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LAND USE LAND COVER CHANGE DETECTION IN GIBE SHELEKO NATIONAL PARK, SOUTHWESTERN ETHIOPIA

Purpose. *The main aim of the study was to assess land use land cover change detection (LULCC) from 1990 to 2016 in case of Gibe Sheleko National Park (GSNP), Southwestern Ethiopia.*

Methodology / approach. *Multi-temporal Landsat images and topographic map were acquired in 2016. Field observation using GPS was carried out to generate the ground truth points for image classification and accuracy assessment from December 2016 to June 2017. A total 200 GPS points were purposively collected. The data were analysis by using ERDAS IMGINE 2010 and ArcGIS 10.3.1 software. Supervised classification was carried out to identify the overall land use land cover class.*

Results. *Forest land was rapidly declined with average of 478.5 ha/year for the last 27 years. This revealed that over 66.8 % of forest was diminished from 1990 to 2016 due to anthropogenic factors in the study area. Bush & shrub land was upraised from 12600 ha (31.5 %) to 20600 ha (51.5 %) from 1990 to 2016. Grazing land and bare land was also showed an increment of 3500 ha and 2240 ha with average increment of 134.6 ha/year and 86.5 ha/year respectively from 1990 to 2016. This indicated as most forest land was changed in to bush & shrub land due to human induced factors. Hence, it brings negative effects on the wildlife conservation and socio-economic development.*

Originality / scientific novelty. *This study is orginal research finding by employ above indicated methedology and stated the last 27 years land use land cover change of Gibe Sheleko National Park for fist time. It also discovered that the rate of land use land cover change in the study area for the past 27 years.*

Practical value / implications. *The main results of the study of land cover change can be used to ensure planning to be sustainable and integrated management of the natural resources. Participatory management practice should be implemented in the study area to regenerate the changed land use type.*

Key words: *Gibe Sheleko National Park, Land Use Class, Land Use Land Cover Change.*

Introduction and review of literature. Land use-land cover change(LULCC) refers to the quantitative changes in the area extent that changes may result either from land conversion or modification [1]. Change in land cover (biophysical attributes of the earth's surface) and land use (human modified earth's surface) has been accelerating as a result of socio-economic and biophysical drivers [2]. LULCC is closely linked with the issue of the sustainability of socio-economic development since they affect essential parts of our natural resource such as vegetation, water resources and biodiversity [3]. Improper practices of LULCC including deforestation, uncontrolled and excessive grazing, expansion of agriculture, and infrastructure development are alter essential element of watershed such as various wildlife and

indigenous tree species [4], at various temporal and spatial scales [5].

Human beings are the major contributors to land cover changes and are the ones experiencing the consequences of these changes. LULCC could lead to loss or a decreased different products and services for human, livestock, agricultural production and can undermine environmental health [6]. LULCC can also negatively affect the potential use of an area and may ultimately lead to land degradation. LULCC with widespread reduction of forests and grasslands increased carbon emission from the region that leads to global warming. Ethiopia is characterized by rapid environmental conversions and modifications attributed to various adverse human actions [7].

Although a number of studies have been conducted on land cover changes [8], the current historic information of LULCC in Ethiopia is not adequate. It is crucial to generate site specific information on land cover dynamics to ensure planning of sustainable and integrated management of the land resources.

Gibe Sheleko National Park (GSNP) is essential part of Gurage Zone in terms of topography, species diversity, vegetation and socio-economic conditions. This area designated as a National Park in 2009 to conserve numerous biological diversity. However, there is adequate information regarding to LULCC from past to current in the study area. Therefore, this study is indispensable to fill the gaps.

Thus, this study was addressed relevant issues on LULCC and its relation to the socio-economic set up of the study area and try to provide valuable information which may contribute to the sustainability of natural environment in terms of biodiversity conservation and land resource management system. Furthermore, this study is valuable for conservation policy maker, scientific communities, natural resource manager and planning and management activities because it constitutes key environmental information.

This finding is primarily essential for Gurage zone water-shade managers, policy-makers, development planners, protected area managers and NGOs who have interested on land resource management programs in the watershed as it evaluates the impact of their program on the well-being of land and base for further natural resource conservation.

The purpose of the article. The main aim of the study was to assess LULCC from 1990 to 2016 in case of GSNP, Southwestern Ethiopia.

Materials and methods. *Study area description.* GSNP newly emerged national park of Ethiopia and managed by Southern Nation Nationality and People Regional State. The study site is located in Gurage Zone, 178 and 18km far from south west of Addis Ababa and Wolkite respectively. It is geographically located between $7^0 54' 00''$ N to $8^0 21' 30''$ N and $37^0 27' 00'' E$ to $37^0 45' 00'' E$ (Fig. 1). It covers an area of 360 square km. It is bordered within three districts of Gurage Zone namely Cheha, Abeshigie and Enemurena-Ener in Eastern part and Gibe river in western side [9]. Average rainfall ranges from 960–1400 millimeter and altitudinal ranges 1050 to 1835 m above sea level. The study site is classified in climatic zone of Woyna-Dega based on traditional Ethiopian classification and dissected by deep gorges of the Gibe
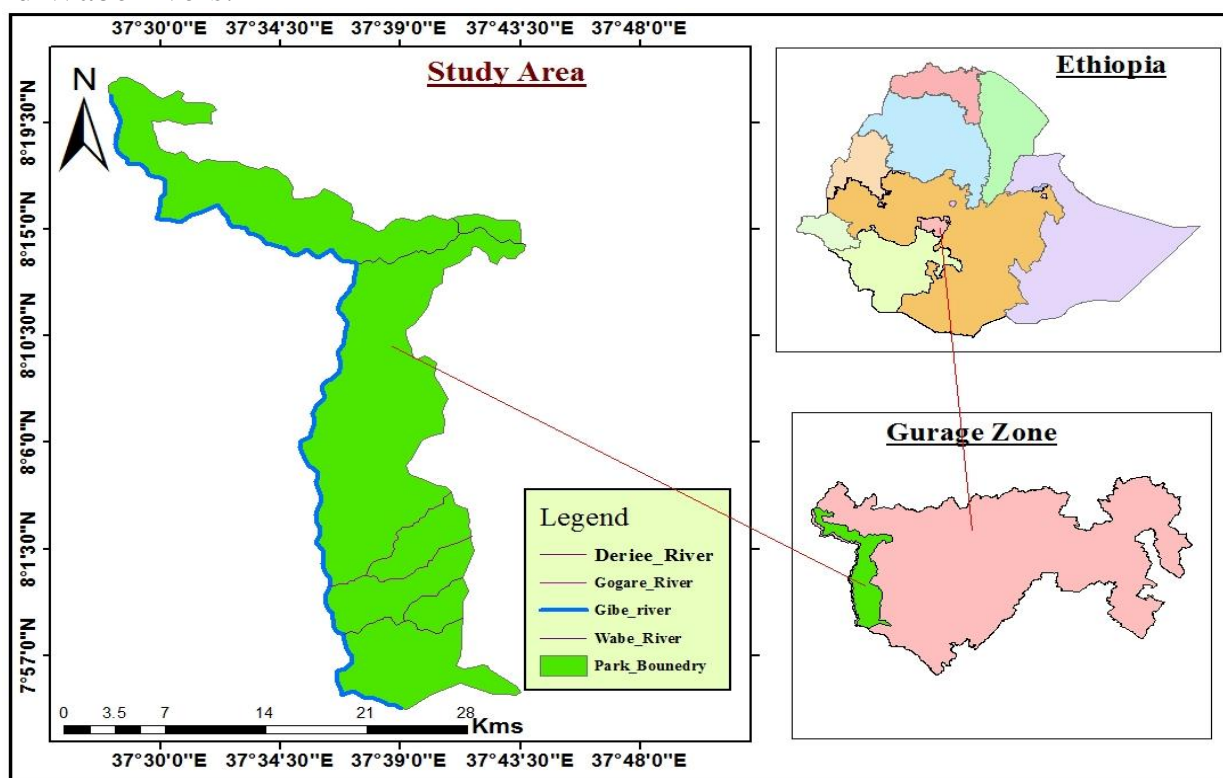
and Wabe rivers.

Fig. 1. Location map of the study area

Source: our own analysis.

Methodologies. *Data collection methods.* Multi-temporal Landsat images of different periods of the study area were acquired freely from Website: http://earthexplorer.usgs.gov that used for LULCC classification. The images were retrieved from path 168 and row 55. Moreover, Georeferenced topographic map was used for geo-referencing satellite imageries. Landsat images and topographic map were acquired from Ethiopian Mapping Agency in 2016. While the ground control points were collected in the field via global positioning system (GPS) to generate the ground truth points for image classification and accuracy assessment from December 2016 to June 2017. To obtain the land reference data, purposive sampling method was conducted, because of rough topography and data acquired from different land use types of the study area. A total of 200 training sample points were taken purposively. Of which 70, 40, 40, 30, and 20 sample training point from cultivated land, forest land, bush & shrub land, grazing land and bare/degraded lands were selected respectively.

Furthermore, interview was conducted to collect major shift information in the land use occurred and cause of LULCC in the study area.

Land use land cover data analysis. After collection of all the necessary data, analysis was made through digitizing, calculating and classifying the necessary information of each thematic layers using ERDAS IMGINE 2010 and ArcGIS 10.3.1 software. Furthermore, simple statistical methods, such as percentage, average and graphic tabulation were also employed for presentation and interpretation of the data. The procedure followed during the selected layer analysis as follows:

I. Image pre-processing. Image pre-processing is normally required prior to the main data analysis and extraction of information. Selecting appropriate satellite imagery was the first task in image data processing. The raw digital images cannot be used as map without correcting geometrically thus, in order to work in geographical information system(GIS), the images must be linked to a co-ordinate system and a projection of the earth's globe (Universal transverse Mercator (UTM), Zone 37 North, Datum Adindan). The topographic map of this study area with scale of 1:50,000 was used to correct the image geometrically with road and river intersection on the images themselves. After the raw data georeferenced, clipped with the boundary of the study area for further processing.

Moreover, visual interpretation of multi-temporal satellite images were enhanced through the use of contrast stretching in ERDAS IMAGINE software.

II. Image classification and Change Detection. Supervised classification was carried out to identify the overall land use land cover type based on training area. After classify the major LULC types in the study area, post classification comparison change detection technique was used for detection of land cover change of the study area from the year of 1990 to 2016. Finally, LULC maps of the different year were generated independently. The classified LULC data were used for change detection analysis. The comparison of the LULC statistics assist in identifying the percentage change between t1(time one) and t2(time two). Thus, different comparisons based on satellite images, of different period were done.

Results and discussion. *Land Use Land Cover Change Detection. Land use land cover changes from 1990 to 1999.* The LULC classes of GSNP in 1990 were forest, cultivated, shrub and grazing land (Fig. 2). From the total study area, forest land use type was covered 18600 ha (46.5%), shrub land comprised an area of 12600 ha (31.5 %). Cultivated land and grazing land covered 7400 (18.5 %) and 1400 ha area (3.5 %) of the study site respectively (Table 1). Thus, forest and shrub land were together covered area of 31200 (78%) ha during 1990 in the study area.

During 1999, forest land was covered area of 12060 ha (30.15%) and bush & shrub land was covered 13700 ha area (34.25 %). The remaining cultivated, grazing and degraded land were comprised an area of 1800 ha (4.5%), 9000 ha (22.5%) and 3440 ha (8.6 %) respectively (Table 1). The forest coverage of the study area was declined from 46.5 % to 30.15 % for the last one decade. Therefore, 6540 ha of forest land was lose for the last ten years (1990–1999). About 726.6 ha average of forest land was changed to other LULC type annually in the study area. Similarly, 4700 ha of cultivated land was also diminished for the last one decade in the study area. The coverage of this LULC type was reduced from 16.25 % to 4.5 % for the last ten years. Hence, 522.2 ha of average of cultivated land was altered to other LULC type per year in the study area.

While, bush & shrub land was showed that 1100 ha of land increment; it's area coverage was increased from 31.5 % to 34.25 % for the last ten years. Therefore, 122.2 ha average of land was converted to bush & shrub land from other LULC type per year due to several deriving forces. The land coverage increment of bush & shrub

land probably emanated from conversion of forest coverage. Similarly, grazing land was also further increased by a total 6700 ha of land for the past ten years. It raised from 5.75 % to 22.5 % in area coverage; thus 744.4 ha average of land was changed to grazing land from other LULC type per year in the study area. There wasn't degraded land in the study area during 1990 though after ten years 3440 ha (8.6 %) of the study area was exposed for severe degradation due to human induced factor. Whereas, 4700 ha (11.75 %) of cultivated land was changed to other land use class with 522.2 ha/year rate of change (Fig. 2, Table 1).
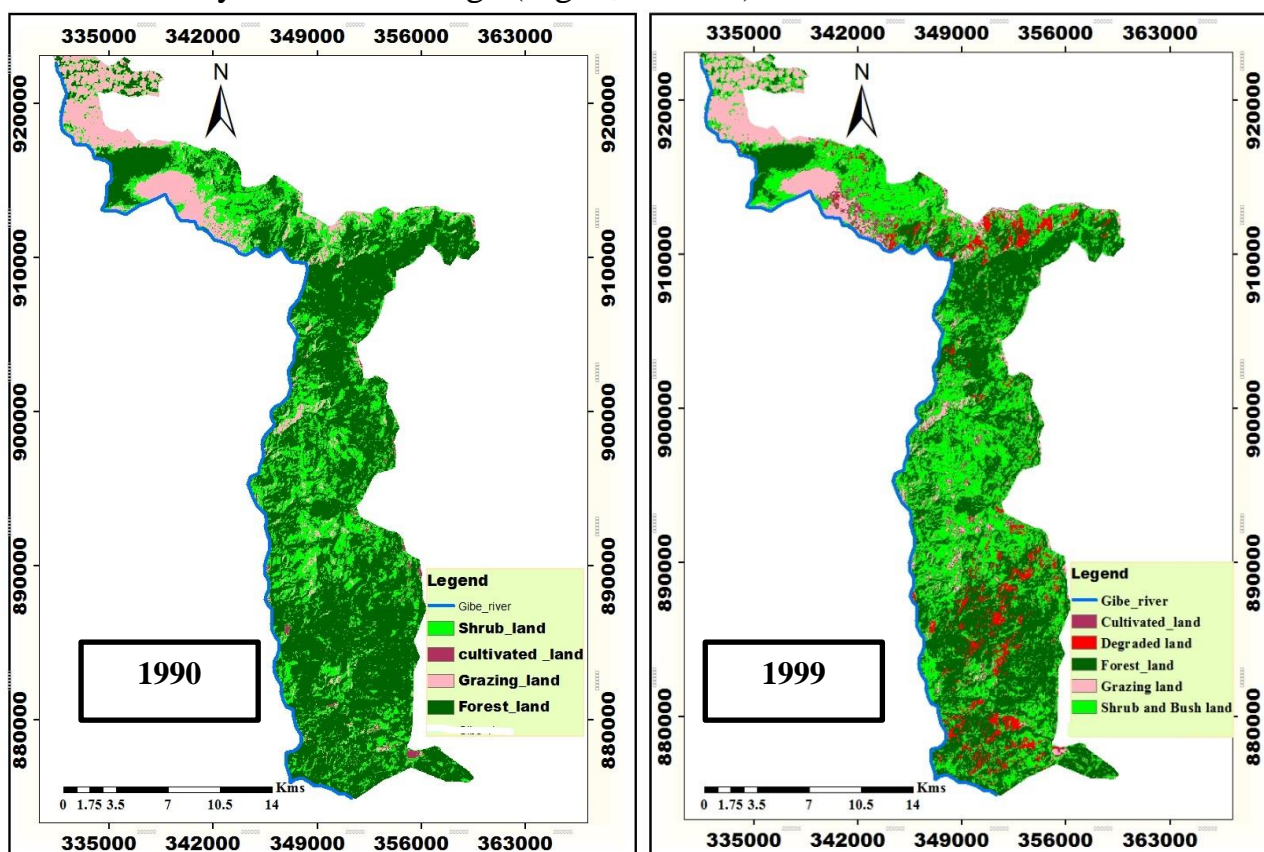

Fig. 2. Land use land cover map of GSNP in 1990 and 1999
Source: our analysis of 2016/17.

Table 1

Land use land cover change detection in GSNP from 1990 to 1999

LULC	Year				Amount of change	
	1990		1999			
	Area (ha)	Percent	Area (ha)	Percent	Area (ha)	Mean annual (ha)
Forest land	18600	46.5	12060	30.15	-6540	726.6
Shrub / bush & shrub land	12600	31.5	13700	34.25	+1100	122.2
Cultivated land	6500	16.25	1800	4.5	-4700	522.2
Grazing land	2300	5.75	9000	22.5	+6700	744.4
Degraded land	-	-	3440	8.6	+3440	382
Total	40000	100	40000	100		

Note. + increased and – decreased.
Source: our own analysis 2016/17.

Land use land cover class in 2016. The LULC classes in 2016 were cultivated land, grazing land, bush & shrub land, forest land and degraded land (Fig. 3). The greatest share of LULC from classified types was bush & shrub land, it covered 20600 ha (51.5 %) area of the park in 2016. Whereas, forest, grazing, cultivated and degraded lands were covered an area of land 6160 ha (15.4 %), 5800 ha (14.5 %), 5200 ha (13.0 %) and 2240 ha (5.6 %) respectively (Table 2).
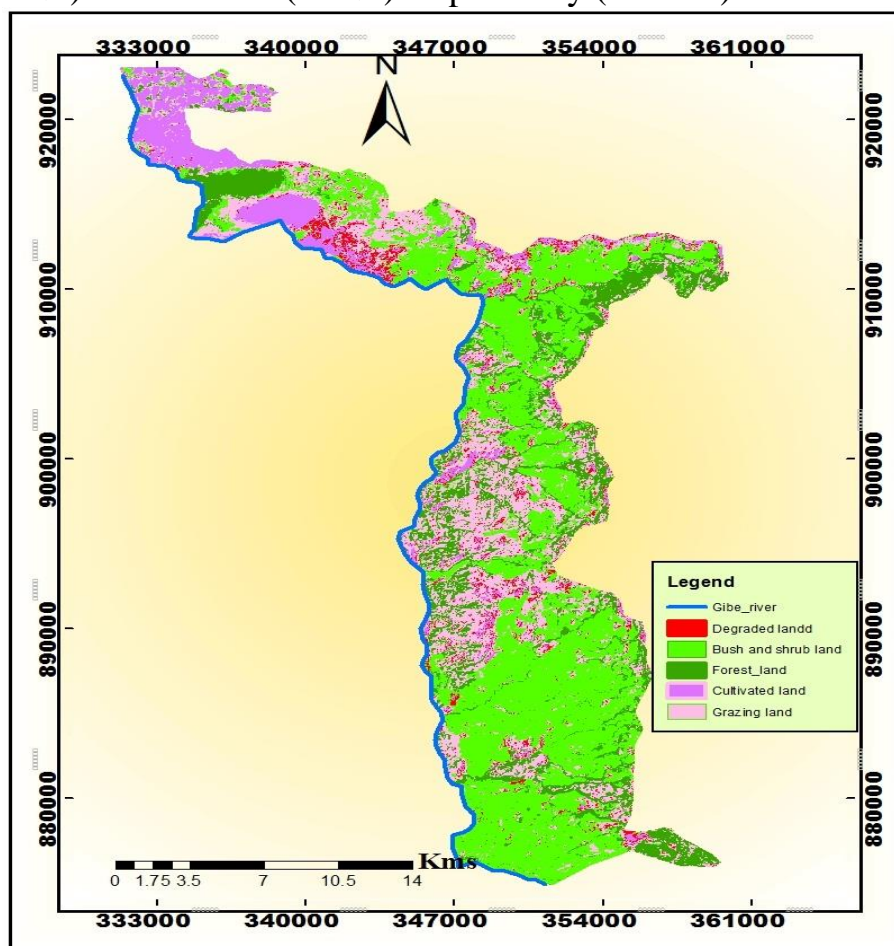

Fig. 3. Land use land cover map of GSNP in 2016
Source: Arc-GIS analysis result.

Land use land cover change from 1999 to 2016. A total 5900ha of forest land was continuously declined from 1999 to 2016. It was alarmingly declined from 30.15% to 15.4% cover of land even the area was designated as national park since 2009. Consequently, 347.06 ha average forest land was altered from other LULC class in the study area per year for the last seventeen consecutive years (Table 2) (Fig. 3). Grazing and bare (degraded) lands were showed mild reduction; 3200 ha and 1200 ha of land were declined respectively from the last seventeen years. This might be the conservation action was effective after establishment of the park to minimize further grazing of livestock and degradation due to uncontrolled human activities. The coverage of grazing land was declined from 22.5 % to 14.5 %. While degraded land was diminished from 8.6 % to 5.6 % in the study area. This could be the enhancement of conservation activities and minimizing the intensity of grazing after the study area designation as national park in 2009. However, cultivated land and

bush & shrub land were recorded 3400 ha and 6900 ha of land increment respectively for the last seventeen years. Bush & shrub land was increased the proportion from 34.25 % to 51.5 % in the study area. Therefore, bush &shrub land was the dominant LULC type in the study area in 2016. According to [10] finding farm and settlement land is the dominant LULC type in Bench Maji Zone with total area coverage of 9,014.14 km^2 (36.8 %). The proportion of cultivated land was raised from 4.5 % to 13 % in the study area for the last seventeen years (Table 2). This was primarily due to the presence and further expansion of government farmland, locally known as Mirt-zer cultivated land inside national park. Illegal human encroachment and agricultural land use might be also contributed.

Table 2

Land use land cover change in GSNP from 1999 to 2016

LULC	Year				Amount of change	
	1999		2016			
	Area (ha)	%	Area (ha)	%	Area (ha)	Mean annual (ha)
Forest land	12060	30.15	6160	15.4	-5900	347.06
Bush & Shrub land	13700	34.25	20600	51.5	+6900	405.88
Cultivated land	1800	4.5	5200	13.0	+3400	200
Grazing land	9000	22.5	5800	14.5	-3200	188.24
Bare (degraded) land	3440	8.6	2240	5.6	-1200	70.59
Total	40000	100	40000	100		

Note. + increased and – decreased.
Source: our own analysis result of 2016/17.

Land use land cover changes detection from 1990 to 2016. LULCC are complex and interrelated that is the expansion of one land use type is at the expense of others [11; 12]. This study was indicated that, forest land was rapidly declined by 12440 ha with average loss of 478.5 ha/year for the last 27 years in the study area. During 1990 the forest land was 18600 ha (46.5 %) however, after 27 years reduced to 6160 ha (15.4 %) in the study area. This disclosed that 66.8 % of forest land was diminished for the last 27 years due to anthropogenic factors (i.e. Agricultural expansion, illegal settlement and deforestation for fuel wood). The conversion of forest to other land use class was persisting even the study site designated as national park. However, the coverage of bush & shrub land was upraised from 12600 ha (31.5 %) to 20600 ha (51.5 %) from 1990 to 2016 in the study area. About 8000 ha of land was changed from other LULC class to bush & shrub land use class. Which means that 307.75 ha average of land was changed to bush & shrub land class per year. This indicated that most of forest land was changed to bush & shrub land from 1990 to 2016 due to human pressure [10] including deforestation for charcoal production and fuel wood. This result is also supported by [13], the major driving forces LULC are human induced factors. Cultivated land was recorded slight declination; which reduced from 6500 (16.25 %) to 5200 (13 %) with mean annual reduction of 50 ha for 1990 to 2016. This might be due to the rate of illegal agricultural expansion was reduced through protection effort after the study area was designated as national park. Jaleta

et al. [14] stated that drought lead change of less cultivation activities which has lead shrub and bush growth at its expense.

However, grazing land and bare land were showed increment of 3500ha and 2240 ha with average annual increment of 134.6 ha and 86.5 ha respectively from 1990 to 2016. Degraded (bare) land was raised from 0 % to 5.6 % between the year of 1990 and 2016 in the study area (Table 3). Those changes can be at the expense of forest and wood & shrub land [15]. According to [14] the overall trend of bare land has increased in Meja Watershed. This finding also in-line with [16] finding, population pressure and exploitive nature of agricultural practices has led to current depletion of vegetation covers and over-utilization of natural resources. According to [17] finding due to population pressure and unstable institutional set-up, almost all natural forests have been cleared throughout Ethiopian highlands and its localities. According to [18] result, the 90 % land use types were converted into various LULC types. Hence, the negative results of LULC are loss of biodiversity, soil degradation, and environmental deterioration [19].

Table 3

Land use land cover change in GSNP in 1990, 1999 and 2016

LULC	Year						Amount of change (1990–2016)	
	1990		1999		2016			
	Area (ha)	Percent	Area (ha)	Percent	Area (ha)	Percent	Area (ha)	Mean annual (ha)
Forest land	18600	46.5	12060	30.15	6160	15.4	-12440	478.5
Bush & Shrub land	12600	31.5	13700	34.25	20600	51.5	+8000	307.75
Cultivated land	6500	16.25	1800	4.5	5200	13.0	-1300	50
Grazing land	2300	5.75	9000	22.5	5800	14.5	+3500	134.6
Bare (degraded) land	-		3440	8.6	240	5.6	+2240	86.15
Total	40000	100	40000	100	40000	100	x	x

Note. + increased and – decreased.
Source: our own analysis result of 2016/17.

Accuracy Assessment Results. The accuracy of the supervised classification was checked by using error matrix. The confusion matrix is a table with the columns representing the reference (observed) classes and the row classified (mapped) classes.

From collected 40GPS sample points, 36 were within the corrected class in forest land, of 40GPS sample points, 33 were within the correct class in bush & shrub land, of 70 GPS points, 58 sample points were within the correct class in cultivated land, from 30 GPS points, 18 were within the correct class in grazing land and from 20 GPS points, 17 were within the correct class in bare land (Table 4). The overall accuracy result was 81 %, hence 81 % of LULC types were classified accurately, and only 19 % of the LULC types were classified inaccurately. Accordingly, almost all LULC types mapped with a very good accuracy if the overall classification accuracy result is 81 % [20].

Table 4

Accuracy assessment for supervised image classification

Automated classification	Field (Reference) data						User accuracy (%)	Error of commission (%)
	Forest land	Bush & Shrub land	Cultivated land	Grazing land	Bare land	Row total		
Forest land	36	2	2	0	0	40	90.0	10.0
Bush & Shrub land	5	33	0	2	0	40	82.5	17.5
Cultivated land	3	4	58	5	0	70	82.8	17.2
Grazing land	2	4	4	18	2	30	60.0	40.0
Bare land	0	0	1	2	17	20	85.0	15.0
Column total	46	43	65	27	19	200	-	-
Producer's accuracy (%)	78.2	76.74	89.2	66.60	89.5	-	-	-
Error of Omission (%)	21.8	23.26	10.8	33.40	10.53	-	-	-

Note. NB: Over all accuracy = (36+33+58+18+17) : 200) · 100 = 81 %.
Observed value = (36+33+58+18+17) : 200 = 0.81.
Source: our own analysis result of 2016/17.

Conclusions. This study revealed that, there wasn't degraded land use type in the study area during 1990 though after ten years 8.6 % of the area was exposed for huge degradation due to human pressure. Grazing and bare (degraded) lands were showed mild reduction since 2009 (i.e. the study area designated as national park) though forest land was continuously changed to other land use type from 1999 to 2016. This might be the conservation action was effective after establishment of the park to minimize further grazing and degradation. Subsequently, 66.8 % of forest land was diminished from the study area for the last twenty-seven years as a result of human population pressure; such as expansion of agricultural land, deforestation for fire wood and illegal human settlement. However, bush & shrub land, grazing and bare land recorded vast expansion 1990 to 2016 in the study area. The study showed that extended forest land might be converted to bush & shrub land type, which accounts more than half percent the study area after 27 years. It brings negative effects to the wildlife conservation, contribute for climate change and drying up of streams and river. Hence, immediate conservation measure and participatory wildlife management should be implemented. Moreover, further study should be conducted to identify the rate of driving force of LULCC and make & apply conservation policy in the study area.

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