Assessment of the Trend, Cause and Effect of Deforestation Using GIS and Remote Sensing in Goba District, Bale Zone, South Eastern Ethiopia

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Abstract

The conversion of forested areas to non-forest land was a series problem in study area of Goba district. The objectives of this study were to assess the trends, causes and effects of deforestation in Goba district, Bale zone, Ethiopia. Descriptive research method was employed to achieve these stated objectives. Satellite image of the three times and socio-economic survey were the main data sources for this study. ERDAS imagine 9.2 and ArcGIS 10 tools were applied for land use and land cover type classification, and analysis and mapping. These land use land and over change data were obtained from USGS. Socio-economic data collected through questionnaires, focus group discussions and interviews on the causes and impacts of land use and land cover change were analyzed quantitatively using SPSS software and content analysis for qualitative data. These analyzed data were expressed in percent and in words. The result shows that there was variation in the extent of land use and land cover change among different categories/classes at different study periods. Open area and Bush land showed decreasing change during first period of comparison and increasing change in the second period of comparison. In contrast, agricultural area, Bale temperate vegetation and built up area showed increasing. Built up area, agricultural area and Bale temperate vegetation increased by 80.05, 15.84, and 7.40 percent respectively, however, open area, grassland, forest land and bush land decreased by 1.58, 1.21, 0.97, and 0.28 percent per year for the last 29 years respectively. In general, in study district forest cover was 50.87% of the total area in 1986 and decreased to 36.57% in 2015 whereas agricultural area was increased from 3.45% to 19.28% respectively. This implies an increasing agricultural area at the expense of other land use cover categories, particularly natural forest. The study indicated that increasing population, forest fire and fuel wood consumption, overgrazing, and agriculture and settlement expansion and road construction caused forest cover change in the district. A decrease in livelihood incomes, volume of the surface water and in contrary increase in rain fall and temperature variability and forest product costs were among the major observed effects of deforestation in study area. Based on these findings, the study recommends the need to introduce and develop agricultural extension services, alternative energy sources and awareness raising services to the study area.

Keywords

Deforestation, Remote Sensing, GIS, Land Use and Land Cover, Goba District

1. Introduction

The world's forests provide a great service and benefits to our ecosystems. It provides foundations for life on earth through ecological functions by regulating the climate, water and soil resources and also by serving as habitats for plants and animals [1]. Moreover, it also provides a variety of essential goods for domestic and export markets [2]. Similarly, forests are also used for recreation, tourism and other local opportunities [3]. However, deforestation, on the other hand, is a form of environmental degradation which involves the conversion of forest to non-forest areas; the degradation that reduces forest quality in terms of the density and structure of the trees: the ecological services supplies, the biomass of plants and animals, the species diversity and the genetic diversity [4].

The current environmental challenge of the world is the result of decline in forest cover at alarming rate. According to [5] about 16 million hectares of world forest were deforested in 1990s and about 13 million hectares of the world's forest were lost due to deforestation per annum from 2000 to 2010. [4] report indicated that global forest coverage from 1990 to 2000 decreased by 0.22% and from 2000 to 2005 decreased by 0.18% per year. [6] pointed out that about 11.4 million hectares of tropical forests were disappeared annually in the 1980s and 17.20 million hectares per year in the 1990s.

Ethiopia is one of the Sub-Saharan African countries endowed with rich biodiversity, good water resource potential and natural resources. However, the rate of destruction of forests in the country is high [7]. According to [5] Ethiopia's forest cover was 15.11 million hectares in 1990 and declined to 12.2 million hectares in 2010 which resulted in a loss of 2.65% of forest cover due to deforestation. Between 1990 and 2010, the country lost on average about 140,900 ha or 0.93% per year and totally between 1990 and 2010, Ethiopia had been lost 8.6% or around 2,818,000 hectares of its forest covers [5] despite relative increasing coverage currently. Bale eco-region is one of the biodiversity hotspot sites in the country. However the average annual deforestation rate of this eco-region was 3.44% between 2001 and 2009 which ranges from 1% to 8% [8]. Other preliminary study by [9] has shown that between 2000 and 2011 the Bale Mountain eco-region project area experienced annual deforestation that ranges from 1.1% to 6.6%, and the entire eco-region has an average deforestation rate of 3.7%. The study Goba district is one part of Bale eco-region area experiencing deforestation.

Field observation and experience of the area show that there has been high rate of deforestation and its associated effects (socio-economic and environmental impacts) have becoming a threaten issues in study district. However, detailed study about extents, trends, causes and effects of deforestation at district level is very limited. Understanding up to date information on the extent and trends of deforestation and identifying causes and its environmental and socio-economic implication are essential to design strategic plan that ensure sustainable utilization of forest resources. Therefore, the aim of this study is to investigate the extent and trends of deforestation and the causes and its subsequent effects in order to suggest sustainable use and management of forest resources that could improve the quality of ecosystem and local livelihoods. Remote sensing and GIS technologies are essential to provide forest information for government and civil society in time and in cost effective way. Thus, these technologies were applied for land use land cover type changes analysis and mapping whereas socio-economic survey was used in identifying the driving forces and its subsequent environmental and socio-economic aspects. The specific objectives of the study were: 1) To assess the spatio-temporal trend, rate and map out the extent of deforestation in 1986, 2000 and 2015 in Goba district of Bale zone; 2) To identify the causes of deforestation; 3) To identify the socio-economic and environmental effects of deforestation in Goba district.

2. Methods and Materials

2.1. Description of the Study Area

Goba district is one of the districts in Bale zone, Oromia Regional State of Ethiopia. It lies between 5˚57'30"N to 7˚12'00"N latitude and 39˚35'00"E to 40˚15'00"E longitude. The altitude of the study area ranges from 2400 to 4377 masl. It has a total area of 1,674 km^2. It is found at the distance of 445 km from Addis Ababa the capital city of Ethiopia (**Figure 1**).

Goba district is highland area characterized by various mountain ranges, plains, rugged and gorges. Accordingly, the land configuration of the district accounts about 45% plain, 18% mountains, and 37% rugged and gorges [10].

This varied topography has attributed to the prevalence of varied microclimate of an area. As the result the district is characterized by a great temperature variation with altitude. The monthly temperature ranges from minimum 4˚C to a maximum of 25˚C. Goba district experiences two rainy seasons of summer and spring (Bimodal rainfall). The mean annual rainfall vary from 900 mm in

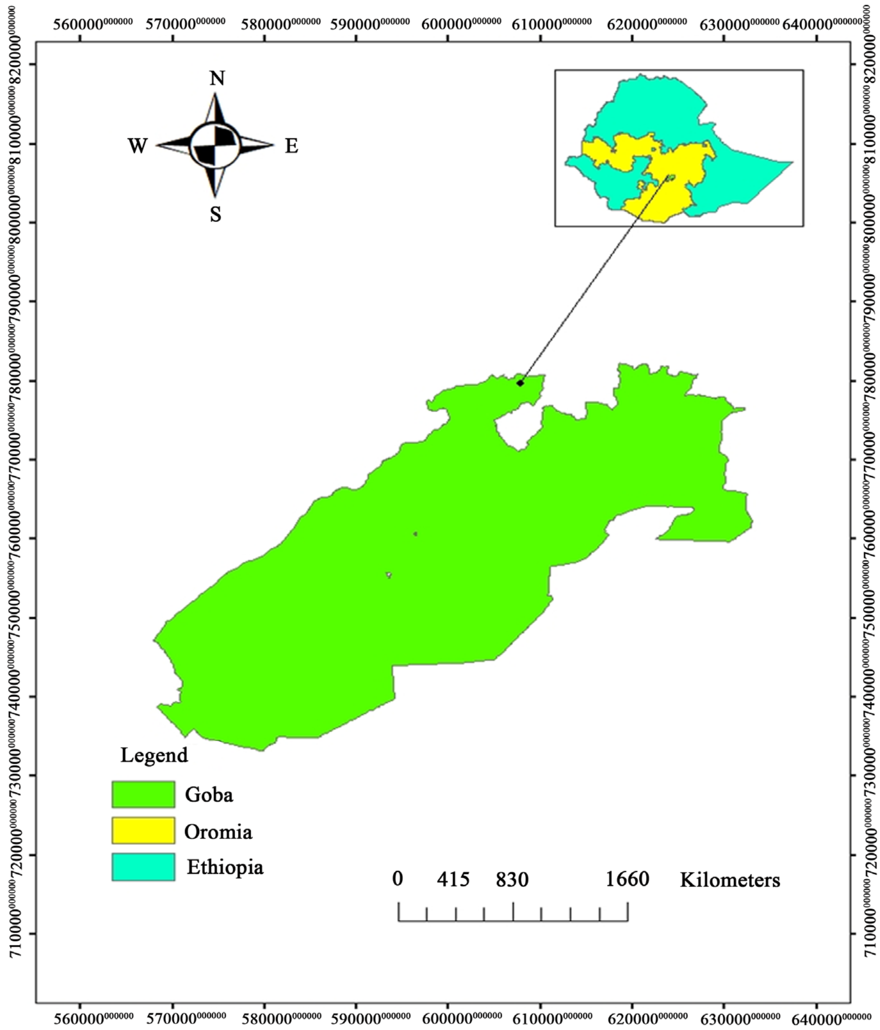


Figure 1. Map of the study area.

lowlands to 1400 mm in highlands (Robe Metrological Station, 2015). These diverse landscapes provide possibilities of producing a variety of crops [10].

Agriculture is the back bone of the economy and provides means of occupation for almost all populations in the district. The district has two major cropping seasons namely summer (*Maher*) and spring (*Belg*). Cereals, horse beans, field beans and lentils are important crops grown. In addition different vegetables and oil seeds are grown in the district. Agriculture is dominantly practiced together with animal rearing. Agricultural productivity is constrained by population pressures, limited knowledge about modern technology, cost returns and risks and lack of infrastructure especially road which help the farmers to sell their own products to markets [10].

2.2. Research Methods

Descriptive research is used to describe the necessary information concerning the status of the phenomena and to describe what exist with respect to variable or conditions in a situation obtained [11]. Therefore, descriptive research method was employed to address all issues in the objectives of research. Satellite images were used to assess trends and extent of land use and land cover changes whereas socio-economic data were collected from selected households, elders, experts of land administration and environmental protection office and agriculture and rural development offices and members of the community of district to identify the driving forces and its subsequent socio-economic and environmental effects of deforestation (**Table 1**). Additionally analysis of satellite image and field visit was included in the study. During field survey seventy three ground truth data were collected randomly using Garmin GPS 72H for the supervised image classification from the study area.

Based on the existing problems five *kebeles*/villages were purposely selected from the total 15 kebeles in the Goba district. These selected kebeles were Shedam, Adaba Gafaca, Rira, Wajitu Shabe and Fasil Angasso. Using [12] sample size determination criteria 390 farmer house holders' were selected by random sampling technique whereas 20 key informants and 5 groups having 6 members of FGDs were purposely selected. Liker or rating scale method was used to analysis socio-economic survey because it is suitable for such large scale survey as it is quick for respondents to answer and easy to analyze using statistical techniques.

2.3. Procedures of RS Data Processing

Image preprocessing such as image rectification (involve radiometric and geometric Correction), image enhancement (to increase visual distinction), and image registration was done in order improve the quality of the data and registration to the exact UTM37 position.

Image classification was categorized using supervised classification. Supervised classification is useful when ground truth data of an area is available and was adopted for this study. During field visit the various land use land cover classes were taken by systematic sampling using GARMIN 72 GPS devise. 73 samples were used to represent the identified land use land cover types. The satellite images were classified in to seven land use and land cover types using

Table 1. Source of data.

N°	Data type	Date of production	Path and row	Resolution	Source
1	Landsat image TM	1986	167/55	30 m	USGS
2	Landsat image ETM+	2000	167/55	30 m	USGS
3	Landsat image ETM+	2015	167/55	30 m	USGS
4	Goba district shape file	2007			EMA
5	Administrative and local Government Map of Ethiopia	2007			EMA
6	Social-economic data				Field survey

the sample training signature prepared from the Ground Control Points (GCPs) collected. These classified land use and land cover types were agricultural land, grass land, forest land, Bale temperate vegetation, open area, bush land and built up area. GIS and ERDAS tools were used for LU/LC types classification based on visual interpretation of satellite imagery and field observation. Representative data sets for a given class and the variability of a class taken into account.

After classification, majority analysis was used in order to avoid minor fragmented classification arrangements on the output map. Ground verification after classification was made in order to check the precision of the classified LU/LC map. Accordingly GCPs such GPS points were collected, topographic map was compared, field observation was conducted as well as local elders were consulted. Normally, the map from time 1 is compared with the map produced at time 2, and a complete matrix of categorical change was obtained. So that, two comparisons was made based on three satellite images classified maps, 1986, 2000 and 2016. The first comparison was between 1986 and 2000; and the second comparison was between 2000 and 2015 maps. Useful and effective remotely sensed data require techniques of accuracy assessment. Therefore, the overall classification accuracy for the study area was 87.67% and the overall kappa statistics was 0.8562 which represents a probable 85% better accuracy than if the classification resulted from a random assignment. The result obtained in this study fits to the view of [13].

2.4. Land Cover and Land Use Classes and Definitions

Based on [14] classification, the satellite images and ground truth for the recent image, the land use land cover classes analyzed for changes were: agricultural land, grass land, forest land, Bale temperate vegetation, open area, bush land and built up area (**Table 2**).

Table 2. LU/LC classes analyzed for trends of deforestation.

No	Class	Definition
1	Agricultural area	Areas of land ploughed/prepared for growing various crops. This category includes areas currently under crop, fallow and land under preparation.
2	Grass land	It is the land cover includes areas of shrubs, short tress, bushes, pasture lands, grazing areas dominantly covered with grasses.
3	Forest land	"Forest" is a minimum area of land of 0.05 - 1.0 hectare with tree crown cover (or equivalent stocking level) of more than 10 - 30 per cent with trees with the potential to reach a minimum height of 2 - 5 meters at maturity *in situ.*
4	Bale temperate vegetation	The species that cannot be included/categories under shrub or grass like Hellicrasiem.
5	Open area	Bare land is Vacant land that has no buildings on it, no vegetation cover and no crop cultivation and is not being used.
6	Bush land	In reference to the landscape, "bush" refers to any sparsely-inhabited region, regardless of vegetation.
7	Built-up area	Area occupied by people for habitation.

All image processing was carried out using Arc GIS 10 and ERDAS imagine 9.2 software. The Land Use and Land cover maps obtained from three satellite images were compared by categorizing into two groups from 1986 with 2000 and 2000 with 2015. This helps to establish the degree of forest cover change during the past thirty years.

While, ERDAS and Arc GIS tool were used to analyze the spatio-temporal trends and extent of deforestation over the last three decades (1986, 2000 and 2015) in Goba district. Accordingly, Land Sat TM (1986), Land Sat ETM+ (2000) and Land Sat ETM+ (2015) satellite imageries with their 30m resolution for each year were used to estimate trends and extents of changes. The accuracy was essentially a measure of how many ground truth pixels were classified correctly. The kappa value is a measure of the agreement between classification and reference data with the agreement due to chance removed. [15] ranked the kappa values, ranging from −1 to 1, into 3 groups: 1) those greater than 0.80 represented strong agreement between the classification and reference data; 2) those between 0.40 and 0.80 represented moderate agreement; and 3) those less than 0.40 represented poor agreement. The Kappa coefficient lies typically on a scale between 0 and 1, where the latter indicates complete agreement, and is often multiplied by 100 to give a percentage measure of classification accuracy. In this study, the accuracy assessment of LU/LC classification was done for 1986, 2000 and 2015 (**Tables 3-5**). The overall classification accuracy the study area 87% and the overall kappa statistics was 0.8562 represents a probable 85% better accuracy than if the classification resulted from a random assignment (**Table 6**). The result obtained in this study fits to the view of [13] who stated the minimum level of accuracy in the identification of land use/land cover categories from remote sensor data should be at least 85%. Therefore, the classification accuracy of the study meets this requirement.

Socio-economic data collected through questionnaire and interview were coded so as to simplify further tasks. The scores were summarized from the sheet and made ready for analysis. After that, it was analyzed using both qualitative and quantitative techniques. For interview questions, it was analyzed using

Table 3. Accuracy assessment of LU/LC Classification for 1986.

Class Name	Reference Totals	Classified Totals	Number Corrected	Procedures Accuracy	User Accuracy
Forest land	10	12	10	100.00%	83.33%
Bush land	11	10	10	90.91%	100.00%
Grass land	10	10	9	90.00%	90.00%
Bale temperate area	10	11	10	100.00%	90.91%
Agriculture area	11	13	10	90.91%	76.92%
Open area	10	10	8	80.00%	80.00%
Built up area	11	7	7	63.64%	100.00%
Totals	73	73	64		

Table 4. Accuracy assessment of LU/LC Classification for 2000.

Class Name	Reference Totals	Classified Totals	Number Corrected	Procedures Accuracy	User Accuracy
Forest land	10	11	10	100.00%	90.90%
Bush land	12	10	10	83.33%	100.00%
Grass land	11	10	10	90.90%	100.00%
Bale temperate area	11	12	10	90.00%	90.90%
Agriculture area	12	13	10	83.33%	76.92%
Open area	10	11	9	81.81%	90.00%
Built up area	10	9	8	88.88%	8.00%
Totals	76	76	65		

Table 5. Accuracy assessment of LU/LC Classification for 2015.

Class Name	Reference Totals	Classified Totals	Number Corrected	Procedures Accuracy	User Accuracy
Forest land	13	10	9	90.00%	69.23%
Bush land	11	9	9	100.00%	81.81%
Grass land	10	10	9	100.00%	100.00%
Bale temperate area	12	10	10	100.00%	83.33%
Agriculture area	11	13	9	90.91%	69.23%
Open area	10	8	10	100.00%	100.00%
Built up area	10	9	8	88.88%	80.00%
Totals	77	77	65		

Table 6. Kappa statistics value for each category.

Class Name	Kappa value for each category
Forest land	0.8069
Bush land	1.0000
Grass land	0.8841
Bale temperate area	0.8947
Agriculture area	0.7283
Open area	0.7683
Built up area	1.0000
Over all Kappa statistics = **0.8562**	

descriptive narrations but the Quantitative data was analyzed using descriptive statistics.

3. Results and Discussion

3.1. Land Use Land Cover Classification for 1986, 2000 and 2015

The study area has identified seven land use land cover categories, which were:

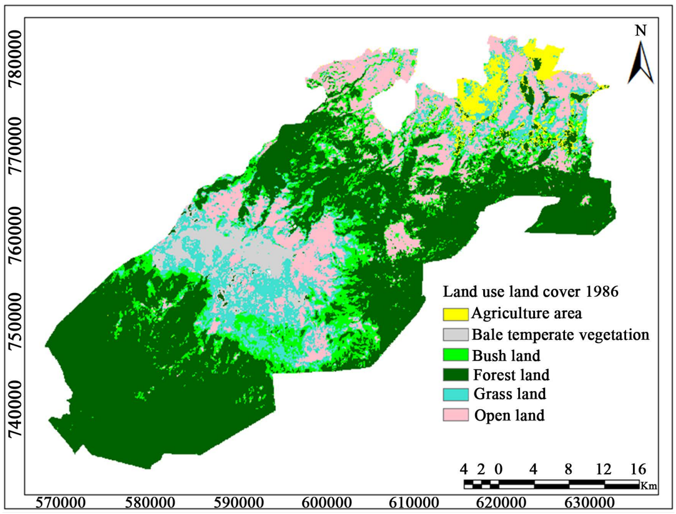
agriculture area, Bale temperate vegetation, bush land, forest land, grass land, open area and built-up area. The land use land cover classification for 1986 from TM satellite image (**Figure 2(a)**) showed that majority of the study area was under forest land and open area accounting for 77,019.573 ha (51.558%) and 23,440.098 ha (15.691%) respectively, while agriculture area, Bale temperate vegetation, bush land and grass land amounted to about 4815.134 ha (3.223%), 6191.952 ha (4.145%), 19,367.166 ha (12.965%), and 18,549.560 ha (12.417%) respectively (**Table 7**). Most portion of the land use land cover class was forest land during this period.

The land use land cover classification for 2000 from ETM+ satellite image (**Figure 2(b)**) show that forest land and agricultural area accounting for 79,558.857 ha (53.258%) and 21,944.478 ha (14.69%) respectively. Whereas, Bale temperate vegetation, open area, built up area, bush land, and grass land were amounted to about 14,911.729 ha (9.982%), 9054.552 ha (6.061%), 1332.094 ha (0.892%), 7355.747 ha (4.924%) and 15,225.727 ha (10.192%) respectively (**Table 7**). Most portion of the land use land cover class was forest land during this period.

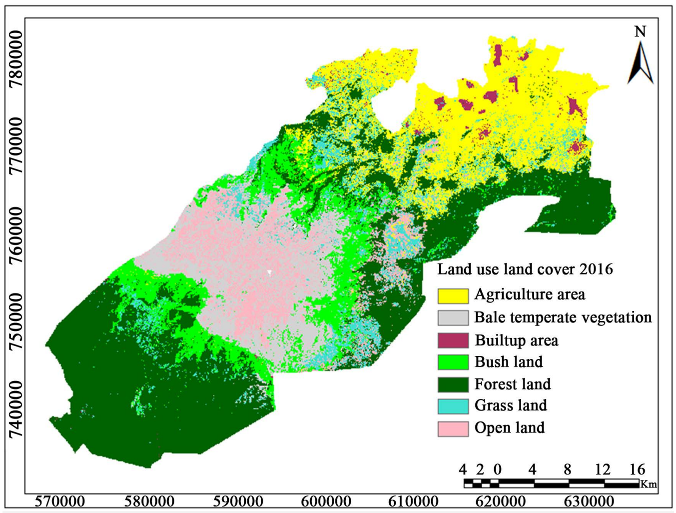
Land use land cover classification for 2015 from ETM+ satellite image (**Figure 2(c)**) showed that forest land and agricultural area accounting for 55,366.093 ha (37.063%) and 29,193.977 ha (19.543%) respectively. Whereas Bale temperate vegetation, open area, built up area, bush land, and grass land were amounted to about 19,485.410 ha (13.044%), 12,914.990 ha (8.646%), 1764.690 ha (1.181%), 18,372.319 (12.299%) and 12,285.926 ha (8.224%) respectively (**Table 7**). Most portion of the land use land cover class was forest land during this period and however, the percentage of forest coverage had been decreased compared to the former two periods.

Table 7. LU/LC classes, their corresponding areas for 1986, 2000 and 2015.

Land cover type	Area in % in 1986		Area in % in 2000		Area in % in 2015	
Land Cover		Area (%)		Area (%)		Area (%)
Agricultural area	4815.134	3.223	21,944.478	14.690	29,193.97	19.543
Grass land	18,549.560	12.417	15,225.727	10.192	12,285.92	8.224
Forest land	77,019.573	51.558	79,558.857	53.258	55,366.09	37.063
Bale temperate vegetation	6191.952	4.145	14,911.729	9.982	19,485.41	13.044
Open area	23,440.098	15.691	9054.552	6.061	12,914.99	8.646
Bush land	19,367.166	12.965	7355.747	4.924	18,372.31	12.299
Built-up area	0.000	0.000	1332.094	0.892	1764.690	1.181
Total	149,383.48	100	149,383.18	100	149,383.40	100



(a)



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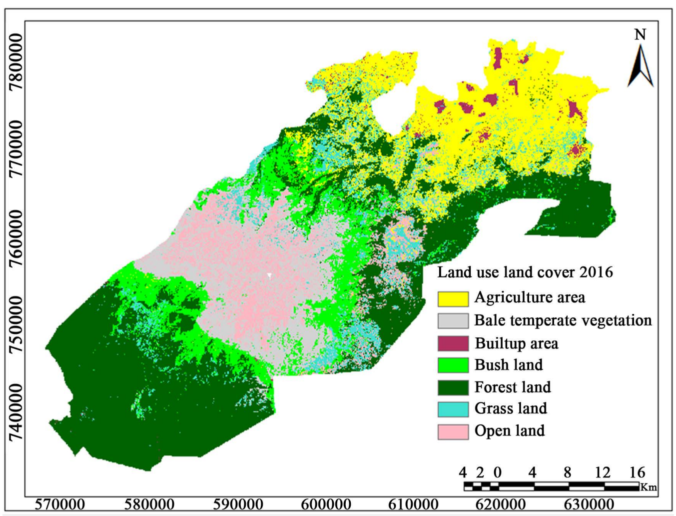


(c)

Figure 2. (a)-(c) LU/LC maps for the years 1986, 2000 and 1015.

3.2. LU/LC Change Detection for 1986 to 2000 and 2000 to 2015

The results of land use/land cover map shows that the area of grass land and open area declined in both periods. The rate of change was greater in the periods of 1986 to 2000. Open area, bush land and grass land showed a general decline throughout the periods (1986-2015) whereas agricultural area, Bale temperate vegetation and built-up area in contrast showed general trend of increase in these periods. Forest land on the other hand increases in from 1986 to 2000 but decreased from 2000 to 2015 in accelerated way (**Table 8**).

The major cover changes observed during 1986-2000 period had been the reduction in the area of open area and bush land categories, by 14,385.55 ha and 12,011.42 ha respectively, and grasslands on the same way decrease by 3323.83 ha. On the contrary there were a considerable increase in the agricultural area, forest land and Bale temperate vegetation by 17,129.34 ha, 2539.28 ha and 8719.78 ha respectively. Based on the change detection matrix most of **Table 8**, the reduced open area, bush land and grassland had been changed to Agricultural, Bale temperate vegetation and Forest lands. Though the overall change on grasslands and forest land had been negative, there had also been forest conversion to agricultural area and built up area in this period. Therefore, the removal of forest land to expand cultivation and cutting of trees for different purposed had been the most important scenario worthy of considering in this particular period. In this period, expansion of farmlands and intense deforestation were directly linked to population growth within that period. Rise in human population in this period had in turn been the result to get additional land for cultivation and settlement through forest clearance. On the other hand, the forest had been the source of wood for construction and other domestic uses like fuel.

In the second period from 2000-2015 (**Table 8**) the area covered by forest land, grass land, open area, has been decreased while the area covered by Bale temperate vegetation, built up area and agricultural area had been increased. The major changes observed in this period were decrease in the overall area of forest land and an increment of agricultural area and built up area. Over the past nearly 30 years, the conversion statuses of different LULC classes had different

Table 8. LU/LC change detection for 1986 to 2000 and 2000 to 2015.

Classes	From 1986-2000	From 2000-2015
1) Forest land	+2539.284	−24,192.764
2) Bush land	−12,011.419	+11,016.572
3) Grass land	−3323.833	−2939.801
4) Bale temperate vegetation	+8719.777	+4573.681
5) Agriculture area	+17,129.344	+7249.499
6) Open area	−14,385.546	−3860.438
7) Built-up area	0.00	+432.596

magnitude and rates. In this period, there has been significant conversion between forest land to farmland, grassland, BTV and from cropland to other land classes. The details of LULC conversion statistics between 1986 and 2000 and 2000 and 2015 are shown in Table 9 and Table 10. Based on the change detection matrix parts of the forest lands were continuously cleared to expand agricultural and built areas.

3.3. Trend and Rate of Forest Cover Change for 1986 to 2000 and 2000 to 2015

The trend and rate of forest cover change has been done to make it possible to visualize and analyze the spatial pattern of change, which would help to identify the various factors that cause forest loss, to determine their relative importance and effect for the successive analysis and for the formulation management strategy. It also highlights the seriousness of the forest cover change dynamics which strengthens the need for protected forest cover establishment by using remote sensing and GIS techniques with the integration of field survey.

Table 9. Land use land use matrix of 1986 and 2000.

		Land use and land cover class in 1986						
		Forest land	Bush land	Grass land	BTV	Agriculture area	Open area	Total area in ha
Land use and land cover class in 2000	Forest land	64,934.2	7682.13	2584.89	118.71	612.63	2713.71	**78,646.27**
	Bush land	656.55	1774.53	2905.38	494.73	333.36	1253.16	**7417.71**
	Grass land	2410.65	3227.76	4363.56	1791.36	115.73	3690.18	**15,599.24**
	BTV	6166.08	1789.74	2685.33	2957.49	221.31	1836.54	**15,656.49**
	Agriculture area	1279.08	2667.15	3918.69	0	3209.76	10460.8	**21,535.48**
	Open area	1398.87	2021.31	1743.21	798.3	132.66	3033.36	**9127.71**
	Built-up area	133.21	228.15	370.62	35.73	203.04	429.84	**1400.59**
	Area in%	**76,978.64**	**19,390.77**	**18,571.68**	**6196.32**	**4828.49**	**23,417.59**	**149,392.6**

Source: Extracted from analysis of Land sat images of 1986, and 2000. Note: The numbers in the class total row indicate initial state where as the class total column indicates the final state. The diagonals indicate areas remained unchanged.

Table 10. Land use land cover change matrix between 2000 and 2015.

		Land use and land cover class in 2000							
		Forest land	Bush land	Grass land	BTV	Agriculture area	Open area	Built-up area	Total area in ha
Land use and land cover class in 2015	Forest land	50,278.5	244.0225	867.6675	3089.88	518.355	379.305	26.145	**55,403.88**
	Bush land	13,008.6	613.8225	2240.595	2022.525	9.9675	375.75	90.27	**18,361.53**
	Grass land	3726.43	379.215	2357.888	725.9725	3154.748	2026.305	101.6325	**12,472.19**
	BTV	3110.6	3514.905	5843.228	4389.525	154.3725	2140.513	307.8675	**19,461.01**
	Agriculture area	6047.44	1138.68	886.8725	1939.69	16263.25	2020.568	692.82	**28,989.32**
	Open area	2108.3	1558.328	3420.608	3394.8	311.4225	2141.458	61.47	**12,996.39**
	Built-up area	271.957	60.5025	46.5075	84.603	1049.378	68.8725	117.45	**1699.271**
	Area in%	**78,551.83**	**7509.476**	**15,663.37**	**15,647**	**21,461.49**	**9152.772**	**1397.655**	149,383.6

The percentage share (relative to the total of study area) for each year forest cover value and with its trend indicate that in the year 1986, 51.558% of the study area was covered with forest resources, while it was increased to 53.258% in 2000 and this was again decline to 37.063% in the year 2015 **Figure 3** and **Table 11**.

Table 12 shows that the calculated result indicated the average rate of forest covers gain from year 1986 to 2000 was 181.38 ha (1.70%) per year and from year 2000 to 2016 lost was 1512.05 (16.20%) ha per year. Besides, considering the annual rate of forest cover loss from the entire period (1986 to 2016) was 721.78 (14.50%) ha per year.

3.4. Changes Detected by NDVI Differencing

NDVI image differencing cannot provide detailed change information. It can only give the Information of increase or decrease in NDVI value. The negative threshold indicates loss or low in NDVI and positive threshold indicates area of high or increased NDVI. As indicated in **Figures 4(a)-(c)**, there was change of land cover in general in the three years of image. To this effect the standard value decreased in certain amount, showing that there were changes or decrease of green vegetation. So, one can conclude that there is deforestation.

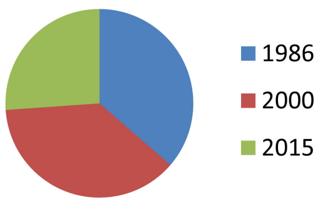


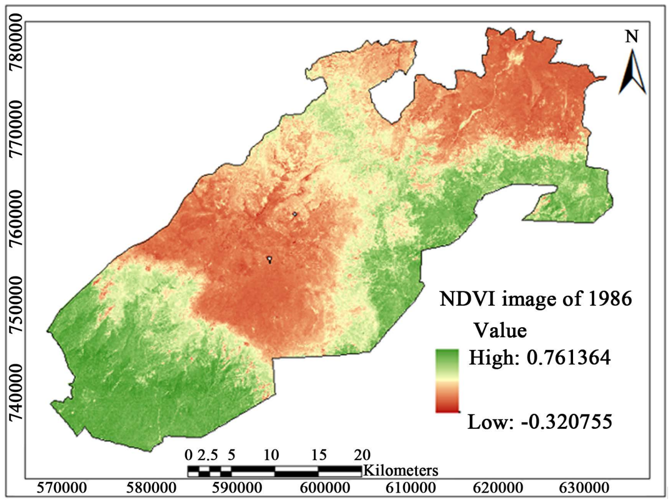
Figure 3. Forest covers in years.

Table 11. Temporal distributions of forest covers with their corresponding areas and change for 1986, 2000 & 2016.

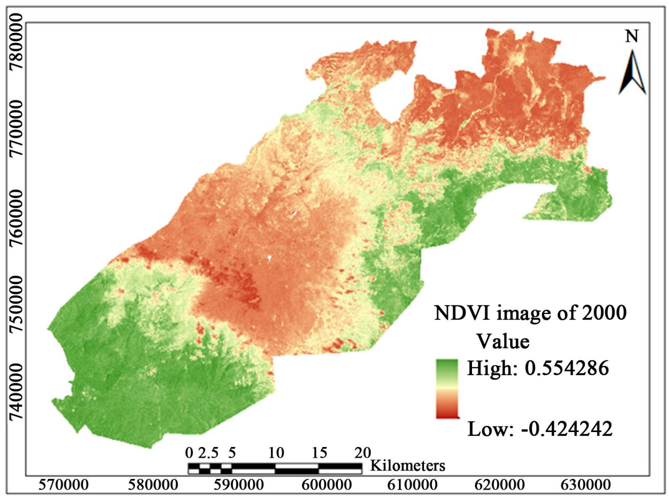
Year	Forest area (ha)	Forest cover in%
1986	77,019.573	51.558
2000	79,558.857	53.258
2015	55,366.093	37.063

Table 12. Rates of forest cover change in years.

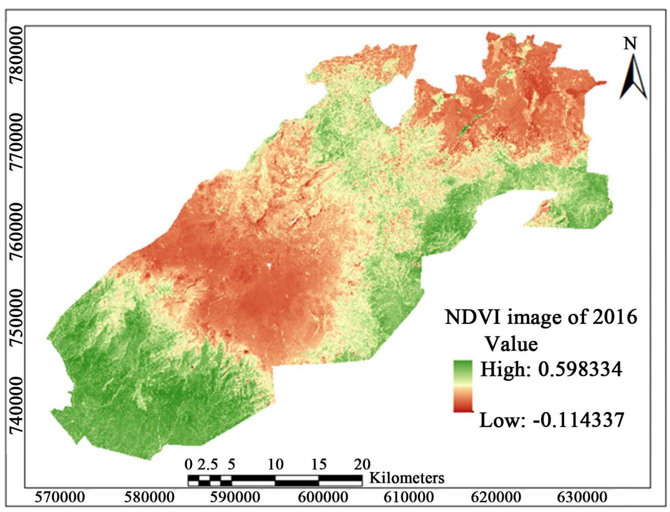
Year	Hectares per year	Rate of forest gain or loss	
		Rate of change	**% per year**
1986 to 2000	+2539.284	+181.38	+1.70
2000 to 2015	−24,192.764	−1512.05	−16.20
1986 to 2015	−21,653.48	−721.78	−14.50



(a)



(b)



(c)

Figure 4. (a) NDVI image of 1986 of Goba district; (b) NDVI image of 2000 of Goba district; (c) NDVI images for the years 1986, 2000 and 2015 of Goba district.

3.5. Causes of Deforestation

Data gathered through questionnaires on respondents view on deforestation causes and its effect on rural livelihoods was analyzed using simple descriptive statistical techniques such as percentage and frequency. Majority (92%) of the respondents interviewed stated that the total population of the district has been increasing over years (Table 13). The point in case is that the population density of study district was increased from 23.60 to 26.25 person/km^2 between the years 1986 and 2015 and thus adversely affected forest resources in the study area. This is because increased population demands extra land for food, settlement; forest Wood for construction, for fire wood consumption as well as for other various forest products. For instance, agricultural land was increased by 19.543% between 1986 and 2015 at the expense of forest (Table 7). As interviewed office expert told, the average per capital consumption rates of fuel wood in Goba district was 0.0013 m^3 per day per individual for 2015 population of the district. The annual demand of fuel wood in the study area was in average estimated as 23,725 m^3.

Most respondents (90%) were agreed to the perception that road construction and forest fires were also another causes of deforestation in the study area. The points in case are constructed road from Gobat town to Delo Mena town and forest fire in 2000 and 2014 that destroyed many areas (Table 13 and Figure 5 and Figure 6(a) and Figure 6(b)). Respondents have agreed with the opinion that settlement expansion, overgrazing and fuel wood collection were another causes of deforestation in the study area (Table 13 and Figure 7).

Similarly, the information collected from local people through focus group discussion was evident that cutting trees for the demand of constructional material, for agricultural purposes due to the lack of enough farming land and income generation purposes was considered as the causes of deforestation in the

Table 13. Respondents' opinion on causes of deforestation in case of Goba district.

N°	Item	Scale of responses					
		DA		U		A	
		F	%	F	%	F	%
1	Population increment	22	6.11	4	1.11	334	92.78
2	Road constructions	21	5.84	12	3.33	327	90.83
3	Forest fires	17	4.72	4	1.11	339	94.17
4	Settlement expansion	22	6.11	7	1.95	331	91.94
5	Overgrazing	14	3.89	18	5.00	328	91.11
6	Fuel wood	11	3.06	31	8.61	318	88.33
7	Urbanization	324	90	25	6.94	11	3.06
8	Mining	342	95	13	3.61	5	1.39

Source: (Field Survey, 2016). Where DA = Disagree, U = undecided, A = Agree.

Figure 5. Partial view of road construction.

(a) (b)

Figure 6. (a) and (b) forest fire in 2014 in Goba district.

Figure 7. Partial view of settlement encroachment and firewood collection.

area. In the forest blocks of Goba district, namely Fasil Angasso, Shedam, Adaba Gafaca and Wajitu Shabe kebeles were where high amount of deforestation was recorded. Whereas in Rira kebele the extent of deforestation was low due to high level of awareness of the community the importance of conserving forest resource. This research finding is in line with other research conducted in Ethiopia. For instance, [16] stated that the increasing demand for croplands, grazing land, construction and fuel wood including charcoal production are the main reason for the forest cover change in Ethiopia.

3.6. Major Effects of Deforestation on Local Environment and Livelihoods

It is revealed that the majority (95.84%) of the respondents agreed that deforestation has directly affected their livelihood incomes (**Table 14**). Because the

Table 14. Respondents opinions on the major effects of deforestation on local livelihoods in Goba district.

N°	Items	Scale of response					
		DA		U		A	
		F	%	F	%	F	%
1	Affect livelihood incomes	3	0.83	12	3.33	345	95.84
2	Decrease of the amount of surface water volume	1	0.28	6	1.67	353	98.05
3	Increase local temperature	16	4.44	7	1.94	337	93.62
4	Affect variability of rainfall	12	3.33	20	5.56	328	91.11
5	High erosion prevalence	12	3.33	11	3.06	337	93.61
6	High loss of habitat of animals and plants	5	1.39	23	6.39	332	92.22
7	Increase of forest products price (*i.e.* fire wood, timber etc.)	7	1.94	19	5.28	334	92.78
8	House hold consumption is high	18	5	13	3.61	329	91.39

Source: (Field Survey, 2016). Where DA = Disagree, U = undecided, A = Agree.

diverse ecosystem services/benefits it provides to local communities, surrounding villages and towns has reduced. One of these effects was a scarcity of firewood and construction materials. As a result of this community was forced to travel long distance to get it. In addition to this, the increased cost of fire wood was challenging the living conditions of, especially low income households. For instance, the price of one bundle firewood before 20 years was 3 to 5 birr but in 2015 its cost was increased to 80 or 90 birr (Interview, 2015). This is in line with the finding of [17] and [18] that pointed out deforestation and its effects on local livelihoods income.

The LULC dynamic significantly modifies the hydrological aspect of the watersheds, affecting water resources and the environment on a local and global scale [19]. This change of the LULC pattern, such as deforestation and subsequent cultivation, could reduce the infiltration rate and percolation of rainwater to recharge streams, springs, and underground water. In line with this majority of the respondents (98.05%) agreed that the destruction of forest resource for various purposes has resulted the declining/decreasing of surface water volume over time. The source from interview and focus group discussion indicated that more than 40 spring and streams rise from this district high lands and join with five basic rivers namely Wabe shebele, Genale, welmel, Dumel and Weib. This water resource from this watershed/high land is serving more than 12,000 million people in downstream. However, information obtained from interviews with focus groups, and elders confirmed that the volume of water from these streams and rivers and their flow patterns have decreased over time.

As indicated in **Table 14** majorities (93.62%) of respondents perceive that deforestation has increased local temperature. The evidence that they gave was the possibility of presently growing a variety of crops and animals rearing at higher elevation which was only limited to few crops and livestock. This meant a decrease in the growing period from six to four months; the cultivation of short-matured crops, mainly in higher, cool altitudes as well as the cultivation of warm temperature crops in cool temperature zones. Similarly, most (91.11%) number of the respondents agreed that rainfall is decreasing over time with the declining of forest cover in the area. In related way from interview and group discussion indicated that the district experienced a high degree of variability and decrease in rainfall amounts.

Local farmers, and particularly elders in the study catchment, underlined the observations of the changes in climate over time. The climate change was verified by a number of physical/ecological and socio-economic indicators. The physical indicators expressed by farmers included: the drying up of the wetland and its conversion to cropland; livestock diseases, probably linked to vector borne diseases; a decrease in the growing period from six to four months; the cultivation of short-matured crops, mainly in higher, cool altitudes; the decrease in stream volume; and the duration and amount of rainfall. The socio-economic factors considered to be climate change indicators include the long distance people need to travel to fetch water and drinking water for animals, as well as the cultivation of warm temperature crops in cool temperature zones.

From data gathered through open ended question it is understood that, the geographical setting of the study area has a diverse ecological condition that has resulted a wide range of altitude and relatively high amount of rainfall. As a result of this diverse ecological condition the area was originally the land of many indigenous tree species such as Hagenia abyssinica, Juniperous Podocarpus, Erica arboreal, and other valuable tree species. However the exploitation of these indigenous forests through settlement and agriculture expansion has greatly affected the ecology and biological diversity of the area. In addition, according to interviewed key informants view various types of wild animals which used to inhabit the locality have now disappeared and other become more vulnerable to such risk due to de-vegetation of the area. Generally, the growing human population created and still is creating pressure on the remaining forests.

According to respondents view the impacts of deforestation are complex and widespread. More critically, it threatens the livelihoods and traditions of rural and forest dwelling people across the district. Many people rely directly on forests, through harvesting forest products and medicinal uses. According to their view forest resource destruction or clearing over time attributed to forest communities to travel further distances to access to forest products that sustain their socio economic wellbeing. According to the opinion of most (93.61%) respondents the destruction of forest resource has attributed to the prevalence of erosion in the district. Most of majority of the perception of the interviewed respondents pointed out that soil erosion was a critical problem (**Figure 8**). As

Figure 8. Sample soil erosion in study area. Source: (Goba Woreda communication office: 2015).

perceived by Local land users, sheet erosion was the most common form of soil erosion in the cultivated lands of the study district. This soil erosion has been a significant contributor to the worsening of soil fertility in their area.

4. Conclusions

The study was carried out in Goba district of south eastern Ethiopia. The aim of the study was designed to quantify the trend and to identify the cause and effect of deforestation in the study area using integrated techniques of GIS and remote sensing. The study showed that there was variation in trends and extent of change in land use and land cover types during the two study periods: 1986 to 2000 and 2000 to 2015. During these analysis periods while forest land and grass land were constantly decreased in contrary Bale temperate vegetation, Agricultural area, Open area and Built-up area were constantly increased. In these three study periods while forest land was decreased about 37%, agricultural land was increased by 19%. The increase of agricultural land in 1986, 2000 and 2015 has been due to population increment. Population increment, road constructions, forest fires, settlement expansion, overgrazing, fuel wood, urbanization and mining were community identified driving forces of land use and land cover change in Goba district. Decrease in local livelihood incomes, decrease surface water volume, increase local temperature and variability of rainfall, high erosion prevalence, high loss of habitat of animals and plants increase of forest products price (*i.e.* fire wood, timber etc.) were the result land use and land cover change, specially natural forest.

To minimize deforestation in the district, the respondents pointed out that all forest frontier forest parts should be communally involved in planning, management and profit sharing. Community participation in forest ownership and management needs to be encouraged with restrictions on extraction and conversion. Moreover, effective implementation, mitigation strategies should involve active stakeholder participation, development of management plans, monitoring and enforcement.

Recommendations

This finding indicated that the forest cover land of Goba district was declined and its effects on local livelihoods and environment were serious. To protect the forest resources from further depletion and to use on a sustainable basis, the following feasible recommendation was made.

- Raising the carrying capacity of the study area through livelihood diversification and agricultural intensification minimizes the pressure on the remaining forest resources of the study area.
- Furthermore, uncontrolled overgrazing was leading to different types of ecological problems such as de-vegetation and soil erosion. So that, an intensive livestock rearing has to be encouraged.
- Most of the house hold in the district depends on fire wood for energy consumption. It was one major cause of natural forest destruction in this area. Therefore, the study area population should be encouraged to use alternative energy sources such as fuel efficient stoves, solar energy, and other alternative sources to increase efficiency and sustainability of forest resources.
- Conserving and increasing forest cover of the study area by planting various types of indigenous vegetation and other plantation of tree species with a workable afforestation and reforestation programs.
- To protect the forest resources from further destruction and address negative impacts of deforestation awareness creation at all levels and specifically among the farmers dwelling along the margin and inside the forest areas should be developed in an organized way.
- Improving and reconsidering the implementation of policies, proclamations, guidelines and regulations and other legal frameworks which are essential in regulating forest resources.
- More research should be carried out using GIS and Remote Sensing on deforestation is recommendable.

Conflicts of Interest

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

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