegetation Index, NIR=Near Infra-Red Band R= Red Band

2.7. Drivers of LULC changes

LULC changes are influenced by many driving factors. Human activity is often mentioned as the major driver of LULC Changes in the study area. To better understand LULC changes, data that include field observation, focused group discussion (FGD), and key informant interview (KII) were collected. KII and FGD were selected based on the recommendation of local community leaders and agriculture extension workers. The participants included elders (male and female), agriculture extension workers, and jobless youth. The informants were asked for consent to participate in the discussion and were given clear information about LULC changes in the study area. Data were analysed using IBM SPSS version 20.

3. Results and Discussion

3.1. Results

3.1.1. Land-use and land-cover classification

The four land classes identified in the study include forest, agriculture, settlement and water bodies, and water-wetlands (Figure 3a, 3b, 3c). Forest and water wetlands have decreased in the three successive periods while agriculture and settlement have increased.

3.1.2. Land-use and land-cover change

The results revealed that the extent of land cover changes from forest to agriculture in the last three decades was rapid. The decline of water wetlands was not as dramatic as the loss of forests (Table 3).

3.1.3. Land use land covers change detection

LULC change detection showed that settlement and agriculture land coverage increased, while forest lands and water-wetlands decreased (Table 4). Settlement increased from 26% to 34%, agriculture expanded from 28% to 34%, while forest declined from 31 to 20%, and water-wetlands decreased from 15 to 12%.

3.1.4. Overall accuracy assessment (1999, 2009, & 2019)

Image classification accuracy was checked with an accuracy matrix using 140, 173, and 158 randomly selected control points, respectively (Tables 5, 6, and 7). Image classification was shown matched with ground truth points and the overall accuracy of the study area was 92.86%, 94.22%, and 94.3%, respectively.

3.1.5. Normalized difference vegetation index (NDVI)

The statistics and visual observation of the NDVI images over three successive periods (1999, 2009, and 2019) showed that major land cover changes had taken in the study area (Figure 4a, 4b, 4c) and Table 8.

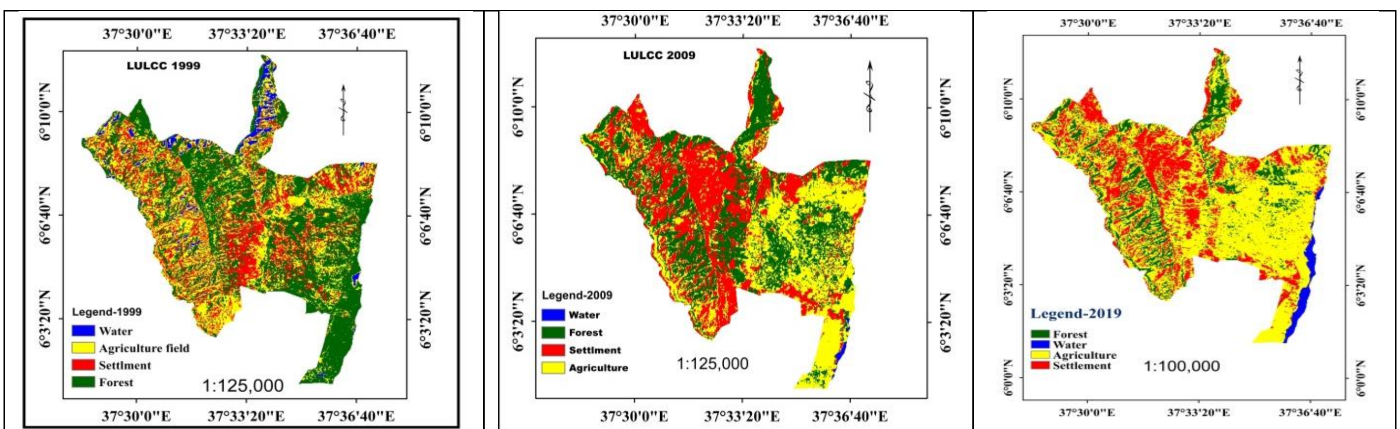

Figure 3a | Figure 3b | Figure 3c

Figure 3: Land-use and land-cover change from 1999-2019 (3a, 3b, and 3c)

Table 3: Land use land covers change (1999 - 2019)

Area	**Area (ha) (1999 -2009)**	**%**	**Area (ha) (2009 - 2019)**	**%**	**Area (ha) (1999-2019)**	**%**
Forest - Agriculture	1416.156	11.4	2671.36	21.51	1878.42	15.13
Forest - Settlement	500.144	4.03	284.27	2.29	376.529	3.03
Agriculture - Forest	155.922	1.26	105.00	0.85	50.315	0.41
Agriculture-Settlement	142.651	1.15	408.7	3.29	376.529	3.03
Agriculture - Water	235.9683	1.9	166.1	1.34	232.268	1.87
Water - Agriculture	384.342	3.09	401.85	3.24	277.00	2.23

Table 4: Land use land covers change detection from 1999 to 2019

Land class	**1999-2009**		**2009-2019**		**1999-2019**	
	ha	**%**	**ha**	**%**	**ha**	%
Settlement	3257.7	26	4156.5	34	4230.3	34
Agriculture	3527.9	28	3831.9	30	4257.6	34
Forest	3811.9	31	3611.9	29	2442.1	20
Water-wetlands	1821.0	15	818.2	7	1488.4	12

Table 5: Overall accuracy of the study area (1999)

	Ground truth					
Land class	Settlement	Agriculture	Forest	Water	Row Total	User's Accuracy (%)
Settlement	50	2	1	0	53	94.34
Agriculture	0	29	0	1	30	96.67
Forest	2	2	26	0	30	86.67
Water-wetlands	0	1	1	25	27	92.6
Column Total	52	34	28	26	140	
Producers' Accuracy %	96.15	85.3	82.86%	96.15		92.86

Table 6: Overall accuracy of the study area (2009)

	Ground truth					
Land class	Settlement	Agriculture	Forest	Water	Row Total	User's Accuracy in %
Settlement	47	2	1	0	50	94
Agriculture	1	60	2	0	63	95.25
Forest	1	1	36	0	38	94.74
Water-wetlands	0	1	1	20	22	90.91
Column Total	49	64	40	20	173	
Producers' Accuracy in %	95.92	93.75	90	100		94.22

Table 7: Overall accuracy of the study area (2019)

Land class	Ground truth Settlement	Agriculture	Forest	Water	Row Total	User's Accuracy %
Settlement	54	2	1	0	57	94.74
Agriculture	1	40	1	0	42	95.25
Forest	1	1	30	0	32	93.75
Water-wetlands	0	1	1	25	27	92.59
Column Total	56	44	33	25	158	
Producers' Accuracy in %	96.43	90.91	90.91	100		94.3

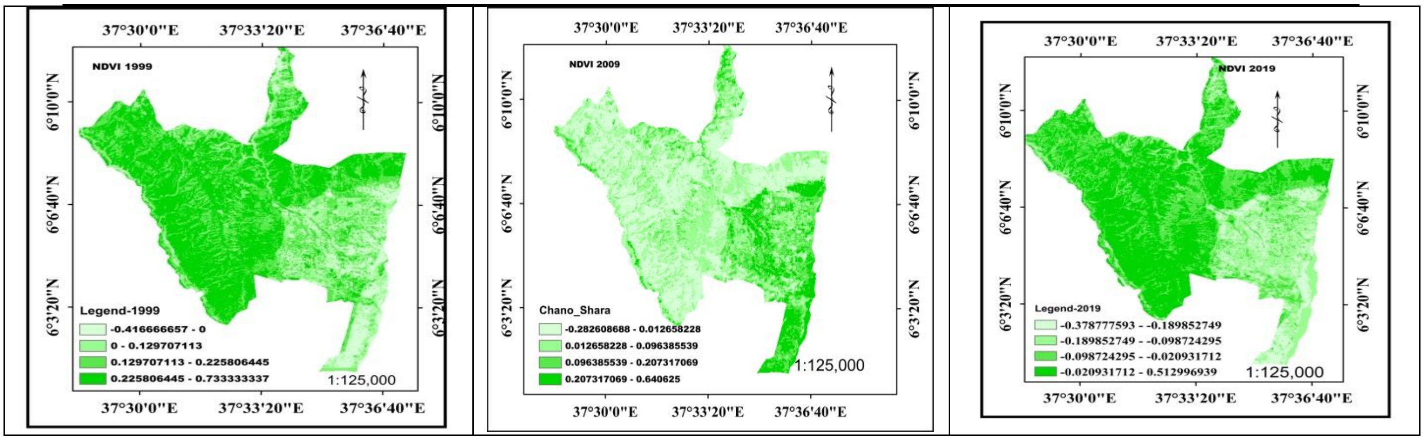

Figure 4: NDVI of the study area from 1999-2019 (4a, 4b and 4c)

3.1.6. Drivers of LULC changes

Focus group discussants and Key informant interviewees reported that agricultural expansion is the leading cause of forest cover change, followed by settlement expansion, while demographic and economic factors were indirect causes of LULC changes in the study area (Tables 9 and 10).

Table 8: NDVI result of the study area

Statistics	1999	2009	2019
Low	-0.42	-0.28	-0.37
High	0.73	0.64	0.51
Mean	0.18	0.059	-0.21
SD	0.11	0.095	0.11

Table 9: Proximate causes of LULC changes

No	Driver	Frequency	%	Rank
1	Fuelwood collection, tree cutting & charcoal prod.	8	22.9	3
2	Agricultural expansion	11	31.4	1
3	Expansion of settlement	9	25.7	2
4	Fire	2	5.7	5
5	Overgrazing	5	14.3	4
	Total	**35**	**100**	

Table 10: Underlying causes of LULC changes

No	Driver Categories	Frequency	%	Rank
1	Demographic	13	37.1	1
2	Biophysical	8	22.9	3
3	Economic	10	28.6	2
4	Institution and policy	4	11.4	4
	Total	35	100	

3.2. Discussion

The classification of satellite images shows a clear conversion of land covers into farmlands and settlements. According to the LULC categories, from 1999-2019, forest lands gradually decreased while agricultural and settlement lands increased. This might be due to an increased population in the study area and fewer job opportunities for the youth. Kassa and Forech (2020), Ariti et al., (2015), and Mengistu et al., (2012) show that farmlands in the Rift Valley of Ethiopia have expanded. Muzein, (2006) has shown that more than 80% of the total terrestrial productive land in the Ethiopian Central Rift Valley was lost to agriculture.

In the satellite image of 1999, the forest was the dominant LULC type, making up 31% of the study area, followed by agriculture (28%), settlement (26%), and water wetlands (15%). In 2019, the overall land class changed. Agriculture and settlement equally occupied the largest portion (34%) of the study area. The remaining land portions were occupied by forest and water wetlands. The conversion of forest to agriculture and settlements increased progressively, while the conversion of water wetlands to agriculture and water wetlands to the forest was a very small percentage due to fluctuation of both lakes (Chamo and Abaya water volume. This might be due to small-scale irrigation by pumping water from the lakes and rivers for the production of fruit and vegetables (Desalegn et al., 2014; Hamere, 2017; Twisa and Buchroithner, 2019; Dibaba et al., 2020; Team, 2021). Hailemariam et al., (2016) also showed that urban settlements and agriculture expansion were highest in the area compared to other LULC types, while forest areas exhibited a decreasing trend. Demand for food and grazing land for the growing population appears to be the driving factor (Song et al., 2014; Hassen and Assen, 2018; Mekuria et al., 2018).

The quantitative results of change analysis of 30 years divided into three study periods (1999-2009, 2009-2019, and 1999-2019) and a change matrix from 1999 to 2019 revealed the extent of changes that occurred in different LULC classes throughout the three decades. Agriculture and settlement generally increased progressively, while natural forest and water wetlands consistently decreased over the study periods. The change results revealed that, over the second (2009-2019) and third (1999-2019) study periods, forest lands decreased by more than 9%, while water wetlands increased by 5%. The total forest area converted to agriculture between the second and third study periods amounts to -200ha, while water-wetlands converted to agriculture between the first and second study periods amount to -1002.8ha. The forest cover of the study area decreased from 31% to 20% between 1999 to 2019. A similar trend was observed in the water-wetlands land class (Figure 5). Findings from other studies such as Zeleke and Hurni (2001), Rudel et al., (2002), Lu et al.(2004), Ramankutty et al., (2006), and Dessie and Kleman (2007) indicate an increasing trend in agriculture and settlement to fulfill the growing food demand and to solve youth questions for income generation, housing, and job.

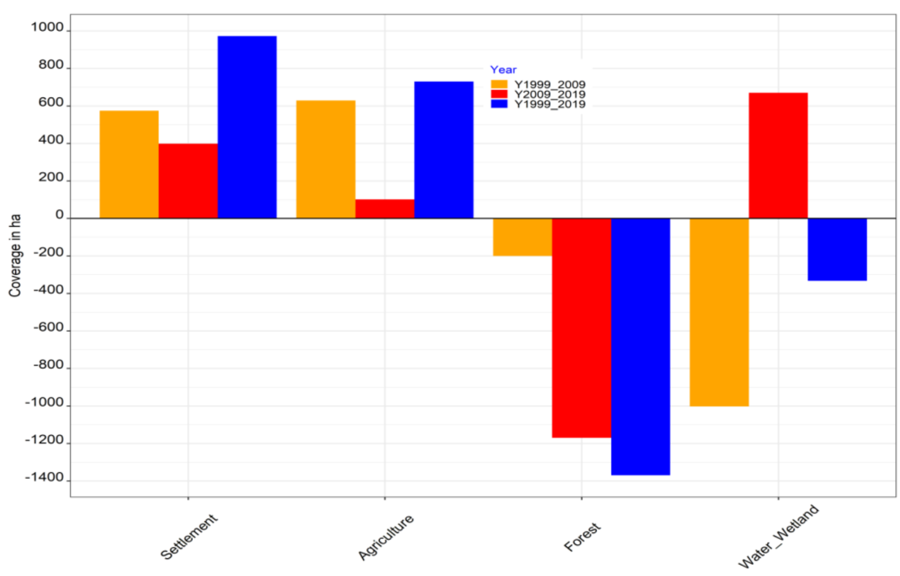

Figure 5: Change detection of the study area

The accuracy assessment was performed using land-use maps, ground truth points, and Google Earth. Three periods (1999, 2009, and 2019) of land use classification have shown the user's accuracy and producer's accuracy are greater than 85%, as well as the overall accuracy of 92.86%, 94.22%, and 94.3%, respectively. These values indicate that the LAND SAT images and the methodologies used were accurate. The Kappa coefficient was also calculated, with a value of K= 0.9, which indicates that the classification is almost perfect since it is greater than 0.8. Mantelas et al. (2012) and Zhang et al.(2018) argued that overall accuracy values greater than 0.8 indicate the Landsat, and the methodologies used to have high accuracy.

The results revealed that the upper threshold value of NDVI was approximately 0.73, and the lower threshold value was -0.42. The pixels showing an NDVI value above the threshold were identified as vegetated areas, while low NDVI values represented non-vegetated areas. For non-vegetated areas, the researcher found that low NDVI values represented water bodies (lake Abaya and rivers), ranging from -0.28 to -0.42, while the pixels having NDVI values in the range of 0.51 to 0.73 were considered as vegetation cover (Table 9). NDVI analysis has proven that there had been changes in vegetation cover between 1999 and 2019 images and higher values were recorded in 1999.

The key informant interviewee (KII) identified five direct and four indirect factors as important drivers for LULC changes in the study area. Agricultural expansion (31.4%) and expansion of settlement (25.7%) were the top direct drivers of LULC changes in the study area. In addition, some of the KIIs reported that population growth (37.1%) and economic (28.6%), and biophysical (22.9%) factors were indirect causes of LULC changes. In agreement with our findings, these causes were also reported by Ayele et al., (2018) and Mekuria et al., (2018). Fuelwood collection and charcoal production was the main degradation drivers for the African continent (Hosonuma et al., 2012; Solomon et al., 2018; Mande, 2020). According to Defries et al., (2010) and Fisher (2010), the existing deforestation in Africa is still largely driven by small-scale subsistence agriculture.

Our focus group discussion (FGD) in the different kebeles indicated that population pressure greatly impacted forest dynamics. The demographic data of the study area had increased over the past three decades. Accordingly, in the Gamo highland, there is land scarcity. Hence, there is migration to the lowlands for settlement and farming. This causes the clearing of dense forests in the low land area. Lambin et al., (2003) showed that human population pressure causes an accelerated conversion of natural habitats into agricultural and settlement areas to meet the mounting demand for food and housing. In the FGD, the elders pointed out that unemployed youths depend on the selling of fuelwood as an immediate source of income during the decline or failure of crop production due to drought. This is a common survival strategy of rural populations in the events of degradation, drought, and rainfall variability across Africa (Campbell, 1990). In Ethiopia, resettlement and villagization programs during the Military Government (1977-1978) significantly contributed to the expansion of settlements and agriculture. Due to the low policy enforcing capacity of the then government, landless farmers cleared forests and occupied as much land as possible to increase the chances of land ownership. Studies in other parts of the country also reported population pressure as a major driver of LULC changes (Zhang et al., 2005; Dessie and Kleman, 2007; Aerts et al., 2016).

4. Conclusion

In this study, four land classes in the study area were investigated: forest, agriculture, settlement, and water-wetlands. The changes observed in 2009 and 2019 were more rapid than the changes in 1999 due to the expansion of small-scale irrigated farmlands for fruit and vegetable production. Moreover, field observations, KIIs, and focus group discussions confirmed that the main cause of LULC changes in the study area was the expansion of agriculture and settlement. On the other hand, demographic, economic, and biophysical conditions are indirect drivers of LULC changes. The researchers will recommend that promoting a non-agricultural economy for the unemployed youths and creating forest reserve areas with a buffer zone help minimize land use and cover conversion.

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