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Land Use Land Cover Change Trend and Its Drivers in Somodo Watershed South Western, Ethiopia

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Land use land cover (LULC) dynamics are a widespread, accelerating, and significant process driven by human actions. LULC changes analysis is one of the most precise techniques to understand how land was used in the past, what types of changes are to be expected in the future, as well as the forces and processes behind the changes. This study was carried out to evaluate the historical and future trends as well as driving forces of LULC changes in Somodo watershed South Western, Ethiopia. It was accompanied using satellite image of Landsat5 TM 1985 and 1995, Landsat7 ETM+ 1999, 2005 and Landsat8 OLI/TIROS 2017. In addition, field observations, Key informant interview (KII) and Focus Group Discussion (FGD) were also conducted. ERDAS Imagine 9.1, QGIS 2.18 and IDRSI Selva 17.00, software were used for satellite image processing, map preparation, and LULC change prediction respectively. During the 32 year period between 1985 and 2017, the proportion of area covered by forest and agriculture was decreased by 60.57 ha (12.7%) and 5.22 ha (1.1%) respectively. In contrast, home garden Agroforestry/settlement and grassland were increased by 49.77 ha (7.5%) and 16.02 ha (6.7%) respectively. If the existing rate of LULC change lasts, in 2029 agriculture and forestland are predicted to increase by 91.24 ha and 20.52 ha respectively, while grassland and home garden Agroforestry/settlement are predicted to decrease by 99.97 ha and 11.79 ha respectively. LULC change in the study area is an outcome of several proximate and underlying drivers. The major proximate driving forces of LULC change in the watershed are illegal logging and fuel wood extraction, Expansion of plantation, expansion of settlement, agricultural expansion, and construction of infrastructures. Demographic, Economic, Technological, Institution and policy, and Biophysical factors constitute the major underlying drivers of LULC change in the study area. Population growth is the major underlying cause for LULC change in the study area. Then, Participatory Forest Management through plantation and community nursery expansion is required for forest cover improvement in the watershed. This study also suggests further study on the impact of LULC change in the area.

Key words: Drivers, geographic information system (GIS), Land use/Land cover Change prediction, Somodo Watershed.

INTRODUCTION

Throughout the course of human history, the land has been tightly attached to economic, social, infrastructure and other human activities (Lambin et al., 2003). Land use and land cover (LULC) are distinct yet closely linked characteristics of the Earth's surface (Solomon, 2016). Land use describes the way and the purposes for which human beings employ the land and its resources (Alemayehu et al., 2009).

While land cover refers to the ecological state and physical appearance of the land surface (such as Closed forests, woodlands or grasslands) (Mwavu and Witkowski, 2008). Land use/cover is a composite term, which includes both categories of land cover and land use (Ioannis and Meliadis, 2011). The land use/cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by the man in time and space (Zubair, 2006).

Land cover change occurs through conversion and intensification by human intervention, altering the balance of an ecosystem, generating a response expressed as system changes (Dale, 1997). For centuries, humans have been altering the earth’s surface to produce food through agricultural activities (Assefa, 2012). In the past few decades, conversion of grassland, woodland, and forest into cropland and pasture has risen dramatically, especially in developing countries where a large proportion of human population depends on natural resources for their livelihoods (FAO, 2005). The increasing demand for land and related resources often results in changes in land use/cover (Assefa, 2012) and it has local, national, regional and global causes (Olson et al., 2004). Land use/cover dynamics are widespread, accelerating, and significant process driven by human actions (Leh et al., 2011) but also producing changes that impact humans (Agarwal et al., 2002).

Factors driving LULC change include an increase in human population and population response to economic opportunities (Lambin et al., 2001). Population growth is a major driving force in land cover change and contributes to resource degradation (Woldamlak, 2002). Deforestation and forest degradation have been influenced by a combination of underlying driving forces, including unclear land tenure, poor economic conditions, population growth, market (wood extraction), and socio-political factors (Bekele, 2003; Dessie and Christiansson, 2008). On top of the rapid change in LULC of forestland, grazing land or bushlands to cultivated lands is becoming a common practice in most parts of Ethiopia (Amanuel and Mulugeta, 2014).

Other important drivers of LULC change includes policies related to human settlement and land tenure (Murphree and Cumming, 1993) and agricultural (Reed, 1996); changes in technology (Grübler, 1994), culture (Rockwell, 1994) and political or socio-economic institutions (Midagso, 2008). The size of Ethiopian population was 40 million in 1984, 53.4 million in 1994, 73.7 million in 2007, 84.2 million in 2012, 85.89 million in 2013 as projected by (CSA), this population become nearly 100 million in 2015 (BTI, 2016). Rain fed agriculture is the major economic activity of the country providing employment for over 85 percent of the population (Devereux, 2000). Ethiopia's forests have suffered severe deforestation and degradation from an increased demand for fuel wood, construction wood, and cropping and grazing land (Wogayehu, 2003).

Understanding the dynamics and driving forces behind LULC changes at the local level is fundamental to development planning, and the analysis of land-related policies (Tekle and Hedlund, 2000), and understanding of possible future choices (de Sherbinin, 2002). LULC changes have increasingly become a key research priority for national and international research programs examining global environmental change and impact analysis of the changes, which is a standard requirement for land use planning and sustainable management of natural resources as highlighted by many researchers (Petit et al., 2001). Determining the effects of LULC changes on the ecosystem requires knowledge of past land use practices, current LULC patterns, and future projections (Woldamlak, 2002). LULC changes studies are proven essential for the qualification and quantification of central environmental processes and environmental change (Verburg et al., 2002). It is also vital for the influence of environmental management on biodiversity, water budget, radiation budget, trace gas emissions, carbon cycling, livelihood (Verburg et al., 2002), urban and rural agricultural land use (Lambinet al., 2003); Muzein, (2008), and a wide range of socio-economic and ecological processes (Ozbakir et al., 2007). Which on the aggregate affect global environmental change and the biosphere (Fashona and Omojola, 2005).

LULC changes can affect biodiversity, biogeochemical cycles, soil fertility, hydrological cycles, energy balance, land productivity, and the sustainability of environmental services (Lupo et al., 2001). Hence, there is a need for continuous monitoring of the changes and prediction (Kindu et al., 2013). It is so pervasive that when aggregated globally, it significantly affects the functioning of the earth's systems directly contributing to climate change (Lewis, 2006). LULC changes result in soil erosion and the formation of gullies, which are among the major cause of land degradation (Selamyihun, 2004). The highest average rates of soil loss are from previously cultivated lands, which are presently unproductive because of degradation and improper land use (Midagso, 2008).

Land through inappropriate agricultural practices, high human and livestock population pressure have led to severe land cover change. In Ethiopia, also most population lives in rural areas and depends directly on land for their livelihood (Tesfaye et al., 2014). The heavy dependence of households on woody biomass fuel (Kalkidan et al., 2017). As a result, soil erosion,

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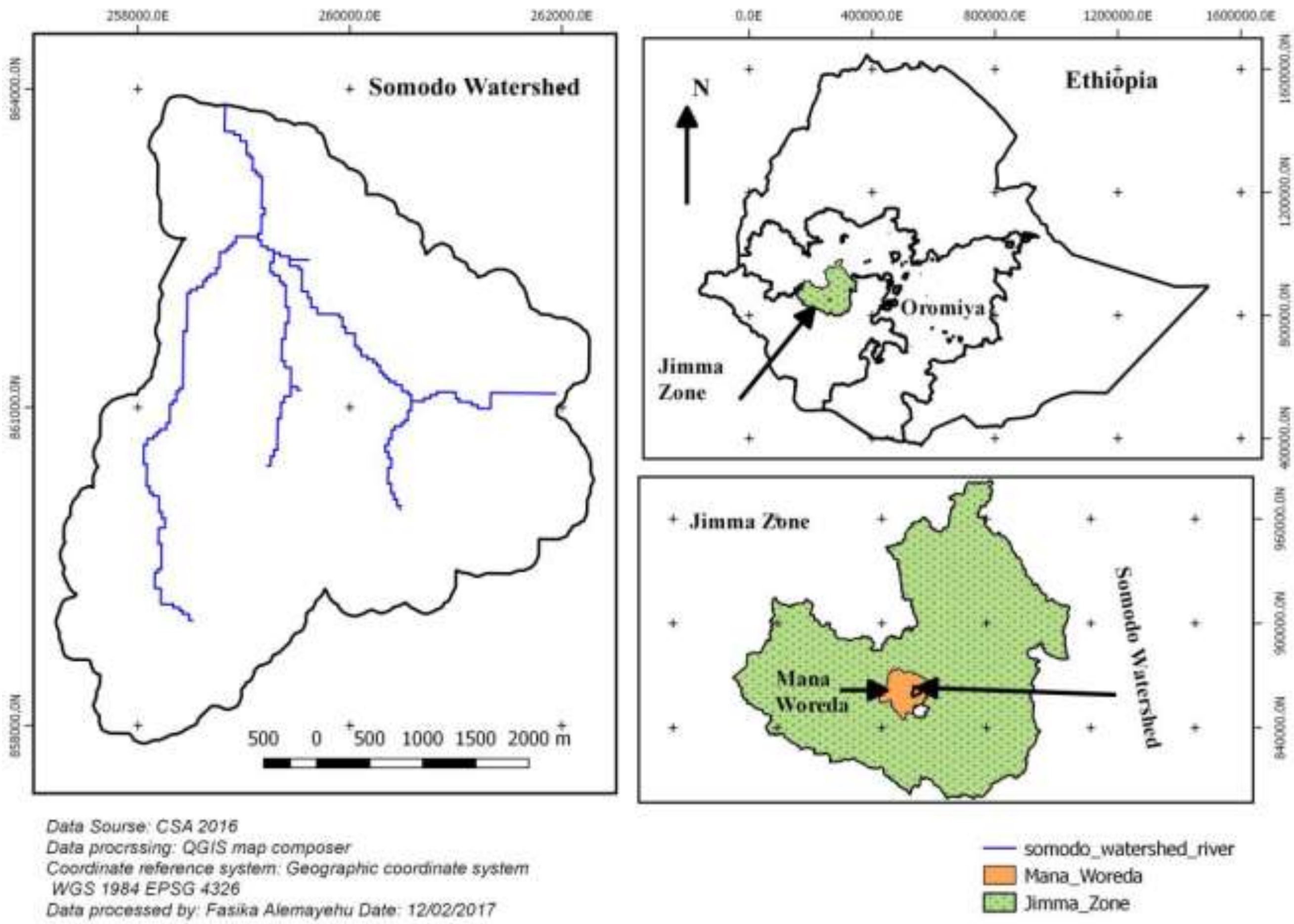

Figure 1. Study area map of Somodo Watershed.

biodiversity loss, and land degradation occur in the study area. Soil erosion will again lead to loss of groundwater due to poor infiltration capacity and washed away of the soil nutrient and desertification will occur. This all will contribute to low productivity leading to poverty.

Therefore, a systematic analysis of LULC change is so crucial to exactly comprehend the extent of the change. Studies of LULC changes in Ethiopian highlands concentrate in the Northern Ethiopian highlands areas early settled and where population pressure is relatively high (Belay, 2002). There have been very limited studies LULC change and driving forces in the southwestern regions of the country. Even if there are a few studies conducted in Southwestern Ethiopia, there is no study on land use land cover change in Somodo watershed. LULC change is basic data on the extent and trend in the study area that would help for planning and the adoption of sustainable land management practices. In addition, it help to understand the extent and the trend of LULC changes dynamics and its impact on communities' livelihood. Such studies are scanty in the present study area. Therefore, this study is mainly aimed to analyze the trend and driving forces of land use land cover change in the watershed.

MATERIALS AND METHODS

Description of the study area

Somodo watershed is located at the upper part of Didessa catchment in Blue Nile river basin in Jimma zone, Mana district/woreda, Southwestern part of Ethiopia. It lies between 7o46'00'' - 7o47'00''N latitude and 36o47'00''-36o48'00''E longitude with altitude ranging from 900- 2050m a.s.l. (Figure 1). ManaWoreda is located 368 km southwest of Addis Ababa and 20 km west of Jimma town. The Somodo watershed covers 1848 ha, the dominant soil is Nitisol, and about 68% of the watershed soil is extremely acidic (Kalkidan et al., 2017).

Method and data acquisition

Both primary and secondary data were used for the work. The fieldwork was started with a reconnaissance visit to the study area and followed by primary data collection. During reconnaissance survey, ground information was acquired, in order to define the nature of the ground covers such as Natural forest, Plantation forest, grassland, cultivated land, home garden Agroforestry, and settlement. Field samples from each land use type were collected using GPS. The history of each land use type was collected from local peoples by focus group discussion and key informant interview in the study area.

Secondary data, spatial and written information (Maps and reports, respectively), were acquired through downloading from freely available institutional web pages like United States Geological Survey (USGS) and Global Land Cover Facility (GLCF) websites. The DEM was acquired from USGS and used to create the watershed boundary, using the GRASS GIS module available in QGIS as plugins. The secondary data was collected from satellite imageries, which were selected based on political and social changes; such as 1985, the upcoming of Derg regime and the occurrence of large-scale investment and settlement; 1995, the upcoming of FDRE; 1999/2000-2005, and the starting of ADLI (agricultural development led industry); 2016/2017, starting of GTP-2 to look into the outcome of GTP-1.

Four major LULC types were identified by using the field data and satellite images of Landsat TM, 1985 and OLI, 2017. Rivers, streams, and springs were not included in the classification because of the low resolution of the images (30 m). In the classification, the class forest included plantation forest, riverine forests, and dry evergreen forest. Definition of each land use land cover is described in Appendix Table 12. This is because as they had the same spectral nature on the images, it was difficult to differentiate one from the other.

Data analysis

Satellite image analysis

The geographical positioning system (GPS) is used to take control (ground truth) points; ERDAS Imagine 9.1 was used for image processing and classification. QGIS 2.18 Software was used for GIS raster and vector data analysis and mapping. IDRSI Selva 17.00 was used for prediction of LULC change. IBM SPSS 20 was used for socio-economic data analysis and graph preparation.

Satellite imageries of 1985, 1995, 1999, 2005 and 2017 were downloaded from USGS and GLCF (http://earthexplorer.usgs.gov/). These images were already orthorectified using ground control points and digital elevation model (DEM) data to correct for relief displacement. The satellite image data were imported to Erdas Imagine 9.1 image processing software to create a layer stack for each year. The Coordinate Reference System of all images was UTM Zone 37 with the WGS84 datum. Image subsetting and image enhancement (histogram equalization) techniques were applied to the raw TM, ETM+, and OLI Landsat images.

The unsupervised classification was performed before and during the fieldwork to understand the general land cover classes of the study area. After fieldwork, maximum likelihood supervised classification was applied on Erdas imagine 9.1 using training sites. Training sites for the recent image (OLI/TIRS) were defined by using ground truth points collected from the field. For the old images (TM and ETM+), training sites were defined by using a spectral value of a recent image, result of unsupervised classification, ancillary data (Google earth) and information obtained from elder individuals. Totally, of 200 Ground Truth Points collected during the fieldwork 40% or 80 Ground Truth Points (20 from each LU/LC types) were used to support classification of recent year image (OLI/TIRS), while the remaining 60% (120 Ground Truth Points) were used for classification accuracy assessment of the 2017 image. The image classification was carried out to produce land cover layer through a supervised image classification method applying the training samples created using the field data and interoperation of the images (Google earth and stacked images for the different years).

Accuracy assessment

For classification accuracy, assessment error matrix was produced for all images in this study. GPS points used in the classification accuracy assessment were independent of ground truth points used in the classification. According to Anderson et al. (1976), the recommended standard of accuracy in the identification of LULC change mapping from the remote sensing data should be 85 to 90%. The Kappa coefficient was also used to assess the classification accuracy (Peesapati and Harinarayan, 2015). It expresses the proportionate reduction in error generated by a classification process compared with the error of a completely random classification (Congalton, 1991). The Kappa statistic incorporates the off-diagonal elements of the error matrices (that is, classification errors) and represents agreement obtained after removing the proportion of agreement that could be expected to occur by chance.
The overall accuracy and Kappa statistics is calculated by using (Jensen, 2003) formula as follows:

Overall accuracy = Number of pixels correctly classified/ Total number of pixel

Kappa (Kˆ): It reflects the difference between actual agreement and the agreement expected by chance and estimated as:

$$\hat{K} = \frac{Po - Pe}{1 - Pe}$$

Where Po = proportion of correctly classified pixels and determined by diagonal in error matrix; Pe = proportion of correctly classified pixels expected by chance and incorporates off-diagonal.

LULC change detection analysis

LULC change detection analysis was computed in three different ways:

1) Total LULC change in hectare calculated by as:

Total LULC = Area of a final year - Area of initial year

Positive values suggest an increase whereas negative values imply a decrease in extent.

2) Percentage LULC change calculated using the following equation:

$$\text{PercentageofLULC} = \frac{\text{Area of a Final Year} - \text{Area of Initial Year}}{\text{Area of Initial Year}}$$

3) An annual rate of LULC change: computed using the following simple formula

$$r = \frac{Q2 - Q1}{t}$$

Where: r, Q2, Q1, and t indicates the rate of change, recent year LULC in ha, initial year LULC in ha and interval year between initial and recent year respectively.

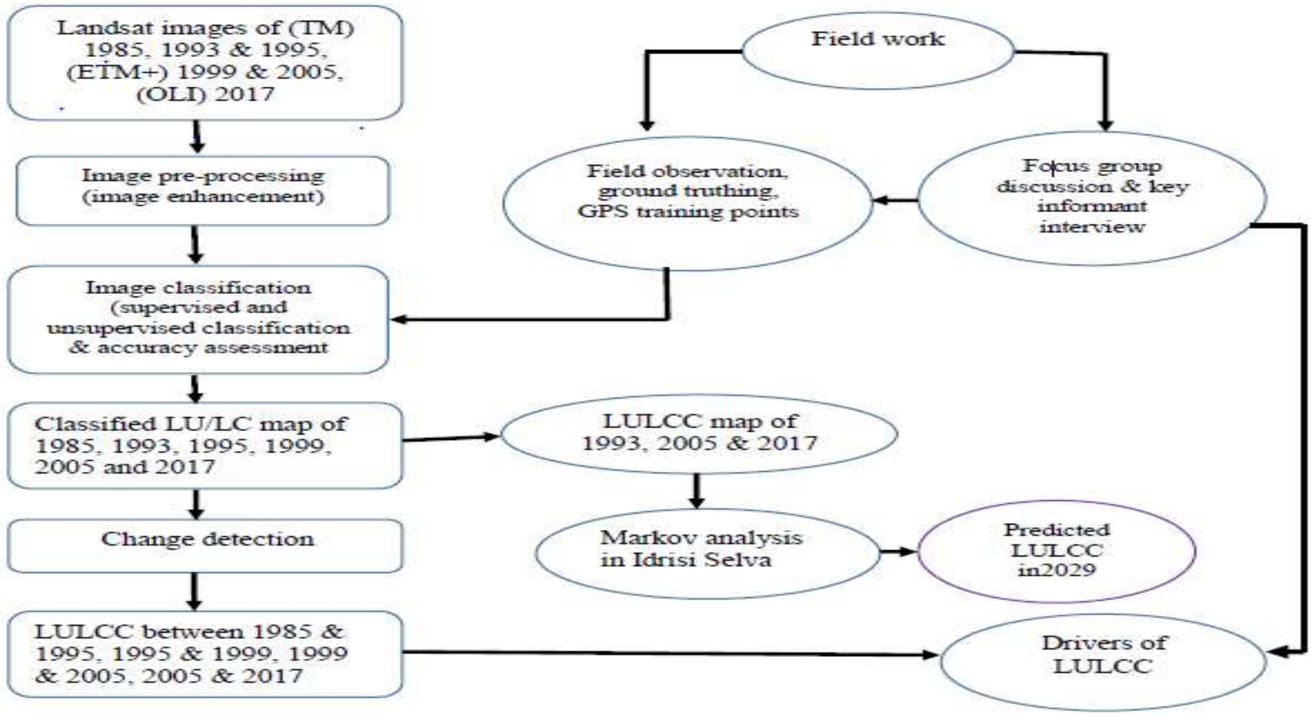

Figure 2. A flowchart that shows the general methodology of this research.

LULC change modeling

For this study, the Markov Chain Model (MCM) implemented in IDIRIS Selva were used to predict LULC change for the year 2029. Conversion matrixes were analyzed for each period to clearly show the source and destination of the major LULC changes. Analysis of conversion matrix was computed by overlaying classified images of two study years on ERDAS image 9.1. MCM provides a transition probability matrix, a transition areas matrix and a set of conditional probability images.Prior to predicting future LULC in 2029 the predictive power of the model was first validated by predicting the LULC for the year 2017. Accordingly, the LULC for the year 2017 was predicted considering the LULC map of 1993 and 2005. Then the predicted LULC areas of 2017 were compared with the actual areas interpreted from 2017 satellite image and the result was tested with the actual values using Chi-square (X^2) test with 0.05 error under 95% confidence interval. After validating the performance of the model, a real "prediction" for the year 2029 was carried out. LULC change maps for the year 2005 and 2017 were used to predict the land requirement in 2029. The year 2029 is selected for prediction since Markov chain model requires the same time interval between base year (2017) and predicted year (2029) to be equivalent with the time interval between the initial year (2005).

General methodology applied

Landsat imageries were downloaded from Geological Survey (USGS) and Global Land Cover Facility (GLCF) for the specified years and pre-processed using ERDAS IMAGINE 9.1 and classified through supervised and unsupervised image classification system with the help of QGIS. Accuracy analysis of classified image was performed using Kappa coefficient and LULC change detection between 1985, 1995,1999, 2005 and 2017 was done. With the help of Markov analysis in Idrisi Selva LULC in 2029 were projected. In addition, major causes and drivers of LULC change were assessed through focus group discussion and key informants interview (Figure 2)

RESULTS AND DISCUSSION

Land use/Land covers of the study area

Overall accuracy for the five years land use/ land cover classification of this study was 87.33, 92.00, 94.00, 88.00 and 88.00% for the respective years of 1985, 1995, 2005, and 2017 with kappa coefficient or statistics of 0.8208, 0.8781, 0.9101, 0.8289 and 0.8303 (Appendixes 2) respectively. In 1985 HG agroforestry/settlement were the dominant LULC types with the area of 663 ha. By 2017 these LULC types were dominantly increased to 713 ha (Table 1).

LULC analysis from the Landsat imagery of TM and ETM+ showed that starting from the mid-1980s to mid-2000s agricultural land continuously increased. However, in the year 2005, this land use type decreased. Agricultural land accounted for 472 ha (26%), 519 ha (28%) and 567 ha (31%) of the total area of Somodo watershed in the years 1985, 1995 and 1999 respectively (Table 1). However, LULC analysis from the ETM+ imagery of 2005 indicated that the area coverage of grassland and forestland were increased as compared to their previous area coverage. Forestland covered about 414 ha (22%) of the study area in 2017 (Table 1).

In contrast, during the same period, home garden agroforestry/settlement covered 713 ha (39%) of the

Table 1. Areas of LULC types in Somodo watershed (1985 – 2017).

LULC category	1985		1995		1999		2005		2017	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Agriculture	472	26	519	28	567	31	396	21	466	25
Forest	474	26	377	20	362	20	401	22	414	22
Grass	239	13	112	6	63	3	330	18	255	14
Home garden Agroforestry	663	36	839	45	856	46	721	39	713	39

Table 2. Rate and percentage change of LULCs in Somodo watershed.

LULC category	1985-1995		1995-1999		1995-1999		2005-2017		1985-2017	
	Rate (ha/yr)	%	Rate (ha/yr)	%	Rate (ha/yr)	%	Rate (ha/yr)	%	Rate (ha/yr)	%
Agriculture	47.7	10.1	47.7	9.2	-170.73	-43	70.11	17.7	-5.22	-1.1
Forest	-97.2	-20.5	-15.48	-4.1	39.51	9.8	12.6	3.2	-60.57	-12.7
Grass	-126.81	-53.2	-48.96	-43.8	266.85	80.9	-75.06	-22.8	16.02	6.7
Agroforestry	176.31	26.6	16.74	1.9	-135.63	-18.8	-7.65	-1.1	49.77	7.5

study area. On the other hand, during the entire study periods starting from 1985 to 2017, the smallest portion of the land in the study area was covered with grassland (Table 1). Grassland accounted for 239 ha (13%), 112 ha (6%), 63 ha (3%), 330 ha (18%) and 255 ha (14%) of the total area of Somodo watershed in the years 1985, 1995, 1999, 2005 and 2017 respectively. On the map of 1985, home garden agroforestry/settlement land predominates and followed by forestland, agriculture land, and grassland of the total area coverage. In 2017 home garden agroforestry/settlement land, still dominate the coverage followed by agriculture land.

The trend of LULC change in Somodo Watershed

Somodo watershed experienced different LULC changes between 1985 and 2017. The area of forestland, agricultural land, home garden agroforestry/settlement and grassland showed a fluctuating trend between the study periods (Figure 4). Forestland showed the largest decline with a rate of 60.57 ha and Home garden agroforestry/settlement showed the highest increase inclining by an estimated 49.77 ha in the period from 1985 to 2017 (Table 2).

In the period between 1985 and 1995 the land under Agriculture increased by 47.7 ha (10.1%) and the land under home garden Agroforestry/settlement increased by 176.31 ha (26.6%), while forestland decreased by 97.2 ha (20.5 %) and grassland decreased by 126.81 ha (53.2%) (Figure 4 and Table 2). As reported from discussion and interview with focus groups and key informants the rise of agriculture and home garden Agroforestry with the settlement between 1985 and 1995 was linked with resettlement program from other areas and the influx of illegal migrants during the Derg regime around 1985. As stated by FGDs and KIIs the enormous reduction of vegetation between 1985 and 1995 was during the transitional period (1990/1991). It is for the reason that during this transitional period, the new government was not settled well and no one was in charge of protecting the natural resources of the country.

The efforts to improve agricultural systems by the Derg regime similarly played a great role in the expansion of agriculture. Following the end of the battle, local peoples participating in the battle were returned to their previous area and consequently cleared the forest and convert grasslands into agriculture and home garden agroforestry to satisfy their livelihood necessities. The result for the second period (1995-1999) indicated that the land under forest and grassland continued to decrease by 15.48 ha (4.1%) and 48.96 (43.8%), the land under agriculture and home garden agroforestry/settlement continued to increase by 47.7 (9.2%) and 16.74 (1.9%). The increment of agriculture during this period is due to the starting of ADLI around 1999/2000. The reason for other LULC types changes are due to the same reason with the second period as the gap between 1995 up to 1999 is 4 years too short for other changes to come.

The result for the third period (1999-2005) indicated that the land under forest and grassland increased by 39.51 ha (9.8%) and 266.85 ha (80.9%) respectively as compared to the second period (1995 - 1999). During this period grassland was increased at the expense of other LULC categories mainly agriculture and HG agroforestry/ settlement. This is due to that after the high conversion of

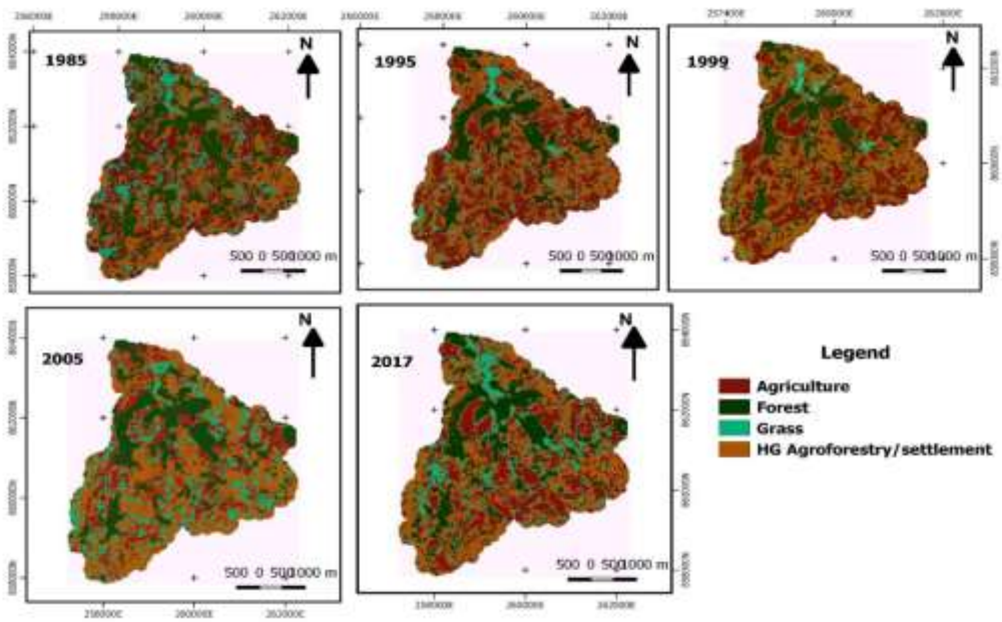

Figure 3. Map of LULC types of Somodo watershed produced based on satellite images obtained from USGS and GLCF.

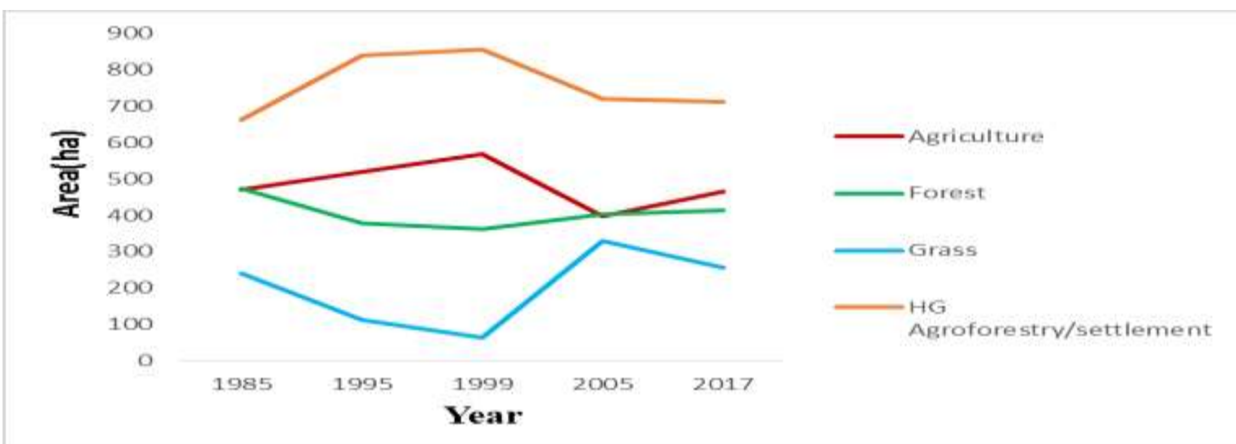

Figure 4. The trend of LULC change in Somodo watershed.

forestland into agriculture the land becomes degraded and soil erosion occurred. Therefore, that to regenerate the soil fertility and to get more yields from the cropland, conversion of agriculture into grassland were done by fallowing the land for some years. On the other hand, agriculture and home garden agroforestry/settlement decreased in the third period due to the occurrence of soil erosion and the following of croplands.

Increase in forest resource during this period linked todifferent factors. The foremost reason is integrated and participatory forest management project was implemented in the country by the current government around 1999-2005/2006. Also as a result of the starting of ADLI (Agricultural Development Led Industry) with the aim of regenerating the soil fertility, to decline soil erosion, to raise crop productivity and gaining the fertility of the land by planting trees and leaving the croplands to grow grass. Therefore, those extensive plantations were carried out by the project and by smallholder farmers in the watershed. In agreement to the result of this study, Tesfaye et al. (2014) reported increment in forest cover between 1986 and 2008 in GilgelTekeze catchment, Northern Ethiopia. As the researcher appealed the increment in forest, cover was due to tree plantation activities. According to Desalegn et al. (2014), the rise in forest cover between 1975 and 1986 is owing to the implementation of huge afforestation campaign by the Derg government in the central highlands of Ethiopia.

According to the discussant of FGD, the increment in grassland was an outcome of shifting cultivation practices subsidized for conversion of agricultural land to grassland. It was also clarified that in some cases, cultivated lands also permanently left for grazing. In line with Shiferaw, (2011) expansion of grassland at the expense of forest and shrubland in BorenaWoreda of South Wollo Highlands, between 1985 and 2003. Alemayehu (2015) also reported the expansion of grassland at the expense of agricultural land in FagitaLekomaWoreda, Awi Zone, Northwestern Ethiopia between 1973 and 2015. The fourth period (2005-2017) result shows that agricultural land increased by 70.11 ha (17.7%) and forestland increased by 12.6 ha (3.2%). In contrast, grassland and home garden agroforestry/ settlement decreased by 75.06 ha (22.8%) and 7.65 ha (1.1%). According to discussants of Somodo watershed, agricultural land increased at the expense of grassland, due to that the degraded cropland fallowed in the past for grasses to grow regenerates soil fertility.

Consequently, farmers in the study area converted the land back into agriculture. In line with this study, Tefera and Sterk (2008) reported from the western highlands, the Fincha watershed cropland was endlessly expanding from comparatively flat areas in 1957 and 1980 too steep lands in 2001 at the expense of grazing land.

The starting of Participatory integrated watershed management project by Jimma Agricultural Research Center (JARC) in 2011 was the reason for forestlands to increase as the information obtained from the discussion in the study area. Similar to this study Tefera and Sterk (2008) stated a minor increase of forest cover from 1980 to 2001, probably to be due to reforestation activities carried out since the 1980s in Fincha'a watershed, western Ethiopia. During the 32 year period between 1985 and 2017, the proportion of area covered by forest and agriculture was decreased by 60.57 ha (12.7%) and 5.22 ha (1.1%) respectively. In contrast, home garden agroforestry/settlement and grassland were increased by 49.77 ha (7.5%) and 16.02 ha (6.7%) respectively (Table 2). The major findings from the analysis of Landsat images revealed a great reduction in the area of forest and a corresponding increase in the area of home garden agroforestry/settlement over the 32-year period. Focus group discussions and interviews conducted in Somodo watershed also support this trend showing an increase in land under home garden Agroforestry/settlement over time, with a corresponding reduction in land under forest and grass cover. This is because, during the last time the area was characterized as relatively low population some extent undisturbed environmental condition. However, the largest part of lands that were covered by forest before 32 years is now replaced by home garden Agroforestry and settlement. In agreement to the findings of this research, Dessie and Christiansson (2008) also reported a significant forest decline in parts of the south Central Rift Valley region due to the introduction of coffee farming between the late 1800s to about 1930. However, it is contrary to the work of Alemayehu (2015) who reported the expansion of forestland between 1973 and 2015 with the corresponding reduction of cultivated land in Fagita Lekoma Woreda, Awi Zone, Northwestern Ethiopia.

Generally, the information obtained from FGD participants and key informants, confirmed that the major reasons for the continual expansion of home garden agroforestry/settlement between 1985 and 2017 in the watershed are rapid population growth, illegal logging and fuel wood collection, gradual change in the economic activities of communities in the area, soil erosion, resettlement policies, an institution such as the appearance of research center. In addition, the reason for the increment of grassland between 1985 and 2017 was low productivity of cultivated lands. The farmer's awareness of. Over 87.3 ha of grassland in 1985 was again used for crop production in 2017 (Table 3). In addition, the afforestation programs in the study area contributed its share for the conversion of grassland into Agroforestry during the fourth study period, which is as much as 88.02 ha (Table 3). The farmers are giving more attention for covering of their land by trees and cash crops because of its economic advantage.

Land Use/Land cover change matrix

Results of the LULC change matrix analysis are presented under Appendix Table 1. During the study period between 1985 and 2017 about 901.35 ha (48.7%) of the study area landscape remained unchanged. This implies 946.4 ha (51.2%) of the total landscape of the study area was converted from one LULC type to the other (Table 3). From all LULC types, grassland experienced the lowest persistence, whereas home garden Agroforestry land was the most persistent cover type. The net persistence for forest and grassland was large (relatively far from zero), whereas agriculture and home garden agroforestry/settlement were closer to zero (Table 3). The net persistence closer to zero indicates the higher tendency of LULC types to persist rather than decline or increase.

Land Use/Land cover change projection

The table below shows the statistic of LULC projection for 2029. As indicated from (Table 4), Agroforestry/ settlement still maintains the highest position in the class whilst grassland retains its least position in 2029. Agricultural land takes up the second position, followed by Forestland. The state of 2029 LULC depends only on

Table 3. LULC change matrix between 1985 and 2017.

LULC category	Agriculture	Forest	Grass land	Agro forestry	Total	Loss
Agriculture	**205**	24	89	153	472	266
Forest	17	**302**	23	132	474	173
Grass land	87	9	**54**	88	239	184
Agroforestry	157	78	88	**340**	663	323
Summary					**901.35**[1]	
Total 2017	466	414	255	713	1848	
Gain	261	112.05	200.34	373.05		
Net change (NC)[2]	-5.22	-60.57	16.02	49.77		
Net persistence (Np)[3]	-0.02541630	-0.20065593	0.29519071	0.146451271		

[1]sum of diagonals and represents the overall persistence, 2 NC = gain−loss. 3 NP = net change/diagonals of each class.

Table 4. Projected LULC for 2029 and Predicted Change between 2017 and 2029 in Somodo Watershed.

Years	Classes	Agriculture	Forest	Grass	Agroforestry	Total
2029	Area(ha)	557.62	434.43	154.64	701.1	1848
	Area (%)	30.18	23.51	8.37	37.94	100.00
2017-2029 change	Area(ha)	91.24	20.52	-99.97	-11.79	
	Area (%)	19.6	4.9	-39.3	-1.65	

the state of 2017 and the time is uniform in duration between 2005-2017 and 2017-2029. As stated by Araya, (2009) trend of the LULC change in the future time can be detected when predicted LULC at time t2 compared with LULC of the base year at time t with reference to the class area metrics. Therefore as compared to the base year 2017 in 2029 agriculture and forest are predicted to increase by 91.24 ha and 20.52 ha respectively, while grassland and home garden Agroforestry/settlement are predicted to decrease by 99.97 ha and 11.79 ha respectively. The growth of agriculture is expected to come largely at the expense of grassland and home garden Agroforestry/settlement respectively. This is because it is seen in the probability matrix (Appendix Table 1) the probability of these LULC categories to change to agriculture is high i.e. 0.5485and 0.2048 with this order.

Drivers of LULC changes in Somodo watershed

LULC change in the Somodo watershed is a result of several proximate and underlying causes.

Proximate (Direct) causes

The FGD participants and key informants in the study area indicated that five major proximates (direct) driving forces appear to explain a large part of LULC change in Somodo watershed. These are: (i) illegal logging and fuelwood extraction (ii) Expansion of plantation (iii) expansion of settlement (iv) agricultural expansion (v) and construction of infrastructures such as school, road and research center (Table 5).

In the watershed, Kalkidan et al. (2017) reported average annual biomass fuel consumption per households was 4813.48kg/year which is estimated total per capita consumption per day was12kg. The per capita consumption of wood was higher than estimated (2.6kg) provided by the cooperation agreement in the energy sector (CESEN, 1987). However, the heavy reliance on biomass energy has become a threat to forest ecosystems and a major cause of land degradation in the area. On the other hand, some farmers clear the forest and change the land into agricultural activities due to the expansion of settlement in the study area. After the appearance of participatory integrated watershed management by Jimma Agricultural Research Center in the watershed, forest/plantation cover showed improvement.

Underlying causes

The above-mentioned proximate causes were triggered by different underlying causes of LULC change. As shown in the Figure 6 population of ManaWoreda

Table 5. Summary of proximate causes of LULC change in Somodo watershed.

Drivers	Frequency	%	Rank
Agricultural expansion	7	14.6	4
Expansion of settlement	8	16.7	3
Expansion of plantation	9	18.75	2
Illegal logging and fuelwood collection	11	22.92	1
Fire	2	4.17	7
Overgrazing	5	10.42	6
Infrastructure	6	12.5	5
Total	12	100	

Table 6. Summary of underlining drivers of LULC change in the study area.

Drivers category	Frequency	%	Rank
Demographic	11	28.95	1
Economic	9	23.7	3
Technological	3	7.9	5
Institution and policy	10	26.32	2
Biophysical	5	13.16	4
Total	12	100	

increased with time. According to the discussants in the watershed, population growth is the major driver compared to others. In line with this study, Binyam (2015) stated that agricultural expansion got more severe in the 1980s when large numbers of people moved to South West Ethiopia in the scope of organized resettlement programs.

According to key informants and FGDs during the Derge regime, the resettlement policy and villagization policy or which is called “Sefera" contributed to the expansion of settlements and agriculture. The other main policy contributed to the agricultural expansion in the study area during the Derge regime was "Land to Tiller" where by privatization of communal lands was carried out. National and regional policies on land use and economic development such as infrastructural development (such as roads and schools, etc.), attaining food self-sufficiency through investment on agriculture are the other factors contributing to LULC change.

Lack of proper land use plans is also the policy related driver of forest and grassland cover change. It is characterized by the encroachment of vegetated lands especially forest and grasslands for settlement and agriculture, cultivation of steep slope and the opening of very dense forest areas through road construction. In order to survive, farmers in the study area convert forestlands in to agriculture and agroforestry, since as the information gained from FGD and KII revealed that the farmers of somodo watershed does not have alternative income source other than coffee and Khat from their home garden agroforestry's yield, the agricultural crop yields, the firewood and the charcoal they vend. As the information gathered from KII and FGD soil erosion is the biophysical driver of LULC change in the study area. Due to agricultural expansion, illegal logging and fuelwood extraction forestlands has been degraded. When the forestland becomes degraded, the soil loses its protective layer, so that wind and water erosion easily occur.

CONCLUSION AND RECOMMENDATION

Somodo watershed has been experiencing different LULC changes. The main finding of this study revealed that a fluctuated change of LULC types between 1985 and 2017 due to some proximate and underlying drivers in the study area. During 32 years period home garden agroforestry/settlement and grassland were increased respectively, with a corresponding decline in the area of forestland and agriculture. Findings of the LULC change analysis between 2005 and 2017 showed expansion of agriculture and forestland while reduction of grassland and home garden agroforestry with differing rate was observed. In 2029, agriculture and forestland are expected to increase respectively. On the other hand grassland and home garden, agroforestry/settlement are predicted to shrink respectively. According to discussants of Somodo watershed agricultural land increased at the expense of grassland, due to that the degraded cropland which was followed in the past for grasses to regain soil fertility consequently, farmers in the study area converted the land back into agriculture.

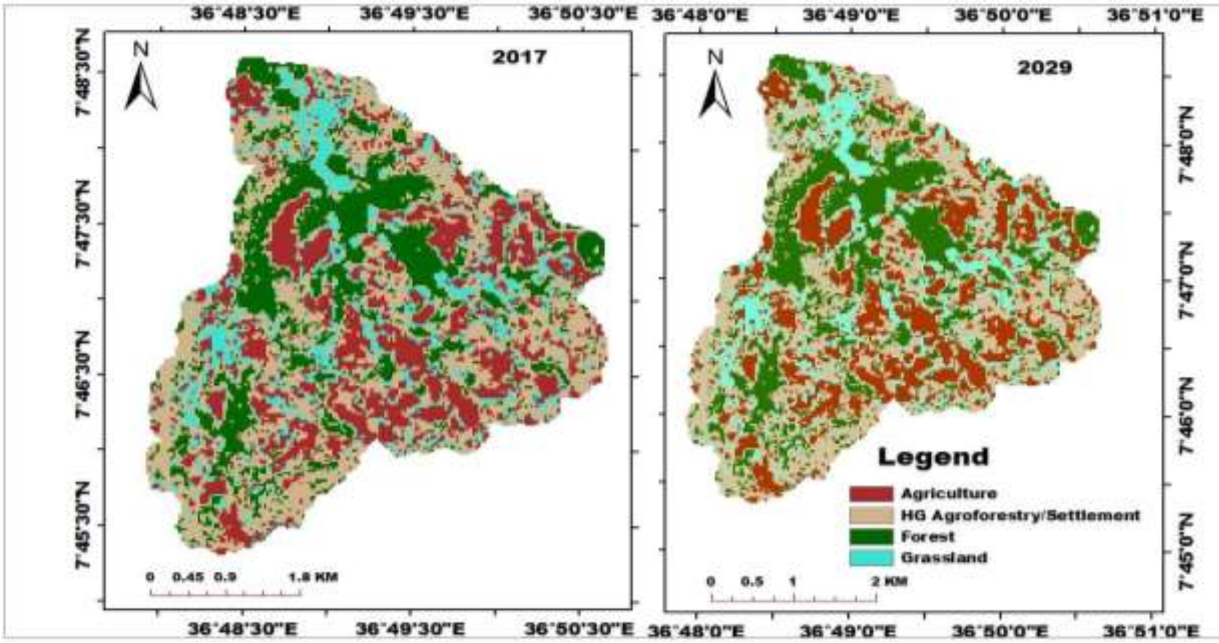

Figure 5. Classified image (2017) & projected image (2029) map of LULC change in Somodo watershed.

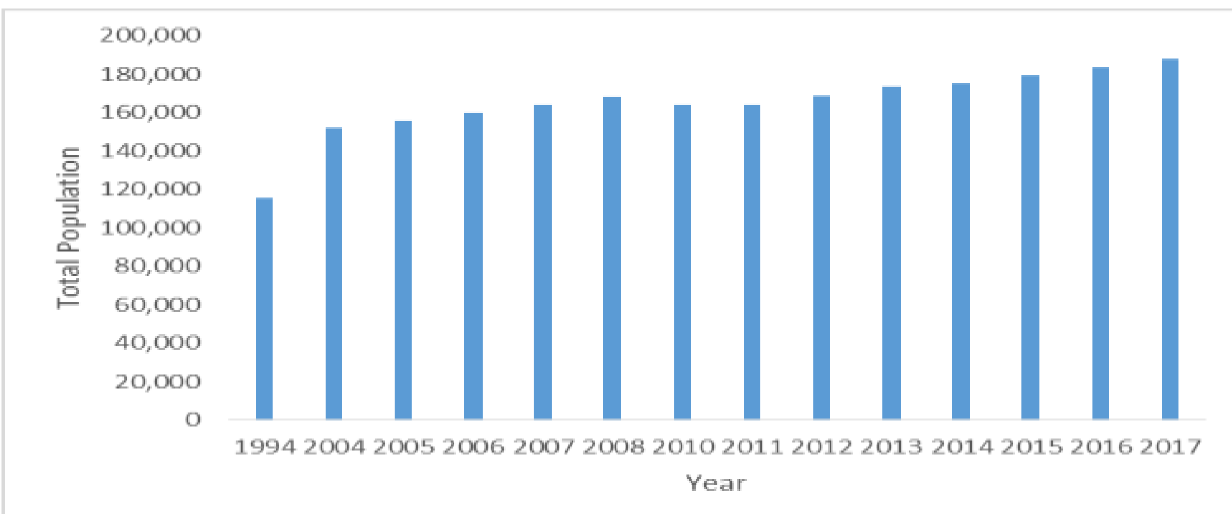

Figure 6. Population growth in ManaWoreda from (1994-2017) derived from Central Statistical Agency (CSA).

LULC change in Somodo watershed is a result of different interactions between proximate and underlying causes. The major proximate driving forces of LULC change in the study area are illegal logging and fuelwood extraction, expansion of plantation, expansion of settlement, agricultural expansion, and construction of infrastructures. On the other hand, the major underlying driving forces are Demographic, Economic, Technological, Institution and policy and Biophysical factors were identified by the key informant and focus group discussants of this study.

The study highly recommends Participatory Forest Managementstarted by Ethiopian Institute of Agricultural Research, Jimma agricultural research center should be practiced by all stakeholders to improve forest coverage of the watershed. This study also suggests further study on the impacts brought by land use land cover change (especially, watershed hydrology and climate), since this study addressed only the change in land use land cover change and driving forces behind the change.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Appendix

Land Use/Land Cover Change Matrixes

Appendix Table 1. LU/LCC matrix between 1985 and 1995.

LU/LC category	Agriculture	Forest	Grass land	Agroforestry	Total
Agriculture	**259.38**	10.44	21.96	179.82	471.6
Forest	6.57	**318.51**	4.14	145.26	474.48
Grass land	109.8	0.81	**36.72**	91.26	238.59
Agroforestry	143.55	47.52	48.96	**423.09**	663.12
Total	519.3	377.28	111.78	839.43	1847.79

Appendix Table 2. LU/LCC matrix between 1995 and 1999.

LU/LC category	Agriculture	Forest	Grass land	Agroforestry	Total
Agriculture	**390.96**	0	8.1	120.24	519.3
Forest	0.45	**316.71**	0.36	59.76	377.28
Grass land	22.86	0.81	**24.12**	63.99	111.78
Agroforestry	152.73	44.28	30.24	**612.18**	839.43
Total	567	361.8	62.82	856.17	1847.79

Appendix Table 3. LU/LCC matrix between 1999 and 2005.

LU/LC category	Agriculture	Forest	Grass land	Agroforestry	Total
Agriculture	**215.82**	0.36	189.63	161.19	567
Forest	8.28	**317.7**	3.06	32.76	361.8
Grass land	10.89	0.63	**23.94**	27.36	62.82
Agroforestry	161.28	82.62	113.04	**499.23**	856.17
Total	396.27	401.31	329.67	720.54	1847.79

Appendix Table 4. LU/LCC matrix between 2005 and 2017.

LU/LC category	Agriculture	Forest	Grass land	Agroforestry	Total
Agriculture	**171.54**	14.67	99.99	110.07	396.27
Forest	0.45	**320.58**	3.6	76.68	401.31
Grass land	174.6	5.94	**53.82**	95.31	329.67
Agroforestry	119.79	72.72	97.2	**430.83**	720.54
Total	466.38	413.91	254.61	712.89	1847.79

Appendix Table 5. Transitional probability area matrix derived from LU/LC map of 2005 and 2017.

LU/LC category	Agriculture	Forest	Grass	Agroforestry	Total
Agriculture	171.27	18.9	106.6	144.09	440.86
Forest	36.37	324.63	5.94	125.01	491.95
Grass	205.62	4.5	35.28	74.61	320.01
Agroforestry	144.36	86.4	6.82	357.39	594.97
Total	557.62	434.43	154.64	701.1	1847.79

Appendix Table 6. Transitional probability matrix derived from LU/LC map of 2005 and 2017.

LULC category	Agriculture	Forest	Grass	Agroforestry
Agriculture	**0.3684**	0.0407	0.2809	0.3099
Forest	0.0018	**0.6785**	0.0144	0.3053
Grass	0.5485	0.0176	**0.1392**	0.2947
Agroforestry	0.2048	0.1225	0.1657	**0.507**

Error Matrixes

Appendix Table 7. Error matrix for the LU/LC map of 1985.

Reference data						
Classified	**Agriculture**	**Forest**	**Grassland**	**Agroforestry**	**Total**	**Users accuracy** (%)
Agriculture	36	0	0	6	42	85.71
Forest	1	28	0	5	34	82.35
Grassland	0	1	15	0	16	93.75
Agroforestry	1	2	3	52	58	89.66
Total	38	31	18		63	
Producers Accuracy	94.74%	90.32%	83.33%		82%	
Overall Classification Accuracy = 87.33%						
KAPPA (K^) STATISTICS						
Overall Kappa Statistics = 0.8208						

Appendix Table 8. Error matrix for the LU/LC map of 1995.

Reference data						
Classified data	**Agriculture**	**Forest**	**Grassland**	**Agroforestry**	**Total**	**Users accuracy (%)**
Agriculture	36	0	0	1	37	97.30
Forest	0	37	0	1	38	97.37
Grassland	0	0	3	0	3	100.00
Agroforestry	3	7	0	62	72	86.11
Total	39	44	3		64	
Producers Accuracy	92.31%	84.09%	100.00%		97%	
Overall Classification Accuracy = 92.00%						
KAPPA (K^) STATISTICS						
Overall Kappa Statistics = 0.8781						

Appendix Table 9. Error matrix for the LU/LC map of 1999.

Reference data						
Classified data	**Agriculture**	**Forest**	**Grassland**	**Agroforestry**	**Total**	**Users accuracy (%)**
Agriculture	46	0	0	1	47	97.87
Forest	2	31	0	0	33	93.94
Grassland	0	0	4	0	4	100.00
Agroforestry	1	3	2	60	66	90.91
Total	49	34	6		61	
Producers accuracy	93.88%	91.18%	66.67%		98%	
Overall Classification Accuracy = 94.00%						
KAPPA (K^) STATISTICS						
Overall Kappa Statistics = 0.9101						

Appendix Table 10. Error matrix for the LU/LC map of 2005.

Reference data						
Classified data	**Agriculture**	**Forest**	**Grassland**	**Agroforestry**	**Total**	**Users accuracy (%)**
Agriculture	21	0	0	1	22	95.45
Forest	1	37	0	2	40	92.50
Grassland	0	0	19	5	24	79.17
Agroforestry	5	4	0	55	64	85.94
Total	27	41	19		63	
Producers Accuracy	77.78%	90.24%	100.00%		87%	
Overall Classification Accuracy = 88.00%						
KAPPA (K^) STATISTICS						
Overall Kappa Statistics = 0.8289						

Appendix Table 11. Error matrix for the LU/LC map of 2017.

Reference data						
Classified data	**Agriculture**	**Forest**	**Grassland**	**Agroforestry**	**Total**	**Users accuracy (%)**
Agriculture	42	0	2	4	48	87.50
Forest	1	30	0	0	31	96.77
Grassland	1	0	12	2	15	80.00
Agroforestry	4	4	0	48	56	85.71
Total	48	34	14		54	
Producers Accuracy	87.50%	88.24%	85.71%		89%	
Overall Classification Accuracy = 88.00%						
KAPPA (K^) STATISTICS						
Overall Kappa Statistics = 0.8303						

Definition of LULC

Appendix Table 12. Description of major LULC types identified in somodo watershed.

LULC types	Description
Forest	Vegetation cover that is dominated by woody species and naturally or artificially grown and has high cover density.
Agriculture	The cultivated plants that cover the land for certain season of the year and irregular reflectance due to variation in species composition includes areas allotted to rain-fed cereal crops (such as Corn, Barley, Chickpea, and Wheat).
Home garden agroforestry/settlement	Made to include areas allotted to cash crops (chat), coffee and horticultural crops particularly vegetables (such as onion, potato, and cabbage) and fruit trees (Mango, Avocado and orange) including some forest trees. Scattered settlements surrounded by home garden agroforestry are classified as home garden agroforestry/settlement since the low spatial resolution Landsat imagery fails to separate the scattered rural settlements with agroforestry lands.
Grassland	Grass-dominated the land. It has some uniformity in land coverage and thus possibly reflects solar radiation in a relatively uniform manner.