academicJournals

Vol. 10(1), pp. 1-11, January 2018
DOI: 10.5897/IJBC2017.1123
Article Number: 275541666925
ISSN 2141-243X

http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Evaluation of land use land cover changes using remote sensing Landsat images and pastoralists' perceptions on range cover changes in Borana rangelands, Southern Ethiopia

Habtamu Teka[1*], Casper I. Madakadze[2], Joel O. Botai[3], Abubeker Hassen[4], Ayana Angassa[5] and Yared Mesfin[6]

[1]Department of Animal and Range Sciences, Madda Walabu University, Ethiopia.
[2]Department of Plant Production and Soil Science, University of Pretoria, P. Bag X20 Hatfield, Pretoria, 0028, South Africa.
[3]Department of Geography, Geo informatics and Meteorology, University of Pretoria, Pretoria, South Africa.
[4]Deparment of Animal Science and Wilde life, University of Pretoria, Pretoria, South Africa.
[5]School of Animal and Range Sciences, Hawassa University, Awasa, Ethiopia.
[6]Department of Natural Resource Management, Arsi University, Rustavi, Georgia, Ethiopia.

Received 23 June, 2017; Accepted 24 October, 2017

Studies on land-use/land cover (LULC) changes through remote sensing techniques represent vital tools for generating rational information for sound decision making on natural resources management. Related to the launching of the first Landsat satellite in 1973 there is a region of attention on the use of remote sensing techniques as tool for planning the appropriate management in rangelands. This study therefore aimed at mapping LULC changes and identifying the associated changes that have occurred in the Borana rangelands up to 2003 as well as assess pastoralist perceptions on the driving forces. Landsat image scenes of Multispectral Sensor, Thematic Mapper and Enhanced Thematic Mapper Plus acquired in 1973, 1986 and 2003 were used to investigate LULC changes over time. The analysis of images revealed that woodland cover of the Borana rangelands increased from 11.3% in the 1973 to 49.26% in 2003. However, grassland cover declined from 58 to 32% during the same period. Cultivated areas gradually increased from 2 to 5% but it is lower compared to the woodland cover expansion rate. The decrease of normalized difference vegetation index (NDVI) values for 2003 compared to the 1973 is also an evident for the reduction of vegetation. Severe droughts, population increase, poor government policy are among the major drivers of LULC changes in the study area. The implementation of appropriate pastoral land-use policies based on the ecological potential of the region and pastoralists local knowledge have all been suggested for ensuring sustainable management of Borana rangeland and improve the livelihood of pastoralists.

Key words: Land use land cover, land absorption coefficient, land consumption rate, normalized difference vegetation index.

INTRODUCTION

In the tropics, it is well acknowledged that human activities such as land cultivation, grazing, mining and settlements represent the main drivers of land use land cover (LULC) changes and land dynamic (Meyer, 1995). Such human activities including direct or indirect anthropogenic pressures are sources of continuous threat on territorial land on one hand and impact negatively the livelihood security of people who depend on such land ecosystem on the other hand. In the case of land ecosystem such as rangelands, pastoralists are among the people who are mostly affected by such human activities.

Elsewhere, rapid human population growth, increased frequency of droughts and expansion of settlement in arid and semi-arid environment are among the well-known drivers of land use changes (Vitousek et al., 1997). On the contrary, in arid and semi-arid areas for example, vegetation changes are triggered by both anthropogenic and natural factors such as soil moisture (White et al., 2008), erratic and uneven distribution of rainfall (Fensham et al., 2005) and grazing (Rahlao et al., 2008). However, up to date remote sensing tools used were mostly directed to assess land vegetation cover changes because plants are key indicators of the healthiness of ecosystem and its ecological dynamics (Jensen, 1996).

Knowing that plants are part of arid and semi-arid ecosystem and that such ecosystems are highly susceptible and vulnerable to natural and anthropogenic perturbations that often affect the livelihoods of security of pastoralists, therefore it is essential to identify the driving forces (for example biotic and abiotic) of land use changes, especially for appropriate management of ecosystem and ensuring the livelihoods security of pastoralists. This implies gathering data on the type of ecosystem and its land use dynamics. As a result, remote sensing and geographic information systems are one of the key tools available to land use planner. In Judean Mountain and the Judean Desert in the Mediterranean and Arid ecosystems, Shoshany et al. (1994) has successfully monitored vegetation cover change through remote sensing technique.

Multi temporal satellite image plays an important role in monitoring of vegetation cover changes in rangeland through prepared LULC map (Palmer and Fortescue, 2003) and Normalized Difference Vegetation Index (NDVI) (Eklundh and Olsson, 2003). Using multiple satellite images acquired at different dates over the same study area provides an opportunity to planners to monitor changes in land cover by using proxy parameters such as vegetation index differencing (Purevdoria et al., 1998). For land use planners, Landsat series [that is the multi-spectral scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+)] provide with multiple satellite image data that plays a major role in detecting changes land use land cover change (De Fries and Belward, 2000). Schmidt and Gitelson (2000) used Advanced Very High Resolution Radiometer (AVHRR) satellite image for monitoring temporal and spatial vegetation cover changes in Israeli transition zone.

However, in arid and semi-arid environment, such multi-temporal satellite imagery have been poorly applied for monitoring and planning for land use changes, such as Borana rangelands, Southern Ethiopia. As a result, carrying out research on the dynamics of LULC changes through multi-temporal satellite approach could therefore play an important role in providing valuable information to planners on the way to successfully plan changes and map changes over time (Moshen, 1999).

The importance of traditional knowledge is widely acknowledged as valuable tools for natural resources management and monitoring changes over time. In East Africa, the Borana rangelands was known as one of the best remaining pastoral lands however, increasing rangeland use has driven vegetation decline and threaten traditional knowledge of pastoralists with regards to access, use and management of natural resources of that area. Pastoralists' approach over management of the Borana rangelands consist of mobility of herds during wet and dry season, strong community norms and regulations on range and water resource use (Coppock, 1994).

Rangelands use by shift from grazing land to crop land and other livelihoods activities has driven changes in Borana areas and in pastoralists while contributing to erode traditional knowledge of pastoralists on livestock grazing practices (Desta and Cppock, 2004). For appropriate land use planning, monitoring and safeguarding, it is crucial to document pastoralists' traditional knowledge on rangeland uses and their perceptions on land use/land cover changes.

This study aimed at improving rangelands (grasslands, woodlands and cultivated lands) management by detecting land use/land cover changes over time (1973-2003) in the Borana rangelands of Ethiopia. The specific objectives were two folds: 1) map LULC document, the major driving forces of such changes and patterns of change over time period of 1973 to 2003 using satellite (Landsat) image data analysis, and 2) assess pastoralists' perceptions on rangeland cover changes in

*Corresponding author. E-mail: dreyaman@gmail.com. Tel: +251-913870962.

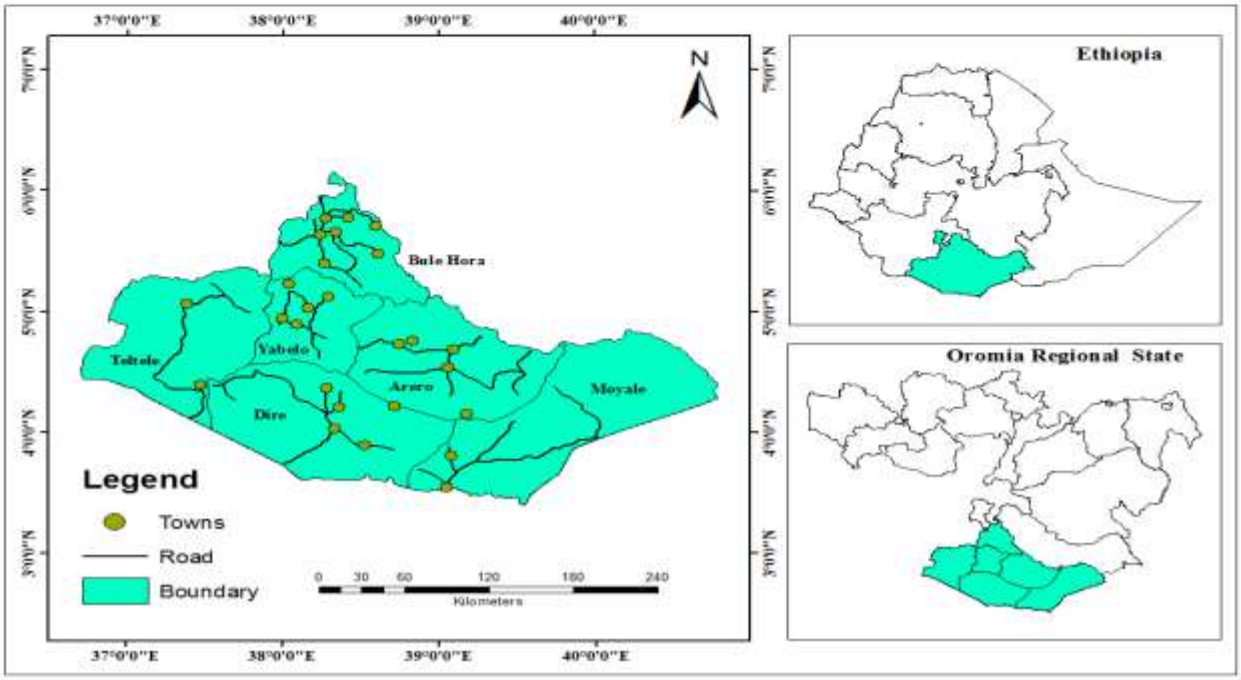

Figure 1. Location of the study area in Borana rangeland in Southern Ethiopia.

the study area.

MATERIALS AND METHODS

Study area

The study area Borana rangelands, covers approximately 63,939 km^2 (Figure 1), and hold the largest pastoral population in Oromia Regional State of Ethiopia. The Borana rangeland is located between 4° to 6°N of latitude and 36° to 42° E of longitude and its altitude ranges from 1000 to 1600 (Coppock, 1994). The area is characterized by arid and semi-arid climate with annual rainfall ranging on average between 500 and 700 mm (Helland, 1982). Rainfall is bimodal with 60% of the annual high precipitation encountered during March-May (main rainy season) and the remaining is encountered during September-November (short rainy season). The long dry season is from late November to early March. The mean annual temperature varies from 15 to 24°C and shows little variation across seasons. The vegetation cover of Borana rangelands is mainly evergreen and semi evergreen bush land, with shrubby *Acacia* and *Commiphora*. The rangeland is dominated by alien genera, and dwarf shrub grassland (Gemedo, 2004). The geology of the area is dominated by 40% quaternary deposits, 38% basement complex formation and 20% volcanic (Coppock, 1994).

The satellite images

For this study, Landsat image of Multi Spectral Scanner (MSS), Thematic Mapper (TM) and Enhanced Thematic Mapper Plus (ETM+) for the year 1973, 1986 and 2003 obtained from Global Land Cover Facility (https://www.landcover.org) were used, respectively (Table 1). In order to cover the study area, eight satellite images were mosaic and thereafter extracted by using the study area boundary. LULC classification was done based on classification criteria drawn for East African rangelands by Pratt and Gwynne (1977) (Table 2).

Prior to image classification and NDVI analysis the acquired satellite images were geometrically corrected and radiometrically normalized then registered image to image. These applications were carried out using ENVI; satellite image analysis software.

Image classification and data analysis

For vegetation cover changes analysis, a post classification comparison of change detection method was used. The most widely used method of change detection is a comparative analysis of spectral classifications for series of time produced independently (Singn, 1989). Landsat images of three years were independently classified using supervised classification method. Since class change precision depends on spectral separation, the interest class group was created and used by maximum likelihood classifier and smoothed with filter to reduce the misclassified pixels (Erdas, 1999).

Overall, our analysis was based on hybrid classification approach (Odindi et al., 2012). In this approach, the ISODATA unsupervised classification algorithm was used to categorize the natural classes. Separability parameters were used for the reliability test of the methodology. Classes that show low degree of separability were regrouped until seven dominant classes were obtained. By combining the visual images inspection of false color composite and unsupervised classified image, two sets of samples each with 25 points were created namely: the training set and post-classification set. The training set was used as Regions of Interest (ROIs) in the maximum likelihood of supervised classification while

Table 1. Satellite images acquired for three different times in the Borana rangelands.

Month	1973		1986		2003	
	Path	Row	Path	Row	Path	Row
January	181	56	169	56	169	56
January	181	57	169	57	169	57
January	180	56	168	56	168	56
January	180	57	168	57	168	57
January	179	56	167	56	167	56
January	179	57	167	57	167	57

Table 2. LULC classes used and their brief definitions in Borana rangelands.

Number	Class	Definition
1	Woodland	Area naturally covered by dense indigenous tree
2	Grassland	Area dominated by indigenous grass and forbs
3	Bareland	Area neither covered by vegetation nor used for crop production
4	Cultivated/built up area	Areas used for cropping and settlement

the post-classification ROIs was used for accuracy assessment using the confusion matrix (Congalton, 1991). Supervised classification was repeated three times and the derived outputs for the 2nd and 3rd land cover classifications yielded similar results which showed level of accuracy and consistence in the classification. Consequently, the LULC classes were sized down from seven classes to four classes comprising of grassland, woodland, bareland, and cultivated/built up area.

Once the classification was made for 1973, 1986 and 2003, the percentage of LULC changes was calculated as follows:

% trend change = (observed change/sum of change) x 100

The annual rate of change was obtained by dividing percentage change by the number of the study years: 1973-1986 (13 years) and 1973-2003 (30 years). The greenness of the study years were evaluated by calculating NDVI values as follows:

NDVI = (NIR-RED)/ (NIR+RED)

The prediction of LULC class changes to another class in the future based on past changes was done using Markov chain model (Aavikson, 1995). This is done by computing transition matrix of pixels in each class for two time periods. The matrix contains unchanged pixels diagonally, while other cells contain pixels that have changed the probabilities of change between classes computed by dividing each cell value by its row total.

On the other hand, the spatial distribution of occurrences within each land use category was interpreted using land consumption rate (LCR) and land absorption coefficient (LAC) formula as follows:

LCR = A/P
LAC = $(A_2\text{-}A_1)/(P_2\text{-}P_1)$

Where, A = areal extent of the rangeland in hectares, P = population. A_1 and A_2 are the area extends (in hectares) for the early and later years, and P_1 and P_2 are population numbers for the early and later years, respectively. LCR is a measure of compactness and indicates a progressive spatial expansion of settlers and LAC is a measure of change in consumption of new state of land by each unit increase in human population. The 1973, 1986 and 2003 population statistics were obtained from the censuses of Ethiopian Central Statistics Authority (CSA) (CSA, 2008) following a recommended 2% growth rate of pastoral area. The estimated population figure was calculated using the following formula:

$$n = r/100 * Po \quad (1)$$

$$Pn = Po + (n * t) \quad (2)$$

Where, Pn and Po are the estimated population and base year population, respectively, r = growth rate (2%), n = annual population growth, and t = number of years projecting for the given period.

Pastoralist perceptions on the driving forces of changes of vegetation and land cover

The major driving forces of change of vegetation and land cover in the study area were investigated using 200 key knowledgeable pastoral respondents. A group discussion was carried out with local key informants, community development practitioners, and with local and regional relevant professionals. Semi-structured interviews with the key informants were also used to generate information to identify the major causes driving changes of vegetation or land cover, and to understand the perception of Borana pastoralists on these changes. Scores were given for the identified drivers of change and these were put in order of priority. Secondary data was used for comparison of the present and the past status of vegetation and land cover changes and to identify the scale and degree of these changes. The correlations and strength of the relationships between independent (pastoralist perceptions in vegetation and land cover change) and dependent variables (Landsat image data) were computed using Stata version 10.

Table 3. Classification of land-use /cover changes in the Borana rangelands of southern Ethiopia.

Land type	1973		1986		2003	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Woodland	462294	11.3	1762173	39.31	2213242	49.26
Grassland	2363172	57.75	1505662	33.59	1425993	31.74
Bareland	1186877	29.01	1036548	23.12	630843	14.04
Cultivated	79533.6	1.94	178476	3.98	222895	4.96
Total	4091877	100	4482859	100	4492972	100

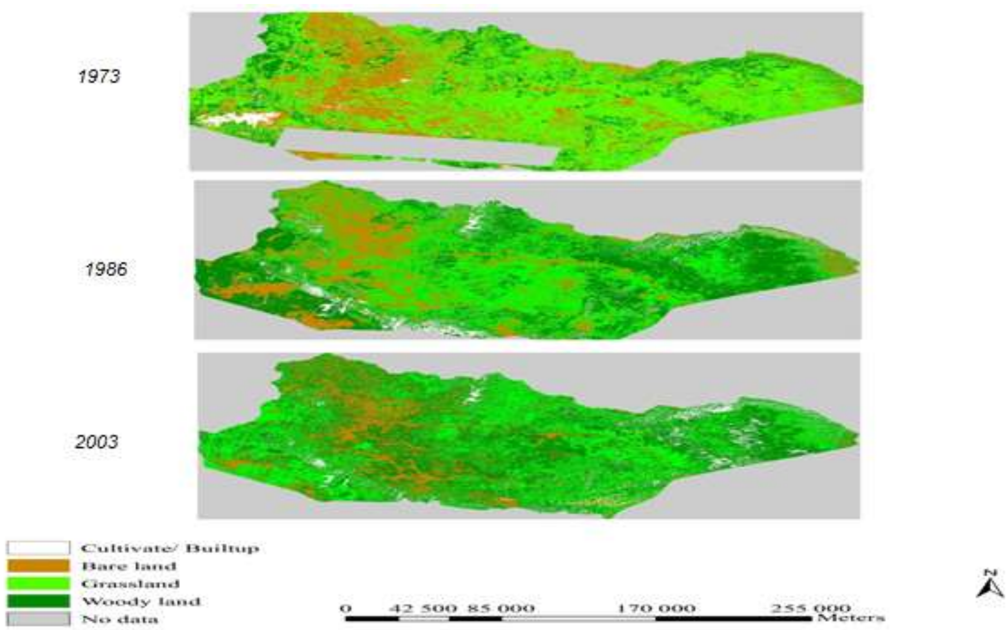

Figure 2. Land-use/land-cover change classification maps.

RESULTS

Classification accuracy assessment

Highest producer's accuracy (71%) and low omission error (28%) was recorded for grassland of the year 1986 Landsat image. In contrast, the producer's accuracy (66%) was low for the cultivated/built-up area for the same year. For bare land, the producer's accuracy (73%) was higher in 2003 than (71%) 1973. The overall classification accuracy of 1973 was 67.3 and 69.1% and 69.5% for the year 1986 and 2003, respectively.

Change detection and LULC

In the Borana rangelands, grassland shows significance decrease over the year that is by 24.16% from 1973 to 1986 and by 26.01% from 1973 to 2003. In the contrary, woodland exhibits an increase of 28.01% from 1973 to 1986 and 37.92% from 1973 to 2003. The other land use did not have such a big change (Table 3 and Figure 2). Over the 30 years period, the changes associated with woody, grass, bareland and cultivated land cover per year were estimated at 1.27, 0.87, 0.50 and 0.1%, respectively.

LULC map (Figure 2) shows an increment of woody plant in 2003 and decrease of bareland compared to the years 1973 and 1986. The decrease could be attributed to canopy cover damage when remote sensing images were taken at that period of time. Since no remote sensing images were available for few parts of Southern Borana, therefore these areas were excluded in the present analysis, especially those for the year 1973.

The NDVI value also revealed the reduction of vegetation cover or biomass from the 1973 to 2003. In

Table 4. Land-use/covers changes following Transition probability matrix from the year 1973 to 2003 in Borana, Southern Ethiopia.

Parameter	Land cover 2003				
	LULC class	**Woodland**	**Grassland**	**Bareland**	**Cultivated land**
Land cover 1973	Woodland	0.66	0.36	0.06	0.09
	Grassland	0.34	0.28	0.21	0.18
	Bareland	0.40	0.29	0.18	0.13
	Cultivated land	0.04	0.29	0.19	0.13

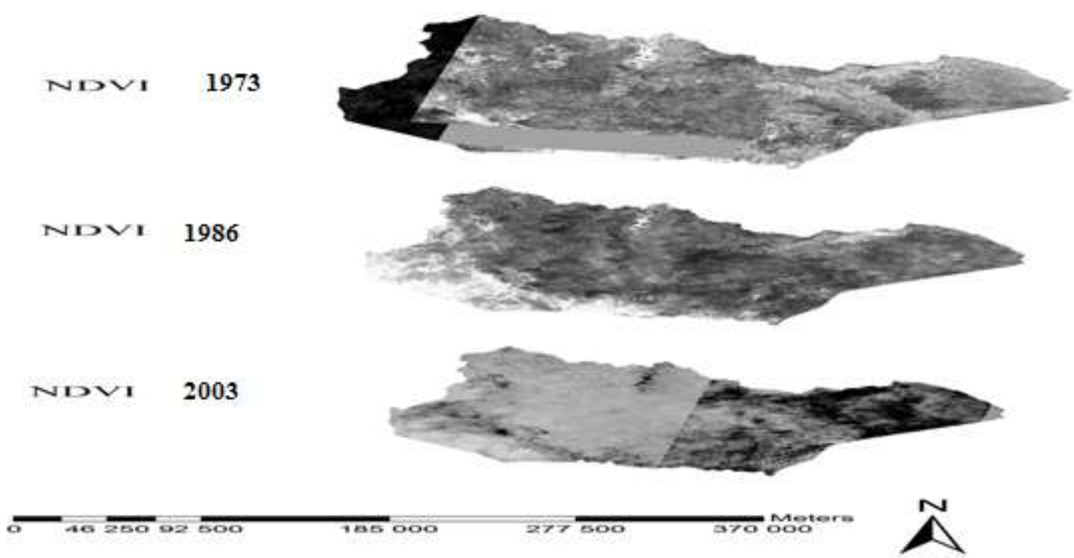

Figure 3. Trend of NDVI changes in the Borana between the 1973 and 2003.

1973, 46.14% of the total area was bareland, whereas, 53.86% was covered by vegetation (Table 4 and Figure 3). The minimum negative NDVI value was -0.93, while the bareland portion and the maximum NDVI value was 0.93, especially for the dense vegetation parts of the study area. For the year 2003, the non-vegetation covered area was 57.20%, (with a minimum NDVI value of -0.65) whereas the vegetation covered area was 42.80% (maximum value of NDVI 0.83).

LULC change prediction

After using the Markov model to detect land cover change, a 4 by 4 matrix table of land cover categories for the year 1973 and 2003 was constructed to predict the probability of LULC class changes over the years. As shown in Table 4, woodland had 0.66 probability of remaining woodland and a 0.36 of changing to grassland in 2003. On the other hand, a 0.34 probability of change from grassland to woodland showed that there might be a high level of instability in grassland during this period. The 1973 grassland cover had a 0.28 probability of remaining grassland in 2003. Bareland also had a 0.18 probability of the remaining bareland in 2003. Cultivated land had a 0.13 probability of the remaining as cultivated land. Moreover, cultivated land had a 0.29 probability of changing to grassland and a 0.19 probability of changing to bareland.

Detection of change of land consumption rate and land absorption coefficient

The land consumption rate (LCR) for cultivation was 0.12 in the 1973, 0.23 in the 1986 and 0.16 in the 2003 (Table 7). LCR showed a slight increment within this time period. In general, Land Absorption Coefficient (LAC) was 0.21 (1973-2003). During the different period, LAC was 069 (1973-1986) and 0.084 (1986-2003). Both LCR and LAC

Table 5. Population, land consumption rate and absorption coefficient changes in Borana Southern Ethiopia.

Parameter	Period of the year		
	1973	1986	2003
Population	641,982	786,364	1,317,409
LCR	0.12	0.23	0.17
LAC (1973-2003 years)		0.69	

LCR = Land consumption rate; LAC= land absorption coefficient.

Table 6. Pastoralists' perception towards rangeland cover changes in the study area.

Major driving forces	% Respondents
Drought/rainfall variability	22.60
Policy issue	21.56
Increment of livestock population	18.81
Bush encroachment	12.73
Settlement	10.19
Change of livelihood	8.88
Increment of human population	5.10
Number of water points	0.13
Total	100

showed that as population increased the land absorption ability declined drastically.

The corresponding human population values for the recorded time period are also presented in Table 5. From 1973 to 1986, the LAC increased with population but declined sharply as population increased.

Driving forces of land-use/cover change and their correlation

According to Borana pastoralists', eight forces driving changes in LULC changes were identified. Among them recurrent drought, policy issue and increment of livestock population are mentioned as the prime factors (Table 6).

From group discussion, it is understood that continuous heavy grazing pressures have contributed to changes of land-cover from grassland to woodland. Human population growth is partly due to the infiltration by the highland farmers in the area. In addition, the recent expansion of public services like water points, school and health posts might have contributed to the expansion of settlements in the study area. From a policy perspective, sedentarization of pastoralists is a government rural development strategy. This has widely affected pastoral land-use patterns over the years. Moreover, the opportunistic farming activities also instigate the expansion of settlements in order to manage the farm plot as mentioned by our respondents. The steady increase of human population attracts the boom of livestock population, which pressurizes the changes of land-use. Overall, people stated that the changes in land-use/cover are mainly caused by frequent droughts and increasing numbers of dry years among other drivers, which highly affected their livelihoods. Further, the correlation and strength of their relationship among different driving forces and dependent variables (rainfall and year time series) are presented in Tables 7 and 8.

DISCUSSION

The observed decline of bareland cover in 2003 compared to 1973 might be explained by the poor capture of satellite sensing image of woody plant canopy. The larger canopy cover observed in Southern Ethiopia might have been interpreted as vegetation cover instead of bareland (Haile et al., 2010). However, data collected through on ground observation, local community responses and NDVI values tend to reveal that the bareland cover increased in recent years compared to the 1973. The expansion of bareland in the fragile and environment is often explained by cultivation practices leading to pronounced period of soil erosion even during small rain events and wind effects. In the Afar low-land of north eastern Ethiopia (Tsegaye et al., 2010) and in southern Ethiopia (Mintesnot, 2009) similar changes have also been reported in arid environments (Elmore et al., 2000). In addition, Solomon et al. (2007) have all reported that the increasing expansion of woodland cover around patch of resource areas was attributed to the increase of grazing pressures around these areas. In areas where there was low grazing pressure, high density of woody plants was reported (Brown and Archer, 1999).

NDVI is known as a measure of a photo that is from synthetically active vegetation in a given area (Asrar et al., 1985; Myneni et al., 1995; Weiss et al., 2004). The NDVI had strong correlations with biomass, vegetation phenotype, density of leaf and canopy cover (Petter and Eve, 1995; Tucker et al., 1985; Weiss et al., 2004). The NDVI analysis across the Borana rangeland showed, the

Table 7. Correlations between the different driving forces with dependent variables such rainfall.

Driving forces and measurable parameter	P	RF	WL	GL	BL	CL	LS	Reg equation with RF	R^2
Rainfall	-0.78								
Woodland	0.89	-0.98						WL= 8896731+ (-18514x)	0.95
Grassland	-0.89	0.99	-0.98					GL= -2570223+10820.7x	0.99
Bareland	0.90	-0.97	0.99	-0.98				BL= 3290943+ (-5839.5x)	0.94
Cultivated land	0.92	-0.96	0.99	-0.99	0.99			CL= 750724.9+(-1473.72x)	0.92
Livestock population	0.96	-0.57	0.73	-0.60	0.74	0.77		LS= 487946.9+ (-359.62x)	0.32
Human population	0.99	-0.69	0.83	-0.72	0.83	0.86	0.98	HP= 2970867+ (-5130.91x)	0.47

P=Period from 1973-2003; RF=rainfall; WL= woodland; GL= grassland; BL= bareland; CL= cultivated land; LS= livestock population; Reg = regression; R^2= confidence of determination.

Table 8. Correlation between the different driving forces with dependent variables such year time serious.

Driving forces and measurable parameter	P	RF	WL	GL	BL	CL	LP	Reg equation for period of year 1973-2003	R^2
Rainfall	-0.78								
Woodland	0.89	-0.98						WL= -1.04+53249x	0.80
Grassland	-0.89	0.99	-0.98					GL= 5.6+-27345.6x	0.64
Bareland	0.90	-0.97	0.99	-0.98				BL=-3.27+16960.5x	0.81
Cultivated land	0.92	-0.96	0.99	-0.99	0.99			CL= -8592780+4413.32x	0.84
Livestock population	0.96	-0.57	0.73	-0.60	0.74	0.77		LS =-3411217+1893.3x	0.92
Human population	0.99	-0.69	0.83	-0.72	0.83	0.86	0.98	HP = -4.49+23091x	0.98

P=Period from 1973-2003; RF=rainfall; WL= woodland; GL= grassland; BL= bareland; CL= cultivated land; LS= livestock population; Reg = regression; R^2= confidence of determination.

highest positive and negative NDVI values were largely observed from the 1973 MSS imagery. For the inherent biases in reflectance measurements of the MSS sensors and the atmospheric cloud cover, high positive value of NDVI could be associated with the high percentage of grassland cover (Peters and Eve, 1995). On the other hand, the low value of NDVI value in year 2003 might be due to the high proportion of woody plant cover (Nemani et al., 1996). The other probable reasons for the low value of NDVI obtained in year 2003 were driven by canopy coverage and the extent of bareland use. They all have certainly contributed to reduce the NDVI value. Overall, NDVI values are useful measurement in understanding the vegetation cover of the Borana rangelands and can be used in rangeland monitoring and management approaches.

Over the years, between 1973 and 2003, Borana rangelands has demonstrated persistent LULC changes and this might be associated to different factors sure as rainfall variability and heavy grazing pressure (Oba and Kotile, 2001) shift in the traditional management practices and poor government regulations mainly ban of rangeland fire and developing communal rangelands (Oba et al., 2000). According to

Angassa and Oba (2008) and McCarthy et al. (2002), banning of range fire facilitates the propagation of weeding species and inhibits woody plant growth. Consequentially, the survival of desirable herbaceous is undermines by dominated weeding species (Singn, 1989). Gemedo et al. (2006) noted that woody vegetation clearing out for home construction purposes, enclosure management along with the pastoralist's involvement in agricultural cropping activities through land clearance also contributes to woody plant decline.

The observed increase of cultivated/built in Borana rangelands might be explained by the farming activities pastoralists used as an alternative for lowering drought risk and rainfall uncertainty (Campbell et al., 2005). Frequently, occurring drought (1972/1973, 1984/85 and 1999/2000) results to food insecurity and livestock loss in Borana rangelands. In addition, infiltration by large groups of farmers from the neighboring areas also contributed to the expansion of cropping in the study area. Similar to East African pastoral land, the expansion of cropland in the Borana rangeland has significantly contributed to the change of grassland management practice to cultivate land practice (Reid et al., 2004).

Despite pastoralists resistance (Chatty, 2007), voluntary crop farming and settlements have been established in the Borana areas for generating income and livelihood diversification (Reid et al., 2004). Pastoralists resist the expansion of cultivation and sedentarization and mainly this reduces the size of their rangelands and mobility to utilize the unevenly distributed resources in this unpredictable environment (Chatty, 2007).

In semi-arid areas of East Africa, the changes of land-use/cover have been accelerated by government policies since the 1973 (Omiti et al., 1999; Reid et al., 2004). This is also true in the case of Ethiopia. Recurrent drought is among the prominent natural catastrophes that have caused changes of land cover (Ndikumana et al., 2001). As an alternative, pastoralist had shifted their land uses from grassland to woodland and other land use forms (Coppock, 1994; Gemedo, 2004). Among other drivers of shift in the rangeland cover included population increase of human and livestock, conversions of rangelands to crop land in valley bottoms (dry season grazing areas) and increasing pressure on grazing due to multiple (ranch and private enclosures) end uses and competition for land from other tribes (*Gari and Somali*) in Borana grazing area (Oba and Kotile, 2001). Although dry land cropping represents an opportunity for pastoralists to increase income without damaging the land (Campbell et al., 2005), however, other scholars indicated that it represents a way of increasing risks and threats to the livelihood of pastoralists (Little et al., 2008). This has to do with the fact that increasing land cropping in semi-arid area contribute to aggravate desertification and expansion of bareness lands Traditionally, the Borana pastoralists used to regulate their rangelands by traditional by-laws. However, these by-laws have been violated since the 1973 by inappropriate intervention policies of the government. As a result, such inappropriate intervention policies might have contributed to explain the current impacts on rangeland use and cover in the Borana area.

Earlier studies (Angassa and Oba, 2008; Coppock; 1994; Oba et al., 2000) have shown that an increase in the abundance of woody vegetation cover could have been driven by the ban of fire and continuously high grazing pressures. On the other hand, there is expansion of woody plant cover in the areas where there is little grazing due to aggressiveness of some species (Brown and Archer, 1999). In the present study, encroachment of woody cover across the Borana rangeland is highly pronounced so that the shifts from grassland to woodland would be approximately five-times greater in just three decades. These changes might have significant implications on pure pastoralism practices that rely on livestock production for the most part. The recent demand for land use forms for farming purpose has certainly led to a push for more use of land for large scale mechanized farming along with the expansion of large private farming activities in semi-arid areas. In those areas, climate variability plays a major role in regulating ecosystem function. Since drought represents one of the major climatic factors affecting negatively LULC changes therefore it is more likely that traditional land-use practices might be influenced by drought in Borana. This means that the observed LULC changes in the Borana rangelands might adversely affect ecosystem dynamics. The latter may have a negative impact on livelihoods of pastoralists in turn. As a result, to sustain pastoralists' livelihoods support systems and masteries normal ecosystem functioning in the Borana rangelands the following important issues should be addressed: a) careful implementation of initiatives related to pastoralist driven land use policies that are ecologically sound, and b) regulating population growth in the rangelands.

Conclusions

Providing key information on LULC changes is vital for understanding land use dynamics and monitoring resources over time. Gathering such information could contribute to policy makers with insights to make informed decision over land use planning and enhancing pastoralists' livelihoods through proper support. This study has demonstrated the usefulness of satellite remote sensing image used in producing land- use/cover maps and changes in the Borana rangelands for the past 30 years. It is evidenced that: i) the proportion of woodland cover increased in the year 2000 compared to the 1973 whereas, the grassland proportion declined for the same period; ii) the increase in cultivated land/built up area represents a recent phenomenon related pastoralist grassing systems; iii) bareland increased affecting therefore the productivity of the rangeland and eventually the livelihoods of the pastoral communities in southern Ethiopia; and iv) drought, population pressure, inappropriate government policy and mismanagement of rangelands are the major driving forces of changes in land-use/cover in Borana rangeland areas.

In the case of Ethiopian rangelands, drought, human and livestock's population increase, conversions of rangelands to crop land in valley bottoms represent the main drivers' forces of land cover changes. Such changes have impacted pastoralists' livelihoods. In order to survive, pastoralists have shifted their land uses from grassland to woodland and other land use forms (Coppock, 1994; Gemedo, 2004). In the long run, pursuing such land uses shift might not be sustainable approach because additional rangelands will continue to be degraded. Appropriate response to the issue of further degradation of rangelands calls for providing a careful implementation of pastoralists' land use policies that are not destructive of the ecosystem and its functioning.

Further studies should focus on promoting lower stocking rates and reducing human and livestock population's growth through educational campaigns and raising public awareness on the necessity of conserving the ecological functioning of the ecosystem and sustainable livelihood of pastoralists in the Borana rangelands of southern Ethiopia at the same time

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Angassa A, Oba G (2008). Herder perceptions on impacts of range enclosures, crop farming, fire ban and bush encroachment on the rangelands of Borana, Southern Ethiopia. Hum. Ecol. 36:201-205.

Asrar G, Kanemasu ET, Yoshida M (1985). Estimates of leaf area index from spectral reflectance of wheat under different cultural practices and solar angle. Remote Sens. Environ. 17:1-11.

Brown JR, Archer S (1999). Shrubs invasion of grassland: recruitment is continuous and not regulated by herbaceous bio-mass or density. Ecology 80:2385-2396.

Campbell DJ, Lusch DP, Smucker TA, Wangui EE (2005). Multiple methods in the study of driving forces of land use and land cover change: A case study of SE Kajiado District, Kenya. Hum. Ecol. 33:763-794.

Central Statistical Agency (CSA) (2008). Central Statistical Authority Report of the 2007 Population and Housing Census. Addis Ababa, Ethiopia, CSA.

Chatty D (2007). Mobile peoples: Pastoralists and herders at the beginning of the 21st Century. Rev. Anthropolog. 36(1):5-26.

Congalton RG (1991). A review of assessing the accuracy of classifications of remote sensed data. Remote Sens. Environ. 37:35-46.

Coppock DL (1994). The Borana Plateau of Southern Ethiopia. Synthesis of Pastoral Research, Development, and Change, 1980-91. Systems Study No. 5. Addis Ababa, Ethiopia: International Livestock center for Africa (ILCA).

De Fries RS, Belward AS (2000). Global and regional land cover characterization from satellite data: an introduction special issue. Int. J. Remote Sens. 21:1083-1092.

Elmore AJ, Mustard JF, ManningSJ, Lobell DB (2000). Quantifing vegetation change in Semi- arid environments. Precision and accuracy of special mixture analysis and normalized difference vegetation index. Remote Sens. Environ. 73:87-102.

ERDAS (1999). Field Guide Earth Resources Data Analysis System. ERDAS Inc. Atlanta, Georgia. P 628.

Fensham RJ, Fairfax RJ, Archer SR (2005). Rainfall, land use and woodland cover change in semi-arid Australia savanna. J. Ecol. 93:596-606.

Gemedo D, Brigitte LM, Isselstein J (2006). Encroachment of woody plants and its impact on pastoral livestock production in the Borana lowlands, Southern Oromia, Ethiopia. Afr. J. Ecol. 44:237-246.

Gemedo D (2004). Vegetation Ecology, Rangeland Condition and Forage Resources Evaluation in the Borana Lowlands, Southern Oromia, Ethiopia. PhD Thesis,Georg-August Universität Göttingen, Germany. Cuvillier Verlag Göttingen.

Haile G, Assen M, Ebro A (2010). Land use /cover dynamics and its implication since 1960's in the Borana rangelands of southern Ethiopia. Livest. Res. Rural Dev. 22(7).

Jensen JR (1996). Introductory digital image processing, A remote sensing perspective, (2nd edn). Upper Saddle River, New Jersey: Prentice Hall.

Little PD, McPeak J, Barrett CB, Kristjanson P (2008). Challenging orthodoxies: understanding poverty in pastoral areas of East Africa. Dev. Chang. 39:587-611.

Meyer WB (1995). Past and Present Land-use and Land-cover in the U.S.A. Consequences 1:24-33.

McCarthy N, Kamara A, Kirk M (2002). The effect of environmental variability on livestock and land use management: The Borana plateau, Southern Ethiopia. Socioeconomics and policy research working paper 35. ILRI (International Livestock Research Institute), Nairobi, Kenya and IFPRI (International food policy research institute), Washington, DC, USA. 35p.

Mintesnot Z (2009). Bush encroachment mapping using classification and spectral mixture analysis in Borana rangelands: A case study of Yabello Woreda. MSc Thesis, Addis Ababa University, Ethiopia.

Moshen A (1999). Environmental Land Use Change Detection and Assessment Using with Multi - temporal Satellite Imagery. Zanjan University press.

Myneni RB, Hall FG, Sellers PJ, Marshak AL (1995). The interpretation of spectral vegetation indexes. IEEE Trans. Geo Sci. Remote Sens. 33:481-486.

Ndikumana J, Stuth J, Kamidi R, Ossiya S, Marambii R, Hamlett P (2001). Coping mechanisms and their efficiency in disaster-prone pastoral systems of the greater horn of Africa: effects of 19995-97 droughts and the 1997-98 El-nino and the responses of pastoralists and livestock. ILRI Project Report Nairobi, International Livestock Research institute.

Nemani RR, Running SW, Pielke RA, Chase TN (1996). Global vegetation cover changes from coarse resolution satellite data. J. Geophys. Res. 101:7157-7162.

Oba G, Kotile DG (2001). Assessment of landscape level degradation in southern Ethiopia: Pastoralists versus ecologists. Land Degrad. Dev. 12:461-475.

Oba G, Post E, Syvertsen PO, Stenseth NC (2000). Bush cover and range condition assessments in relation to landscape and grazing in southern Ethiopia. Landsc. Ecol. 15:535-546.

Odindi J, Mhangara P, Kakembo V (2012). Remote sensing land-cover change in Port Elizabeth during South Africa's democratic transition. SAFR J. Sci. 108:5-6.

Omiti JM, Parton KA, Sinden JA, Ehui SK (1999). Monitoring changes in land-use practices following agrarian de-collectivisation in Ethiopia. Agric. Ecosyst. Environ. 72(2):111-118.

Palmer AR, Fortescue A (2003). Remote Sensing and Change Detection in Rangelands. Durban, International Rangelands Congress.

Peters AJ, Eve MD (1995). Satellite monitoring of desert plant community response to moisture availability. Environ. Monit. Assess. 37:273-283.

Rahlao SJ, Hoffman MT, Todd SW, McGrath K (2008). Long-term vegetation change in the succulent karoo: South African following 67 years of rest from grazing. J. Arid Environ. 72:808-819.

Reid RS, Thornton PK, Kruska RL (2004). Loss and fragmentation of habitat for pastoral people and wildlife in East Africa. Concepts and issues. Afr. J. Range For. Sci. 21:171-184.

Schmidt H, Gitelson A (2000). Temporal and spatial vegetation cover changes in Israeli transition zone: AVHRR- based assessment of rainfall impact. Int. J. Remote Sens. 21:997-1010.

Shoshany M, Kutiel P, Lavee H (1994). Monitoring Temporal Vegetation Cover Changes in Mediterranean and Arid Ecosystems Using a Remote Sensing Technique: case study of the Judean Mountain and the Judean Desert. J. Arid Environ. 33:9-21.

Singn A (1989). Digital change detection techniques using remotely sensed data. Int. J. Remote Sens. 10:989-1003.

Solomon T, Snyman HA, Smit GN (2007). Rangeland dynamics of southern Ethiopia: (1) botanical composition of grasses and soil characteristics in relation to land use and distance from water in semi-arid Borana Rangelands. J. Environ. Manag. 85:443-452.

Tsegaye D, Moe SR, Vedeld P, Aynekulu E (2010). Land use/cover dynamics in northern Afar rangelands, Ethiopia. Agric. Ecosyst. Environ. 139:174-180.

Tucker C, Vanpraet CL, Sharman M, van Ittersum G (1985). Remote sensing of land use and vegetation from mesoscale hydrological studies. Int. J. Remote Sens. 21:213-233.

Vitousek PM, Mooney HA, Lubchenco J, Melillo JM (1997). Human domination of earth’s ecosystem. Science 277:494-499.

Weiss JL, Gutzler DS, Coonrod JE, Dahm CN (2004). Long-term vegetation monitoring with NDVI in a diverse semi-arid setting, centeral New Mexico, USA. J. Arid Environ. 58:248-271.

White JD, Gutzwiller KJ, Barrow WC, Randall LJ, Swint P (2008). Modeling mechanisms of vegetation change due to fire in a semi-arid ecosystem. Ecol. Model 214:181-200.