

Land Use and Land Cover Dynamics in Guraferda district, Southwest Ethiopia

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ABSTRACT

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In Ethiopia, land use land cover dynamics is one of the major environmental problems. Agricultural expansion has a great role on the changes of land use and land cover in southwest Ethiopian landscapes. This study was therefore carried out to examine the rate and pattern of land use/land cover changes in Guraferda district, southwest Ethiopia. Data was extracted from four periods of Landsat imagery (Landsat TM 1990, 2000, 2010, and Landsat OLI 2021) and used to analyze the historical land use and land cover changes. In addition, ground truth point data, field observations, and discussion with elders were also employed to validate results from remotely sensed data. ERDAS IMAGINE version 9.1 was used for image processing. The analysis extracted from these remote sensing data revealed that, in 1990, the dominant LULCs were forestland, grazing land and shrub land covering 41.6%, 29.4% and 28.3% of the total area, respectively with 0.64%, small coverage of agricultural land. However, land use analysis revealed an expansion of agriculture/settlement and reduction of forest and shrub land over the last 31 years (1990 to 2021). In the period 1990 to 2021 the forest and shrub land use decreased by 425 and 1,200 ha/year, respectively, whereas agriculture/settlement and grassland increased by 820 and 518.2 ha/year, respectively. Plantation coffee also showed substantial expansion rate (287.7 ha/year) on the expense of forestland and shrub land between 2010 and 2021. Conversion from natural habitat (forestland and shrub land) to other land uses (agriculture/ settlement and coffee plantation) is likely to have a large impact on forest ecosystems and biodiversity. Therefore, better use of prevailing land resources needs appropriate land use policy improvement and strategic planning that ensure both economic gain and environmental welfares.

1. INTRODUCTION

Land use and land cover (LULC) dynamics are extensive, accelerating and significant processes driven by human being actions that produce some changes that impact individuals (Agarwal et al 2000; Lambin et al 2001). Land cover relates to the physical condition of the ground surface, such as forest, shrub land, grassland, agriculture land while land use reflects the actions of human beings that applied to cover the land the use of the land for different purposes such as farming fields and settlement zones (Lambin et al 2001). These modifications have adverse impacts on the socio-economy of community (Lambin and Giest 2003), environment like deforestation, biodiversity loss, climate change and increase flooding and temperature (Awasthi et al 2002; Chapin et al 2000; Reis 2008). Most of the land use-land cover dynamics were caused by human activities done to meet their daily needs such as food, shelter, fresh water, medicinal products and others (Gebreslassie 2014; Minta et al 2018; Serneels and Lambin 2001; Sherbinin 2002).

LU/LC dynamics are one of Ethiopia's most serious environmental issues. Deforestation, in particular, has negative consequences for human livelihood systems. These were recorded at the local level and added up to changes at the national level (Daniel 2008). The majority of the conversions were from natural forest to agricultural land (Dessie and Kleman 2007). The local level of land use and land cover dynamics caused extended land degradation, which affected both the protection of the natural environment and people's livelihoods (Efrem et al 2009). Similarly, land use and land cover modifications that are negatively influenced are generally caused by mismanagement of agricultural, urban, range, and forest lands (Gete and Hurni

2001).

Southwestern Ethiopia was almost completely covered by montane rainforests at the beginning of the 19th century (Chaffey 1979; Reusing 1998; Reusing 2000). The current land use land cover dynamics that have resulted in deforestation are related to cropland expansion under investment of small-scale farming and commercial farming/large-scale plantations of tea, coffee, soapberry rubber and black pepper causes, and settlement (Bedru 2007; Belay 2010; Dereje 2007; Mekuria 2005). The decline of natural forest cover in the region and threatens biodiversity, land quality, and sustainability and the livelihood of the local community (Kassa et al 2017).

The study area has a high rate of land use/land cover dynamics as a result of resettlement, expansion crop land and large-scale coffee plantation at the expense of the natural forest (Abere 2011; Gessese 2017; Mengistu and Woldetsedik 2018). The general trend in the moist afro-montane forest area has converted forests into other forms of land use, particularly agricultural land. Such changes have been common in recent decades; this type of conversion has been necessitated by rapidly increasing population pressure in guraferda (Gessese 2017; Kassa et al 2017). Nevertheless, resource availability, their dynamics and management differ significantly over time and from area to area (Lambin et al 2001). With the exception of a study made on the driver of LULC change (Gessese 2017; Mengistu and Woldetsedik 2018), the impact of resettlement on woody plant species and local livelihood (Abere 2011), the impact of deforestation on soil fertility, soil organic carbon and nitrogen stocks (Kassa et al 2017), there is little information in the study area that would help to understand historical LULC dynamics and related issues. As a result,

this study examined the rates and trends of LULC dynamics (1990–2021) in the Guraferda district in southwest Ethiopia, as well as the implications for environmental sustainability.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was carried out in the *Guraferda* district in southwestern part of Ethiopia, in Bench *Sheko* administrative zone of Southern Nations, Nationalities and Peoples' Region. Located 635 Km

southwest of Addis Ababa, the capital of Ethiopia and 42 Km away from *Mizan-Teferi* city. Geographically, it is positioned between 6°29'5" to 7°13'20" N and 34°55'59" to 35°26'13" E (Figure 1). The topography of study area constitutes lowland (78.25%) and midland (21.75%) and characterized by hill and mountain landforms. The district is most known by the *Susuka* Mountain bordering the *Gambela* national regional state and *Ambesa* Mountain to north.

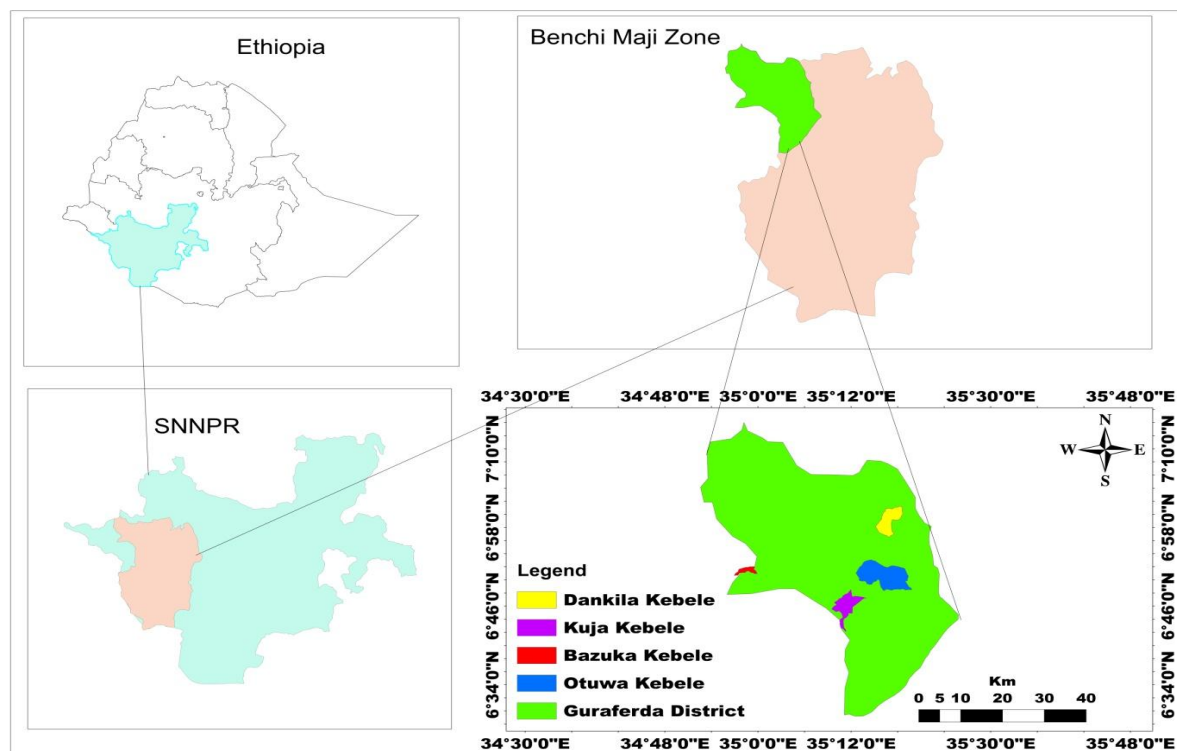


Figure 1. Study area map

The altitude ranges from 700 to 1995 meters above sea level. The mean annual rainfall is between 1500 and 2400mm. The average monthly temperature in the district is 29.5°C (Belay 2010). The dominant forest type in the district is *afromontane* rainforest with the main tree species *Combretum spp.*, *Oxytenanthera abyssinica* (A.Rich.) Munro, *Boswellia papyrifera*, *Lannea schimperi*, *Anogeisus leiocarpus*, and *Stereospermim kunthianumcham* (Demissew et al 1996).

The dominant soil type is *Nitisols* (Dewitte et al 2013). The livelihood is predominantly based on plough-based agriculture cash crops, rice, sorghum, maize, sesame and ground nuts, particularly settler people (Helamo and Tassew 2018). Farmers largely rely, especially native people, on the production of NTFPs such as honey, coffee, spices such as ginger, black pepper and *timiz*, medicinal plants, and generate significant income from forest goods and services.

Satellite Image Processing and Classification

Time series of remotely sensed Landsat Thematic Mapper (TM) and Operational Land Imager (OLI) images of 1990, 2000, 2010, 2021 have been downloaded from the United States Geological Survey (USGS) website, <https://earthexplorer.usgs.gov> to analyze and detecting the LULC changes in the study area (Table 1). The reason why images from these years were selected is based on the major political and social changes that occurred in the district. These are 1990/1991 the upcoming of FDRE government, and 2000 resettlement program organized by FDRE government was implemented starting from 2001 and 2010 the occurrence of very large-scale investment. Finally, in order to identify the current LULC changes, preferred to use 2021 as a reference year. To reduce the effect of cloud cover and seasonal variation, the dry season was selected to acquire satellite images so that a clear image could be obtained for the study area.

Therefore, it can be assumed that these years indicate important points in the dynamics of LULCC in the area. The Landsat image is a medium resolution image (30m) that is freely available and has been widely used for land use and land cover classification and urban land use observations (Das and Angadi 2021). These multi-dated Landsat images were imported into ERDAS IMAGINE 9.1 and Arc view GIS 3.2 software. The spatial and temporal dynamics of the different LULC classes were investigated using remote sensing data from the period 1990 to 2021, covering 31 years. The study period was divided into four-time intervals (1990–2000, 2000–2010, 2010–2021 1990–2021) based on the availability of reliable remote sensing data. In addition to Landsat satellite image, the field work was assisted by representatives from PAs and community leaders. Extensive walkthroughs were conducted in the study *kebeles*. The land classes were verified by field observation. Stratified random sampling techniques were used to collect GPS points.

Table 1: Description of the Landsat images

Satellite/ Sensor	Path/ Row	Acquisition date (yyyy/mm/dd)	Spatial Resolution (m)	Scene cover (%) cloud
Landsat-5/ TM	170/055	1990/03/03	30	4.00
	170/056	1990/12/16	30	2.00
	171/055	1990/11/21	30	4.00
	170/055	2000/03/14	30	6.00
	171/055	2000/03/21	30	15.00
	170/055	2010/02/06	30	6.00
	171/055	2010/01/28	30	14.00
Landsat-8/ OLI	170/055	2021/03/08	30	11.06
	171/055	2021/01/10	30	1.91

For satellite images, pre-processing on the raw image was carried out which are appropriate to the desired output must be applied to the imagery. These enhance the quality of the image data by reducing or eliminating various radiometric and geometric errors caused by internal and

external conditions. Radiometric and geometric correction of Landsat satellite images is usually referred to as preprocessing (Jensen 2015). Band selection and stacking, image mosaicking, and clipping of the imageries with the study boundary were performed. In the

band selection step, those bands which are suitable for identifying and differentiating between different land cover types were selected. These are blue, green, near-infrared, and short-wave infrared bands. As these bands are separate images, each in black and white color, it is difficult to identify the land cover types contained in the images. The image bands were combined into single image file to form multi-band image, which then help facilitate the land cover identification on the images. Since the study area has fallen in three Landsat scenes, mosaicking of these scenes were required so that full image covering the study area can be generated.

The second step is the processing in this step, the pre-processed images were classified into land use and land cover classes to form thematic layers. For doing this, a supervised classification technique was used. A supervised classification

technique aims at classifying land cover by training an algorithm with samples of material spectral signatures (Congedo 2021). Training sites were identified based on the information obtained from field visits, discussion with elders, and interpretation of the raw images and Google Earth image. The classification was performed using the maximum likelihood classifier as defined by Congalton (2001). Maximum likelihood (ML) algorithm is one of the most popular supervised classification methods which is based on the probability that a pixel belongs to a particular class by assuming that these probabilities are equal for all classes and that the input bands have normal distributions (Rawat & Kumar 2015). Accordingly, five LULC classes were distinguished (Table 2) namely, agriculture/settlement, natural forest, shrubs, grass, and coffee plantation.

Table 2: Description of Major LU/LC types identified in Guraferda District

LU/LC classes	Description
Forestland	This class describes areas with evergreen trees, mainly naturally. It consists of indigenous tree species and is managed only to a very limited degree, in which the native vegetation is largely conserved or reconstructed through successional processes (Wiersum 1997).
Shrub land	Areas covered with small trees, bushes, and shrubs, mainly ranging from closed canopy, to open canopy areas are considered shrublands (Bewket 2002).
Grassland	Grassland has naturally occurred areas which are predominantly covered with grass and some scattered trees and pastures are assumed as grassland (Bewket 2002).
Agriculture	This class describes land which is mainly used for growing crops. Crops on this land are rain-fed small-scale farmland and land used primarily for the production of food (Bewket 2002).
Coffee plantation	Plantation coffee is a form of commercial farming in which coffee crops were grown under selected trees

In classification process, accuracy assessment is the most important step. The aim of accuracy assessment is quantitatively to assess how successfully pixels were sampled into the true land cover classes. The process used to estimate the accuracy of image classification by comparing the classified map with a reference map. About 43, 49, 50, 33, 30 for agriculture, forest, coffee plantation, grassland and shrub land, respectively number of random ground truths points were used for verification of LULC classification outputs (Table 3). The general accuracy and Kappa analysis were calculated to assess the degree of classification accuracy

of the error matrix (Peesapati and Harinarayan 2015). Overall accuracy is the sum of correctly classified values (diagonals) divided by the total number of randomly generated reference values of the error matrix (Lillesand et al 2004). The Kappa coefficient, which measures the difference between the actual agreement of classified map and chance agreement of random classifier compared to reference data, was also calculated as: -

$$K_{hat} = \frac{N \sum_{i=1}^k X_{ab} - \sum_{i=1}^k (X_a \times X_b)}{N^2 - \sum_{i=1}^k (X_a \times X_b)}$$

Where: K_{hat} = Kappa coefficient; N is total number of values; $\sum_{i=1}^k X_{ab}$ is observed accuracy; $\sum_{i=1}^k (X_a \times X_b)$ is chance accuracy.

Table 3: Reference data for each land use/cover type for the study years

LULC classes	Number of Reference data							
	1990	%	2000	%	2010	%	2021	%
Agriculture	3	1.46	5	2.44	14	6.83	22	10.73
Natural forest	83	40.49	81	39.51	70	34.15	64	31.22
Shrub land	46	22.44	39	19.02	43	20.98	41	20.00
Grass land	73	35.61	80	39.02	70	34.15	67	32.68
Coffee plantation	-	-	-	-	8	3.90	11	5.37
Total	205	100	205	100	205	100	205	100

Post classification of maps were carried out using ArcGIS to compute change in the study area by cross tabulating combines of time intervals (1990 and 2000, 2000 and 2010, 2010 and 2021, 1990 and 2021). Transitions between different land uses and land covers were evaluated to measure the changes in areas between different land uses. The values of the changes between the dissimilar LULC classes were used for statistical analysis to reveal the amount of dynamics in the study areas. The rate of land use/land cover change computed using Puyravaud (2003) equation: -

$$r = \frac{1}{t_1 - t_2} \ln \left(\frac{A_2}{A_1} \right)$$

Where r is percentage of land use change per year and A_1 and A_2 are the amounts of land use type in ha at time t_1 and t_2 , interval year between initial and recent year respectively.

The author also used focus group discussion to obtain qualitative information from a predetermined and limited number of persons sharing a common feature. Four group discussions were undertaken one at each selected

kebele. Focus group interviews, and observation were conducted in four *kebeles* in the study area to acquire additional information on the long-year experience of land use and land cover practices of the district. This casual in-depth interview and intensive discussion were done with eight to ten participants. This is due to the long-time land use system of the individuals in the study area.

3. RESULTS AND DISCUSSIONS

3.1. Land Use and Land Cover Dynamics (1990 -2021)

The landscapes of the study area have a noticeable change in land use and land cover over the last 31 years. In 1990, forest was the dominant LULC, covering approximately 41.6% of the total area (249,057.5ha). The forest with small disturbances, dominated around the northeast and western parts of the district and the agricultural land covered approximately 0.64% found around the Middle Eastern part (Figure 2 and Table 4). However, analysis of four time periods (1990, 2000, 2010, and 2021) revealed that the expansion of agricultural land, but

during periods between 1990 and 2021, forest was still the dominant type of land use, although it declined coverage (Table 4). The coffee plantation was a newly introduced land use type since early 2010s with small coverage of 1.55% (249,057.5

ha) in the study area. In addition to remote sensing results, based on information from the focus group discussion and the administrative office of the district land, coffee plantation coffee investment started in the 2009/2010 in district.

Table 4: Area of land use and land cover (LULC) classes for the periods 1990, 2000, 2010, and 2021 in *Guraferda* in southwest Ethiopia.

LULC Classes	1990		2000		2010		2021	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
AL(ha)	1590.66	0.64	3881.16	1.56	15401.07	6.18	27000.18	10.84
FL(ha)	103693.41	41.63	99214.2	39.84	98076.24	39.38	90505.35	36.34
SHL(ha)	70528.14	28.32	56396.43	22.64	51750.09	20.78	33326.19	13.38
GL(ha)	73245.33	29.41	89565.75	35.96	79965.09	32.11	89308.08	35.86
CP (ha)	-	-	-	-	3865.05	1.55	8917.74	3.58
Total	249057.54	100	249057.54	100	249057.54	100	249057.54	100

AL= Agricultural land, FL = Forest land, SHL = Shrub land, GL= Grassland, CP= Coffee plantation.

Currently, approximately (36.34%) of the total area is covered by forest, followed by fluctuating coverage of grasslands (35.8%), while agriculture, shrublands, and coffee plantations occupy 10.8%, 13% and 3.6%, respectively (Table 4). Agricultural land, coffee plantation, and grass land area increased by 9.15%, 3.23 percent, and 0.64%, respectively, over the entire study period, while shrub land and forestland decreased by 0.43 percent and 2.42%, respectively (Table 5). This finding is consistent with the findings of (Gessese 2017; Gebreslassie 2014; Gessesse and Kleman 2007; Kassa et al 2017; Gete and Hurni 2001) on the expansion of agricultural land at the expense of forest and shrub land in southwest and central Ethiopia.

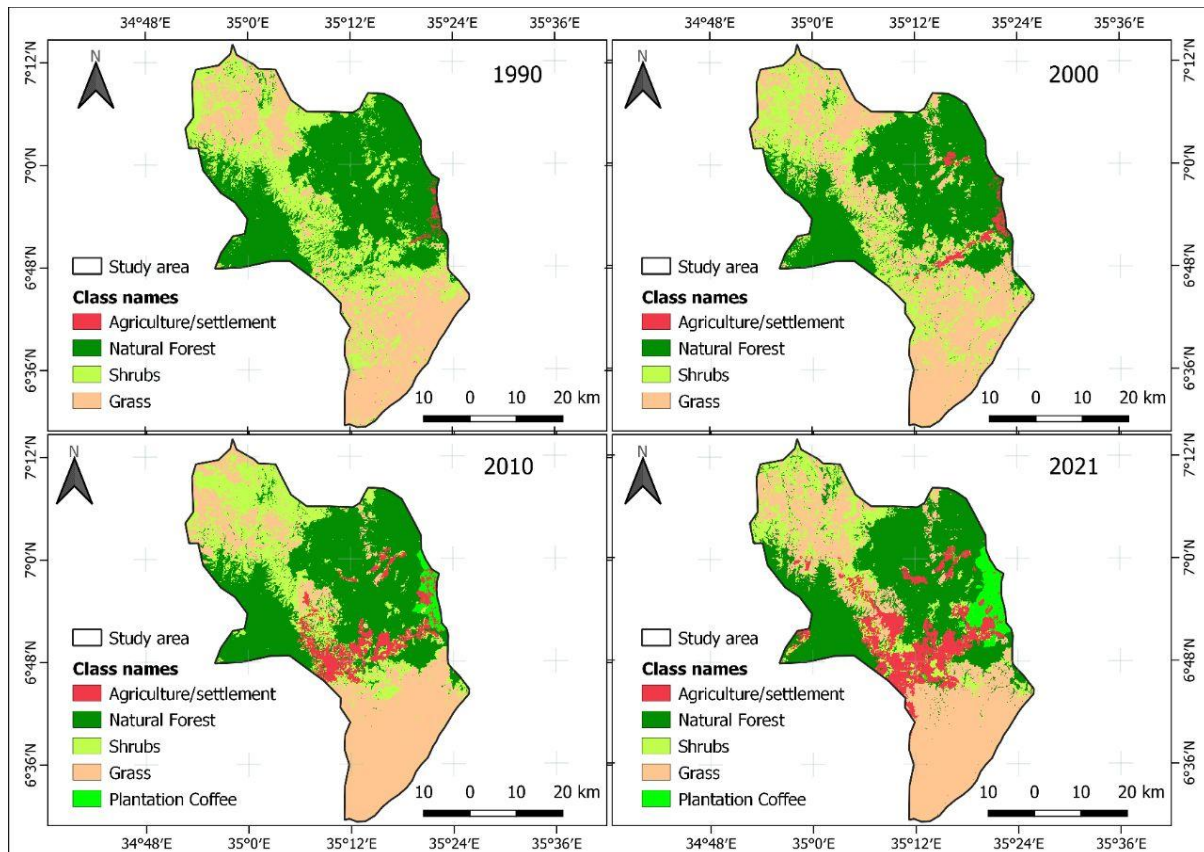


Figure 2. Land use land cover dynamics (1990, 2000, 2010 and 2021) in Guraferda district, southwest Ethiopia.

The rate and trend of land-use/land-cover change in the study area have indicated a significant change between the 1990 and 2021 periods. Agricultural land expanded at annual rate of 8.9% between 1990 and 2000. Similarly, the period between 2000 and 2010 shows faster expansion at a rate of 13.8 % per year. Between 2010 and 2021, agricultural land increased at a minimal rate of 5% per year than before. The agricultural area increased with a rate of 9.15% extremely higher than any other type of land use and land cover between 1990 – 2021 time intervals. In the study area expansion of agricultural land corresponding with large scale agricultural farming, settlement and resettlement program were conducted by *Derg* and FDRE regime (Kassa et al 2017).

Coffee plantation was a newly introduced land use type around the 2010s that occupied only 1.5% (3,865.05 ha) in 2010, has shown a dramatic increase and reached 3.58% (8,917.74 ha) of the total area in 2021. Coffee plantation land expanded at a rate of 10%, 7.6% and 3.23% per annum in periods 2000–2010, 2010–2021 and 1990–2021, respectively. Large scale plantation of coffee and other commercial agriculture (e.g., black pepper, cereal crop, and rubber production) were expanded in area through destroying of natural forest. Due to this coffee plantation area has increased by 287.7ha per annum during last years. The rapidly growing domestic food demand and large-scale plantation of coffee at the expense of the natural forest (Kassa et al 2017).

Table 5: LULC changes for the periods 1990-2000, 2000-2010, 2010-2021, and 1990-2021

LULC Classes	Annual rates of change				Change in area (%)			
	1990-20	2000- 10	2010-21	1990-21	1990-20	2000-10	2010-21	1990-21
AL(ha)	229.05	1,152	1,054.5	820	8.9	13.8	5.1	9.15
FL(ha)	-448	-113.8	-757.1	-425	-0.44	-0.12	-0.73	-0.43
SHL(ha)	-1413	-464.6	-1,675	-1,200	-2.24	-0.86	-4	-2.42
GL(ha)	1,632	-960	849.4	518.2	2	-1.13	1	0.64
CP (ha)	-	386.5	459.4	287.7	-	10	7.6	3.23

AL= Agricultural land, FL = Forest land, SHL = Shrub land, GL= Grassland, CP= Coffee plantation.

Currently, the district forest was remnant moist *Afro-montane* forests, dense forest were common on the landscapes in 1990 (Figure 2). Landscape forest cover was reduced with in three decades from 41.63 % to 36.3%) in periods between 1990 and 2021 (Table 4 and Figure 2). In the same period, shrublands that account for about 13.4% (33326.19 ha) were reduced from 28.3% to 13.4% of area coverage. The highest rate of deforestation recoded in two periods, 1990–2000 and 2010-2020, at the rate of 448 and 757 ha per year, respectively (Table 5). Shrub land increased sustainably with rates exceedingly higher than any other land use and land cover type in the same time periods (Table 4 and 5). Shrub land expanded at a rate of 1413, 464.6, 1,675 and 1,200 ha per annum in periods 1990 - 2000, 2000- 2010, 2010 -2021 and 1990 – 2021, respectively (Table 5). During the period (1990 - 2000), intensive settlement and population pressure induced expansion of agricultural land in the period between 2010-2021 large-scale commercial investments were the causes for extensive

reduction of forest and shrub land in the area. Reduction of the area under forest and shrub land and, conversely, increase in the area under agricultural land in Ethiopia (Gebreslassie 2014; Gessesse and Kleman 2007; Gessese 2017; Nigussie 2016; Zeleke and Hurni 2001). The overall accuracy of the classified images was 87.32%, 84.88%, 84.88% and 86.34% was achieved for the Landsat TM of 1990, 2000, 2010 and OLI 2021 with kappa statistics of 0.809, 0.774, 0.789 and 0.814 respectively (Table 6). According to Lillesand et al (2004), the classification of the image with the value > 80% overall accuracy and Kappa statistics was satisfactory.

Land Use/Land Cover Change Matrix

Conversion matrixes were analyzed for each period to show the source and destination of the major LULC classes. Analysis of conversion matrix was computed by overlaying classified images of two study years on ERDAS 9.1.

Table 6: Error Matrixes of Image Classification

	Year: 1990					
Classification	Agriculture/settle ment	Fore st	Shru bs	Gras s	Row Total	User Accuracy (%)
Agriculture	2	1			3	66.67
Forest		79	4		83	95.18
Shrubs	1	3	38	13	55	69.09
Grass			4	60	64	93.75

Column Total	3	83	46	73	205	
Producer Accuracy (%)	66.67	95.18	82.61	82.19		
Overall accuracy (%)	87.32					
Kappa Coefficient	0.809					

	Year: 2000					
Classification	Agriculture/settlement	Forest	Shrubs	Grass	Row Total	UA (%)
Agriculture	5			1	6	83.33
Forest		81	1		82	98.78
Shrubs			30	21	51	58.82
Grass			8	58	66	87.88
Column Total	5	81	39	80	205	
Producer Accuracy (%)	100	100	76.92	72.50		
Overall accuracy (%)	84.88					
Kappa Coefficient	0.774					

	Year: 2010						
Classification	Agriculture/settlement	Forest	Shrubs	Grass	Coffee	Row Total	UA (%)
Agriculture	11					11	100
Forest		69	6	2		77	89.61
Shrubs	2	1	31	13		47	65.96
Grass	1		6	55		62	88.71
Coffee					8	8	100
Column Total	14	70	43	70	8	205	
Producer Accuracy (%)	78.57	98.57	72.09	78.57	100		
Overall accuracy (%)	84.88						
Kappa Coefficient	0.789						

	Year: 2021						
Classification	Agriculture/settlement	Forest	Shrubs	Grass	Coffee	Row Total	UA (%)
Agriculture	19			1		20	95
Forest		62	7			69	89.86
Shrubs	3	1	23	4		31	74.19
Grass			10	62		72	86.11
Coffee		1	1		11	13	84.62
Column Total	22	64	41	67	11	205	
Producer Accuracy (%)	86.36	96.88	56.10	92.54	100		

Overall accuracy (%)	86.34
Kappa Coefficient	0.814

Throughout the period, conversion of forest and shrublands to agricultural land was significant conversion compared to other types of LULC types (Tables 7). During the 1990-2020 period, forestland and shrublands were also important sources of land for the expansion of agricultural land. The result of this study showed that important part of the landscapes in the study area change in land use and land covers. Agricultural land expansion, the most prominent phenomenon, is most associated with large-scale decline in forest and shrub lands. According to the change detection matrix in 1990 to 2021 through the previous 31 years, agriculture was displayed a continuous increment at the expense of forest and shrub land. During this period, LULC changes detected in the study area revealed the greater areas of forest and shrub land were sourced and changed to agricultural land/settlement and

plantation coffee LULC (Tables 7).

Between 1990 and 2021 year, deforestation were high, 21,800.5 ha of forestlands were mainly converted to agricultural land and plantation coffee LULC classes. Similarly, 50885.9 ha of shrub land was mostly converted to grassland and agriculture LULC classes whereas, 13277 ha of grassland changed to shrub land and agriculture LULC classes. Agriculture replaced approximately 26627.3ha of the land that used to be covered by other types of LU / LC. The major conversions were to shrubland (15921ha) and forest land (7409.7 ha) type (Tables 7). This is possibly a different trend in that most studies pointed out agricultural land expansion at the expense of forestland and shrub land in most parts of Ethiopian (Gessesse and Kleman 2007; Minta et al 2018; Zeleke and Hurni 2001).

Table 7: Conversions between major (LULC) between 1990 and 2021, *Guraferda* southwest Ethiopian.

Land use/ land cover class	AL(ha)	FL(ha)	SHL(ha)	GL(ha)	Total (ha)	
1990 - 2000						
AL(ha)	946.8	402.75	150.12	90.99	1590.66	
FL(ha)	1434.06	94338.1	5405.49	2515.77	103693.41	
SHL(ha)	1456.65	4217.31	31084	33770.16	70528.14	
GL(ha)	43.65	256.05	19756.8	53188.8	73245.33	
Total (ha)	3881.16	99214.2	56396.43	89565.75	249057.54	
2000 - 2010						
	AL(ha)	FL(ha)	SHL(ha)	GL(ha)	CP (ha)	Total (ha)
AL(ha)	2187	235.53	447.57	16.38	994.68	3881.16
FL(ha)	2268.99	89743.7	3413.52	925.02	2863	99214.2
SHL(ha)	5511.87	5944.68	22853.5	22079.52	6.84	56396.43
GL(ha)	5433.21	2152.35	25035.48	56944.2	0.54	89565.75
Total (ha)	15401.07	98076.24	51750.09	79965.09	3865.05	249057.54
2010 - 2021						
AL(ha)	11763.27	326.25	1436.94	289.98	1584.63	15401.07
FL(ha)	4770.09	83113.5	4599.54	2008.35	3584.79	98076.24
SHL(ha)	7889.22	5239.08	17425	21068.82	127.98	51750.09
GL(ha)	2354.49	1816.74	9853.83	65938.1	1.98	79965.09
CP (ha)	223.11	9.81	10.89	2.88	3618.4	3865.05
Total (ha)	27000.18	90505.35	33326.19	89308.08	8917.74	249057.54
1990 - 2021						
AL(ha)	372.87	42.66	57.33	91.71	1026.0	1590.66
FL(ha)	7409.7	81892.9	4399.02	2422.17	7569.6	103693.4
SHL(ha)	15921.1	7817.85	19642.2	26825.9	321.03	70528.14
GL(ha)	3296.52	751.95	9227.61	59968.3	0.99	73245.33
Total (ha)	27000.18	90505.35	33326.19	89308.08	8917.7	249057.5

Note: AL= Agricultural land, FL = Forest land, SHL = Shrub land, GL= Grassland, CP= Coffee plantation. The row of the table stands for the final year, and the column of the table symbolizes the initial year of the change. The diagonal numbers in bold show the unchanged area.

4. CONCLUSIONS

Time-series analysis extracted from remote sensing data revealed a significant change in LULC in *guraferda* southwest Ethiopian. Land use/land cover dynamics in southwest Ethiopia, involve large-scale expansion of agricultural land at the expense of natural habitats (forest land, grazing land and shrub land), is the most important change that reflects a well-known human influence on natural resources. These changes are driven by

agricultural expansion strategies of the government (policy environments), which support conversion of forest land to large-scale commercial agricultural, such as coffee plantation. On the other hand, the changes were driven by the farmers' choices; As the fertility / productivity of the clop land fertility/productivity decrease, farmers try to have new arable land by clearing natural vegetation in the study area. Therefore, better use of prevailing land resources needs appropriate land use policy improvement

and strategic planning that ensure both economic gain and environmental welfares.

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