Scientific Research Publishing

Land Use and Land Cover Dynamics in the North-Eastern Somali Rangelands of Eastern Ethiopia

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Abstract

Drastic changes have occurred in Siti zone rangeland over nearly the last three decades, due to rapid land conversion dynamics in the area. In the zone, the land-use change over time and space and temporal trends rangeland condition have never been studied. This study analyzed land use and land cover (LULC) change dynamics since the 1980s. Three dates, 1985, 2001 and 2017, Landsat images were used for classification and analysis of the various LULC. The three images were geo-referenced, re-sampled and processed for classification, using the maximum likelihood classifier algorithm. Moreover, field observations and information from local people were used for triangulation to patterns LULC dynamics. From 1985 to 2017, the general trend observed in the land use/cover change in the rangeland resources in the study districts implies a loss of grassland cover was compensated by an increase in cultivated areas, settlement and shrub/bush land cover. Moreover, the encroachments of invasive plant, *Prosopis*, settlement and the promotion of cultivation to pastoral way of livelihood have exacerbated the decline of rangeland cover. The study findings have shown important changes in the LULC patterns in the north-eastern Somali rangelands of eastern Ethiopia. These trends are certainly the characteristics of a pastoral way of life turn to settlement. This suggests that major changes in the socio-ecological driving forces affecting landscape dynamics have occurred in the last three decades or so.

Keywords

Pastoralist, Remote Sensing, *Prosopis*, Agriculture, Rangeland,
Land Use/Cover

1. Introduction

Somali Regional State (SRS), a major pastoral ecosystem in East Africa, has a total land area of about 327,000 km^2, of which about 90% is classified as rangeland [1]. The rangelands are suitable for pastoralism, more than 80% of the populations in the SRS depend fully or partially on livestock production for their livelihood [1], so it is the dominant types of land-use systems in the region [2]. Moreover, more than half of Ethiopian pastoralists live in SRS [3]. Pastoralists raise livestock under extensive conditions using natural rangelands as the main forage for their herds. Livestock production serves pastoralists as a source of food, cash, social security and status, transport and pack animals [3]. Besides, pastoralists make a significant contribution to Ethiopian economy [1]. Recent studies on total economic valuation of pastoralism in Ethiopia have shown that 45% of agricultural GDP is sourced from livestock sector in 2008/09 and almost all of Ethiopia's live animal and meat exports come from pastoral areas of the country [4].

Pastoralism is rarely viewed as a major future form of land use, because well-documented cases of rangeland degradation and the subsequent losses of ecosystem services [5] that threaten the livelihoods of pastoralists, due to its conversion to other land use [6]. For instance, increasing sedentarisation of pastoralists in Ethiopia [7] [8] [9] has heightened pressure on rangeland resources. Demand for firewood, charcoal and construction materials was behind a dramatic 97% decline in woodland cover between 1972 and 2007 in Afar rangeland of North-eastern Ethiopia [9]. Similarly, declines in the density of multipurpose woody species in Siti and Liben zones of SRS were due to the tree falling for construction material and firewood and charcoal demand of growing nearby towns [3] [8]. Moreover, the conversion of rangelands into cultivated land has been reported in Ethiopia [10] [11]. All these changes have an adverse effect on biodiversity of the ecosystems and sustainability of rangeland productivity [12] [13]. It is, therefore, important to understand the drivers and trends influencing these conversions as a prerequisite for analysis of land use and land cover change processes [14] [15]. Land-use/cover change is a multifaceted process caused by the interaction between anthropogenic and natural factors at different temporal and spatial scales [6] [16]. However, understanding of land-use/cover dynamics and consequences is negligible due to lack of empirical information at local levels, particularly in the Ethiopian rangelands [16] [17]. The Somali rangeland in North-eastern Ethiopia is one notable example where not only no information exists regarding land-use/cover changes, but also the driving factors behind the on-going processes have not been thoroughly investigated. A better understanding of the socio-environment interactions associated with land-use/cover changes requires an in-depth analysis of how the changes affect the physical environment (*i.e.*, land degradation) and the feedback on livelihood strategies and vulnerability of the people [13] [16]. To track landscape structural changes and complexities over time requires the mapping of changes from past to present. In

this regard, the recently increased availability of satellite data and advancements of remote sensing and geographic information systems (GIS) tools help to quantify and detect land-use/cover changes [16] [18] [19]. In this study, remotely sensed satellite data and people perception data were integrated to investigate land conversion dynamics. Besides, LULC maps can be a powerful tool to compare their changes in an area over time and with them possible to analyze a large area of land in a short period of time [20]. The objective of this study is to analyze the land use and land cover dynamics for the past 32 years (1985-2017) in north-eastern Somali rangelands of eastern Ethiopia. The study provides insight that demonstrates the importance of integrating multiple data sources in analyzing land conversion dynamics. Moreover, the findings are expected to draw recommendations on sustainable rangeland management that might guide decisions and provides insight to policymakers on sustainable pastoral livelihood development programs.

2. Materials and Methods

2.1. The Study Areas

The Siti administrative zone is located in the north-west of the SRS, lies within 40.554˚-42.966˚ east and 9.265˚-11.096˚ north [3] [21]. The zone is made up of seven districts. Among these, Shinile, Aysha'a and Afdem were selected for this study (Figure 1). Most of the landscapes of the study areas are characterized by low-lying flat terrain (undulating hills), stony outcrops interspersed with plains of loose soil covered by bush and woody grasses, while only insignificant lands are steeply dissected mountains ranging from 950 to 1350 m above sea level. The zone receives an average of 500 to 700 mm of rain annually [22] and mean annual temperature ranges between 22.5˚C and 32.5˚C, depending on the location within the zone [23]. There are two rainy seasons, namely the "*Diraa*" or "*Gu*" (short rains) from mid-March to mid-May and the "*Karan*" (long rains) from mid-July to mid-October. The dry seasons are "*Hagaa*", from mid-May to mid-July, and "*Jilaal*", from mid-October to mid-March [2] [22]. The dominant tree species include, *Acacia tortilis*, few and scattered *Acacia senegal*, *Acacia bussei*, *Acacia aeforta*, *Zizyphus mauritania*, *Acacia mellifera*, *Balanites rotundifolia* and *Tamarix aphylla*. In most parts of the study Districts, Prosopis juliflora has spread over most parts of the bush land along the main roads and along the seasonal and perennial water courses [2] [3]. The Siti zone has an estimated population of 456,434, of which 245,928 are males and 210,506 females [24]. It is estimated that 80% of the 96,988 rural inhabitants in Shinile district, all the 50,043 rural inhabitants in Aysha, and all of the 31,991 rural inhabitants in Afdem are pastoralists. The other 20% in Shinile are engaged in agro-pastoralism. Less than 5% of the population is involved in commercial activities in urban or trading centers (Population estimates for 2007 based on 1994 census: in [22]). The main ethnic group in Site is Somali, representing 95% of the population [24].
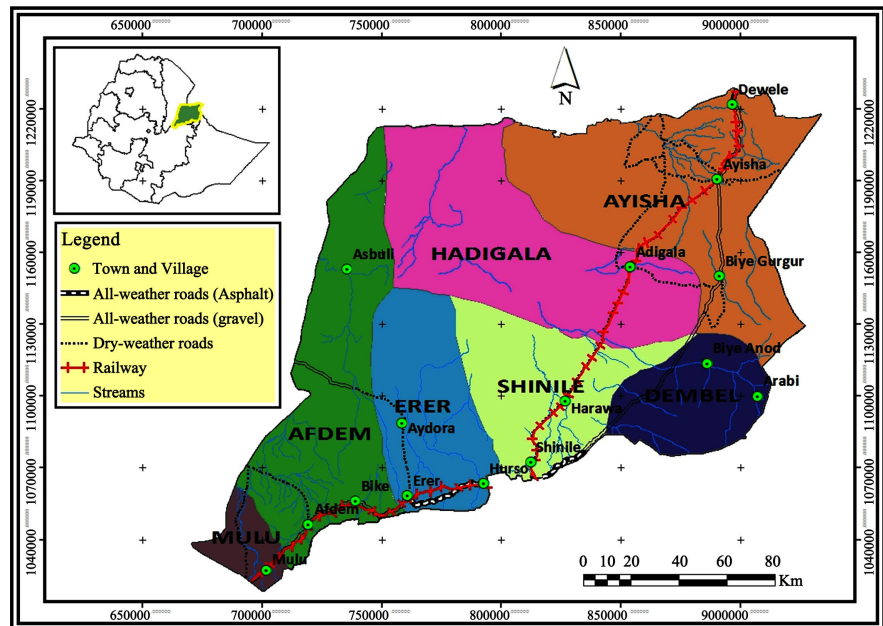
Figure 1. Map of the study areas, Siti zone.

2.2. Data Collection

The data used for land use and land cover (LULC) classification in the study were remotely sensed images. Three dates (1985, 2001 and 2017) of Landsat imageries, with path 166 and row 52 and 53 for Ayisha, and path 167 and row 52 and 53 for Afdem and Shinile, were acquired (source: https://earthexplorer.usgs.gov/) and their brief descriptions are summarized in Table 1. These Landsat satellite images were choice in terms of their image quality, with no cloud cover; and the need to ascertain the LULC trends over the 32 year period was considered long enough to generate adequate changes.

The field surveys in study areas were conducted in the July to September of 2018. A hand-held "Garmin 12" Global Position System (GPS) receiver, with ±3 meter accuracy, was used to pick some 216 coordinates of selected LULCs as ground control points from the field accompanied by key informants. The locations of these reference data were determined at random by identifying and locating the land use classes of interest in the field and their GPS points and coordinates picked and recorded.

Moreover, participatory tools, such as focus group discussions (FGDs) and key informant interviews (KIIs), and also resource mapping and transect walks, were used to collect qualitative data. A total of four FGD (two female and two male groups) and six KII were conducted in each district (total of twelve FGDs and 18 KII from the three study districts). FGDs using semi-structured interviews were held, and the participants were grouped into two (male and female). The discussion was used as a means of generating ideas regarding issues related to land management and mapping the distribution of resources. Different segment of the community groups, such as elders, women representatives, agriculture or natural resource experts, development agents (DAs), Kebele and district level

Table 1. Characteristic of Landsat used.

Satellite Sensor	No. of bands	Spectral resolution (μm)	Spatial resolution (m)	Observation date
Landsat OLI_TIRS (Operational Land Imager and Thermal Infrared Sensor) (Landsat-8)	11	Band 1-7: 0.43 - 2.29 Band 8 (Panchromatic): 0.5 - 0.68 Band 9: 1.36 - 1.38 Band 10-11: 10.6 - 12.51	Band 1-7 & 9: 30 Band 8: 15 Band 10-11: 100	2017
Landsat ETM + (Enhanced Thematic Mapper Plus)	9	Band 1-5: 0.45 - 1.75 Band 6: 10.4 - 12.5 Band 7: 2.08 - 2.35 Band 8 (Panchromatic): 0.5 - 0.9	Band 1-5 & 7: 30 Band 6: 60 Band 8: 15	2001
Landsat Multispectral Sensors (MSS)	4	0.5 - 1.1	60	1985

government officials (administrators) and selected pastoralist and agro-pastoralist from the respective study district (Kebele), were key informants who participated in the research. A specific checklist of questions was used to interview the key participants (DAs, Kebele and district government officials and communities' "tribe" leaders). Moreover, FGDs and KIIs were used in the LULC identification, to have a clear understanding of the main categories of LULC as well to find out what types of changes are expected over time, which were used later to triangulate the LULC dynamics in the study areas. Issues intended to be addressed by the research were analyzed using findings from both quantitative and qualitative surveys and applying triangulation method. The basic concept is that integration of quantitative and qualitative data maximizes the strengths and minimizes the weaknesses of each type of data [25] [26] [27].

2.3. Data Analysis

In all images, satellite image pre-processing, both geometric rectification and image enhancement were conducted. In this study, the geo-referencing strategy adopted was a GPS ground control points registration [9] [20], using ENVI 4.3 software [28]. The 2017 Landsat-8 image was geo-referenced using ground control points with a root mean square error (RMSE) of 0.21 pixels. The ETM+ and MSS images were geo-referenced using the 2017 Landsat-8 image as a master image. The Universal Transverse Mercator (UTM) geographic projection and WGS 1984 Zone 38 North datum were used in geo-referencing the images. To make the Landsat MSS (1985) image compatible, *i.e.*, to be analyzed together with other Landsat images [29], were re-sampled to a 30 m pixel size using the nearest neighbor re-sampling technique after [30].

Image enhancement was used to increase the details of the images by assigning the image maximum and minimum brightness values to maximum and minimum display values [29]. Landsat data are 8-bit data and the Digital Numbers have values from 0 to 255. Accordingly, the original low dynamic ranges of the images were stretched to full dynamic range using histogram equalization

and this made visual interpretation better [20]. The general methodological flow diagram of LULC dynamics were shown in **Figure 2**.

In this study, for image classification and change detection, both unsupervised and supervised image classification methods were adopted [20] [31]. Unsupervised classification was first carried out to have an idea of representing the overall LULC clusters of pixels. And then supervised classification was employed to categorize the images using ground truths (training areas) which were defined based on the results of unsupervised classification (the cluster of pixels) and ancillary data (Google Earth).

Based on [32], land-use land-cover classification system, five land use land cover classes, bare land, cultivated land, grassland, settlements/built-up areas and shrub land, were classified in accordance with [33] [34] classification criteria for East African rangelands (**Table 2**). For this identification, some of the LULC classes was required frequent field visits and FGDs with pastoralist and also consulted secondary data, to have a clear understanding of the main categories of LULC as well to find out what types of changes are expected over time. The classification algorithm used in the ENVI 4.3 software [28] was supervised maximum likelihood classifier (MLC). Image differencing was performed in ArcGIS 10.1 software [35] to ascertain the levels of change from one land use type to the other and by how much in terms of area in hectare.
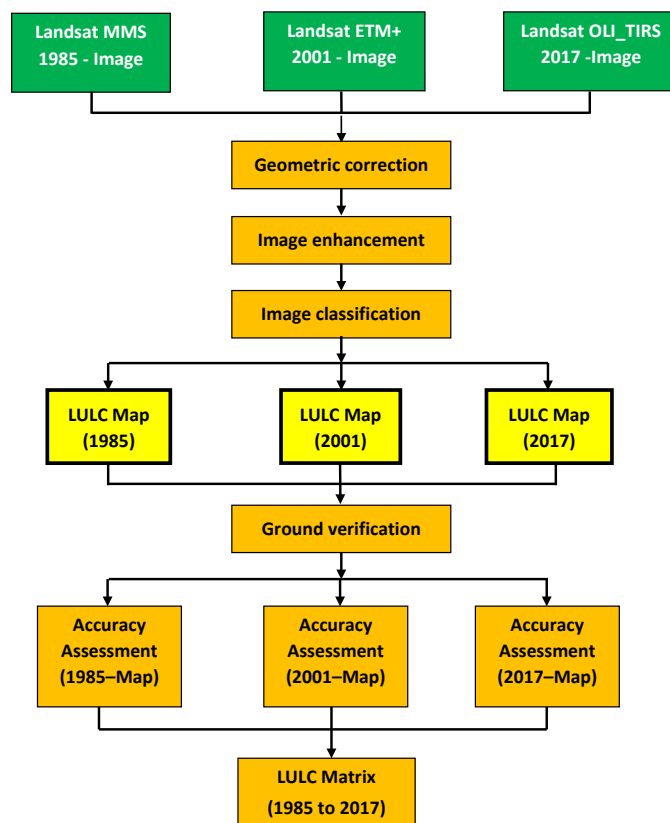
Figure 2. Flow chart of the process followed to create the data on the land cover classification analysis.

Table 2. Description of land use and land cover types identified.

LULC Classes	LULC Description
Shrub land	Land covered by small trees, bushes, and shrubs, and in some cases such lands are mixed with grasses; It is less dense than the woodland.
Grassland	Small grasses and herbs are the predominant natural vegetation. It also includes land with scattered or patches of trees and this land cover is used for grazing and browsing.
Cultivated land	Areas allotted to extended crop production, Cropping fields.
Settlement	This is a land use dominated by a permanent settlement area that included towns and rural villages and roads.
Bare land	A non-vegetative land, which mainly covered by rock outcrops, sand, and lava (volcanic ash).

Classifying LULC maps from satellite images; require a quality check on the acceptability of the results of the classes that have been trained and assigned to each pixel in the image, *i.e.*, an accuracy assessment were conducted. The use of aerial photographs and previous LULC classes as well as the use of GPS shows identified ground control points (GCPs), which are, in most instances land use types. The area of interest has invariably been used to corroborate the accuracy of LULC classification [36]. The classified LULC maps may contain some sort of errors because of several factors, from classification technique to the methods of satellite data capture. In order to use the classified maps, the errors must be quantitatively evaluated through classification accuracy assessment and intended to produce information that describes reality. Therefore, an accuracy classification assessment was performed through the standard method [37]. The accuracy of the 1985 image was determined form expert knowledge of the study Districts along discussion with elders. The 2001 accuracy were determined using co-ordinate points of land uses obtained from the Google Earth image. The 2017 classification was assessed using the GPS points of selected LULC types collected in the field. These were used in the accuracy assessment procedure. In the absence of base maps and aerial photographs of the study area, GPS points of 216 LULC types were selected as GCPs to ascertain the accuracy of the classification. This was done using the Kappa hat statistical analysis. Thus, total accuracy, and Kappa statistics were computed. In principle, all the output maps have to meet the minimum 85% accuracy [32].

Visual comparison of features and matrix analysis (image differencing) were adopted to determine the LULC change detection [38]. Areas that are converted from each class to any of the other classes were computed and the change directions were also determined. The land-use/cover changes between the three periods (*i.e.*, 1985, 2001 and 2017) were quantified and a change detection matrix of "from-to" change was derived [39] [40] to show land cover class conversion transitions during the 30-year period by overlaying the 1985 and 2017 images. In relation to the transition matrix, net change and net change-to-persistence ratio [9] [39] [40] were computed to show the resistance and vulnerability of a given

land-use/cover type. All, this was executed in ArcGIS cross-tabulation tool functionality of ArcMap 10.1 software [35].

3. Result

3.1. Land Use Land Cover Dynamics in Afdem District

The accuracy assessment was conducted for all the classified imageries (maps) via a standard method. The producer's, user's and total accuracy and the Kappa statistics were computed. The overall classification accuracy of the images yielded a Kappa hat statistic of 87.94%, 85.2% and 89.72% for the 1985, 2001 and the 2017 images, respectively. This is an indication of classification accuracy of moderately substantial to almost perfect agreement (Table 3).

The LULC maps that show spatial distribution of five LULC classes for 1985, 2001 and 2017 were given in Figure 3 the area coverage of the LULC categories were summarized in Table 4. In all study years more than half of the district coverage was bare land that includes exposed rock surface, exposed sand soil and volcanic lava (Table 4 and Figure 3). The study revealed the grassland was intact in the first study period while overtime-decreased trends of conversion of grassland to shrub land were observed. As a result, the share of shrub land increased from 7.2% (41,370 ha) in 1985 to 19% (108,680 ha) in 2001, to 16.9% (96,290 ha) in 2017. Expansion in the extent of cultivated land and settlement also followed the same trend as shrub land did, and their area coverage in 2017 was about 4.2 times higher than its original cover of 1985.

Table 3. LULC classes and accuracy assessment of the classified images of Afdem district.

LULC Classes	Accuracy (%)					
	1985		2001		2017	
	Producer's	User's	Producer's	User's	Producer's	User's
Shrub land	76.67	80.6	83.3	57.14	80.6	70.59
Grassland	76.47	100	86.6	89.8	86.3	88.6
Cultivated land	87.24	85.24	85.8	88.8	86.8	76.67
Settlement	82.31	82.31	88.64	97.5	95.5	96.8
Bare land	66.67	57.14	79.8	85	87.4	89.5
Over all accuracy	87.94		85.2		89.72	

Table 4. Areas of LULC of Afdem district between 1985 and 2017.

Years	1985		2001		2017	
LULC class	Area (ha)	%	Area (ha)	%	Area (ha)	%
Shrub land	41,375	7.2	108,679	19	96,287	16.9
Grassland	182,986	32	128,828	22.5	106,508	18.6
Cultivated land	13,126	2.3	30,947	5.4	25,943	4.5
Settlement	5188	0.91	29,533	5.2	50,405	8.8
Bare land	328,849	57.5	273,537	47.9	292,381	51.2
Total	571,524	100	571,524	100	571,524	100
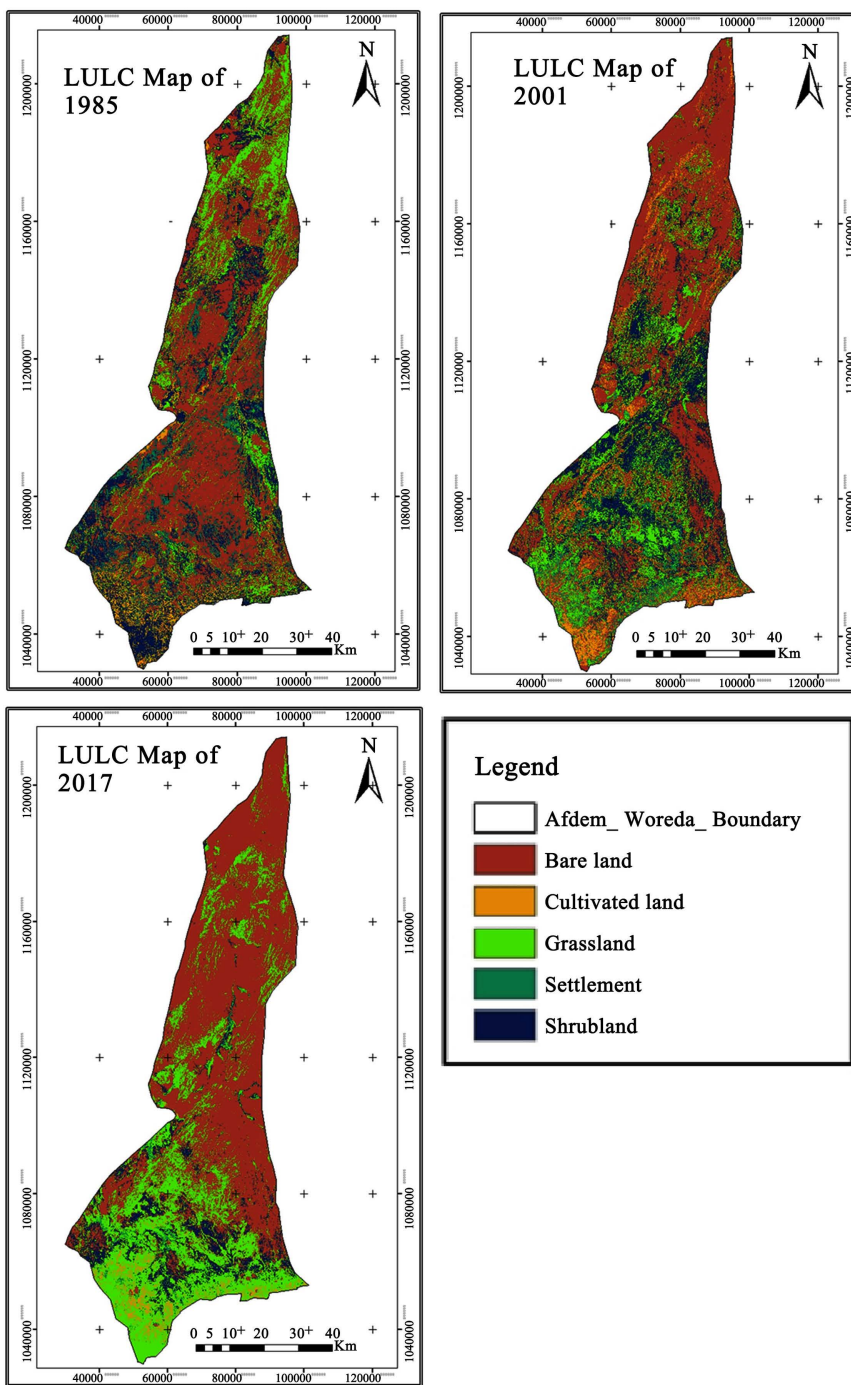
Figure 3. Afdem District LULC Map of Years 1985, 2001 and 2017.

The LULC class trend analysis shows the direction in which the various classes are heading using their respective initial years of comparison as the base. Between 1985 and 2001, the 16-year period, grassland decreased by 54,158 ha, and also bare land decreased by 55,312 ha. While shrub land, settlement and cultivated land areas increasing by 67,304 ha, 17,824 ha and 24,345 ha respectively (Table 4). This was the case since the district has and continues to its vegetation cover in the area began to decline tremendously, and most of the land, particu-

larly, the grassland cover had been converted into shrub land, cultivated land and settlement.

The LULC trends between 2001 and 2017 indicated that human activities had begun taking considerable toll on the land use and cover types. Settlement and bare land increased by 20,870 ha and 18,880 ha, respectively (Table 4). Grassland, shrub land and cultivated land decreased by 22,310 ha, 12,390 ha and 5050 ha, respectively (Table 4). The significant decrease in the grassland was due to rapid urbanized settlements that were converted these grassland and shrub land areas over the period. As a result, the settlement was showed a significant incensement in area of coverage. Today, most of the grassland areas have been converted to settlement and bare land.

The land use change matrices depict the changes in extent and directions in LULC classes. As evident from Table 5, between 1985 and 2001, the area of LULC persistence or retention, constituted a total of 256,787 ha representing about 45% of the total area. "Persistence" is indicated in Table 5 as the bolded diagonal elements for each land-use/cover class. The most LULC conversion occurring within this period is the conversion of bare land into grassland a total conversion area of 69,253 ha. As seen in Table 5, there was a substantial increase in settlement uses by 67,304 ha representing 62% change over the period. This was gained from the conversion of bare land as well as grassland by 67,948 ha and 25,224 ha, respectively.

The LULC matrix from 2001 to 2017, portrayed major land use conversions/transitions from one land use class to another. At this time, various land use class types were in real transition of change after the base year's land use cover anomalies. This was particularly so for the diagonal matrix of land uses that maintained their types in the following reference years by a decrease over the previous reference year at a total of 151,532 ha. This was about 26% of the total land area. The highest conversions from one type to another, however, was from grassland and shrub land to bare land cover with 79,659 ha and 62,851 ha respectively in 2017 (Table 6).

Table 5. LULC change matrices of the afdem district (1985-2001).

LULC Class		2001 Image					1985 Total
		BL	CL	GL	SET	SL	
1985 Images	BL	**190,246**	4808	61,419	4428	67,948	328,849
	CL	4893	**3776**	1893	2446	118	13,126
	GL	69,253	21,922	**47,545**	19,042	25,224	182,986
	SET	987	186	2190	**827**	998	5188
	SL	8158	255	15,781	2790	**14,391**	41,375
	2001 Total	273,537	30,947	128,828	29,533	108,679	571,524
	Change (ha)	−55,312	17,824	−54,158	24,345	67,304	
	Change (%)	−20	+58	−42	+82	+62	

BL = Bare land; GL = Grasslands; SET = Settlement; CL = Cultivated land; SL = Shrub Land. Bolded diagonal elements represent proportions of each LULC class that were static (persisted) between 1985 & 2001.

Table 6. LULC change matrices of the afdem district (2001-2017).

LULC Class		2017 Image					2001 Total
		BL	CL	GL	SET	SL	
	BL	**130,026**	7342	76,281	11,011	48,877	273,537
	CL	5052	**2005**	14,327	99	9464	30,947
2001 Images	GL	79,659	6664	**5661**	14,978	21,866	128,828
	SET	15,315	6491	675	**3306**	3746	29,533
	SL	62,329	3441	9564	21,011	**12,334**	108,679
	2017 Total	292,381	25,943	106,508	50,405	96,287	571,524
	Change (ha)	18,880	−5050	−22,310	20,870	−12,390	
	Change (%)	+7	−20	−21	+41	−13	

BL = Bare land; GL = Grasslands; SET = Settlement; CL = Cultivated land; SL = Shrub Land. Bolded diagonal elements represent proportions of each LULC class that were static (persisted) between 1985 & 2001.

Furthermore, there was a substantial increase in settlement uses by 20,870 ha representing 41% change over the period. This was gained from the conversion of grasslands as well as shrub land by 14,978 ha and 21,011 ha, respectively (Table 6).

3.2. Land Use Land Cover Dynamics in Shinile District

Like the previous Afdem district, the accuracy assessment of all the classified imageries from Shinile district was conducted in a standard way. For all maps, the producer's, user's and total accuracy and the Kappa statistics were computed. Overall, the maps met the required minimum 85% accuracy (Table 7).

For the whole study period, much of the district coverage was the natural vegetation, including, shrub land and grassland (Table 8 and Figure 4); while the classes of grassland (44.7%) in 1985, shrub land (35%) in 2001, and bare land (43.8%) in 2017 comprised the largest share of the total area. The study also revealed increased trends of conversion of grassland to shrub land. As a result, the share of shrub land increased from 16.7% (62,440 ha) in 1985 to 28.7% (107,230 ha) in 2017. Similarly, cultivated land showed increased in trends. Like the previous district, the grassland cover was diminishing continuously from its level of 44.7% (167,261 ha) in 1985 to 17.1% (64,085 ha) in 2017. However, areas of bare land and settlement showed inconsistent pattern of conversions.

The land use change matrices depicted the changes in the extent and directions in LULC classes. Between 1985 and 2001, the area of LULC persistence or retention, constituted a total of 107,281 ha representing about 29% of the total area (Table 9). As evident from Table 9, there have been a remarkable increases in the area of shrub land (68,296 ha), cultivated land (9121 ha), settlement (5223 ha), and bare land (7055 ha) during the first study period although some portion of their extents were converted to other LULC classes. In contrast, the only shrinkage was evident in the extent of grassland (89,691 ha) however the added area from the classes of bare land (20,186 ha), settlement (853 ha), shrub land

(9956 ha) and cultivated land (166 ha) could not compensated its losses in the course of the first period.
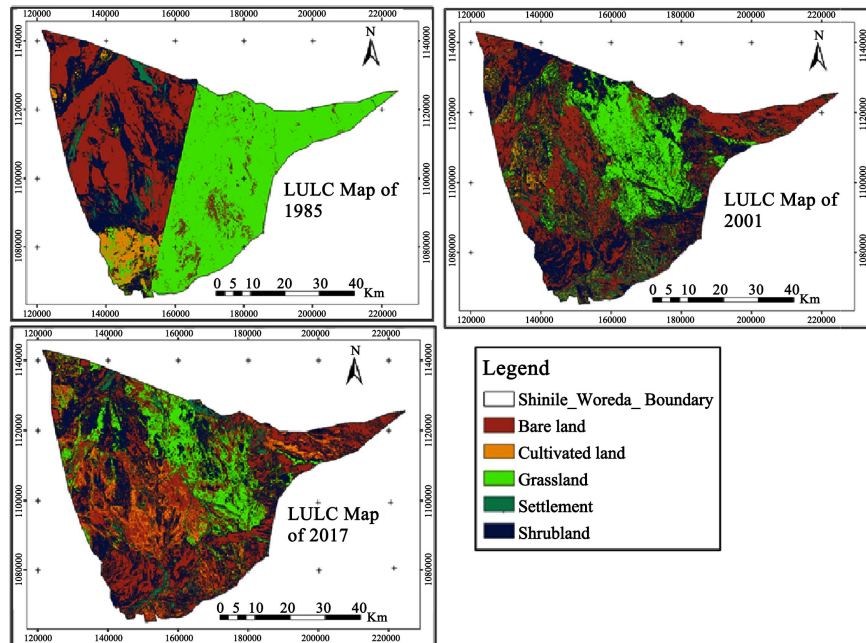

Figure 4. Shinile District LULC Map for Years 1985, 2001 and 2017.

Table 7. LULC classes & accuracy assessment of the classified images of Shinile district.

LULC Classes	Accuracy (%)					
	1985		2001		2017	
	Producer's	User's	Producer's	User's	Producer's	User's
Shrub land	87.08	94.87	76.79	76.74	81.64	81.4
Grassland	81.54	87.18	88.42	86.36	87.20	80.85
Cultivated land	90.60	82.98	94.87	92.63	93.21	93.02
Settlement	84.08	80	96.79	96.74	95.5	100
Bare land	93.91	100	87.18	88.42	86.56	86.05
Over all accuracy	87.15		88.91		88.96	

Table 8. Areas of LULC of Shinile district between 1985 and 2017.

Years	1985		2001		2017	
LULC class	Area (ha)	%	Area (ha)	%	Area (ha)	%
Shrub land	62,440	16.7	130,732	35	107,230	28.7
Grassland	167,261	44.7	77,570	20.7	64,085	17.1
Cultivated land	16,457	4.4	25,578	6.8	27,658	7.4
Settlement	9962	2.7	15,185	4.1	11,151	3
Bare land	117,882	31.5	124,937	33.4	163,878	43.8
Total	374,002	100	374,002	100	374,002	100

LULC change matrices of the shinile district (1985-2001).

	LULC Class	2001 Image					1985 Total
		BL	CL	GL	SET	SL	
	BL	**38,267**	11,899	20,186	4795	42,735	117,882
	CL	5301	**88**	166	136	10,766	16,457
1985 Images	GL	57,577	5952	**46,409**	6675	50,648	167,261
	SET	3219	718	853	**553**	4619	9962
	SL	20,573	6921	9956	3026	**21,964**	62,440
	2001 Total	124,937	25,578	77,570	15,185	130,732	374,002
	Change (ha)	7055	9121	−89,691	5223	68,292	
	Change (%)	+6	+36	−115	+34	+52	

BL = Bare land; GL = Grasslands; SET = Settlement; CL = Cultivated land; SL = Shrub Land. Bolded diagonal elements represent proportions of each LULC class that were static (persisted) between 1985 & 2001.

In the second study period (2001-2017), the areas of bare land and cultivated land have been increased by 38,941 ha and 2080 ha respectively despite their initial areas in 2001 simultaneously were lost to grassland, shrub land and settlement (Table 10). As seen in Table 10, the most important contributors to the increase of bare land and cultivated land were shrub land and grassland. Moreover, at this time, the land uses that maintained their types in the following reference years by an increase over the previous reference year at a total of 131,644 ha. This was about 35% of the total land area.

Thus, from all classes in the Shinile district, shrub land (66,778 ha) in the second period also noticeably continued to be the major area loser to bare land while grassland (19,296 ha) to bare land. In contrast, settlement, shrub land and grassland classes were lost their original extents and transformed to other classes.

3.3. Land Use Land Cover Dynamics in Ayisha District

Likewise the other two districts, for Ayisha, the accuracy assessment of all the classified imageries were conducted in a standard way. For all images, the produce's, user's and total accuracy and the Kappa statistics were computed. In general, all images met the required minimum 85% accuracy (Table 11).

For the whole study period, much of this district also covered with natural vegetation, including shrub land and grassland (Table 12 and Figure 5); while the classes of bare land (exposed rock surface and exposed sand soil surface) comprised the largest share of the total area in all times. The study also revealed increased trends of conversion of much of grassland area to settlement. As a result, the coverage of settlement surprisingly increased from 6.5% (47,843 ha) in 1985 to 10.4% (76,123 ha) in 2017. Like the previous two Districts, the grassland cover was diminishing continuously from its level of 14.5% (105,955 ha) in 1985 to 9.3% (67,862 ha) in 2010. However, areas of shrub land and bare land showed expected inconsistent pattern of conversions.
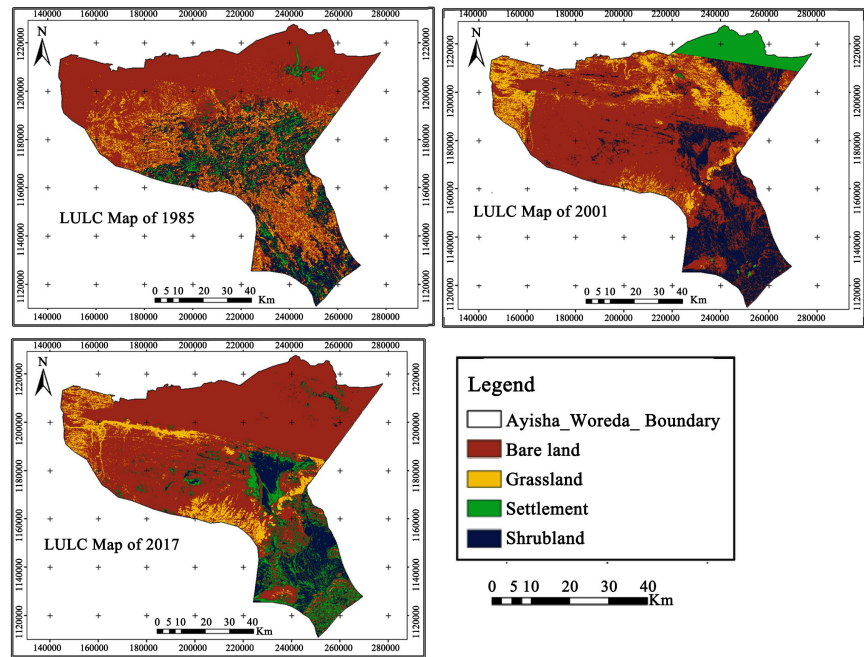
Figure 5. Ayisha District LULC Map for Years 1985, 2001 and 2017.

Table 10. LULC change matrices of the shinile district (2001-2017).

LULC Class		2017 Image					2001 Total
		BL	CL	GL	SET	SL	
	BL	**130,026**	7342	76,281	11,011	48,877	273,537
	CL	5052	**2005**	14,327	99	9464	30,947
2001 Images	GL	79,659	6664	**5661**	14,978	21,866	128,828
	SET	15,315	6491	675	**3306**	3746	29,533
	SL	62,329	3441	9564	21,011	**12,334**	108,679
	2017 Total	292,381	25,943	106,508	50,405	96,287	571,524
	Change (ha)	18,880	−5050	−22,310	20,870	−12,390	
	Change (%)	+7	−20	−21	+41	−13	

BL = Bare land; GL = Grasslands; SET = Settlement; CL = Cultivated land; SL = Shrub Land. Bolded diagonal elements represent proportions of each LULC class that were static (persisted) between 1985 & 2001.

Table 11. LULC classes & accuracy assessment of the classified images of Ayisha district.

LULC Classes	Accuracy (%)					
	1985		2001		2017	
	Producer's	User's	Producer's	User's	Producer's	User's
Shrub land	84.06	76.6	76.79	76.74	81.64	81.4
Grassland	80.38	79.07	88.42	86.36	87.20	80.85
Settlement	91.97	75.47	96.79	96.74	95.5	100
Bare land	86.37	92.31	87.18	88.42	86.56	86.05
Over all accuracy	87.24		86.91		88.96	

Table 12. Areas of LULC of Ayisha district between 1985 and 2017.

Years	1985		2001		2017	
LULC class	Area (ha)	%	Area (ha)	%	Area (ha)	%
Shrub land	97,409	13.3	128,495	17.6	66,818	9.1
Grassland	105,955	14.5	98,046	13.4	67,862	9.3
Settlement	47,843	6.5	47,793	6.5	76,123	10.4
Bare land	480,458	65.7	457,331	62.5	520,862	71.2
Total	731,665	100	731,665	100	731,665	100

The change matrices depicted the changes in extent and directions in LULC classes. Between 1985 and 2001, the area of LULC persistence or retention, constituted a total of 328,381 ha representing about 45% of the total area (Table 13). As evident from Table 13 there has been a remarkable increase in the area of shrub land (31,086 ha), during the first study period despite some portion of their initial extents were converted to other LULC classes. Whereas, a simultaneous shrinkage was observed in the area of bare land (23,127 ha) and grassland (7909 ha), even though considerable area of land added to it from shrub land (61,220.5 ha) and grassland (75,103 ha).

In 2001-2017, the areas of bare land and settlement have been increased by 63,531 ha, 28,330 ha respectively, despite their initial areas of 2001 were simultaneously lost to grassland and shrub land (Table 14). Moreover, at this time, the land uses that maintained their types in the following reference years by an increase over the previous reference year at a total of 446,440 ha. This was about 61% of the total land area. As shown in Table 14, the most important contributor to the increase of bare land was grassland while shrub land lost to settlement. Accordingly, grassland (30,184 ha), just like other districts, noticeably continued to be the major area contributor to bare land.

4. Discussion

In both study areas, Afdem and Shinile districts, five major LULC types (bare land, cultivated land, grassland, settlement and shrub land) were identified. However, in Afdem district, there was no cultivated land, and LULC types were four. There were high values of overall classification accuracy (85.2% - 89.72%) were attained; these indicated a strong agreement between the classified LULC patterns and the geographical data (ground truths). The Kappa statistic is generally accepted as a measure of classification accuracy for both the model as well as the user of the model of classification [41]. Kappa values are characterized <0 as indicative of no agreements and 0 - 0.2 as slight, 0.2 - 0.41 as fair, 0.41 - 0.60 as moderate, 0.60 - 0.80 as substantial and 0.81 - 1.0 as almost perfect agreement [20] [41] [42]. Then it is possible to use the output maps that meet the requirements for the intended application. Moreover, the overall accuracies were very

Table 13. LULC change matrices of the ayisha district (1985-2001).

LULC Class		2001 Image				1985 Total
		BL	GL	SET	SL	
	BL	**289,245**	80,633.5	46,755	63,825	480,458
1985	GL	75,103	**8615**	108	22,129	105,955
Images	SET	31,763	2914.5	**567.5**	12,598	47,843
	SL	61,220.5	5883	362.5	**29,943**	97,409
	2001 Total	457,331	98,046	47,793	128,495	731,665
	Change (ha)	−23,127	−7909	−50	+31,086	
	Change (%)	−5	−8	−0.1	+24	

BL = Bare land; GL = Grasslands; SET = Settlement; SL = Shrub Land. Bolded diagonal elements represent proportions of each LULC class that were static (persisted) between 1985 & 2001.

Table 14. LULC change matrices of the ayisha district (2001-2017).

LULC Class		2017 Image				2001 Total
		BL	GL	SET	SL	
	BL	**371,456**	30,555	26,153	29,167	457,331
2001	GL	61,247	**36,670**	80	49	98,046
Images	SET	45,959	338	**1104**	392	47,793
	SL	42,200	299	48,786	**37,210**	128,495
	2017 Total	520,862	67,862	76,123	66,818	731,665
	Change (ha)	+63,531	−30,184	+28,330	−61677	
	Change (%)	+12	−45	+37	−92	

BL = Bare land; GL = Grasslands; SET = Settlement; SL = Shrub Land. Bolded diagonal elements represent proportions of each LULC class that were static (persisted) between 1985 & 2001.

good with the user and producer accuracies also being considerably high for almost all the land use classes. This is an indication of acceptable LULC classification accuracy for images for which there were no available ground truth data as well as aerial photographs nor a pre-existing land use land cover maps.

In all study districts, there were experienced substantial and increasing rates of land-use/cover changes during 32 years from 1985 to 2017. There have been persistent changes, both spatially and temporally, resulting in an average 41% of the total area experiencing transitional changes among the land cover types. The poor vegetation cover observed in 2001 compared to 1985 and 2017 indicates that most of the vegetation types suffered from short-term direct and indirect drought effects. Supporting the above idea, the FGD held in Afdem confirmed that between 2007 and 2010 the expansion of bear land and lose of indigenous grassland species as well as trees fall down were observed. Moreover, rain fall and temperature variability research findings showed that in the last 30 years, in Shinile, Ayisha and Afdem stations, the annual maximum temperature had an increasing trend by 0.074, 0.059 and 0.095°C, respectively [43].

The bare land-use types were a significant proportion of all the study districts where the surface is predominantly covered by salt flats, volcanic lavas, rocks or sandy soils. Moreover, in 2017, cultivated land in two study districts, Afdem and Shinile, were little and scattering patches; and, it covers around 5% in Afdem and 7% in Shinile, and it showed a significant rise in Shinile but in-consistent in Afdem. Since 2001, the tendency of increase in trends of cultivated land was stagnant. These may be due to increasing drought occurrence, particularly rainfall was reduced since 2000, and these may discourage the more involvement in agriculture. According to FGDs held in Afdem, due to the impact of drought the community forced to shift agriculture, however, due to the lack of rainfall, the cultivation remains as it was. Similarly, the KIIs result held with Afdem district's Agriculture and Natural Resource Office, indicated that the amount of land allocated 50 hectares has been cleaned for irrigation in 2017, and at the end of the year, only 20 hectares of land was used for irrigation but out of these 20 hectares of land the irrigation was effective on 12 hectares of land. Regarding, the amount of hectare of land farmed using rain-fed agriculture in Afdem district; it was 108 and 62 hectares in 2016 and 2017 respectively. Compared to Shinile district (2000 hectare were irrigated), the cultivated land in the Afdem district is the less. Generally, the respondents during FGDs and KIIs attribute the trend to increasing drought occurrence, which discourages more involvements in agriculture. From 2006-2017 years, in Shinille and Afdem districts, a total of 2000 pastoral households were shifted from pastoralism to agro-pastoralism being involved in irrigation scheme and rain feed agriculture [44].

It is also observed in the field that many cropping fields left uncultivated gradually revert to shrub land mainly dominated by annual forbs and *Prosopis* plant less palatable to livestock. The FGD participants described that: *Prosopis* was first introduced in Shinile district in 1978 as a conservation measure. It was planted by conducting community mobilization and campaigns. *Prosopis* has been planted to reclaim degraded land, combat desertification and reduce soil erosion [44] [45] [46]. Regarding its distribution, it mostly found in grasslands and valleys where water is available. *Prosopis* tap roots are able to reach a depth of 20 to 25 m, and some *Prosopis* trees whose roots reached beyond this depth have been reported globally [44]. The result of FGD shows that bare land has shown an increment while grazing lands have decreased and mostly replaced by *Prosopis* plant. Owing to allelopathy, *Prosopis* plants suppress growth of other plants and threaten plant diversity in areas where *Prosopis* plants grow [47] [48]. But due to increased coverage of shrub lands namely *Prosopis*, the community has witnessed becoming a suitable habitat for wildlife and as a result, tigers, cheetah and hyena were observed in the area. At the same time, the FGD has elaborated that they observed the increase of settlement areas as pastoralists have lost their livestock and grazing lands, they become destitute and sought livelihood alternatives in kebele centers and nearby towns. It was also mentioned that the increase of sub kebeles and number of kebeles in the district since 20 years ago.

The LULC changes that were detected in all study areas revealed, in general, the greater areas of grassland and grazing land were transformed into shrub land and cultivated land, bare land and settlement. The latter definitely implies how changes in LULC causing land degradation. This shows forced conversion of the larger part of the natural vegetation cover to agricultural land, bare land and settlement, which were constantly increased in all the three study areas. In this regard, human activities are taken basically into consideration for the expansion of huge agricultural lands through unplanned exploitation of grazing resources for the spontaneously increased population. According to KII result found from both in Shinile and Afdem district agriculture and natural office, revealed that the settlement program involved with clearing of shrub lands for settlement as well as for cultivation, in the form of irrigation and red fed agriculture were practiced in since 2010.

The LULC changes detected in all study areas, if not monitored and controlled may result in land degradation and increase vulnerability of people. Continued land use/cover change, coupled with a drier climate, greatly affects people's livelihoods and puts the pastoralist, agro-pastoralist and small holder farmers' production system under increasing threat. The changes in LULC in study area thus indicate resource degradation and vulnerability of people. The drivers and related changes may therefore influence ecosystem functioning in rangelands through their impact on traditional mobility patterns between wet- and dry-season grazing areas. This may also lead to a decrease in the size of dry-season grazing areas, isolation of crucial habitats such as water sources, indirectly resulting in changing livestock species composition and directly disturbing some plant species that may be threatened with extinction. According to FGDs, in all study districts revealed that most pastoralists no longer keep cattle and have shifted to small ruminants (goats and sheep) that can utilize bush-encroached areas. The present tendency may lead to more land degradation if no effective restoration strategy is made. Regarding to key plant species loss, the FGD held in Ayisha and Shinille district, indicated that since the past 20 years the area had lost most of the following plant species, namely, "Maraa" (*Acacia nilotica*), "Qudhac" (*Acacia tortilis*), "Galool" (*Acacia bussei*), "Garas" (*Dobera glabra*), and "Dareemo" (*Chrysopogon aucheri*). But charcoal production, invasion by *Prosopis* plant and cactus expansion were the main reasons for losing vegetation covers. According to FGD, in the Ayesha and Afdem district, the lack of fodder for their livestock within their vicinity has become a challenge, besides, they mentioned, unavailable of key grazing areas forced them to move other areas.

The general trend observed in the study districts implies a loss of grassland cover and an increase in cultivated areas and shrub or bush land cover. The present tendency may lead to more land degradation if no assisted restoration is made. Continued LULC change, coupled with a drier climate, greatly affects people's livelihoods and puts the pastoral and agro-pastoral production system under increasing threat.

Acknowledgements

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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