Journal of Environment and Earth Science www.iiste.org
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online) DOI: 10.7176/JEES
Vol.9, No.6, 2019

Land Use and Land Cover Dynamics in Eastern Pastoral Rangelands of Somali Region, Ethiopia

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The research is financed by Jigjiga University (Research Publication and Technology Transfer Directorate of Jigjiga University)

Abstract
Drastic changes have occurred in Harshin district rangeland management over nearly the last two decades, due to rapid spread of fencing of 'private' grazing areas, contrary to the communal ownership pattern that informal institutions govern. In Harshin district, the land use change over time and space and temporal trends rangeland condition have never been studied relative to the effects of long term management changes. This study analyzed land use and land cover (LULC) change dynamics since 1980s. Three dates, 1984, 1998 and 2014, 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. The best Kappa hat statistic of classification accuracy was 85%. The results of the classification over the three periods showed that settlement and bare land increased from 7325 hectare (ha) in 1984 to 18,720 ha in 1998. Grassland decreased by 8010 ha over the same period and increased by 53,230 ha by the 2014; shrub land also decreased by 9471 ha and 31,196 ha in 1998 and 2014, respectively. Woodland increased by 6176 ha in 1998, however; it decreases by 33,175 ha in 2014. The study findings have shown important changes in the LULC patterns in the district. The bare land, coupled with shrub land reduction between 1984 and 1998, substantial increments in bare land, settlement land uses, and grassland coverage, while a substantial decrease in woodland coverage were found between 1998 and 2014. These trends are certainly the characteristics of 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 two decades or so.
Keywords: Harshin district, Land use land cover dynamics, Rangeland, Remote sensing
DOI: 10.7176/JEES/9-6-03
Publication date:June 30th 2019

1. Introduction

In Ethiopia, pastoralism represent the largest land use system of the agricultural sector (Kassahun, 2003; Kassahun, 2006); covering about 61% (682, 000 km^2) of the total land area of the country (PFE *et al*., 2010). Moreover, people practicing pastoralism (pastoralists), represent approximately 37% (26.6 million) of the Ethiopia population (Kassahun *et al.,* 2008). More than half of Ethiopian pastoralists live in Somali Regional State (SRS) (Kassahun, 2006); and 17% of the national livestock population also exists in the region (IPS, 2002).

In SRS pastoralist societies, rangelands are based on communal property rights, meaning it used by a group of users, normally the (sub) clan who holds customary rights over a specified territory (Fiona *et al*., 2011; Abebe *et al.,* 2014). Each clan or sub-clan has its traditional boundary and individuals do not own land. All clan or sub-clan members utilize communally the available resources of their territory and share and protect the natural resources. This communal land tenure system of ownership allows pastoralists to pool resources together and reduce the risks associated with variable forage production (Kassa, 2001; Beyene, 2010).

However, in the study area, Harshin district of SRS, property rights to rangeland are undergoing significant transformation (PFE *et al.,* 2010); through rapid spread of fencing of 'private' grazing areas (rangeland enclosure), in contradiction with the communal ownership pattern that clan rules (informal institutions) govern (Fiona *et al*., 2011; Abebe *et al*, 2014). The study area, most of the rangeland is already permanently divided and enclosed by individuals (Beyene, 2009; PFE *et al.,* 2010). According to, Oxfam GB 2009 estimation, 80% of rangeland in Harshin are enclosed; and of the thirteen Kebeles that make up in Harshin district only one is not affected by rangeland enclosures (Fiona *et al.,* 2011).

Rangeland enclosure has been continued in alarming rate in Harshin district (PFE et al., 2010; Fiona et al., 2011); and it affect mobility pattern of pastoralists, which places restrictions on those of clan members or outsiders, requiring access to communal areas, not to pass in establishing enclosures (Aklilu and Catley, 2010). There is said to be leading to rangeland degradation (Homann *et al.,* 2005), decline in animal productivity (Eyasu and Feyera, 2010); and threat to the long-term sustainability (Beyene, 2009; Fiona *et al*., 2011). Moreover, land enclosures and the resulting increased competition over resources are directly blamed for clashes and conflicts between land users in these areas (Fiona *et al*., 2011). However, rangeland enclosure have also a positive aspect, including as means of recovering good quality grazing resources (Angassa and Oba, 2010; Tache, 2011); and, it have been used for income generating activities - fodder production, or sale of pasture, and also producing and selling charcoal (Alison and Desta, 2011).

These new developments of rangeland fragmentation, in terms of establishing enclosures, puts the existing either or debate, with regard to common property or privatization regimes as a general remedy for sustainable management of pastoralist land into question and calls for an increasing understanding on how driving forces creates new pressures on pastoralist land, which in turn prompts responses to local land-use change and subsequently, changes in the existing land management and property rights regime. Past research documents, in study area, were concentrated in identifying those pulling factors triggered the change and socio-economic ebbs that fueled the change in the property right regime. However, they were ignored to incorporate land use change, and access or control over land resources over time and space in rangeland dynamics in their studies. Therefore, this study main purpose is analyzed the land cover and land use dynamics observed since 1980s using geographic information system (GIS) and remote sensing.

2. Material and Methods

2.1. Description of Study Area

Harshin is one of the seven district of Fafan Zone of SRS, located in the southeast of Fafan Zone, 125 km east of Jijiga Town and 30 km away from the international border (Catley and Alula, 2010) (Figure 1). The climate is generally hot and dry, with an average annual rainfall is 300-400 mm. The northern part of the district falling during two rainy seasons, the '*Diraa'* rains (mid-Mar to mid-May) and the heavier '*Karan'* rains (mid-Jul to mid-Oct); while the southern part falling during two rainy seasons – '*Gu'* (Apr - Jun) and 'Deyr' (Oct – Dec), sometimes it also receives '*Karan'* rains (Fiona *et al*., 2011). Birka and seasonal ponds are the main water sources; there are no permanent or seasonal wells (SC-UK and DPPB, 2008; Catley and Alula, 2010). Soil is mostly red and sandy with high water permeability in all of Harshin district (SC-UK and DPPB, 2008). The district has a total human population of 80,215, in of which 45% (36,361) are female and 55% (43,854) male (CSA, 2007). 90 % (71,989) of the district communities dwell in the rural area and depend mainly on livestock production for their livelihood and the rest 10% (8,226) are urban and suburban dwellers (FDREPCC, 2008).

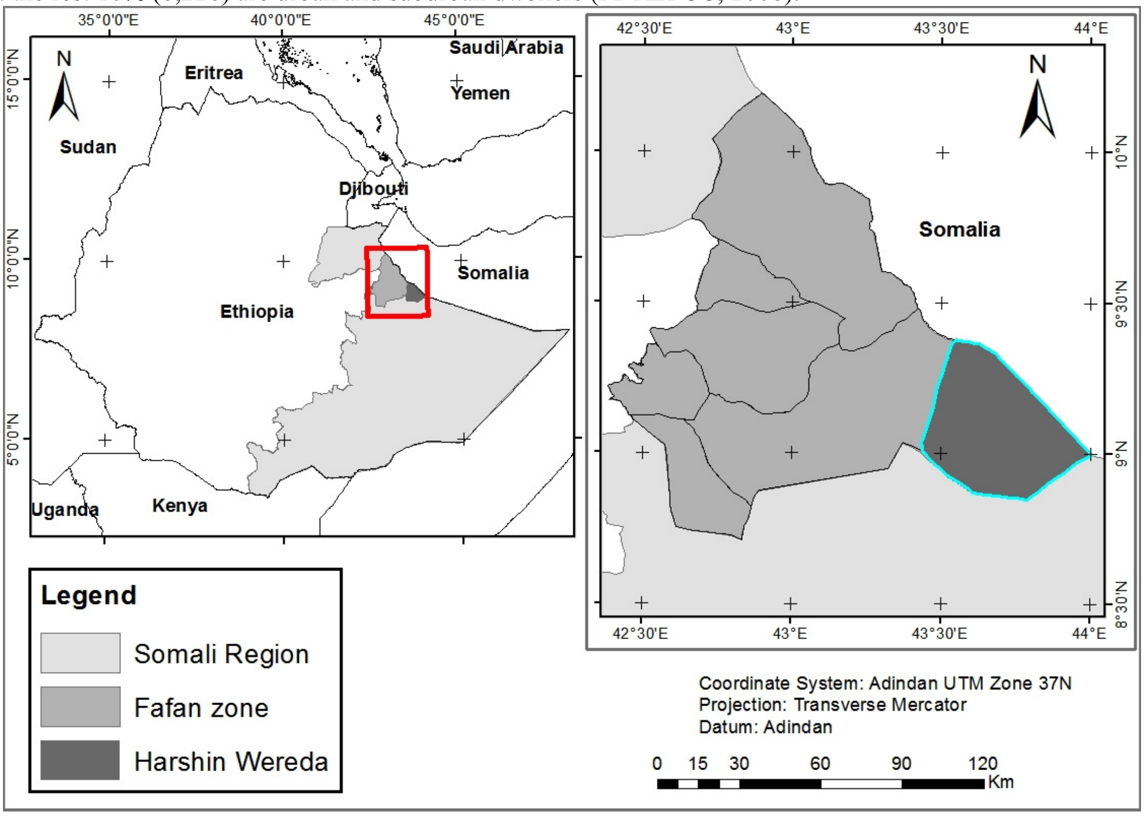

Figure 1. Map of the study area

2.2. Data Collection

Three different Landsat satellite images, with path 165 and row 54, covering the Landsat MSS for 1984 acquired on the 6th June 1984, Landsat 5 TM for 1998 acquired on 29th June and Landsat 8 OLI/TIS for 2014 was acquired on the 25th June, respectively (Table 1), were obtained (Source: http://landcover.org). The choice for the selection of the three dates were choice in terms of their image quality, with limited or low cloud cover; and, they were used for the classification and analysis of the various land use land cover (LULC) classes; and the need to ascertain the LULC trends over the 30 year period was considered long enough to generate adequate changes. The field surveys in study areas were conduction in the August and September of 2015. A hand-held "Garmin 12" Global Position System (GPS) receiver, with ±3m accuracy, was used to pick some 72 coordinates of selected LULCs as ground control points (GCPs) 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.

Table 6. Characteristic of Landsat used

Landsat Satellite Type	Number of bands	Spectral resolution (µm)	Spatial resolution (m)
Landsat OLI_TIRS (Operational Land Imager and Thermal Infrared Sensor)	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
Landsat Thematic Mapper (TM)	7	Band 1-5: 0.45-1.75 Band 6: 10.4-12.5 Band 7: 2.08 – 2.35	Band 1-5 & 7: 30 Band 6: 60
Landsat Multispectral Sensors (MSS)	4	0.5–1.1	60

2.3. Satellite Image Pre-processing

All images were corrected for atmospheric effects using IDRISI's ATMOSC module (based on Chavez (1996) cos(t) model). In this study, the geo-referencing strategy adopted was a GPS ground control points registration (Alemu *et al.,* 2015; Tsegayea *et al.,* 2010), using ENVI 4.3 software (ITT, 2006). The 2014 Landsat-8 image was geo-referenced using ground control points with a root mean square error (RMSE) of 0.21 pixel. The ETM+, TM and MSS images were geo-referenced using the 2014 Landsat-8 image as a master image. The Universal Transverse Mercator (UTM) geographic projection, Clarke 1880 spheroid, and Adindan (Ethiopia) zone 38 North datum were used in geo-referencing the images. To make the Landsat MSS (1984) image compatible, i.e., to be analyzed together with other Landsat images (Lillesand *et al*, 2008), were re-sampled to a 30 m pixel size using the nearest neighbor re-sampling technique after Serra *et al*. (2003). The Landsat 7 ETM+ has a Scan Line Corrector (SLC) failure which causes some areas to be imaged twice while no data is recorded for others. Bilinear interpolation was used to approximate the required image information from adjacent pixels (Mundavaa *et al,* 2014). 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 (Lillesand *et al*, 2008). 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 (Alemu *et al*., 2015). The general methodological flow diagram of LULC dynamics analysis was shown in figure 2.

2.4. Image Classification and Change Detection

In this study, both unsupervised and supervised image classification methods were adopted (Rogan and Chen, 2004; Alemu *et al.,* 2015). 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 Anderson (1976), LULC classification system, six land cover classes, bare land, grassland, settlements/built up areas, shrub land and woodland, were classified in accordance with Pratt *et al.,* (1966) and Pratt and Gwynne (1977) classification criteria for East African rangelands (Table 2). Other phenomena such as cloud cover and line strips on the images were classified but were not used in the land use matrix analysis. For this identification, some of the LULC classes was required frequent field visits and discussions 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 (ITT, 2006) was supervised maximum likelihood classifier (MLC). Image differencing was performed in ArcGIS 10.1 software (ESRI, 2012) to ascertain the levels of change from one land use type to the other and by how much in terms of area in hectare.

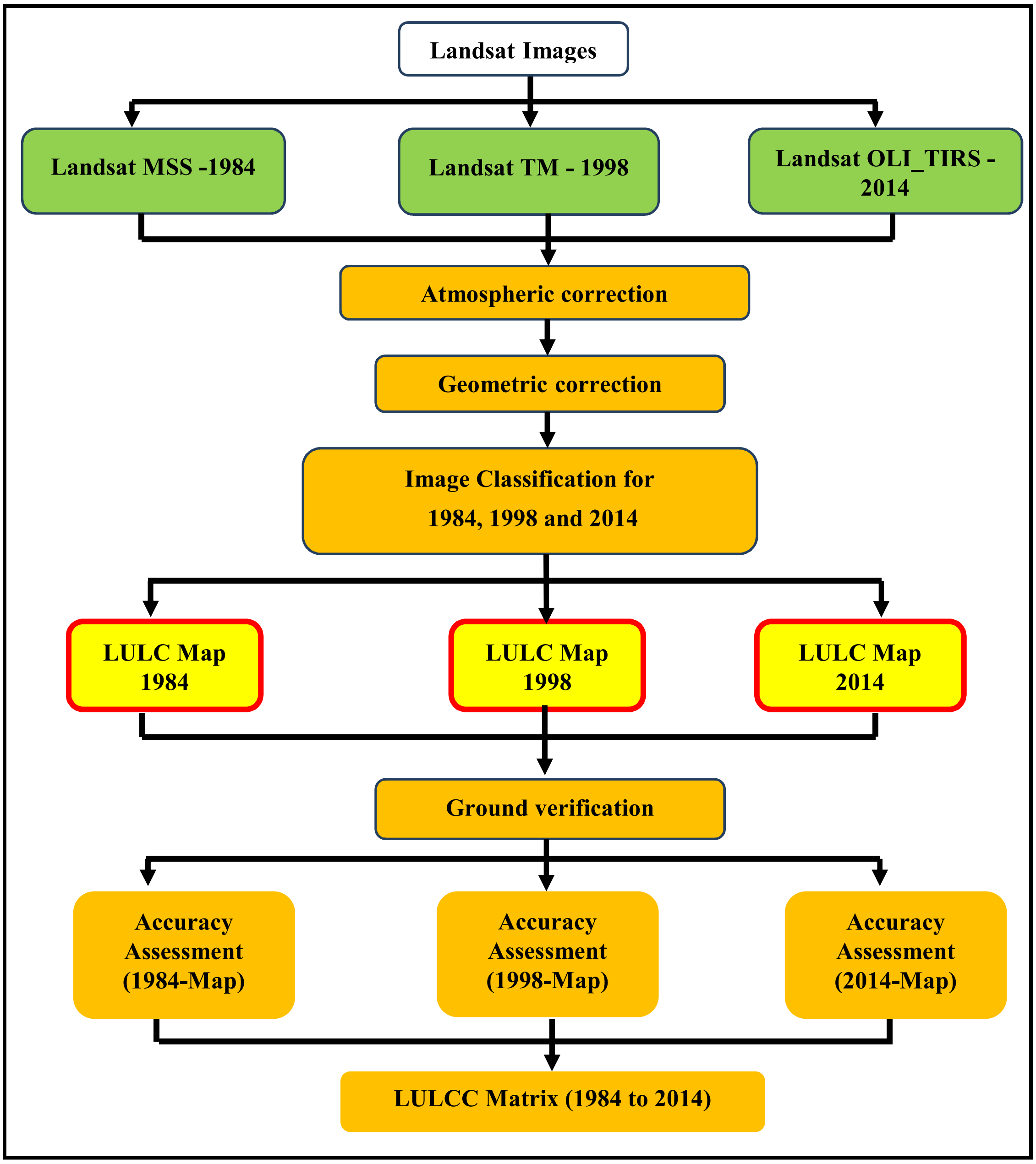

Figure 2. Flow chart of the process followed to create the data on the land cover classification. Green squares indicate the raw datasets used and orange squares indicate the processing performed on the datasets. The final raster LULC datasets are indicated by yellow squares with thick red outlines.

Table 7. Description of Land Use and Land Cover Types Identified

LULC Classes	LULC Description
Woodland	Land covered with relatively tall trees, at least have 20% canopy coverage including integral open space and felled areas that are awaiting restocking, the predominant species found in the area was *Acacia spp*
Shrub/Bush 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	Grassland Small grasses 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
Settlement	This is a land use dominated by permanent settlement areas that included towns and rural villages and roads.
Bare land	A non-vegetative land, which mainly covered by bare soil, sand and rock.

Visual comparison of features and matrix analysis (image differencing) were adopted to determine the LULC change detection (Lu *et al,* 2004). 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., 1984, 1998 and 2014) were quantified and a change detection matrix of 'from-to' change was derived (Braimoh, 2006; Pontius *et al.,* 2004) to show land cover class conversion transitions during the 30-year period by overlaying the 1984 and 2014 images. In relation to the transition matrix, net change and net change-to-persistence ratio (Braimoh, 2006; Pontius *et al*., 2004; Tsegayea *et al*., 2010) 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 (ESRI, 2012).

2.5. Accuracy Assessment
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. The use of aerial photographs and previous LULC classes as well as the use of GPS shows identified GCPs, which are, in most instances land use types. The area of interest has invariably been used to corroborate the accuracy of LULC classification (Peng *et al*., 2008). 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 (Congalton, 1991). The accuracy of the 1984 image was determined form expert knowledge of the study district along discussion with elders. The 1998 accuracy were determined using co-ordinate points of land uses obtained from the Google Earth image. The 2014 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 72 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 (Anderson *et al*., 1976).

3. Result and Discussion
3.1. Accuracy Assessment
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 Kappa statistic is generally accepted as a measure of classification accuracy for both the model as well as user of the model of classification (Maingi and Marsh, 2002). Kappa values are characterized as < 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 (Landis and Koch, 1977; Maingi and Marsh, 2002). The overall classification accuracy of the images yielded a Kappa hat statistic of 81.94%, 72.2% and 84.72% for the 1984, 1998 and the 2014 images, respectively. This is an indication of classification accuracy of moderately substantial to almost perfect agreement (Table 3).

The overall accuracies were very good with the user and producer accuracies also being considerably high for almost all the land use classes. This is an indication of an 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. The high to very high accuracy of classification for the three images, emphasize the precision of the LULC sampled points obtained via the GPS survey.

Table 8. Classification contingency matrix for 1984, 1998 and 2014 images

	1984 ERROR MATRIX					
LULC Classes	**GL**	**WL**	**SL**	**ST**	**BL**	**Total**
GL	6	3	1	0	2	**12**
WL	0	13	0	0	0	**13**
SL	1	0	20	0	0	**21**
ST	1	0	0	12	0	**13**
BL	1	1	0	1	8	**14**
Total	**9**	**17**	**21**	**13**	**12**	**72**
	Reference Totals	**Classified Total**	**Number Correct**	**Producers Accuracy**	**Users Accuracy**	***Classification Accuracy***
GL	9	12	6	66.67%	50%	***81.94%***
WL	17	13	13	76.47%	100%	
SL	21	21	20	95.24%	95.24%	
ST	13	13	12	92.31%	92.31%	
BL	12	14	8	66.67%	57.14%	
	1998 ERROR MATRIX					
LULC Classes	**GL**	**WL**	**SL**	**ST**	**BL**	**Total**
GL	8	1	0	4	1	**14**
WL	0	1	0	0	0	**1**
SL	7	3	3	1	1	**15**
ST	0	0	0	39	1	**40**
BL	0	0	1	0	1	**2**
Total	**15**	**5**	**4**	**44**	**4**	**72**
	Reference Totals	**Classified Total**	**Number Correct**	**Producers Accuracy**	**Users Accuracy**	***Classification Accuracy***
GL	15	14	8	53.3%	57.14%	***72.2%***
WL	5	1	1	20%	100%	
SL	4	15	3	75%	20%	
ST	44	40	39	88.64%	97.5%	
BL	4	2	1	25%	50%	
	2014 ERROR MATRIX					
LULC Classes	GL	WL	SL	ST	BL	**Total**
GL	12	1	2	2	0	**17**
WL	0	3	0	0	0	**3**
SL	3	1	1	0	0	**6**
ST	0	0	0	42	0	**42**
BL	0	0	1	0	3	**4**
Total	**15**	**5**	**4**	**44**	**4**	**72**
	Reference Totals	**Classified Total**	**Number Correct**	**Producers Accuracy**	**Users Accuracy**	***Classification Accuracy***
GL	15	17	12	80%	70.59%	***84.72%***
WL	5	3	3	60%	100%	
SL	4	6	1	25%	16.67	
ST	44	42	42	95.5%	100%	
BL	4	4	3	75%	75%	

GL = Grassland; WL=Woodland; SL=Shrub land; ST=Settlement; BL=Bare land

3.2. Land Use and Land Cover Change Trends

The LULC maps that show spatial distribution of five LULC classes for 1984, 1998 and 2014 were given in figure 2, the area coverage of the LULC categories were summarized in table 4. In all study years much of the district coverage was the natural vegetation, including grassland, woodland and shrub land (Table 4 and Figure 3 and 4); while the classes of grassland and woodland comprised the largest share of the total area. The study revealed the woodland was intact in the first study period while overtime-decreased trends of conversion of woodland to grassland and settlement were observed.

Table 9. Areas of LULC of Harshin District between 1984 and 2014

Year	**1984**		**1998**		**2014**	
LULC class	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**
Grassland	115,341	53.1	107,240	49.4	160,470	73.9
Woodland	49,699	22.9	55,875	25.7	22,700	10.5
Shrub land	44,859	20.7	35,388	16.3	4192	1.9
Settlement	656	0.3	707	0.3	18,628	8.6
Bare land	6669	3.1	18,013	8.3	11,234	5.1
Total	**217,224**	**100**	**217,224**	**100**	**217,224**	**100**

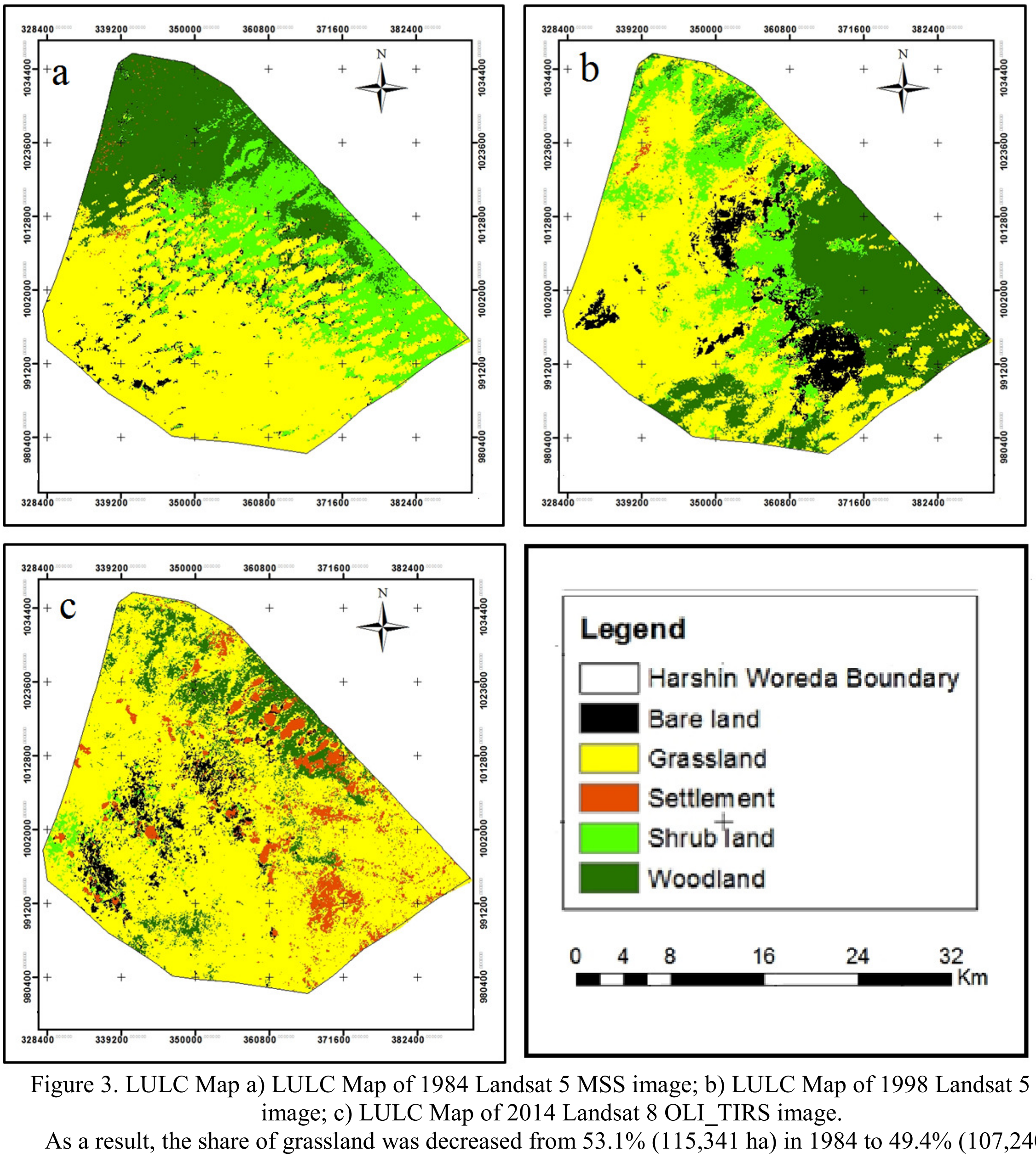

Figure 3. LULC Map a) LULC Map of 1984 Landsat 5 MSS image; b) LULC Map of 1998 Landsat 5 TM image; c) LULC Map of 2014 Landsat 8 OLI_TIRS image.

As a result, the share of grassland was decreased from 53.1% (115,341 ha) in 1984 to 49.4% (107,240 ha) in 1998 to 73.9% (160,470 ha) in 2014. Expansion in the extent of bare land and settlement also were followed the same trend as grassland, and its area coverage in 2014 was about 4 times higher than its original cover of 1984. In contrast, the woodland cover was showed inconsistent trends of conversions; increased from its level of 22.9% in 1984 to 25.7 % in 1998, but decline greatly to 10.5 % in 2013. However, areas of shrub land, decline continuously from its level of 20.7% in 1984 to 16.3 % in 1998, further to 1.9 % in 2014.

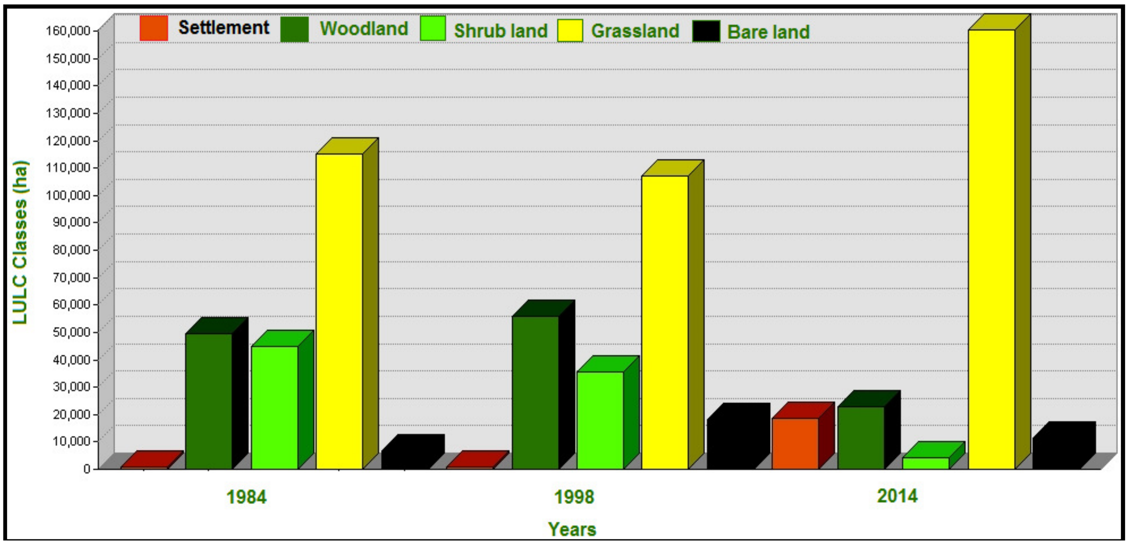

Figure 4: Grouped bar graph of the LULC Area (ha) for 1984, 1998 and 2014

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 1984 and 1998, the 14-year period, grassland decreased by 8010 ha, shrub land also decreased by 9471 ha, with woodland, settlement and bare land areas increasing by 6171 ha, 51 ha and 11,344 ha respectively (Table 5). This was the case since the district has and continues to its vegetation cover in the area began to decline tremendously, and the majority of pastoralists tend own 'private' grazing sources (often enclosed) for livestock grazing. By this year, most of the land, particularly, the shrub and grassland cover had been converted into settlement and bare land.

The LULC trends between 1998 and 2014 indicated that human activities had begun taking considerable toll on the LULC types. Grassland increased by 53,230 ha, while woodland and shrub land decreased by 33,175 ha and 31,196 ha, respectively. Settlement and bare land increased and decreased by 17,921 ha and 6779 ha, respectively (Table 5). The significant decrease in the woodland was due to rapid urbanized settlements that were converted these dense woodland and bare land areas over the period. As a result, the settlement was showed a significant incensement in area of coverage. Today, most of the woodland areas have been enclosed and the trees cut down, and the land has been converted to settlement.

Table 10. LULC change trend from 1984 to 2014

	1984 to 1998		1998 to 2014	
LULC class	**Area (ha)**	**% Change**	**Area (ha)**	**% Change**
Grassland	-8010	-8	53,230	+33
Woodland	6176	+11	-33,175	-146
Shrub land	-9471	-27	-31,196	-7
Settlement	51	+7	17,921	+96
Bare land	11,344	+63	-6779	-60

3.3. Land Use and Land Cover Change Transition between the Years

The land use change matrices depict the changes in extent and directions in LULC classes. As evident from Table 6, between 1984 and 1998, the area of LULC retention, constituted a total of 85,956 ha representing about 40% of the total area. The most LULC conversion occurring within this period is the conversion of woodland into grassland a total conversion area of 22,575 ha. As seen in Table 6, there was a substantial increase in bare land uses by 11,344 ha representing 63% change over the period. This was gained from the conversion of grasslands as well as shrub land by 12,522 ha and 4745 ha, respectively.

Table 11. LULC Change Matrices of the Harshin District (1984-1998)

	LULC class	1998 Image					1984 total
		ST	WL	SL	GL	BL	
1984 Image	Settlement	**7**	41	119	487	2	656
	Woodland	615	**11,462**	14,752	22,575	294	49,698
	Shrub land	55	20,380	**6568**	13,111	4745	44,859
	Grassland	19	22,307	13,024	**67,469**	12,522	115,341
	Bare land	11	1685	925	3598	**450**	6669
	1998 Total	707	55,875	35,388	107,240	18,013	**217,224**
	Change (ha)	`+71	+6177	-9471	-8101	+11,344	
	Change (%)	+10	+11	-27	-8	+63	

ST = Settlement; WL = Woodland; SL = Shrub Land; GL = Grasslands; BL = Bare land

The LULC matrix from 1998 to 2014, portrayed major land use conversions/transitions from one land use class to another. At this time, the 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 an increase over the previous reference year at a total of 95,319 ha. This was about 44% of the total land area. The highest conversions from one type to another, however, was from woodland and shrub land to grassland cover with 38,631 ha and 26,851 ha respectively in 2014 (Table 7).

Table 12. LULC Change Matrices of the Harshin District (1998-2014)

	LULC class	2014 Image					1998 total
		ST	WL	SL	GL	BL	
1998 Image	Settlement	**22.4**	124.2	8.4	544.2	8	707
	Woodland	6844.5	**10,032**	169	38,631	198.6	55,875
	Shrub land	1225.7	5487.9	**472**	26,850.5	1352	35,388
	Grassland	6750	6658	3293	**82,828**	7711	107,240
	Bare land	3785	397	250	11,616	**1965**	18,013
	2014 Total	18,628	22,700	4192	160,470	11,234	**217,224**
	Change (ha)	17,921	-33,175	-31,196	+53,230	-6779	
	Change (%)	+96	-146	-744	+33	-60	

ST = Settlement; WL = Woodland; SL = Shrub Land; GL = Grasslands; BL = Bare land

Furthermore, there was a substantial increase in settlement uses by 17,921 ha representing 96% change over the period. This was gained from the conversion of woodland as well as grasslands by 6845 ha and 6750 ha, respectively. From 2000 to 2005, alone the development of 10 urbanized settlements in areas that had previously been dense forests and pastoral grazing reserves were reported (SC-UK, 2005). Moreover, since 2000, charcoal production was most common practice and a highly profitable business in the District. The increase in charcoal production has been fueled by push and pulls factors. The push factors relate to the increasing challenges of maintaining a livestock-based livelihood system in the face of changing land use and recurring droughts (Sa'ad, 2007; Flintan *et al*., 2011).

Moreover, high demand for charcoal in the area has provided the 'pull' factors. It was estimated 846,720 sacks of charcoal, each 30-35kg, are produced each year in Harshin district (Oxfam GB, 2009). Moreover, Pastoralists in the study area are conscious of the potential threat of woody species and frequently clear most of the shrubs and trees not preferred by livestock on their rangelands (Haftay *et al*., 2013). This has played a role in controlling the encroachment of woody species, which is reported to have negative impacts on the cover of preferred grass species (Gemedo-Dalle *et al*., 2006; Angassa and Oba, 2010).

4. Conclusion

The LULC trends from 1984 through to the years 1998 and 2014 are consistently in favor of settlement/built up/bare land, as well as the grasslands, to an appreciable extent. These trends are certainly the characteristics of pastoral way of life tern to settlement.

In any case, the general observations from the fieldwork, coupled with the classified images, show that woodland and shrub land, greatly reduced the landscape in terms of LULC in the district from 1986 to 2014. However, in comparing the vegetation and non-vegetation covers of the district, it can be observed that LULCs other than settlement/built up areas and bare land (which rapidly increased) are slightly increasing at the expense of woodland covers. As woodland and shrub land reduce in size, particularly from 1998 to 2014, it is an indication of the deforestation activity increased in the district.

The study findings have shown important changes in the LULC patterns in the District. The bare land, coupled with shrub land reduction between 1984 and 1998, substantial increments in bare land, settlement land uses, and grassland coverage, while a substantial decrease in woodland coverage were found between 1998 and 2014. This suggests that major changes in the socio-ecological driving forces affecting landscape dynamics have occurred in the last two decades or so.

Moreover, mapping communal pastoral lands will be a significant step towards differentiating their land. Once communal land is mapped, the process of certification can be considered in consultation with the community involved. Therefore, this study may use as an initial step for such actions.

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