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Drivers for Land Use/Land Cover Dynamics in the South Central Rift Valley Lakes Basin

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Abstract

A thorough understanding of the drivers of land use and land cover (LULC) is required to develop future proper land management strategies to prevent the depletion of natural resources. This study attempted to pinpoint the significant drivers of LULC changes in the Bilate Sub-watershed of the Rift Valley Basin, over the last 45 years. For primary and secondary data sources, descriptive statistics were utilized; additionally, satellite image manipulations, geographic information system and binary regression were used for data analysis. Population growth, agricultural activities, livestock production, fuel wood, and erratic rainfall are the five important drivers of LULC changes as perceived by local farmers. In terms of spatial distribution, six factors contributed to LULC changes: distance to towns, distance to road, and distance to water, gradient, rainfall, and elevation. It was believed that LULC changes were unavoidable, that they occurred at all times in the past, are currently ongoing, and are likely to continue in the future in the world. To avoid the ongoing undesirable LULC changes of resources, it is necessary to create meaningful policies for sub-watershed and other areas with similar geographic settings, as well as focusing on the impact of LULC drivers and investigating their consequences.

Keywords: *Land use, Land cover, Drivers, Geographic information system, Binary regression analysis*

1. Introduction

Land use is the cornerstone of agrarian economies and offers significant social and financial gains. Changes in land use are essential for advancing society and the economy. Driving forces are the elements that alter a system; they may be societal, financial, or environmental, but they may produce favorable or unfavorable results The Afro-alpine region's population growth and intricate interconnections among biophysical, socioeconomic, and cultural dynamics were important driving reasons behind land use change (Fetene et al., 2014).

Land use land cover changes were driven by broad various forces at different parts in the world, more specifically the drivers were well defined like population density (Abate and Lemenih, 2014; Amsalu et al., 2007; Bewket, 2002; Lemma, 2015; Meyer and Turner, 1992; Zeleke and Hurni, 2001), expansion of agriculture; livestock grazing (Belay et al., 2014). In recent studies, climate-related factors such as drought and erratic rainfall were considered as the key drivers of land use and land cover changes (Meyer and Turner, 1992; Shiferaw, 2011).

In Ethiopian highlands, different results obtained nearby drivers of LULC changes (Bewket, 2002; Tegene, 2002). For instance, (Mengistu et al., 2012) recognized weak institutional and socioeconomic contexts, a lack of stable land tenure, and inadequate infrastructure investment as the causes of the changes in the Silte Zone, Southern Ethiopia whereas in Rib watershed land tenure insecurity, poverty, market inaccessibility, and road facilities were the major drivers of natural resource degradation and cause for extinction of biodiversity (Garede and Minale, 2014). Land use change driven by agriculture and land ownership policy-related issues, demographic change has brought to cultivate marginal land contributed to land degradation (Kibret et al., 2016).

The study conducted by (Girma and Hassan, 2014) confirmed that increased number of population, vicinity to road facilities, availability to financial services were found the major causes of land alteration to farming activities. Human activities like the destruction of vegetation cover for cultivation purposes are one of the major drivers of LULC changes in Ethiopian highlands (Amsalu et al., 2007; Bewket, 2002; Zeleke and Hurni, 2001), which resulted in land degradation (Haile, 2004). The human-driven demand for cropland and settlements, and the usage of trees for fuel and construction were exacerbating the LULC change (Bewket, 2002; Gebresamuel et al., 2010). Because of the shortage of employment occasions for fresh graduates in the countryside parts of Ethiopia are enforced to share the land with someone else. This leads to further disintegration of land use and subsequent reduction of cultivable area, eventually the expansion of cultivated land into woodlands, grasslands, and other degraded (Gebreselassie, 2006; Zeleke and Hurni, 2001).

In terms of policy factors, political instability, and sociocultural factors interacting with the human population drove land use changes in the Teso Agriculture Scheme. Moreover, altitude, gradient, land degradation, and distances from major infrastructures are taken as land use drivers (Ebanyat et al., 2010).

Few studies attempted to assimilate the social and biophysical data from different findings, to inspect the relations between the drivers and their influence on modifications of LULC. Nevertheless, the tendencies in LULC dynamics are worrisome globally but have very different causes or reasons in different landscapes (Beilin et al., 2014). (Kuma et al., 2022) found that soil erosion increased in bare land, that the majority of cultivated land was found between slopes of 15-60%, and that crop production has decreased as a result of land use and land cover changes in the Bilate catchment.

Various research findings revealed that LULC change driving factors varied spatially depending on location-specific factors, it needs to integrate socio-economic and biophysical parameters jointed to reach valuable results (Bewket, 2002). An integrated study of driving forces could be helpful to wisely recognize rural farmers' perceptions and natural resources mainly LULC which might support the planning of technically suitable and environmentally friendly land use options.

Therefore, several interventions to address land use change drivers that perceived local people and sustainable watershed development which are influenced by various drivers of LULC types. The major drivers in Bilate Sub-watershed are not stated and elaborated in systematic manner. Accordingly, the present study is aimed to identify and explore the major drivers of land use and land cover changes in Bilate Sub-watershed to recommend an alternative solution to copy the existing problem.

2. Materials and Methods

2.1. Description of the study area

Bilate Sub-watershed is located in Alaba Zone, Southern Ethiopia about 310 km south of Addis Ababa and about 85 km southwest of the Southern Nations Nationalities and Peoples Regional (SNNPR) State capital of Hawassa (Godebo et al., 2018).

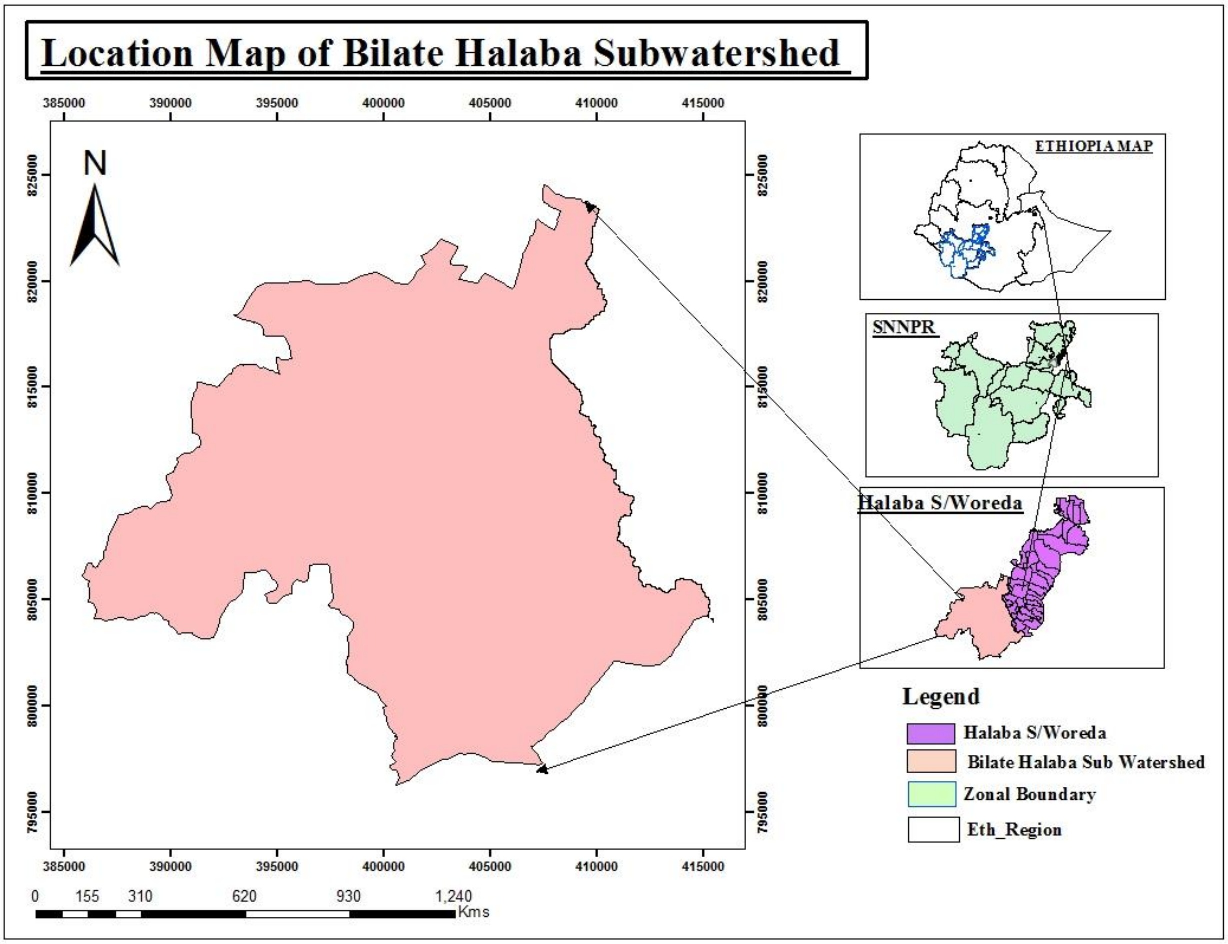


Figure 1. Bilate Sub-watershed map

2.2 Soil

There are four major soils, namely andosols, luvisols, phaeozems, and nitisols (FAO, 1988). The major crops grown in this sub-watershed had been given substantial yields since the soils were sufficient enough to release nutrients with good climatic conditions.

2.3 Climate and land use systems

The study area is mostly Wynedega (Mid-highland) climatic zone, with mean precipitation of 1102mm/year, a mean annual temperature of 21.20C (Godebo et al., 2018). Erratic rainfall characteristics are the major feature of study area which had been influencing crop production, in which few areas supplemented by irrigation practices (Dessalew et al., 2016).

The land use system in the stud area is a mixed cropping pattern had been exercised, maize, sorghum, and haricot bean are the major crops, and they managed by both traditional tillage practices and to some extent rented tractor-driven types of machinery were implemented. In a few cases, crop residues are used as a livestock feed source in the stud area. There is also good experience in growing vegetables and animal feeds with the help of Bedene Alemtena small irrigation scheme(Shiferaw et al., 2011).

2.4 Biophysical data sets

This study used four decades remote sensing imaginers (1972, 1986, 2008, and 2017) with the aid of GIS tools were employed. Google earth, GPS and topographic maps were used to extract and correlate the image data acquisition. For the analysis images, Arc GIS and ERDAS imagine software's used as per outlined in (Godebo et al., 2018; Mathewos et al., 2019).

2.5 LULC changes and accuracy assessment

The identified LULC were classified using a supervised algorithm scheme in ERDAS imagine mechanism with the application of tools described (Jensen et al., 2007), with the aid of field verification and key informant discussion. The major land use and land cover types were identified, and possible changes were elaborated (Godebo et al., 2018). The total accuracy assessment requirements met 80% of the produced maps at four study periods so that it can be further used to identify the drivers of LULC changes (Congalton and Green, 1999).

The spatial datasets were prepared in GIS Environment with the same spatial extent and geographic coordinates and converted to a raster format. The raster datasets were again converted to ASCII format in GIS environment using CLUE -s model (Verburg et al., 2004) numerical analysis. It is analyzed the data sets in SPSS using regression to determine the relationships between drivers and LULC patterns (Verburg et al., 2004).

$$\log\left(\frac{\mathrm{Pi}}{1-\mathrm{Pi}}\right) = \beta 0 + \beta 1\mathrm{X1i} + \beta 2\mathrm{X2i} + \beta 3\mathrm{X3i} + \cdots \beta \mathrm{nXni} \qquad (1)$$

Where Pi=probability of a grid cell for the occurrence of the considered LULC type and the X's=driving factor. The coefficients (β) are estimated through logistic regression using the actual land use pattern as the dependent variable.

The comprehensive approach used in this study to analyze watershed-level drivers included comparing LULC changes with the potential spatially explicit explanatory variables. The regression equation is verified using the relative operating characteristic test (Chen and Pontius, 2010; Kindu et al., 2015).

In this study, 9 drivers were included on the basis of their availability, relevance, and data suitability: elevation, geology, slope, distance to road, distance to water, and distance to towns, soil, rainfall, temperature, and population density. Slope and elevation were used to describe the terrain conditions in the study area. Higher elevation and slope can restrict the transformation of forests into cultivated land. The population was the key socio-economic factor influencing the transformation of all land use categories.

Road network datasets were derived in the ArcGIS environment from the Central Statistical Agency of Ethiopia, topo-map, and aerial photographs. The rainfall datasets were obtained from the Ethiopian National Meteorological Service Agency; station records from 1985 to 2015 of Kulito Town station. The slope data was derived from a 30m*30m digital elevation model and soil data were extracted from recent work (FAO, 1988). Similarly, population data extracted from woreda finance department and extrapolation based on current growth rates. The geology of the Bilate Sub-watershed which has been investigated by the Ethiopian Geological survey comprised volcanic and sedimentary units was used (Tessema, 2015).

2.6 Selection of households for the socio-economic data

The types of data for the research were gathered from both primary and secondary sources, together with reports, formal household interviews, key informant discussions with religious influential, and focus group deliberations with specific local agrarians and development agents (DAs) working at the sub-watershed.

Peasant Associations (PAs) in the upstream, midstream and downstream parts of the sub-watershed and spatial patterns of the LULC were used as criteria for choosing the sampling sites for the household investigation. The sample households were identified using a two-stage sampling design.

Initially, the sub-watershed was purposefully divided into the upper slope, middle slope, and lower slope sections based on the extracted DEM (Figure 2). Second, sample households from three identified Kebeles selected in order to collect household socio-economic survey in the study sub-watershed. Based on altitude or slope, areas belong to larger slope (Kulufo), middle slope (Huletegna Choroko) and lower slopes (Tachegnaw Aresho) were taken. A total of 143 households (HHs) were chosen, because more than 5% of the study population was included, the sample size was deemed adequate. The sample (n=46) represented 8.20 percent of the 500 HHs in Kulufo; (n=47) represented 8.35 percent of the 515 HHs in Huletegna Choroko; and (n=48) represented 8.19 percent of the 720 HHs in Tachegnaw Aresho Kebeles.

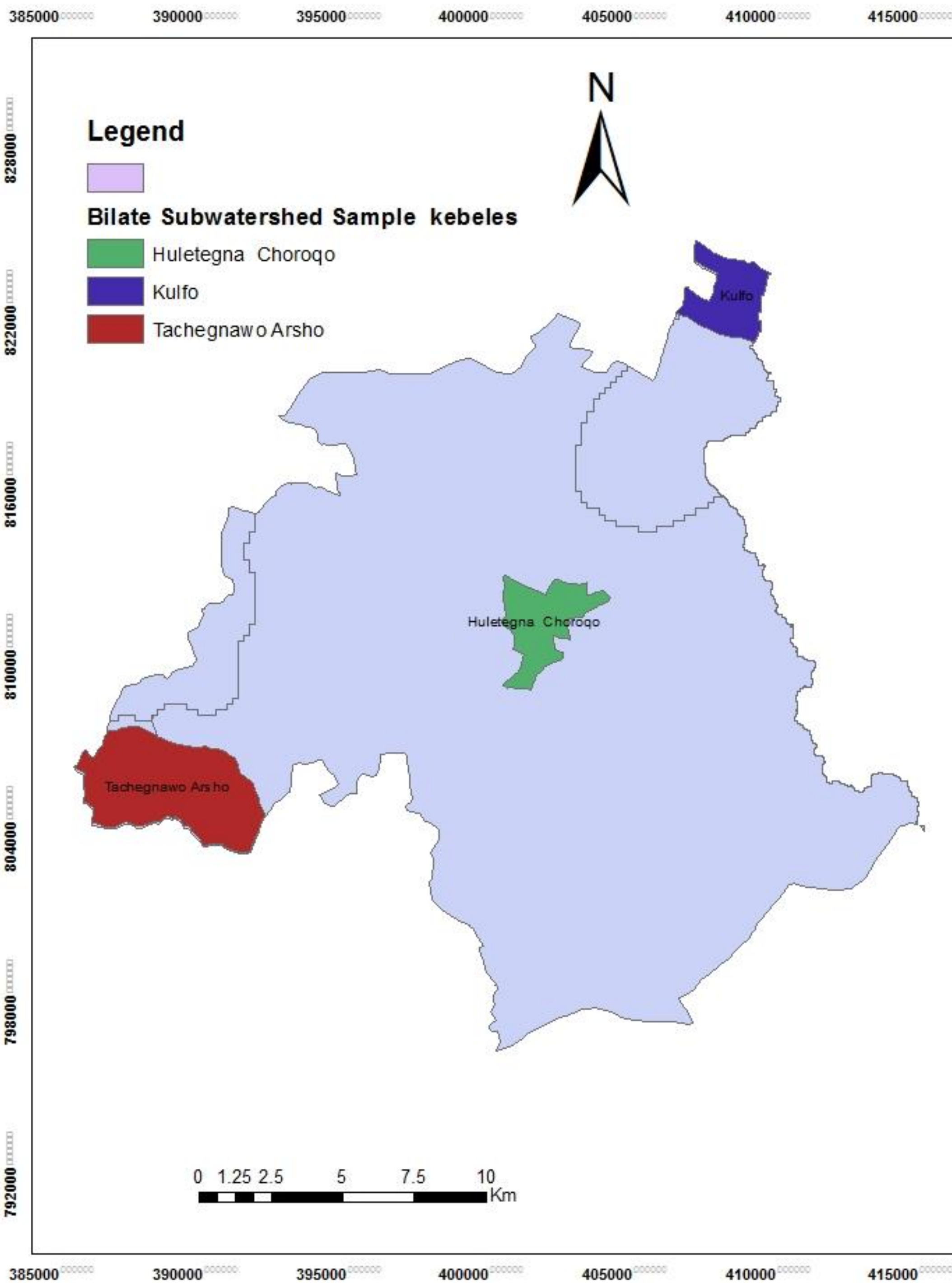


Figure 2. Bilate Alaba Subwatershed sample *Kebeles* for Socio-economic data

From a list of rural farmers, participants in the study were chosen at random to complete the questionnaire and take part in focus group talks. In contrast to purposive sampling, which was limited to key informants because of their familiarity with the sub-natural watershed's resource utilization and land management methods, this methodology ensured that all members and communities were fairly represented in the study.

The main drivers of LULC were evaluated through the questionnaire interview of 143 HHs and 13 key informants (9DAs, 2WAO experts and 2 process owners) in the study. The focus group discussions were held at the village level with 8–12 houses, whereas the questionnaire interviews were done on an individual basis to obtain better quality data. The SPSS Windows Program was used to code and enter the socioeconomic survey data. The total households living on identified sampled 3 rural Kebeles of the study area is 1735, using (Whitley and Ball, 2002; Yamane, 1967) the number of sample size calculated as indicated in equation 2

$$n = \frac{N}{N \times e^2} \tag{2}$$

Where N=total population, n=sample size and e=error or confidence interval, e=0.08 or 8% confidence interval.

2.7 Data analysis

Data analysis methods comprised the use of binary regression analyses, GIS-based processing, and descriptive statistics. While data gathered from group discussions and observations was analyzed using a qualitative approach, descriptive statistics and simple frequency analyses were used to describe socioeconomic characteristics of households, synthesize their replies, and rating the drivers of the dynamics of land use and land cover.

3. Results and Discussions

3.1 Land use and land cover dynamics analysis

The areas of LULC maps of Bilate Sub-watershed for four reference years 1972, 1986, 2008 and 2017 were summarized for different land use types were presented in (Godebo et al., 2018). For the four reference years 1972, 1986, 2008, and 2017, the areas of LULC maps of the Bilate Sub-watershed were summarized for various land use types and were displayed in Table 1. The classes of shrub & grassland and cultivated land made up the majority of the total area in all research years, whereas shrub & grassland covered a considerable portion of the sub-watershed coverage. The study found that there were diminishing tendencies in the conversion of forest area to agricultural use over time. The extent of the settlement increased in a similar pattern to that of the cultivated land, and in 2017 it covered an area that was nearly 6.3 times larger than it had in 1972 (Figure 3).

Table 1. Bilate Sub-watershed LULC area in 1972 and 2017 (Godebo et al., 2018)

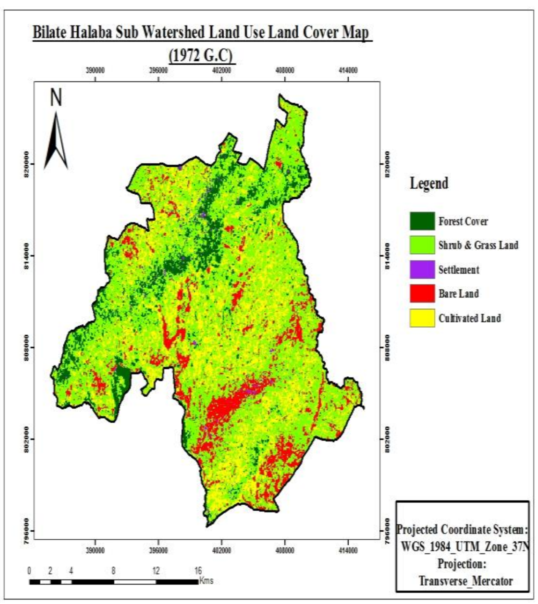
LULC	1972	1986	2008	2017
	Area (ha)	Area (ha)	Area (ha)	Area (ha)
Cultivated land	9403.02	13335.18	15647.97	15737.32
Settlement	317.89	1317	1263.67	2012.13
Shrub & Grass	22304.01	203439.89	19222.46	18207.98

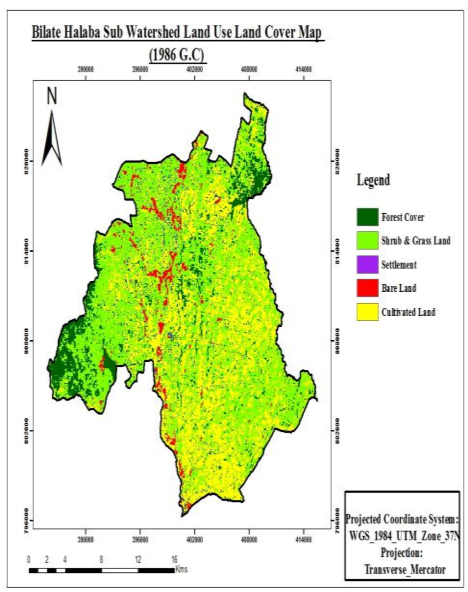
Land				
Forest Cover	3778.14	3962.12	1688.23	1271.35
Bare Land	4468.06	1315.375	2477.59	3067.94

The accuracy assessment was conducted for all classified images using the standard methods. The kappa coefficients and the user's, producer's, and total accuracy were calculated. In general, all of the LULC changes tables met the acceptable accuracy of 85 percent (Table 2).

Table 2. Bilate Sub-watershed LULC classes and accuracy evaluation of categorized images

Classes	Accuracy (%)							
	1972		1986		2008		2017	
	Producer’s	User’s	Producer’s	User’s	Producer’s	User’s	Producer’s	User’s
Forestry Cover	93.94	96.88	100.00	97.06	100.00	100.00	100.00	100.00
Shrub and Grass land	96.97	82.05	96.97	86.49	93.94	79.49	100.00	86.84
Settlement	75.76	100.00	78.79	100.00	90.91	96.77	90.91	93.75
Bare Land	100.00	89.19	96.97	94.12	90.91	100.00	72.73	96.00
Cultivated Land	96.97	100.00	100.00	97.06	84.85	87.50	96.97	86.49
Overall coefficient	92.73		94.55		92.12		92.12	
Kappa coefficient	0.91		0.93		0.90		0.90	





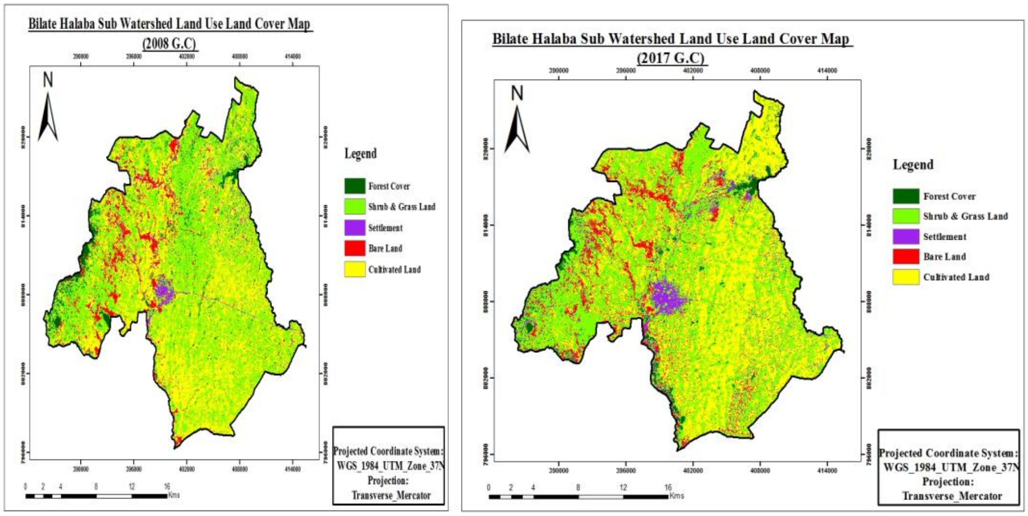


Figure 3: Bilate Sub-watershed of 1972, 1986, 2008 and 2017

3.2 Logistic regression of drivers of change from 1972 to 2017 at Sub-watershed level

The ROC values, which assess the logistic regression models' goodness-of-fit, showed that the five LULC types' spatial distributions were adequately explained by the drivers of those kinds (Table 3). The outcome revealed that all of the LULC kinds' acquired relative operation curve (ROC) values were greater than 70%. This suggests that the probability distribution created using the assumed LULC type drivers was accurate in reflecting the distribution of LULC types found in the examined sub-watershed.

Table 3. β values for the regression's findings regarding the spatial distributions of LULCs in the Bilate Alaba Sub-watershed

	Land use and land cover changes				
Drivers	Forest	Cultivated	Bare land	Settlement	Shrub & grassland
Geology	0.676	2.131	.509	-.423	119.503
Slope	.026	.030	.022	.036	.038
Distance to river	.004	.092	.005	.001	.056
Distance to road	.003	.091	.003	.001	.049
Distance to town	.001	.095	.001	.000	.071
Population	-.138	-.767	.039	-2.323	-1.303
Rainfall	-.005	-.015	-.005	-.008	-.031
Soil	.929	14.570	.525	2.200	10.880
Temperature	.115	.924	.128	.139	-3.754
Altitude	.004	-.006	.004	-.010	.005
Constant	-8.613	-10.320	-9.133	15.198	-36.081
ROC value	0.824	0.962	0.851	0.739	0.970

β reflects the coefficients of regression between the drivers and the various LULC kinds; ROC relative operation curve

The chance of LULC changes is predicted by the positive coefficient values of each of the drivers to be growing, while the negative coefficient values are predicted to be decreasing. According to the findings, there is a distinct correlation between the majority of the coefficient value signs and the range of drivers, which is consistent with the relationship proposed in the hypothesis.

Binary logistic regression analyses were used to determine the major factors influencing changes in land use and land cover (LULC) in the Bilate Sub-watershed from 1972 to 2017 in the research area (Table 3). Among 10 driving factors assumed to affect land use dynamics: elevation, slope, distance to road, distance to water, and distance to towns, soil, and population density. The logistic regression analysis result had shown that only 6 driving factors as the most important driving factors for LULC changes ($P<0.05$) which are the distance to towns, distance to road, distance to water, slope, rainfall, and elevation. It has been found that the environmental factors, such as gradient and altitudinal range, have also had a substantial impact on the variations in the prevalent LULC.

3.3 Socioeconomic characteristics of the respondents

3.3.1 Demographic Characteristics

Table 4 showed that of the 143 sample houses from the three Kebeles that were examined, 37 (24.48%) had a female head of household. They more accurately reflect the proportion of homes in SNNPR with a female head of household (23.3% CSA, 2008. Household heads in the 25–64 age range make up 79.5 percent of the entire sample, and they have more experience with land management techniques than the household heads in the other two age ranges. These households were responsible to take action on natural resources depletion like forest removal from the landscape as they seek additional farmland to provide subsistence.

Table 4. Households demographic, socio-economic, asset and livelihood characteristics sampled *Kebeles* of Bilate Alaba Sub-watershed.

Demographic and socioeconomic characteristics		Peasant Associations (PAs)							
		Kulufo	%	Huletegna Choroko	%	Tachegnaw Aresho	%	Total	%
Gender	Male	31	75.61	31	72.09	46	77.97	108	75.52
	Female	10	24.39	12	27.91	13	22.03	35	24.48
	Total	41	100.00	43	100.00	59	100.00	143	100.00
Age	21-30	11	26.83	10	23.26	21	35.59	42	29.37
	31-40	16	39.02	24	55.81	12	20.34	52	36.36
	42-64	13	31.71	8	18.60	24	40.68	45	31.47

	>65	1	2.44	1	2.33	2	3.39	4	2.80
	Total	41	100.00	43	100.00	59	100.00	143	100.00
Household size	1-5	19	46.34	23	53.49	33	55.93	75	52.45
	>6	22	53.66	20	46.51	26	44.07	68	47.55
	Total	41	100.00	43	100.00	59	100.00	143	100.00
Education level	Illiterate	21	51.22	33	76.74	18	30.51	72	50.35
	Read and write	8	19.51	2	4.65	15	25.42	25	17.48
	Primary school (1-8)	8	19.51	5	11.63	20	33.90	33	23.08
	Secondary school (>9)	4	9.76	3	6.98	6	10.17	13	9.09
	Total	41	100.00	43	100.00	59	100.00	143	100.00
Land holdings (ha)	0.5-1.5	25	60.98	24	55.81	31	52.54	80	55.94
	1.5-2.5	14	34.15	16	37.21	22	37.29	52	36.36
	>2.5	2	4.88	3	6.98	6	10.17	11	7.69
	Total	41	100.00	43	100.00	59	100.00	143	100.00

The mean family size in the sub-watershed was 6.68, which is greater than the country mean (5.4) and nearly half of sampled households (47.55%) had more than 6 members in the family indicated there was more population engaged in agriculture were increased. Farmers in the study sub-watershed were practiced polygamy contributed to raising the population. This is one of the reasons that rapid population expansion and big family sizes are to blame.

However, in the judgments of village elders, having a large family is a benefit for the homes because children are already involved in caring for cattle, bringing water, and gathering fuel wood at a young age. The size of the land and the educational level of the family head are two assets that are crucial to resource management because they have an impact on agricultural yield, as shown in Table 4. The household heads' educational levels in the research sub-watershed differed at the rural Kebeles level, but overall, the percentage of educated and illiterate people was close to 50% (Table 4).

The landholdings of households in the study area varied from 1.4 ha to 2.53 ha with a mean holding size of 1.94 ha per household which is higher than the national average (1.5 ha) which is linked to possessing larger farm size to ignore to proper land management practices. During FGD participants pointed out land renting is very common in which households who had a larger size. 60.9 percent of respondents from three Kebeles in the upper altitude watershed's altitude, 55.8 percent from the mid-altitude, and 52.54 from the lower altitude reported having farms between 0.5 and 1.5 ha in size. A comparatively small share (44.06 %) of all respondents said their farm was larger than 1.5 ha (Table 4).

3.3.2 Farming systems in the study sub-watershed

A cropping system is understood to be a structured decision-making entity where the production of crops and/or livestock is carried out with the intention of gratifying the farmers. The most common crops in the Bilate Sub-watershed in terms of area covered are maize, teff, wheat, pepper, haricot bean, sorghum, and millet. Many additional crops are grown in addition to these ones, but they are less significant economically. Most of the time, maize is cultivated on more than half of the study area's cultivable land, with all other crops taking up the other half. Despite the large amount of area set aside for this crop, the yield per hectare is rather poor. Although one could argue that the amount of rainfall is sufficient to support crop development, the distribution is exceedingly variable, which leads to product failure and, ultimately, drought in the sub-watershed (Shiferaw et al., 2011).

Livestock and crop production are carried out together in mixed farming practices. Particularly in regions where sedentary agriculture is practiced, livestock is crucial for complementing the rural community's means of subsistence. Additionally, keeping cattle is thought of as a security measure and a way to deal with crop failure and natural disasters.

The total number of cattle in the Bilate Sub-watershed was 595,533 (Table 5), but because of the growing human population and the scarcity of grazing area, the amount of livestock per person was less than what was necessary to support a sedentary society.

In mixed farming methods, one of the constraints on the production of animals is the lack of feed. A lack of grazing land (due to population pressure) and a lack of rain, which prevented the growth of adequate feed resources, both serves to exacerbate this situation. In this farming technique, all of the livestock are so malnourished that the owners are in a desperate state (Shiferaw et al., 2011).

Table 5. Livestock Density in Bilate Sub-watershed (Woreda agriculture office recent report of 2017)

Livestock	Quantity	TLU*	Density/ha	LSU/ha
Cattle	148602	148601.70	3.69	3.69
Donkey	28760	18693.94	0.46	0.30
Horse	9048	9048.00	0.22	0.22
Mule	711	817.77	0.02	0.02
Sheep	104494	15674.10	0.39	0.06
Goat	102668	15400.13	0.38	0.06
Poultry	201250	2012.50	0.05	0.00
Total	595,533	210,248.13	5.22	4.35

*TLU values are given as each cattle = 1, mule = 1.15, horse = 1, donkey = 0. 65, sheep =0.15, goat = 0.15 and Poultry = 0.005 (Ramakrishna and Demeke, 2002)

The total stocking level (4.35 LSU per hectare) based on the livestock census shown in Table 5 was higher than the study area's carrying capability. The amount of grazing pasture needed per total livestock unit (TLU) is 1.5 hectares, according to (FAO, 1986).

According to the FAO's estimation, 140,165.4 hectares of grazing pasture would be needed in the study region to accommodate all the livestock units. Compared to what is currently offered in the study area, this is a threefold increase (40,296.31 ha).

Therefore, an additional 99,869.11 hectares of grazing area is required in the sub-watershed to feed the current cattle population. The population growth may be accompanied by an increase in animal numbers, which would have a disastrous impact on the flora watershed's and soil conditions. According to the current investigation, the grasslands have degraded past their carrying capacity and are overpopulated, which the main factor is contributing to the watershed's severe environmental degradation. The overgrazing and soil degradation in the rangelands are made worse by this situation.

3.3.3 Driving Forces for LULC Change in Bilate Alaba Sub-watershed

A total of 9 factors were identified by the sampled households as essential drivers of LULC changes in the study sub-watershed. Specifically, the sampled HHs (N = 143) selected human population density and agricultural activities as the key drivers of LULC changes, the presence of polygamies in the sub-watershed had contributed to raising the population Because the majority of the residents of the sub-watershed are Muslims, having more than two wives has been practiced.

Furthermore, the majority of respondents (97.9, 94.4, 92.3, and 90.9%, respectively) cited agricultural activities, population growth, livestock grazing, and fuel-wood as critical reasons of the observed LULC changes in the study area. Cattle are allowed to graze on the remaining crop stalks on croplands after harvest and on communal grazing lands, which was one of the important drivers for changes in the study sub-watershed. However, based on detailed discussion among FGD members, the existing grazing land is below the carrying capacity of their livestock, which is associated with declining grassland areas over time.

The other factors responsible for the prevalent LULC changes are considered to be rainfall variability (90.2 percent), land tenure (83.9%), land degradation (82.5%), investment (62.9%), and settlement (49%). During the focus group discussions, respondents mentioned changes in the government in 1974, including the 1975 land reform proclamation of land to tillers, which provoked a change in land tenancy from feudal landlord control to peasant associations (Table 6)

Table 6: the frequency of the major driving forces of LULC changes in the Bilate Sub-watershed based on local farmers' perceptions

LULC changes drivers	Opinion of LULC drivers					
	Yes		No		Undecided	
	number	%	number	%	number	%
Agricultural activities	140	97.9	1	0.7	2	1.5

Livestock pressure	132	92.3	7	4.9	4	3.0
Wood extraction	130	90.9	8	5.6	5	3.7
Population pressure	135	94.4	1	0.7	7	5.2
Settlement	70	49.0	38	26.6	35	26.1
Land tenure	120	83.9	11	7.7	12	9.0
Rainfall variability	130	90.9	10	7.0	3	2.2
Land degradation	118	82.5	17	11.9	8	6.0
Investment	90	62.9	32	22.4	21	15.7

In 1984, 1994, and 2007, Ethiopia conducted three national population and housing surveys. The watershed's population was 66,276 in 1972, 80,289 in 1986, 152,175 in 2008, and 185,830 in 2017. The growth rates were calculated using exponential growth, with rates of 2.92, 2.62, and 2.26 percent between 1972-1986, 1986-2008, and 2008-2017, respectively (Table 7; Equation 3). The population in the sub-watershed increased from 66,276 to 185,830 between 1972 and 2017, implying that the population tripled in 45 years.

Population growth is caused by either natural increase or in-migration. Table 7 showed that the rate of population growth in the study sub-watershed has been rapid. Furthermore, the Bilate Sub-watershed is located near other towns (Shone, Demboya, and Durame), which serve as market and administrative centers, allowing for a population inflow to the town. Many developing countries are experiencing rapid urbanization at the moment, which can be explained in part by population growth (Table 7).

This rapidly growing population is driving up demand for forest and other natural resource products such as wood for fuel, construction, and agriculture. Similarly, the then-migration government's and relocations (villagilization) program in the 1980s had an impact on natural resource pressure.

Table 1. The population size of Bilate Sub-watershed between 1972 and 2017 (Bielli et al., 2001; CSA, 2008).

Year	1972	1986	2008	2017
Population size(#)	66,276	80,289	152,175	185,830
Growth rate (%)	2.3	2.92	2.62	2.26

The growing rates were designed on the bases of the works of Bielli et al. (2001) with the assumption of exponential growth in equation 3:

$$P2 = P1e^{rt} \qquad (3)$$

Where P1 and P2 = the population totals for two different time periods, t = the estimated years between the two periods and r = the mean annual growth rate

In the last four decades, different driving factors involved in LULC changes including biophysical and socio-economic components in the study area. Population growth and agricultural activities were the major drivers of LULC changes in the study area/sub-watershed. This finding is consistent with other studies conducted in various parts of Ethiopia, which discovered that population growth and agricultural crops were important drivers of LULC changes (Abate, 2011; Babiso et al., 2016; Bewket, 2002; Dessie and Christiansson, 2008; Gashaw et al., 2014; Hurni et al., 2005; Kidane et al., 2012; Kindu et al., 2015; Mengistu et al., 2012)

Another study by (Beilin et al., 2014) described global market forces were driving forces for land use changes in Sweden. Similarly distance to market was one of the major drivers of LULC change in Munessa-Shashemene landscape (Kindu et al., 2015) of Ethiopian highland population density is inversely correlated with the expansion of arable land, suggesting workforce shortages in the agriculture sector that may ultimately lead to low productivity (Arowolo and Deng, 2018).

Another factor influencing LULC changes in the sub-watershed was the expansion of settlements. Both urbanization and the 1985 national settlement policy for villagization program were responsible for these changes in the studied area. Fuelwood collection was the other significant drivers of the observed LULC changes. Since poor farmers were continuously collected trees from area closure and forest land by cuttings of the acacia-species that occasioned in exacerbated land degradation. Furthermore, the local population depends on the selling of fuel wood as an urgent source of revenue if crop production declines or fails to owe to drought years.

In addition to crop cultivation, farmers also engage in animal production. Cattle are allowed to graze freely on the residual crop stalks on croplands after harvest. Livestock production was another significant factor in LULC modifications. Due to the limited carrying capacity of the already accessible grazing fields, free grazing also takes place in the remaining forests. This might prevent the normal regeneration of the surviving forests in isolated regions, leading to grazing-induced degradation (Kindu et al., 2015; Tessema, 2015).

Significant dynamics of LULC in the nation as a whole and the examined sub-watershed, in particular, led to changes in land tenure policy (McCann, 1995). In 1975, a new land reform that declared the land to be for tillers transformed the nation's approach to land tenure. As a result of their migration from one location to another in search of land, landless people increased the strain on the surviving woods (Dessie and Christiansson, 2008). Land and natural resources currently belong to the State and the Ethiopian people, according to the country's constitution. As a result, the legislation prohibits private ownership of any of the nation's natural forests. Nevertheless, the land use policy has granted the rural community the unlimited right to use the land.

Farmers in the study area received land certificate in 2014 to exercise right to use, but proper sustainable land management is not in place because of the current land use policy of Ethiopia, rural farmers are believed that in certain occasion the land could be transferred to private investor practically observed in some parts of area closures during field trip.

Among the main socio-economic factors, educational level and age significantly influenced some of the drivers of LULC changes in the sub-watershed. Similarly, households' age and literacy levels are important indicators of land degradation as a concern, which is one of the explanations behind the observed LULC shifts (Daba, 2003). In terms of watershed-level analyses of potential factors revealed the contribution of each driver for LULC changes in the studied area. The findings demonstrated that the distance to the main change-causing factors determined where LULC changes occurred. For instance, it was found that LULC alterations were more prevalent around marketplaces and roadways, which were consistent with findings from earlier research carried out elsewhere (Kindu et al., 2015; Lin et al., 2007). The research area's proximity to a major route that connects Addis Abeba to the country's southern region, including Arba Minich and Shashemene, makes it simple for farmers to sell their produce on the market.

Different implications are associated with the ongoing LULC dynamics as a result of the factors in the examined sub-watershed. A decrease in grassland cover, for example, causes the local communities to increase pressure on the forest's remaining area to graze their animals, which harms how quickly natural regeneration may occur (Tessema, 2015).

Population development raises the need for more cultivated land, wood for fuel, and charcoal, which causes losses in vegetative cover (Gashaw et al., 2017). Population growth was the primary factor for the LULC dynamics in the northwest highlands (Bewket, 2002; Gashaw et al., 2014; Gessesse, 2010; Hassen and Assen, 2017). The factors that contributed to the LULC alterations were high population pressure, which in turn increased demand for land and trees, inadequate institutional and socioeconomic contexts, a lack of security about the ownership of property, and unsuitable land use practices (Babiso et al., 2016).

4. Conclusion

This study showed that the interaction between nine causes was primarily responsible for the four decades of LULC variations in the Bilate Alaba sub-watershed. According to rural farmers, the top five important drivers of LULC changes are population growth, agricultural operations, livestock rearing, removal of woody trees for fuel, and rainfall variability. In terms of spatial distribution there were 6 driving factors were contributed for LULC changes; the distance to towns, distance to road, distance to water, gradient, rainfall, and elevation. For the investigated sub-watershed and other areas with a comparable geographic context, it is crucial to do additional research to examine the effects, consider the alternatives for the future, and devise intervention measures for sustainable development. To stop the continuous unfavorable LULC changes of natural resources, appropriate policy and strategy centered on those key drivers are urgently needed. The identified drivers can be used as inputs for future change modeling, well-informed policy making, land use planning, and other related studies in the

Ethiopian highlands.

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