

Research Article

Analysis of Land Use and Land Cover Changes and Trends in Fantalle Range Land, East Shewa Zone, Oromia Regional State, Ethiopia

Meseret Tilahun^{*} , Dawit Abate, Nabi Husein 

Animal Feed Resources and Rangeland Management, Oromia Agricultural Research Institute, Adami Tulu Agricultural Research Center, Adami Tullu, Ethiopia

Abstract

This study was conducted in Fantalle Range lands in East Shewa zone of, Oromia Region, Ethiopia, to assess land use land cover changes, trends, drivers and their socioeconomics. Household surveys were conducted through simple random sampling to collect qualitative data. Qualitative data are used to investigate the causes and effects of land use and land cover changes. SPSS software (version 20) was used for data analysis, and descriptive research methods were adopted. Additionally, map processing was done using ERDAS Imagine (version 9.1) and ArcGIS (version 10.1). The land use land cover classification activity was started by obtaining Landsat images of 1972, 1990, 2000 and 2020 at different intervals from the Earth Explorer (USGS) from the Landsat 4, Landsat 5, Landsat 7 and Landsat 8, respectively. Land use land cover change (LULCC) maps are generated based on year classification. Range land, agricultural land, woody vegetation, bare land and settlement are the five main LULCC categories generated from satellite data. The findings show that in the presence of LULCC, agricultural land, settlements and bare land expand significantly, while range land and woodland show a decreasing trend. The classification results of the 1972 image show that rangeland/grazing land accounts for the largest proportion of the land in this area, accounting for 31.6%. In addition, due to various factors, the number of livestock owned in pastoral areas is also decreasing. The main cause of changes in livestock types is drought, which can cause different impacts, such as feed and water shortages and health problems. Therefore, intervention in land use manipulation is needed to maintain ecosystems and natural resources. Furthermore, rangeland policies should be developed to maintain pastoral and pastoral systems.

Keywords

Woody Vegetation, Rangeland, Fantalle, Drivers, Proximate Drivers

1. Introduction

Land resources are one of the most important resources for mankind. Exploring and using land resource reasonably is the basic principle for development of human society [9] Understanding/detecting the trajectory and extent of LULCC is im-

portant for generating, providing useful and sustained [9] information on the extent of land use/land cover change to policy makers and development practitioners and trend information is extremely important [26] and decision making [4].

*Corresponding author: mesereta28@gmail.com (Meseret Tilahun)

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LULCC is the result of complex human-environment interactions [8, 17]. These dynamics alter the availability of different biophysical resources, including soil, vegetation, water, animal feed, etc. Therefore, land use and cover changes may lead to reduced availability of different products and services for humans, livestock, agricultural production, and damage to the environment [13].

LULCC is driven by multiple factors at the environmental and social dimensions of the land system [8, 12]. Land use change is increasingly recognized as a result of actors and factors of interactions [3]. The causes of LULCC are divided into proximate and underlying forces [10]. The underlying causes of LULCC arise from a complex interaction of social, policy, institutional, economic, demographic, technological, cultural and biophysical factors [2, 10, 7]. Political, legal, economic structures and traditional institutions and their interaction with individual decisions also influence LULCC [18, 19]. Demographic fertility and mortality; households structural changes; and changes in family structure; the breakdown of extended families into multiple nuclear family dynamics; labor supply, migration, urbanization [10] caused a large impact on proximate causes [11].

The arid and semi-arid areas of the Fantalle district are purely pastoral areas with high rangeland areas on which their livestock depend, but from the standard year pastoralists also begin to produce crops. Pastoral areas use a public resource system for livestock production. Responses to habitat loss and fragmentation simplify natural ecosystems for agricultural use, potentially leading to species loss and replacement of invaders.

Therefore, land use interventions are needed to maintain ecosystems and natural resources.

The Fantalle district was known predominantly by rangeland. However, different anthropogenic impacts and developments were undertaken and up to date information on

drivers of LULCC in Fantalle district is found to be lacking. Therefore, this study was conducted to identify types as well as extent of LULCC within four decades and its drivers in the district with the following objectives.

1.1. General Objectives

This study generally aimed at assessing land use/land cover changes and driving forces behind the changes in the Fantalle range land, East shewa zone, Oromia regional state, Ethiopia.

1.2. Objectives

- 1) To assess and map land use land cover change and potential of Fantalle rangeland between different governmental regimes (1950-2020).
- 2) To identify major driving forces of land use/land cover changes in the Fantalle rangeland and delineate the potential area.

2. Material and Method

2.1. Description of the Stud Area

This study was conducted in Fantalle district, East Shewa zone, Oromia regional state, Ethiopia. This is a sparsely populated lowland pastoral and agro-pastoral area. The total land area of Fantalle District is 1,169.85 km² (CSA, 2000). Rainfall is extremely irregular, with an average annual rainfall of 550.9 mm. The mean minimum and maximum temperatures are 17.4 °C and 32.7 °C, respectively. The topography is predominantly plains. Bush and shrubs are the main vegetation used for animal feed [25].

Table 1. LULC categories and their description in the study landscape, Ethiopia.

No	Land cover type	Their expression
1	Settlement	A land-use type that includes rural settlement area, educational, health, socio-economic facilities, residential houses, administrative buildings, small-scale industrial areas, etc.
2	Waterbody	Waterbody is any significant accumulation of water on the surface of Earth or another planet. The term most often refers to oceans, seas, and lakes, but it includes smaller pools of water such as ponds, wetlands, or more rarely, puddles.
3	Agriculture	Agricultural land is typically land devoted to agriculture, the systematic and controlled use of other forms of life
4	Woody vegetation	Woody plants are plants that have hard stems (thus the term, "woody") and that have buds that survive above ground in winter. The best-known examples are trees and shrubs (bushes). These are commonly broken down further into the deciduous and evergreen categories.
5	Grassland	A land-use type where the land is dominated by grasses, forbs, and herbs with nil or little proportion of shrubs that are used for Communal grazing.
6	Bare land	Areas with little or no vegetation cover consist of exposed soil and/or rock outcrops, and quarries.

2.2. Procedures and Activity Implantation Method

The questioner was developed and interred into Cspiro software. A simple random sampling design was used to conduct a household survey to collect data. Qualitative data were collected through interviews with pastoralists and agro-pastoralists to investigate the causes and effects of land use/land cover changes. Household survey data are collected by Cspiro software.

2.3. Fields Works

Field observation and GPS point data coordination were conducted to examine the major types of LULCC for the ground truth verification: This data collection method helps in identifying land use land cover types in the study area, providing accurate assessment of developed land use coverage categories and for Investigate the causes and effects of LULCC.

2.4. LULCC Processing and Mapping Framework

Analysis of data was accomplished through the use of ERDAS imagine (version 9.1), ArcGIS (version 10.1). The LULC classification activity was undertaken with acquisition of Landsat imagery for the different interval year of 1972, 1990, 2000 and 2020 from website of earth explorer (USGS) and Landsat 4, Landsat 5, Landsat 7 and Landsat 8 from <https://libra.developmentseed.org>. These years were chosen due to data availability and quality. Satellite image by its nature have some distortion, noise, haze and stripes. Therefore, image preprocessing activities are required before processing the data. Preprocessing includes import, layer overlay, and sub-setting of the image based on the boundary of Fantalle district, geometric correction, radiometric correction, and removal of stripes, pan sharpening and other image enhancement techniques. Radiometric correction is a removal of atmospheric noise so that it is more representative of the ground truth according to the sensor.

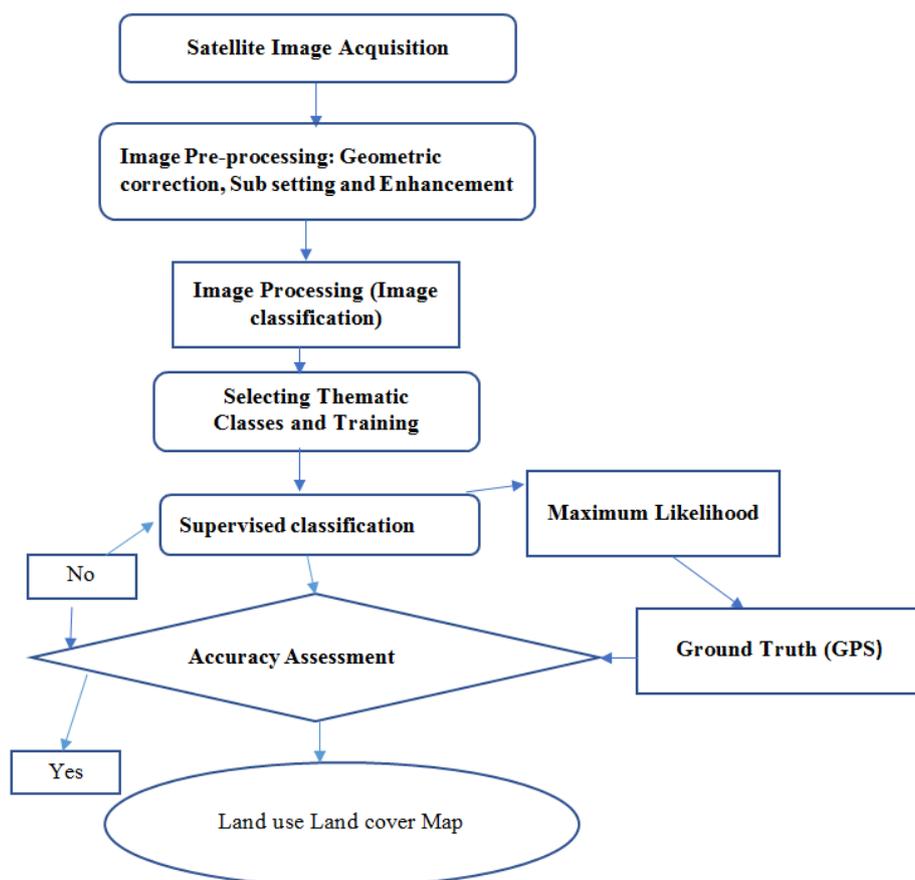


Figure 1. Flow chart of land use and land cover mapping process.

These all previously mentioned activities done were to improve visible interpretability of an image by increasing apparent distinction between the features in the scene.

Table 2. Explanation of imagery statistics and sources used for LULC study in Fantalle, Ethiopia.

Satellite image	Imagery type	Imagery date	Used bands	Source	Spatial Resolution	Path/R	Bands/colours
Land sat_4	MSS	January–1974	4 bands, 1–4	USGS	57*57	169/55	Multi-spectral
Landsat_5	TM	February–1989	5 bands, 1–5	USGS	28.5*28.5	169/55	Multi-spectral
Landsat_7	ETM+	January–2000	8 bands, 1–8	USGS	15*15	169/55	Multi-spectral
Landsa_8	OLI-TIRS	January–2015	8 bands, 1–8	USGS	30*30	169/55	Multi-spectral

2.5. Maximum Likelihood Supervised Classification

Supervised classification is the techniques most often used for the quantitative analysis based on the reflectance properties of remote sensing image data. It uses the spectral signature obtained from training samples to classify an image. Image classification toolbar, can easily create training samples to represent classes. With supervised classification, it can be identified sample of information classes of interest in the image. The supervised classification image of each year involves pixel categorizations by taking training area for each class of LULC. After the training area assigned for each class classification activity was performed. For bare land, cropland, wood land, Grassland and Settlement LULC types taken in training site.

Using Multispectral Band from band 2 to 6 for OLI 2022 to Bands of the preprocessed images the land-use/ land-cover pattern mapped was by supervised classification with the likelihood classification algorithm of ERDAS Imagine version 9.1 software.

Maximum likelihood classification (MLC) is used in this activity which is one of the most known methods of classification in remote sensing, in which a pixel with the MLC is classified into the matching classes/categories. ENVI implements maximum likelihood classification by calculating the following discriminant functions for each pixel in the image [21].

2.6. Data Management and Analysis

The collected survey data were imported into SPSS for analysis. Descriptive statistic was used for data analysis. LULCC map was produced based on year classification (1972, 1990, 2005 and 2020 Landsat images) by ArcGIS (version 10.1).

3. Results and Discussion

3.1. Socio-Economic Status of the Community

The age of respondent ranges 25-70 and their family size mean value is 8.

Table 3. The community's major activity to sustain their life (N=105).

No	Activities	Response	N	%	Ranks	Land ownership
1	Livestock	Yes	90	85.7	1	N
		No	15	14.3		
2	Farm land	Yes	13	12.4	2	91
		No	92	87.6		

The livestock production is the major activity for Fantalle's community, to sustain their life while farm land/crop production is a secondary activity. Most of the people in the community have recently been pastoralists and engaged in farm activities. As shown in Table 3 above, community livelihoods depend more on livestock production, followed by farmland.

Hence, the community categorized as pastoral and semi-pastoral due to the community's livelihood is depend on the livestock and agricultural practices. However, the numbers of pastoral livestock is decreasing due to different driving force as stated on the following Table 7.

Table 4. Demographic and socio economic status of community (n=105).

No	Parameters	Characteristics	N	%
1	Sex	Male	97	92.4
		Female	8	7.60
		Total	105	100
2	Marital status	Single	1	1.00
		Married	102	97.10
		Widowed	2	1.90
		Total	105	100

No	Parameters	Characteristics	N	%
3	Education status	Illiterate	84	80.00
		Formal education	14	13.00
		Religious education	7	6.70
		Total	105	100

Of the respondent 92.4% were male, while 7.6% are female. In addition, 80% and 97.1% were uneducated and married respectively as indicated on the above table 4.

Map of Land Use Land Cover Changes of 1972, 1990, 2005 and 2020.

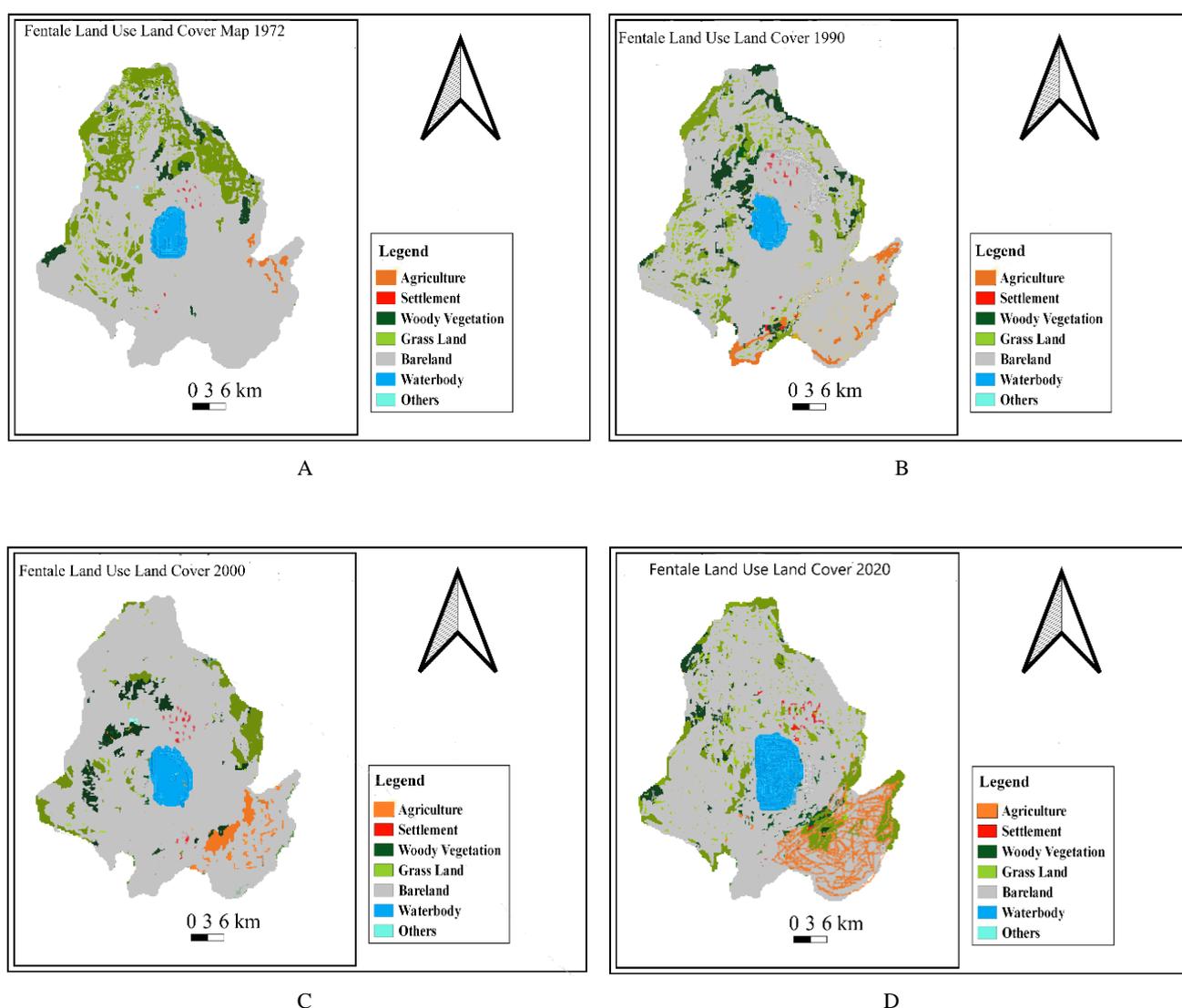


Figure 2. A, B, C & D. Map of Land Use Land Cover Classes of Fantalle Rangeland for the years 1972, 1990 2005 and 2020.

Grazing land, agriculture land, wood vegetation, bare lands and settlements were the five major LULCC classes generated from the satellite data. Findings of the study showed, the existence of LULCC with a significant expansion of agricultural land, settlement and bare land while decreasing trends of rangeland, as indicated on the above maps. However, the woody vegetation fluctuating

time to time. This might be due to invasive species expansion and charcoal production for invasive species controlling.

Table 5. Summary of Land-use/Land-cover change in Fantalle rangeland.

No	LULC classes	1972		1990		2005		2020	
		Area (sq.km)	%	Area (sq. km)	%	Area (sq.km)	%	Area (sq.km)	%
1	Agriculture	206.53	17.7	243.87	20.9	248.54	21.3	290.31	24.88
2	Settlement	24.50	2.1	28.00	2.4	36.17	3.1	38.51	3.30
3	Woody Veg.	114.47	9.81	98.48	8.44	128.94	11.05	58.34	5.00
4	Grassland	354.72	30.4	255.54	21.9	206.53	17.7	175.03	15.00
5	Bare land	416.57	35.7	505.25	43.3	516.91	44.3	570.59	48.9
6	Waterbody	33.84	2.9	33.84	2.9	33.96	2.91	34.07	2.92
7	Others	2.22	0.19	1.87	0.16	10.50	0.9	0.0	0
	Total	1166.85	100	1166.85	100	1166.85	100	1166.85	100

The classification results of the 1972 image (Figure 2A) show that rangeland constituted the largest proportion of land in the district with a value of 31.6%. The remaining constituent of the study area, perhaps the least, is settlement and water body with a value of 2.10% and 2.90% in 1972. In 1990, the agricultural land, settlement and bare land were proportionally increased to 20.9%, 2.4% and 43.3%, respectively (Figure 2B). Bare land was increased due to drought that causes by climate change, overgrazing, and similar reports stated by [23]. However, the woody vegetation and rangeland components decreased proportionally to 8.44% and 21.9% respectively in 1990.

Land-use land-cover classification map was presented in Figure 2B which indicates that in year 2005 a bare land accounts for 44.30% of a total area of the District. It was the largest proportion of land cover. Agriculture land occupies the

second place with 21.30% while the woodland/shrubs comprises about 17.7%. Similar trend was observed for land use land cover changes for the year of 2020 as indicated of the figure 2D. Due to high population number, the settlement and Agricultural land size shows increasing trend in the four decades. This trend result was agreed with ([24] reports at Agarfa district LULCC).

In general, the result shows that the LULCC of the study area had changed significantly during the period of 50 years (Figure 2A to 2D). Such change of land use land cover is an important aspect to determine what is actually changing to what. This information reveals both changes (increment and decrement) and persistence to change overtime. Such kind of information is vital for decisions makers at many levels for natural resources management [22, 24].

3.2. Proximate Drivers of LULCC

Table 6. The reason of land use land cover changes at fantalle district.

No	Reason	Rangeland changes							
		1972		1990		2005		2020	
		N	%	N	%	N	%	N	%
1	Farm land expansion	27	32.3	27	27.59	35	36.47	36	37.93
2	Settlement	6	1.54	14	13.79	21	20.00	17	17.24
3	Invader	14	12.9	13	12.64	16	14.12	18	18.39
4	Degradation	31	38.5	21	21.84	15	12.94	7	5.75

No	Reason	Rangeland changes							
		1972		1990		2005		2020	
		N	%	N	%	N	%	N	%
5	Conflict	12	10.8	15	14.94	9	5.88	6	4.60
6	Water body expansion	7	3.08	6	4.60	8	4.71	8	6.90
7	Drought	6	1.54	6	4.60	9	5.88	11	9.20

The respondent confirmed that the main reason of rangeland change was degradation, farm land expansion, invader and settlement as state on the above Table 6. Due to rapid population growth, communal grazing areas are increasingly being converted into Agricultural land. This has led to enormous pressure on the little remaining grazing/range land, through overstocking (FAO, 2012). As of [5, 6, 14-16, 20] shown that the population growth and expansion of agricultural lands is the main driver of LULCC [1] that agree with this study.

3.3. Underlay Drivers of LULCC

Table 7. The underlay driver of LULCC at Fantalle district.

No	Underlay/indirect drivers	N	%	Rank
1	Demographic	35	64	1
2	Economic factor	14	13.3	2
3	Technology	7	4.0	4
4	Policy and institution	14	13.3	2
4	cultural factors	8	5.3	3

The above Table 7 shows that the demographic/high population number was the main underlay/indirect drivers of land use land cover change at Fantalle district and similar report was stated by [11] at wombera district.

In addition, the economic factor and absence of well recognized policy and institutions for pastoralist were the other factor for land use and land cover changes of the study area.

3.4. Livestock Production Trends

Table 8. The livestock status of Fantalle district with land use land cover changes.

No	Type of livestock	Trend of livestock				% of changes
		1975-1990	1990-2005	2005-2021	2021	
1	Sheep	59.41±7.89	62.15±4.99	54.41±6.00	22.41±3.44	36.69
2	Camel	47.83±6.85	45.48±4.79	38.28±4.15	16.51±2.16	35.03
3	Cattle	43.40±10.61	38.70±8.58	31.58±6.21	13.03±4.00	30.34
4	Goat	32.91±7.89	27.65±5.05	18.11±3.29	7.74±1.94	33.13
5	Donkey	1.89±0.81	2.44±0.93	2.58±0.71	2.50±0.42	36.00

The number of livestock that the pastoral owns were decreasing from time to times due to different factors. The existence of livestock were decreased more than 30% as indicated on the Table 8. This might be due to different anthropogenic and natural driving factors. In addition, due to de-

mographic and border conflict the settlement and farm land expansion also have been major causes for grazing land shrinkages. In addition, it might be due to different factor (climate, agricultural land expansion, overgrazing of rangeland/shrinkage of grazing and settlement.

3.5. Reason of Livestock Changes

Table 9. Reason of livestock type changes.

No	Reason of change	Type of livestock changes							
		Sheep		Camel		Cattle		Goat	
		N	%	N	%	N	%	N	%
1	Sold	9	7.62	16	12.2	25	23.81	23	21.91
2	Drought	75	71.43	66	73.2	54	51.43	39	37.14
3	Health problem	15	13.33	14	9.8	16	14.29	21	20.00
4	Others	7	6.67	9	4.9	10	9.52	22	20.95

The main reason of livestock type change was drought that may causes for different effects, such as feed and water shortage followed health problem. The main reason for livestock feed shortage is changing of the pasture land to crop land and over grazing of the grazing land [27]. The other specified main problem was feed shortages that may occurred with drought problems and this results agree with [25].

The status of rangeland health/condition is poor (94.4%) as perception of the community.

Table 10. Perception of range community on rangeland status.

No	Rangeland status	N	%	Rank
1	Poor	88	94.3	1
2	Good	9	4.5	2
3	Very good	6	1.1	3
4	Excellent	0	0	4

3.6. Rangeland Management Practices

Most of the respondents (67%) did not have awareness the rangeland management practices. The respondent confirmed that the main reason of rangeland change was degradation, farm land expansion, invader (*Prosopis julifera*) and settlement.

Table 11. Rangeland management practices.

No	Response	Range land management		Rank
		N	%	
1	Yes	37	33.00	2
2	No	67	67.00	1

The main reason of rangeland changes was degradation 38.5% following farm land expansion in 1972. Invader and Beseka lake expansion also the great problem for rangeland and vegetation degradations. In general, the Beseka Lake is the major threats for range land degradation rather than habitat expansion through its outlet.

Table 12. Reason of range land changes.

No	Reason	Rangeland changes							
		1972		1990		2005		2020	
		N	%	N	%	N	%	N	%
1	Farm land expansion	26	32.3	19	22.6	18	23.0	14	15.8
2	Settlement	6	1.5	17	19.4	14	15.2	16	26.3
3	Invader	16	16.9	13	12.4	19	26.1	17	31.6
4	Degradation	30	38.5	24	30.6	18	23.9	16	26.3
5	Conflict	10	8.2	14	10.5	13	10.1	12	1.4
6	Water body expansion	7	2.4	9	2.5	12	2.8	15	3.0
7	Drought	6	0.2	8	2.0	11	2.9	15	2.1

4. Conclusion and Recommendation

The land use pattern and its spatial distribution are the major essentials for the foundation of a successful land-use strategy required for the appropriate development of any area. Land-use/Land-cover studies are of enormous importance and subsequently play a strategic role in man's economical, social and cultural progress. The land resource is one of the essential and basic resources for living and developing of human. To be able to achieve the sustainable use of land resource, it is necessary to know the changes, historic and present status of the land resource. The changes of natural environment and impact from human activities which occur suddenly or gradually in the earth's surface of the LUCC. Thus, the study reveals that, the different land use pattern of grazing land, settlement, woody land, bare land and water body were identified in different content. In 1972 the rangeland was the largest and decreased due to anthropogenic factors such as proximate and underlay drivers. Of these, the major proximate driver are overgrazing/degradation, farm land expansion and settlement while the underlay drivers also play great role in LULCC. The livestock production is the major activity for Fantalle's community to sustain their life while agricultural production is the second activity. However, the number of livestock that the pastoral owns were decreasing from time to time due to anthropogenic and natural drivers. The changes of natural environment and impact from human activities which occur suddenly or gradually in the earth's surface of the LUCC. This works concluded as the main reason of rangeland changes was degradation 38.5% following farm land expansion in 1972. Invader and Beseka lake expansion also the great problem for rangeland and vegetation. Of these, the *prosopis julifera* were highly threat shrubs for rangelands at Fantalle districts that hinders the growth of vegetation and

livestock movements. Therefore, needs the intervention of land use manipulation to sustain the ecosystems and natural resources. In addition, the rangeland policy should be developed to sustain the pastoral and pastoral system.

Abbreviations

CSA	Central Statistical Agency
GPS	Geographical Position System
LULCC	Land Use Land Cover Change
N	Number

Conflicts of Interest

The authors declare no conflicts of interest.

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