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Evaluation of Spatio-Temporal Land Use and Land Cover Dynamics Using Geospatial Technologies: The Case of Majang Zone, Ethiopia

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Abstract

The dynamics of land use-land cover changes is one of the phenomena which interweave the socio-economic, political, and environmental issues in Ethiopia. This study investigated the land use-land cover (LULC) changes in the Majang Zone of Gambela Region, Ethiopia over a period of 33 years from 1985 to 2018. Four sets of Landsat imageries (i.e.,1985, 1996, 2007, and 2018) were the input data from which LULC maps were produced and analyzed using remote sensing and GIS applications. Concurrently, key informants' interviews, focus group discussions, and questionnaires were used to identify and describe the drivers of LULC changes. The LULC change analysis revealed a continuous decline of forest lands throughout the first (1985-1996), second (1996-2007), and third (2007-2018) study periods by 10.7%, 17%, and 31.5%, respectively. Similarly, shrub/grasslands decreased in all consecutive three periods by 22%, 29.5%, and 63.7%. On the contrary, settlement areas increased by 53.6% in the first, 102.4% in the second, and 65% in the third period. Agricultural lands also expanded over the study periods by 34.8%, 17.6%, and 26.5%, respectively. The overall results of the analysis showed that between the years 1985 and 2018, forest lands, shrub/grasslands, and water bodies declined by 49.7%, 80%, and 42.3%, while agricultural lands and settlement areas increased by 100.6%, and 413%, respectively. Along with the dynamics, population pressure, land tenure policy, cropland expansion, and settlement expansion were identified as the leading causes that triggered LULC changes observed over the 33 years of the study period. The findings indicated that the Majang zone has been subjected to extensive agricultural investments and settlement expansions at the cost of forest lands and shrub/grasslands. Therefore, it is important to prioritize and design strategies for better LULC systems and natural resource conservation for integrated and sustainable development.

Keywords

GIS, LULC dynamics, Majang, Ethiopia

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1 INTRODUCTION

Land is the main natural resource on which economic, social, infrastructural, and other human activities depends on. Changes in land use-land cover have occurred at all times in the past and are likely to continue in the future (Lambin et al. 2003; Moser 1996). According to Lambin and Geist (2008), a dramatic growth rate of land use-land cover alteration was observed in the past few centuries. Most of the recorded LULC dynamics were the outcome of different practices made to fulfill the instant necessities of human beings (Sherbinin 2002; Serneels and Lambin 2001).

Land use-land cover (LULC) change is the result of a complex interaction between several biophysical and socio-economic conditions, which may occur on various temporal and spatial scales (Shah 2000). According to Turner et al. (1995), the main actors in the LULC change are human beings and the slow natural processes. The driving factors that cause LULC transformation differ in space and time based on human-environment interactions, such as utilization of energy, water, forest and other natural resources in the livelihood activities. Many of the changes in the LULC are increasingly rapid and can have adverse impacts and implications at local, regional, and global scales (Muriuki et al. 2011; Brandon 1998), for instance, it can affect the climatic conditions at different levels (Asenake and Amare 2019; Wubie et al. 2016).

The most significant historical changes observed in LULC across the world has been the expansion of agricultural lands (Houghton 1994). An estimated 4.7 million km^2 of grasslands and 6 million km^2 of forests/woodlands have been converted to croplands worldwide since the 1850s (Lambin et al. 2003, 2001). The amount, rate, and intensity of LULC changes are particularly considerable in developing countries (Rao and Pant 2001). In recent years, African grassland, woodland, and other vegetated areas have increasingly been converted into cropland (MEA 2005). For instance, an estimated 3.4 million km^2 of woody vegetation in dryland zones of Africa has become degraded through human activities such as agricultural expansion and deforestation (Kigomo 2003).

In Ethiopia, LULC dynamics are widespread, driven by human actions, and the consequences of such changes ultimately affects humans (Agarwal 2002) and alters the availability of different biophysical resources including water, soil, vegetation, and animal feed (Wubie et al. 2016). The country is at a crossroads and needs to improve its biophysical resources to feed its growing population (Agumassie 2020; Asenake and Amare 2019). Food and other basic needs of a growing population will lead to a continual conversion of forest lands, communally owned grazing, and shrublands to cultivated lands. So, the growing human population exerts increasing pressure on the landscape as demands multiply for resources such as food, water, shelter, fuel, and other socio-economic benefits. LULC practices generally develop over a long period under different environmental, political, demographic, and social conditions. These conditions often vary and yet have a direct impact on LULC (Ojima et al. 1994).

So, analysis of LULC change is an indispensable basis for the planning of rural development activities, monitoring of food security, land-use, and climate-related studies. In Ethiopia, numerous studies were devoted to investigating LULC changes (Kindu et al. 2013; Amsalu et al. 2007; Hurni et al. 2005; Zeleke and Hurni 2001). For instance, Zeleke and Hurni (2001) reported a sharp decrease in forest cover by 99% and an increase of cultivated lands by 38% between 1957 and 1995 in the Dembecha area of northwestern Ethiopia. Similarly, Amsalu et al. (2007) showed a significant decline in natural vegetation cover, however, there was an increase of plantation in the Beressa watershed in the central highlands of Ethiopia between 1957 and 2000. Kindu et al. (2013) also reported that 95% of woodlands and 59% of natural forests that existed in 1973 were converted to other LULC types in the past four decades in the Munessa-Shashemene landscape of the Ethiopian highlands.

Even though several studies were dedicated to investigating LULC changes in Ethiopia, evidence revealed that studies on LULC changes are very restricted and spatially limited in particular areas, mainly in rift valley regions and the Blue Nile river basin (Muluneh and Arnalds 2011). Verburg et al. (2004) suggested that numerous studies in several parts of Ethiopia are essential for a deep understanding of the changes in the human-environment interactions at various spatial and temporal levels. Majang zone is one of the UNESCO registered forest biosphere reserve site which is; home to diverse plant species, wild animals and means of livelihood for local peoples but it is one of the fragmented and threatened areas in the region. However, the Majang zone is one notable example where slight or no LULC changes information existed for better land-use planning and decision making. Therefore, this research aimed at detecting and examining the magnitude and trends of spatio-temporal LULC changes over the period of 33 years in the Majang zone, Southwest Ethiopia.

2 MATERIALS AND METHODS

2.1 Study Area Description

Majang zone is part of Gambela region, which is 628km away from Ethiopia's capital city, Addis Ababa. Being located in the Southwest of the capital, it is bordered with Sheka and Bench Maji zones of the Southern Nations, Nationalities, and People's Region (SNNPR) in the south, Illu Aba Borra zone of Oromia region in the north and Agnwa zone of Gambela in the west. It is found between 7°10'00''N-7°40'00''N latitude and 34°49'30''E-35° 22'0'' E longitude, covering a total area of 156,032ha (Figure 1). The mean annual temperature varies between 17.6°C and 27.5°C and the average annual rainfall varies between 1401mm and 1800mm. Agriculture and forest products are the main means of livelihoods in the study area. The most common livelihood activities of the Majang zone are the production of food crops (maize and sorghum), perennial crops such as coffee, chat, and honey (UNESCO 2017). The aforementioned food crops are used for consumption in a subsistence manner; whereas, coffee and chat are the main sources of cash.

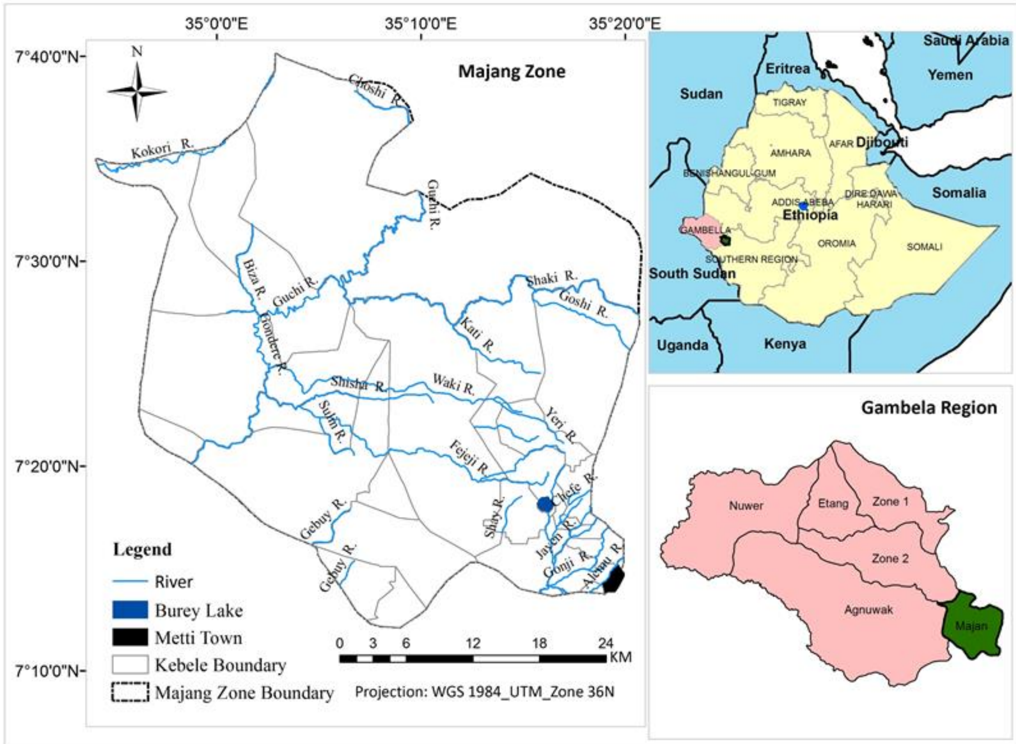

Figure 1. Location map of the Majang zone in Gambela region, Ethiopia.

2.2 Sources of Data

The main types of data used to achieve the desired objectives of the study were Landsat imageries for 1985, 1996, 2007 and 2018 (Table 1). These data sets were obtained from the United States Geological Survey (USGS) data center under the online Landsat archive (https://earthexplorer.usgs.gov/). A topographic map from the Ethiopian Mapping Agency (EMA) was also used in this study for geo-referencing an image. The satellite images were selected at an interval of 11 years by taking into consideration the effect of the periodic variation in the analysis and the data sets were acquired in the same season to evade the impact of periodic alterations (Kindu et al. 2013).

To realize the process behind and the existence of LULC dynamics, both primary and secondary datasets were employed. Consequently, the primary data were collected through structured questionnaires, key informant interviews (KIIs), focus group discussions (FGDs), and field observations. Structured questionnaires (both closed and open-ended) were distributed to randomly selected sample household heads. To obtain detailed information about the stated problems, in-depth interviews were also held with selected key informants: kebele leaders, government officials, and experts. Moreover, focus group discussions (FGDs) were also held to triangulate the reliability and validity of the data collected through other techniques. The discussions were held through interaction of a purposefully formed small group of people, often ranging from 6 to 10 people. Furthermore, field observations were held to obtain insight knowledge about LULC practice. The qualitative data obtained from KIIs and

FGDs were stated in narrative form alongside with the quantitative data. Simultaneously different secondary sources of data were also used in collecting the required information. Multi-temporal satellite images and ancillary data were processed using ERDAS Imagine15, ArcGIS10.3, and Statistical Package for Social Sciences (SPSS) version 23. Moreover, ground control points (GCPs), digitized, and topographic maps were used for geo-referencing satellite imageries.

Table 1. Satellite imagery of Majang zone in Gambela region with their source of archives.

No	Imagery	Resolution(m)	Sensor	Path & row	Date of acquisition	Source
1	Landsat5	30 x 30	MSS	171/65	25/1/1985	USGS
2	Landsat5	30 x 30	TM	171/65	26/1/1996	USGS
4	Landsat7	30 x 30	ETM+	171/65	20/1/2007	USGS
5	Landsat8	30 x 30	OLI	171/65	25/1/2018	USGS

Source: glovis.usgs.gov

2.3 Data Analysis

2.3.1 Satellite Image Classification

The satellite images were classified using supervised classification methods particularly, maximum likelihood image classification techniques. The actual image classification was carried out after the training data had been established and the classification algorithm was designated. For training points, more than 40 samples per LULC classes were randomly assigned (Lillesand et al. 2015). Accordingly, a total of 200 samples were generated for training and testing. To generate the reference data, the training sites were identified based on the information obtained from field observations, discussion with elders, topographic maps, image interpretation, and an aerial photograph from Google Earth.

2.3.2 Change Detection Analysis

Change detection was conducted using the post-classification image comparison technique in which images of different reference years were independently classified, and change detection processes were performed. The vector data were rasterized and zonal statistics in ArcGIS spatial analyst tools were used to compute the change in the area by cross tabulating pairs of time intervals. In addition, the change detection matrix of transitions between different LULC classes was evaluated to measure areas converted among the different LULC (Minta et al. 2018). Quantified values of the conversion between the different LULC classes were used for statistical analysis to indicate the level of the changes in the Majang zone. The percentage of LULC change was computed by the following formula that was set by Kindu et al. (2013).

$$\text{LULC change}(\%) = \frac{(\text{Area final year} - \text{Area initial year})}{\text{Area initial year}} \times 100 \tag{1}$$

Positive values imply an increase whereas negative values suggest a decline in the extent of LULC. The LULC shift index was computed to assess LULC type contributing greatest to particular LULC class extended remarkably. The index is calculated from the following equation (Minta et al. 2018).

$$\mathrm{LUSHI} = \frac{\Delta \mathrm{LC_{i-j}}}{\mathrm{Mean}\Delta\mathrm{LC}} \quad (2)$$

where LUSHI: land use shift index, ΔLC_i: area of LULC class *i* converted to LULC *j* in the period between time 1 and time 2, i.e., the period between target reference years, mean ΔLC: mean of areas of all LULC types converted to LULC type *j* in the period between time 1 and time 2. Furthermore, change detection matrix was derived to illustrate LULC class conversion transitions over the period of 33 years.

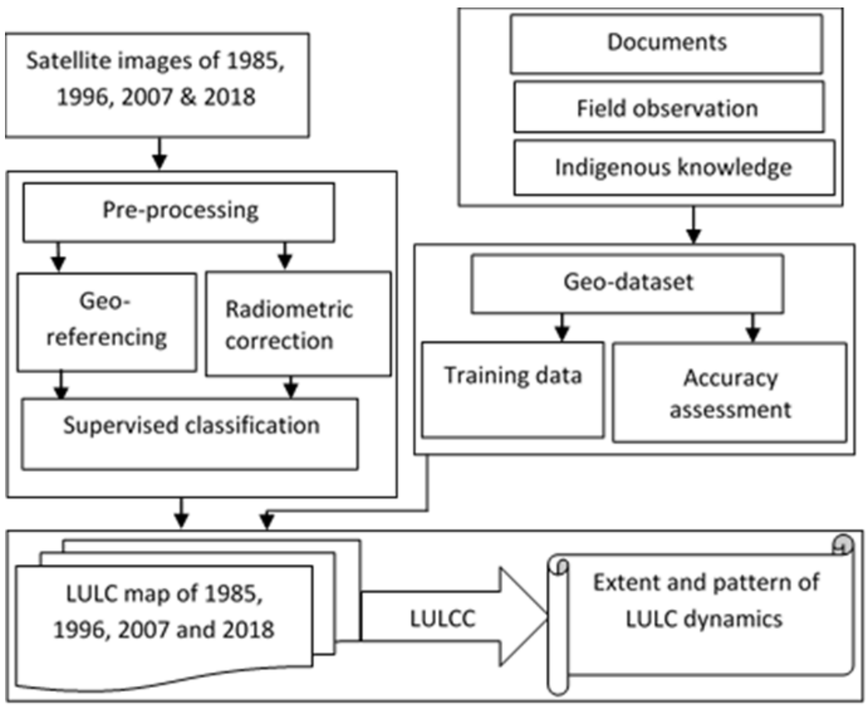

Figure 2. Methodological flow chart of LULC change analysis, Majang zone, Ethiopia.

Table 2. Description of LULC classes used to measure the changes in Majang zone (1985-2018).

LULC type	Description
Agriculture	Areas used for rain-fed crop cultivation. This includes areas currently covered with crops and cash crops (chat, tea and coffee) cultivation.
Forest	Area covered by dense trees, natural or planted and vegetation's forming closed canopies and thick in images.
Settlement	Comprises residential areas (urban built-ups, rural towns, and villages) occupied by living houses or residence.
Shrub and grass	Land dominantly covered by scattered trees, bushes, shrubs, and grassland.
Water bodies	Part of the land surface covered with water like lakes, and freshwater (river and streams). It also includes wetlands (waterlogged and swampy) which relatively dry up during the dry season.

3 RESULTS AND DISCUSSIONS

3.1 Land Use-Land Cover Changes (1985-2018)

The study found that the Majang zone has experienced noticeable changes in LULC at a different rate over the period of 33 years. Thus, agricultural lands, forest lands, settlement areas, water bodies, shrub/grasslands were identified as major LULC classes in the study area (Figure 3, Table 3).

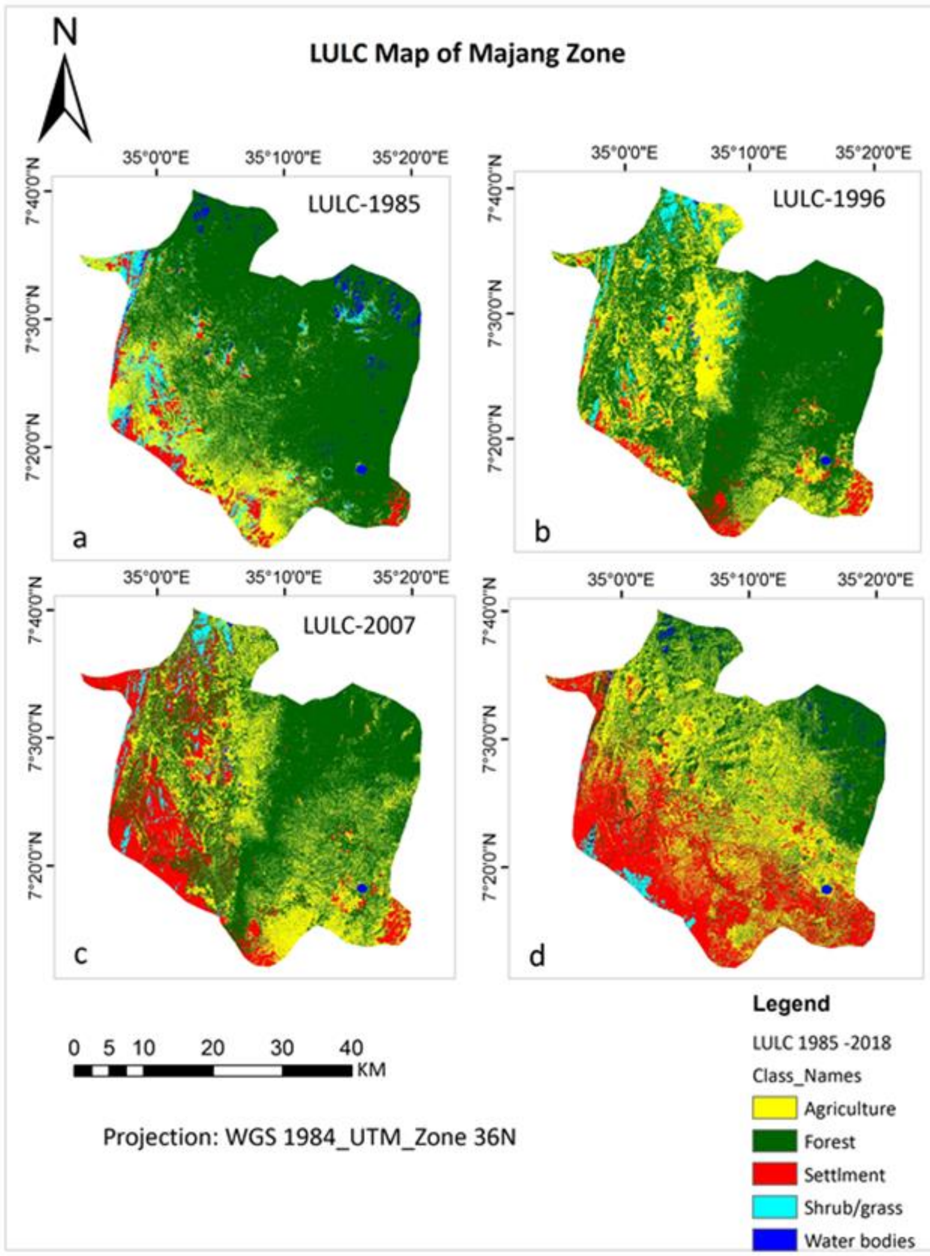

Figure 3. LULC map of Majang zone of the study periods from 1985 to 2018.

LULC classification result shows that in the first study period (1985), the landscape was dominated mainly by forest lands that covered almost 70% followed by agricultural lands (17.3%), settlement areas (5.5%), water bodies (2.2%), and shrub/grasslands (5.6%). Table 3 reveals that in 1996, 62% of the study area was covered by forest lands and followed by agricultural lands (23.3%) and settlement areas (8.4%). The remaining parts were covered by shrub/grasslands (4.4%) and water bodies (1.9%). Likewise, in 2007, the percentage share of the classes showed that 27.4% of the study area covered by agricultural lands, settlement areas (17%), forest lands (51%), shrub/grasslands (3.1%), and water bodies (1.5%). In the last study period (2018), almost two-thirds (62.7%) of the study area were under agricultural lands and settlement areas, while the share of forest lands, shrub/grasslands and water bodies detracted to 35%, 1.1%, and 1.2% respectively.

As the analysis of satellite imageries revealed agricultural lands and built-up areas progressively expanded and became dominant land-use types in all study periods (Figure 4). Settlement areas, which had one of the smallest coverages (5.5%) of the total area in 1985, had alarmingly increased and covered 28% of the landscape in 2018. Similarly, agricultural lands which occupied only 17.3% of the total area in 1985, have had a dramatic increment and reached 34.7% in 2018. However, forest lands, water bodies, and shrub/grasslands of the landscape dramatically shifted to other land use types throughout the study periods. Cultivated land expansion into wetlands and forest lands is an old phenomenon observed in many parts of Ethiopia (Minta et al. 2014; Zeleke and Hurni 2001).

The information acquired from elders and key informants also confirmed that agricultural lands and settlement areas increased at the expense of forest and other land uses. According to the elders, these changes were corresponding with fast population growth and resettlement programs which involved migrants from the northern part of Ethiopia to the study area. Resettlement schemes in Ethiopia, both planned and spontaneous, involved environmental impacts and has also resulted in huge damage to forest areas (Jaleta et al. 2011; Mulugeta and Woldesemait 2011). The expansion of settlement and cropland into the dense forest areas (Majang forest biosphere) have resulted in widespread problems of deforestation and LULC changes.

Table 3. LULC classes with the area in hectare (ha) and percentage (%) share (1985-2018).

LULC Type	1985		1996		2007		2018	
	Area(ha)	%	Area(ha)	%	Area(ha)	%	Area(ha)	%
FL	108353	69.4	96740	62	79576.3	51	54467.5	35
AL	26968	17.3	36355.4	23.3	42753	27.4	54105.5	34.7
SA	8531	5.5	13106.7	8.4	26525.4	17	43759.6	28
SGL	8813	5.6	6865.4	4.4	4836.8	3.1	1756.7	1.1
WB	3367	2.2	2964.5	1.9	2340.5	1.5	1942.7	1.2
Total	**156032**	**100**	**156032**	**100**	**156032**	**100**	**156032**	**100**

where FL-Forest land; AL-Agriculture land; SA-Settlement area; SGL-Shrub/grass land; WB-Water bodies

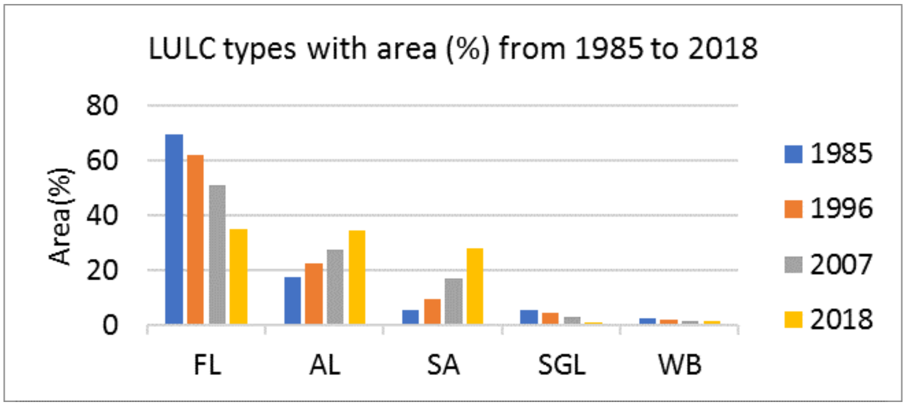

Figure 4. The percentage share of LULC classes of Majang zone (1985-2018).
where FL-Forest land; AL-Agriculture land; SA-Settlement area; SGL-Shrub/grass land; WB-Water bodies

3.2 Trends in Land Use-Land Cover Changes (1985-2018)

Evidence from this study showed that over the entire study periods (1985-2018), the landscape of the targeted study area experienced a remarkable change in LULC in different rates of transformation (Figure 5). Table 4 shows that between the years 1985 and 2018, forest lands, shrub/grasslands, and water bodies significantly declined by 49.7%, 80%, and 42.3%, while agricultural lands and settlement areas increased by 100.6%, and 413%, respectively.

Table 4. LULC change of Majang zone during the study periods 1985-2018.

LULC	1985-1996		1996-2007		2007-2018		1985-2018	
Types	Area(ha)	%	Area(ha)	%	Area(ha)	%	Area(ha)	%
FL	-11613	10.7	-17163.7	17.7	-25108.8	31.5	-53885.5	-49.7
AL	+9387.4	34.8	+6397.6	17.6	+11352.5	26.5	+27137.5	+100.6
SA	+4575.7	53.6	+13418.7	102.4	+17234.2	65	+35228.6	+413
SGL	-1947.6	22	-2028.6	29.5	-3080.2	63.7	-7056.3	-80
WB	-402.5	12	-624	21	-397.8	17	-1424.3	-42.3

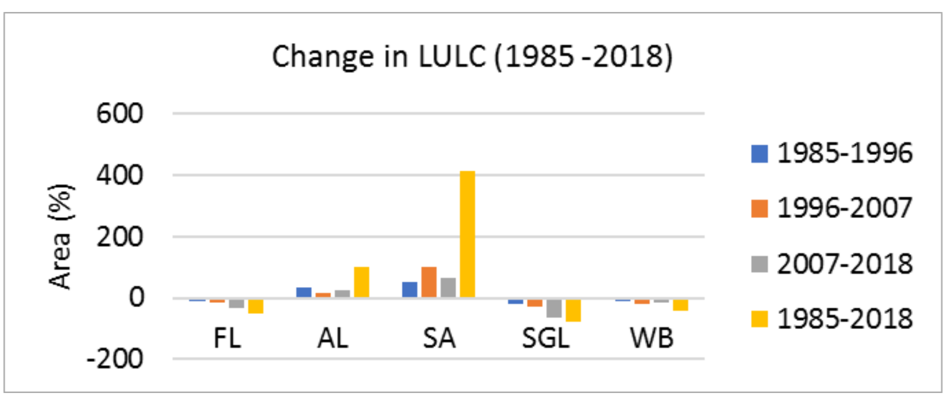

Figure 5. Percentage change of LULC classes of Majang zone (1985-2018).

The change analysis showed that the rate and the trend of conversion varied distinctly among the different classes and intervals of the study periods (Lambin et al. 2003). Settlement areas increased by 53.6%, 102.4%, and 65% throughout the first (1985-1996), second (1996-2007), and third (2007-2018) study periods. Similarly, agricultural lands expanded by 34.8% in the 1st, 17.6% in the 2nd, and 26.5% in the 3rd period (Table 5). So, the result indicates that agricultural lands and settlement areas increased continuously with rates exceedingly higher than any other classes throughout the study periods at the cost of getting diminution of forest lands and shrub/grasslands. The overwhelming encroachment of agricultural lands into forest and shrub/grass was to support the fast-growing population during the periods. This is supported by the findings of Josephson et al. (2014).

On the other hand, forest lands depleted continuously at a rate of much higher than any other classes throughout the study periods. It decreased by 10.7%, 17.7%, and 31.7% throughout the 1st (1985-1996), 2nd (1996-2007), and 3rd (2007-2018) periods respectively. The forest cover of the landscape was reduced by almost half (from 70% to 35%) in the years between 1985 and 2018. Likewise, shrub/grasslands declined throughout the 1st (1985-1996), 2nd (1996-2007) and 3rd (2007-2018) periods by 22%, 29.5%, and 63.7% with different annual rates of change (Table 5). Cultivated land expansion, the most prominent phenomenon, is most associated with an extensive decline in forest cover. The observed remarkable expansion of agricultural lands in Majang zone between 1985 and 2018 at the expense of forest lands also is consistent with the results of Lemenih et al. (2005), Zeleke and Hurni (2001), Tekle and Hedlund (2000), reported that agricultural land expansion at the expense of forest cover reduction, is a common phenomenon in the Ethiopian highlands.

Table 5. LULC net changes with annual rates for the study periods in the Majang zone.

LULC type	Net change in area (%)			Annual rates of change (%)		
	1985-1996	1996-2007	2007-2018	1985-1996	1996-2007	2007-2018
FL	-10.7	-17.7	-31.5	0.9	1.6	2.8
AL	34.8	17.6	26.5	3.1	1.6	2.4
SA	53.6	102.4	65	4.8	9.3	5.9
SGL	-22	-29.5	-63.7	2	2.7	5.8
WB	-12	-21	-17	1	1.9	1.5

where FL- Forest land; AL- Agriculture land; SA- Settlement area; SGL- Shrub/grass land; WB- Water bodies

3.3 Land Use-Land Cover Converted 'From' and 'To'

LULC change matrix is performed by subtracting the digital numbers (DN) value of one date for a given band from the DN value of the same pixel for the same band of another date (Yuan et al. 2005). In the process of classification, it needs assigning the appropriate 'from' and 'to' identifiers. Quantified values were used to detect the extent of the changes between LULC classes in the study area. So, using the formulae of land use shift index, furnished in (Eq.2), LULC converted 'from' and 'to' and the LULC index was computed and tabulated.

Table 6 reveals that in the first (1985-1996) study period, forest lands, shrub/grasslands, and water bodies were lost about 11,990ha, 1,977ha, and 482ha, respectively. In reverse, agricultural lands and settlement areas gained 9,470ha, and 4,741ha, respectively. Hence, there was a conversion of forest, shrub/grass, and water bodies primarily to settlement and agricultural land (Gebrelibanos and Assen 2015; Zeleke and Hurni 2001). Similarly, in the second (1996-2007), and third (2007-2018) study periods, agricultural land gained 6,415ha, and 11,435ha respectively. The settlement area also gained 13,424ha in the 2nd period and 17,239ha in the 3rd period. Whereas, about 17,255ha, and 25,153ha of forest cover were converted to other land use classes in the second and third study periods, respectively. Hence, the change of forest lands significantly increased to agricultural lands, and the settlement areas were converted by human activities (Betru et al. 2019; Minta et al. 2018).

Generally, through the entire study periods, significant LULC transformation has been observed with a significant LULC conversion index. In the Majang zone, over the study period, the dominant LULC type which contributed a lot to the expansion of other LULC classes was a forest with conversion rate ranged between 3.01- 3.74% (Table 7). In all study periods, the forest was converted to agricultural land (24,280.8ha) and settlement area (30,117.8ha). Likewise, 2,886ha of agricultural land and 5,174ha of settlement area was also converted from shrub/grass (6,701ha) and water bodies (1,359.5ha). These bring a greater challenge to the LULC system (Gebrelibanos and Assen 2015; Gete and Hurni 2001); particularly, for shrub/grasslands, water bodies, and forest cover of the study area.

Table 6. LULC change matrix between 1985 & 1996, 1996 & 2007, 2007 & 2018 in hectares.

		LULC class (1996)					Total
		FL	AL	SA	SGL	WB	
LULC class (1985)	FL	**96363**	8414	3576	0	0	108353
	AL	65	**26885**	18	0	0	26968
	SA	23	143.2	**8364.8**	0	0	8531
	SGL	281.3	583.2	1033.3	**6835.4**	79.8	8813
	WB	7.7	330	114.6	30	**2884.7**	3367
	Total	96740	36355.4	13106.7	6865.4	2964.5	156032
		LULC class (2007)					Total
		FL	AL	SA	SGL	WB	
LULC class (1996)	FL	**79484.7**	5175.8	12079.5	0	0	96740
	AL	5	**36337.4**	13	0	0	36355.4
	SA	0	5.7	**13101**	0	0	13106.7
	SGL	81	870.3	1133.3	**4780.8**	0	6865.4
	WB	5.6	363.8	198.6	56	**2340.5**	2964.5
	Total	79576.3	42753	26525.4	4836.8	2340.5	156032
		LULC Class (2018)					Total
		FL	AL	SA	SGL	WB	
LULC class (2007)	FL	**54423**	10691	14462.3	0	0	79576.3
	AL	0	**42670**	83	0	0	42753
	SA	0	5.7	**26519.7**	0	0	26525.4
	SGL	33.2	511.3	2569.6	**1716**	6.7	4836.8
	WB	11.3	227.5	125	40.7	**1936**	2340.5
	Total	54467.5	54105.5	43759.6	1756.7	1942.7	156032

Values in bold cells represent land area remained under that same LULC type.

Table 7. Index of different LULC conversion to agriculture and settlement in the study period.

Area converted to agricultural land (ha)				Area converted to settlement land (ha)			
Source	1985-1996	1996-2007	2007-2018	Source	1985-1996	1996-2007	2007-2018
FL	8414	5175.8	10691	FL	3576	12079.5	14462.3
SA	143.2	5.7	5.7	AL	18	13	83
SGL	583.2	870.3	511.3	SGL	1033.3	1133.3	2569.6
WB	330	363.8	227.5	WB	114.6	198.6	125
Mean[a]	2367.6	1603.9	2858.9	Mean[b]	1185.5	3356	4310
Indexes of d/t LULC conversion to agriculture				Indexes of d/t LULC conversion to settlement			
FL	3.55	3.23	3.74	FL	3.01	3.59	3.35
SA	0.06	-	-	AL	0.02	-	0.02
SGL	0.25	0.54	0.18	SGL	0.87	0.33	0.59
WB	0.14	0.23	0.08	WB	0.09	0.06	0.03

[a] Mean of all LULC classes changed to agriculture lands

[b] Mean of all LULC classes changed to settlement areas

3.4 Accuracy Assessment

Accuracy assessment is a crucial validation technique by which the overall accuracy of satellite image classification as compared to the actual condition is done (Congalton and Green 2009). The aim of accuracy assessment is to quantitatively assess how effectively the pixels were sampled into the correct LULC classes. Accordingly, the overall accuracy, kappa coefficient, producer accuracy and user accuracy were computed and tabulated for classified satellite image of the study period using an error matrix (Table 8).

The results of the accuracy assessment showed that the overall accuracies computed for each of the considered classified satellite images were varied 83% to 92.5%, with the kappa coefficient of 0.80 to 0.90 (Table 8). Thus, the kappa results of this study showed a strong agreement for each of the four classified images, and the overall accuracies were within the acceptable range for further LULC change analysis (Rwanga and Ndambuki 2017; Kindu et al. 2013).

3.5 Causes of Land Use-Land Cover Change

Land use-land cover changes were caused by multiple interacting factors and these causes vary in time and space according to specific humans' environmental conditions. Although LULC changes are the result of human influences, biophysical drivers, and natural processes (Lambin and Geist 2008), the human influences are the dominant factors highly affecting LULC change in Majang zone. Therefore, the possible indirect drivers were population pressure, economic activities, policy and institutional structure whereas, cultivated land expansions, resettlement or villagization, and demand for firewood and construction materials were identified as the main direct drivers in the study area. The drivers noted above were also confirmed as common phenomenon in the whole of Ethiopia (Sishaw 2014).

Table 8. Error matrix of classified satellite imagery of the Majang zone in Gambela region.

Classification accuracy of Landsat Multispectral Scanner (MSS):1985								
LULC Class	Reference Data					Row Total	Producer Accuracy	User Accuracy
	FL	AL	SA	SGL	WB			
FL	36	3	0	3	1	43	0.83	0.76
AL	4	31	1	5	0	41	0.75	0.79
SA	2	3	32	2	0	39	0.82	0.94
SGL	4	2	1	30	1	38	0.78	0.73
WB	1	0	0	1	37	39	0.94	0.94
Column Total	47	39	34	41	39	200	**Overall A = 83%; KC = 0.80**	
Classification accuracy of Landsat Thematic Mapper (TM):1996								
LULC Class	FL	AL	SA	SGL	WB	Row Total	Producer Accuracy	User Accuracy
FL	35	5	0	3	0	43	0.81	0.87
AL	2	34	1	4	0	41	0.82	0.80
SA	1	3	31	2	1	38	0.81	0.93
SGL	1	1	1	33	0	36	0.91	0.77
WB	1	0	0	1	40	42	0.95	0.97
Column Total	40	43	33	43	41	200	**Overall A = 86.5%; KC = 0.83**	
Classification accuracy of Landsat Enhanced Thematic Mapper Plus (ETM+):2007								
LULC Class	FL	AL	SA	SGL	WB	Row Total	Producer Accuracy	User Accuracy
FL	37	3	0	2	0	42	0.90	0.88
AL	3	33	1	4	1	42	0.84	0.78
SA	0	2	35	3	1	41	0.97	0.85
SGL	1	1	0	33	0	35	0.76	0.94
WB	0	0	0	1	39	40	0.95	0.97
Column Total	41	39	36	43	41	200	**Overall A = 89.5%; KC = 0.85**	
Classification accuracy of Landsat 8 Operational Land Imager (OLI):2018								
LULC Class	FL	AL	SA	SGL	WB	Row Total	Producer Accuracy	User Accuracy
FL	38	1	1	0	0	40	0.95	0.92
AL	1	36	1	3	1	42	0.85	0.87
SA	1	2	37	0	0	40	0.92	0.94
SGL	1	2	0	34	0	37	0.91	0.89
WB	0	0	0	1	40	41	0.97	0.97
Column Total	41	41	39	38	41	200	**Overall A = 92.5%; KC = 0.90**	

NB: Overall A – Overall Accuracy; KC- Overall Kappa Coefficient

3.5.1 Agricultural Land Expansion

It is agreed that agriculture has been the major economic activity and means of livelihood in Ethiopia. Accordingly, as shown in satellite image analysis, agricultural land has been expanded greatly from time to time over the study period and changed the LULC of the area. Surveyed result (Table 9) also confirmed that the total landholding size of surveyed household heads before 1985 was about 883.5ha whereas in the year 2018, it expanded to 1,598.4ha with an additional total landholding size difference of 714.9ha. So, this indicates that the competition for agricultural land ownership and expansion of cultivated land for coffee and related agricultural activities became the main reason for LULC changes in the study area.

Table 9. Landholding size difference (in hectare) with in 33 years interval of surveyed household heads.

Years	Rural kebeles						
	Godere District			Mengesh District			Total Area
	Akashi Area	M. Metti Area	Gumari Area	Gubeti Area	Yeri Area	Kumi Area	
Before 1985	508.5	147	158	32	1	37	883.5
Current (2018)	692.5	194.4	351	146.5	115	99	1598.4
Difference	**184**	**47.4**	**193**	**114.5**	**114**	**62**	**714.9**

Furthermore, the information obtained from the key informants revealed that agricultural expansion and investment (large-scale coffee and tea plantation) have been expanded considerably at the expense of forest particularly UNESCO registered Majang forest biosphere reserve and other LULC classes. Cultivated land expansion to increase their income and to satisfy the demand of the livelihoods largely attained at the expense of forests, shrub/grassland, and swampy/water bodies (Ariti et al. 2015; Kindu et al. 2013; Mengistu et al. 2012; Garedew et al. 2012).

Between the years 1985-2018, abundant number of investors were engaged in large scale agricultural investment at the cost of forest cover, which resulted in forest cover loss (Table 10). Thus, the information acquired from key informant interviews (KIIs) confirmed that investments (large-scale coffee and tea plantation) were the main contributing factors for LULC changes in the study area.

Table 10. Investors engaged in large scale agricultural investment in the Majang zone.

Type of investment	Local investors		Foreign investors		Total occupied area (ha)
	No.	Area (ha)	No.	Area (ha)	
Coffee and spice	1	355	-	-	355
Tea plantation	-	-	1	3012	3012
Coffee plantation	21	18194.2	-	-	18194.2
Total	**22**	**18,549.2**	**1**	**3012**	**21,561.2**

3.5.2 Resettlement

The information acquired from elders and officials confirmed that the other main proximate driver of LULC change was the 1985 resettlement program, which was held due to the severe famine that was occurred in the northern part of Ethiopia. The 1985 resettlement has drawn-out people from the northern part to the south and southwestern part of Ethiopia to establish a settlement and their livelihood (Gizaw 2013). Accordingly, the program had resulted in the increment of human settlement and villagization.

Moreover, the elders noted that after the coming in power of new and Ethiopian People's Revolutionary Democratic Front (EPRDF) lead regime, the people who were settled in the study area as a result of resettlement program began to expand their agricultural land near to and inside the dense forest. As a result, the former rural kebeles settlements and farmer associations changed to larger villages and towns. The emerging villages and small towns were highly attracted population and demanded agricultural products and energy sources, which are mainly forest products in the form of fuel wood. So, the emergent villages thought (are not only seeking) for products for consumption but also land resource for expansion.

The satellite image analysis (Table 4) also showed that between the years 1985 and 2018, 53,885.5ha of the forest areas were converted to settlement and agricultural land. It was understood from the key informants, elders, and satellite image analysis that the resettlement program and its counteraction of the people greatly contributed to the destruction of the forest resources, and concurrently caused LULC change of the study area.

3.5.3 Demand for Firewood and Construction Materials

The discussion with key informants and FGDs revealed that fuelwood, charcoal, and other forest products were the main means of energy sources for the majority of the population in the study area. The key informants, again, noted that, many people, who were economically poor, use timber production which is crucial for house construction and furnishing, charcoal, and firewood as a source of income to fulfill the need for their livelihoods. The previous studies conducted by Mohammed and Inoue (2014), and Tefera (2011) also confirmed that firewood and timber production provides an important source of livelihood in Ethiopia. As a result, timber production, fuelwood extraction in the form of charcoal, and domestic fuelwood consumption were also identified as the main proximate drivers of deforestation and LULC changes in the study area.

3.5.4 Population Pressure

The available evidence showed that demographic factors have also contributed a lot to the change. The national demographic conditions indicated that the population in the study area has increased over the years. According to Central Statistics Agency of Ethiopia (1994, 2007), the population of the Majang zone increased from 53,000 in 1994 to 59,248 in 2007, and further increased to 102,530 in 2015 (CSA 2012 projected for 2015), making the population of the area doubled for the past two decades. Accordingly, population growth caused an increase in the associated demand of natural resources and caused an increased pressure on land resources, mainly resulting from a demand for agricultural products (Meshesha et al. 2012; Ariti et al. 2015), construction material, energy sources and settlement which has significantly altered land use practices (Christiaensen et al. 2006).

Based on the results of the interview conducted with local experts, elders, and FGDs, as a result of increasing the local population, human settlement is expanding towards UNESCO registered biosphere reserves or protected forest of the study area. Concurrently, highly increased human population led to an increased demand for agricultural land expansion and other associated demands (Wondie and Mekuria 2018;

Nigussie et al. 2017) which pushed farmers to convert forests, shrubs and vegetation covers into cropland, coffee plantation and settlement areas. Subsequently, altered forest cover resulted in dramatic changes of LULC, and hence changes on the landscape of the study area. This is consistent with the findings of Gashaw et al. (2017) and Bewket (2002), who reported population growth as the main driving factor for LULC change.

3.5.5 Economic Activities

It is agreed that Ethiopia has experienced different regimes with different economic policy background. Accordingly, each of them has played its own role in the expansion of the agricultural land and utilization of forest resources to change the socio-economic conditions of the regime or the people. The Derg regime, officially the provisional military government of Ethiopia changed the economy from feud-capitalist to socialist command economy where it had brought in a significant increase in large scale state farms and demand for forest products in different parts of the country. Similarly, the 1991 change of government brought again change in the economy from centrally planned command economy to a relatively free market economy which again brought increases in agricultural products that highly demanded agricultural land expansion with the expense of forest land loss.

The information acquired from KIIs and FGDs revealed that the pattern of LULC dynamic before and after the coming of EPRDF-led government to power has a significant change difference particularly forest cover change. The discussion with elders also revealed that compared with the later periods, forest cover was dominantly found not only on government owned lands but also on individually owned lands, which in turn, made the forest cover during that time be significantly higher. While after the coming of successive regime (EPRDF), the land reform which took place all over the nation, had changed the socio-economic, political and institutional settings of the society and the land issues too. Extensions of cropland into marginal areas are the main forms of LULC dynamic in most parts of Ethiopia (Lemenih et al. 2005) for supporting the highest percentage of the country's population (Kindu et al. 2015). Such a conversion pressure between the growing population and agricultural yield has required the expansion of cropland into the forest and marginal areas (Nyssen et al. 2004) for sustaining their livelihood. So that the change in the national economic condition has contributed a lot to the expansion of small and large-scale agricultural land at the cost of forest land which resulted in LULC change of the Majang zone.

3.5.6 Policy and Institutional Structure

The interview with higher officials and experts indicated that land policy for large-scale commercial farming and institutional structure were also major factors for the change in land use. To promote investment in agricultural farming, one major strategy that the Ethiopian government adopted was to transfer the land allocation power from the regions to the federal government under the Ministry of Agriculture (Federal Democratic Republic of Ethiopia 2007, Reg No. 135/2007). In 2008 the government designated the Ministry of Agriculture responsible for handling large-scale land for investment by overtaking the power of regional governments, which was to be included in the federal land bank.

On the other hand, regional governments were discouraged from handling large-scale lands for investment. As a result, local law enforcing institutions and concerned bodies were weakened and lacked institutional coordination to administer the land resources which were supposed to be under their discretion. Although such large-scale farm land lease system has become a dominant means of transferring land use rights to individuals, often referred to as 'investors'; it also has become a major source of corruption and conflict in land ownership, bureaucratic inefficiency in land delivery and a haven for unscrupulous land speculators and brokers.

The land market in Ethiopia particularly in the study area is plagued by problems of pervasive illegal activities and widespread social discontent. The discussions with elders and FGDs confirmed that some local officials were the ones who facilitated LULC change by engaging themselves in land grabbing and land market in a corrupted way which is disgraceful as delegated government officials and responsible citizens. Consequently, land grabbing expanded, and many trees were cut for cropland expansion, large-scale farming, settlements, construction, charcoal production, and fuelwood resulted in LULC change. So, corruption and the absence of policy enforcement for the protection of forest lands have resulted in massive forest land decline (Kindu et al. 2015; Eshetu 2014). Moreover, the land tenures system, government institutional structure, land use, and investment policy (Meshesha et al. 2012) were also stated as factors for LULC change.

In addition to the above main deriving forces, key informants further confirmed that physical and social infrastructures such as education, health, road, markets, and provision of agricultural facilities were expanding in the area within the study periods under consideration. The physical infrastructure such as the roads crossing forest areas were constructed earlier than the study period. So, these infrastructures are attracting huge population to the area, and at the same time, they facilitated easy access to resources to the nearby towns and markets.

Furthermore, the key informants also agreed that absence of alternative source of livelihoods also has a significant contribution for the changes. They believed that shortage of off-farm activities as a source of income, and the full dependence of the people on natural resources causes them to further expand their agricultural activities at the cost of forest land resulted in LULC change. In general, the respondents' perception of LULC change was in consistent with the result of satellite images and findings of previous research conducted in different parts of Ethiopia. For instance, population pressure (Garedew et al. 2009; Meshesha et al. 2012), deforestation, agricultural expansion, and lack of alternative sources of livelihoods (Molla 2014) were also reported as factors for LULC changes. Lastly, along with dynamics of LULC change, the information acquired from KIIs and FGDs revealed that the change in LULC caused a decline in the number of wild animals, such as colobus monkeys, green monkeys, bush pig, bushbuck, leopard, buffalo, and many bird species. In some cases, wild animals, including tigers, lions, elephants, and antelope which were found in the area disappeared. Thus, the result of this study might help stockholders to save the fragmented and threatened forest biosphere reserve in the study area.

4 CONCLUSIONS

Land use-land cover change analysis based on satellite imageries extracted from remotely sensed data is essential to indicate how much the landscape transformed through human and natural induced activities on a spatial and temporal scale. The result of the analysis revealed that the Majang zone has identified 5 main LULC classes (agricultural land, forest, settlement, water bodies and shrub/grassland) with remarkable changes at different rates of loss and gain during the entire study periods (1985-2018). The study area has observed a significant decline in the forest, shrub/grass, and water bodies. On the other hand, the landscape experienced a high level of conversion to agricultural land and settlement area at the expense of other LULC classes. The varying rate of conversion of LULC in different periods is likely to have occurred in response to resource availability, following growing population pressure, and changes in socio-economic activities.

The study found that forest land was reduced significantly to other LULC types and this was occurred because of the competition for agricultural land ownership, settlement area, and livelihood activities. Hence, rural communities have considerable dependence on forests for timber, firewood, fodder, and incomes. Furthermore, finding of the study confirmed that, the main underlying drivers of changes were population pressure, economic activities, policy, and institutional structure. Whereas, agricultural land expansions, settlement expansion, and demand for firewood and construction materials were identified as the main proximate drivers to underpin the changes in LULC in the study area.

We can conclude that with the expansion of agricultural land, settlement area, and poor environmental policy, the LULC of the study area changed dramatically from one land-use type to the other. Consequently, the previous forest cover, water body and shrub/grass cover were cleared and converted to other land-use types. So, preserving and protecting the natural landscape of the study area should be given due consideration as a forest is part of natural resources and a source for small streams and plays an important role in regulating the local climate. Accordingly, a land-use policy that focuses on the conservation of agro-forestry and preservation should be maintained. Finally, this study urges an intervention of concerned bodies to look for sustainable LULC management by reversing the common direction of LULC change seen in the area to mitigate the effect of LULC transformation of forest cover and other classes. This will ultimately be used as a basis for sustainable land-use systems and development. Therefore, this study could be an important input for future research and land use policy formulation.

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