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Analyzing the Rate of Land Use and Land Cover Change and Determining the Causes of Forest Cover Change in Gog District, Gambella Regional State, Ethiopia

Obang Owar Othow[1*], Sintayehu Legesse Gebre[2] and Dessalegn Obsi Gemeda[2]

[1]*Department of Geography and Environmental Studies, Jimma University, Jimma, Ethiopia*

[2]*Department of Natural Resources Management, Jimma University, Jimma, Ethiopia*

[*]**Corresponding author:** Obang Owar Othow, Department of Geography and Environmental Studies, Jimma University, Jimma, Ethiopia, Tel: +251-(0)47-111-2202; E-mail: sentjim@yahoo.com

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Abstract

This research study examines the causes of forest cover change, the rate of land use land cover change in Gog district, Gambella regional state between the years 1990-2017 using Geospatial techniques. Land sat TM image of 1990, ETM+ of 2002 and OLI-TIRS of 2017 were used to generate land cover map. Field observation, FGDs, KIs and remotely sensed data were used to analyze the causes and rate of land use land cover change. Six land cover classes including bare land, farmland, water, bush land, forest cover and grass land were used for classifications.

An explanatory sequential approach of mixed research design were used in this study where maximum likelihood technique of the supervised classification was used to classify land cover categories using ERDAS Imagine 2014 software. Out of the six classes, the results show a dramatic increase of farm land from (4%) in 2002 to (23%) in 2017 with annual expansion rate (24.86%) per annum, where forest cover declined from (23%) in 2002 to (18.11%) in 2017 with annual decreasing rate (-1.41%) per annum. The accuracy assessment report for 2017 map shows that an overall accuracy (83%) and Cohen kappa coefficient (82%) for the classifications. This massive declined in forest cover change of the study area was resulted due to commercial farm land expansion, forest fire, population growth, illegal logging, charcoal extraction, fuel wood collection and poor management of the natural resource. Out of all, expansions of large scale commercial agriculture become the leading cause for forest cover change in the study area. This dramatic change in forest cover change has further resulted in soil erosion, loss of soil fertility, migration of animals towards neighborhood countries. This has leaded to low agricultural productivity per plot of land, which contributes to low livelihood status of the rural community in Gog district.

Keywords: Geospatial techniques; Forest cover; Land use; Land cover change

Introduction

Forests are important sources of livelihoods to millions of individual and contribute to national economic development of many countries. They are vital for sinks of carbon and contribute to the rate of climate change, soil formation and water regulation and are estimated to provide direct employment to at least 10 million individuals [1]. Apart from being a source of livelihoods to millions more it is also estimated that about 410 million people are highly dependent on forests for subsistence and income, and 1.6 billion people depend on forest for their livelihoods [2,3].

A study by UNEP, FAO and UNFF [4] explained that the world forest has been decreasing from time to time due to increasing human population and it has been occurring worldwide in many centuries. Unfortunately, the deforestation rate (0.5%) has increased extremely in developing countries in the last 50 to 100 of years.

In Africa forests cover about (21.4%) of the land area which corresponds to 674 million hectares where Eastern Africa alone cover approximately (13%) of the land area under the forests and woodlands based up on FAO report [5].

Ethiopia is one of the few countries in Africa where all major types of natural vegetation are represented ranging from thorny bushes to tropical forests and to mountain grasslands. Some sources [6] indicated that about 35-40% of the country's land area was covered with high forests at the turn of the 19 century. In the early 1990's, only about 2.7% of the land mass was covered by closed forests. According to studies carried out by Ref. [1] the distribution of forest cover in Ethiopia is 15114000 ha in the year 1990 with annual decreasing rate (-140900 ha) between the year 1990-2000; 13705000 ha in 2000 with annual decreasing rate (-141000 ha) between 2000-2005; 13000000 ha in 2005 with annual decreasing rate (-704000 ha) between the year 2005-2010 and 12296000 ha (11.21%) in 2010.

Although it has wide range of vegetation covers, soil types and topography in Africa the country is still one of the most seriously affected by deforestation due to its growing population [7]. According to Ref. [7] the annual rate of deforestation in Ethiopia is estimated between 150,000-200,000 ha which are changing from time to time.

Gog is one of the well-known districts for its forest coverage and fertile soil in Gambella regional state and its one of the area where its categories under the six prioritized areas in term of forest cover of the region [8]. The area underwent a serious deforestation which has affected the livelihood of its inhabitants. The major cause of deforestation in the study area is agriculture practice which contributes

to wide spread deterioration of the environment in general and forest in particular.

The second one is the cutting of trees for construction and fuel wood. Moreover the majority of the people rely more on forest resource for construction of houses and other related activities. Gambella regional state has become the target point for national and foreign investment in Ethiopia where many investors have acquire lands for agriculture purpose.

Gog district has wide range of natural resources in Gambella regional state. Despite to the availability of natural resources; the district has largely suffered from managing and conserving available natural resources at hands for instant every year the district has faced major problems of forest fires, deforestation and unsustainable management of agricultural land and activities. This district is under serious threat due to unsustainable use of the natural resources. The forest cover of the area has been deteriorating and endemic animal and tree species are under human impacts. The majority of rural people of the district lived nearby forest where their livelihoods are more depending on the forest for fuel-wood, fodder, and timber and generates income from forest to maintain their daily needs. In addition to this, they sets fire on forest as a mean of clearing forest to execute their temporal demand of agricultural land and as a result, the natural environment as well as ecological balance of the area is under a serious of threat due to the existent disturbance of forest resource by the local community.

Another problem observed so far is the intrusion of investors in Gog district by putting the lands under unsustainable agricultural practices. According to Ref. [9] the numbers of both local and foreign investors in all regional states of Ethiopia are now increasing from time to time with total transfer of lands reaching to 3.5 million hectares from 1990-2008.

Gambella regional state alone have 818 investors holding approximately 1,016,924.67 million hectares of lands for agricultural purpose where the vast majority of investors (806) are domestic accounting for almost 780,272.67 million hectares of land transfer and the remaining 12 foreign investors holds approximately 236,652 million hectares of lands [10].

The Ethiopian Minister of Agriculture and Rural development also asserted that some of the investors are operating wisely in their lands while the other majority of them are leaving their lands barren and uncultivated. This has call attention for the government of Ethiopia to critically examine those investors who are not working well in their lands and as a result 269 local investors were terminated from their lands [9].

The Oakland institute conducted a study on the impact of large scale agricultural investment on local people livelihoods in Gambella regional state and the finding reveals that investors cleared huge amount of forest resource by practicing slash and burn farming system in their fields. In addition to this they also added that most of the investors are involved in producing charcoals in the fields. This is become a series problem in Gambella regional state in general and Gog district in particular. Unless measure is taken to minimize the severity of the problem in the study area the forest coverage will no longer exist in the future [11].

Many studies have been conducted in the field before nine to ten years ago regarding the causes and consequences of deforestation in the study area [9]. What makes this research study unique from previous research studies is that this research study is most concerning with the application of GIS and RS in forest cover change detection from the year 1990-2017 with quantitative integration and examination of the different land use land cover types in Gog district. Therefore, the general objective of this research was to examine the rate, extent and distribution of forest coverage in Gog district, Gambella regional state, Ethiopia using Geospatial techniques.

Description of the Study Area

Gog, which is situated at 7°27'38"-8°18'57"N and 34°14'59"-35°33'49"E is one of the districts in the Gambella regional state. The district shared great boundary with Dimma in the south, Akobo River in the south west, Jor in the west and Abobo in the north [8] (Figure 1).

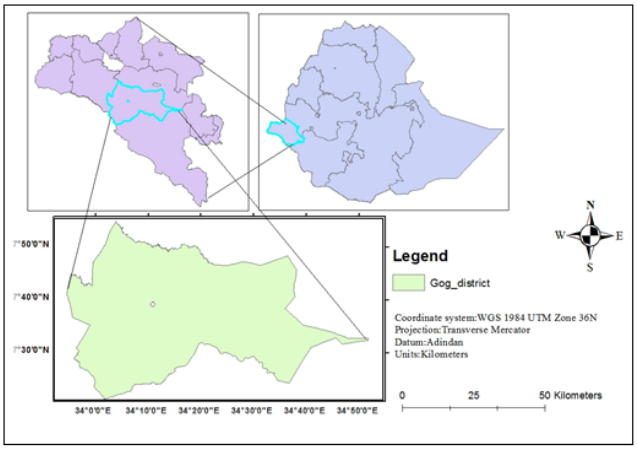

Figure 1: Gog district map.

The area under the study lies in low elevated land with an elevation range between 300-570 meters above sea level and is characterize by flat topography with the highest point Mountain Masango with an elevation of 552 meters. The mean monthly maximum and minimum temperature is 35°C and 19°C respectively and the average annual temperature ranges between 20°C to 30°C. The area is also characterized by unimodal rainfall which falls very heavier during wet seasons (May-Oct) and scanty during the dry seasons (Nov-April) and the annual rainfall ranges between 800-1500 mm to 1900-2100 mm [12]. Gog is one of the known districts in Gambella regional state in terms of fertile land and have four major types of soils. The most dominant soil types in the area are Vertisol, Acrisol, Fluvisol and Nitsol [12]. Agriculture is one of the dominant economic activities practiced in the area. Gog district has great potential for agricultural development of either with the application of irrigation system or using rain fed agriculture. The widespread agricultural activity in the area allowed the farmers to produce exportable agricultural products. The most common farming systems introduced in the study area include mixed farming, slash and burn farming, riverside farming and shifting cultivation. The types of cultivation vary greatly based on the settlement pattern for example those who are living adjacent to riverbank practiced sedentary agriculture with double cropping systems using irrigation where as those who are living apart from the riverbanks are practicing shifting cultivation using rain fed agriculture. Apart from agriculture activity, livestock rearing, fishing, bee keeping,

hunting and poultry are also the most common economic activities carried out in the study area [12].

Materials and Methods

In order to accomplish the specified objectives of this research study both primary and secondary data were used. The primary data was obtained systematically from selected key informants, natural resource management experts and other responsible bodies by using structured interviews and field observation. The secondary data was gathered from related published and unpublished materials.

Land sat TM4 date 09/08/1990, Land sat ETM+ 7 date 06/05/2002 and Land sat 8 date 15/03/2017 at WGS 84 UTM Zone 36 N Path 171 and Row 055 which are cloud free from this website address http://www.earthexplorer.usgs.gov website was obtained for this study.

The satellite images obtained for this study have finer geometric quality as suggested by data provider as well as observed by the investigators.

Ground truth from the field and satellite images were used and analyzed by using ArcGIS version 10.4, and ERDAS imagine 2014 software. ArcGIS was used to reclassify and calculates the pixel values of all LULC classes and complement the display and preparation of maps. ERDAS imagine was utilized for layer stacking of bands 1-7, (where bands 8 and above are omitted from layer stack due to high reflectivity), radiometric calibration particularly atmospheric correction, haze and noise reduction were performed prior to analysis and Google earth was used to check the land use and land covers in the area prior to field observation. The overall processes allowed the investigators to better enhance and improve the images for classification and interpretation and the resulting sampling sizes for point data were 115 points with maximum sample size of 35 samples per class. The sampling size for each class was spatially distributed using a stratified random sampling approach (Table 1).

Spacecraft	Sensor ID	Spatial resolution	Acquisition date	Band	Path/Row
Land sat 4	TM	30 m	08/09/1990	1-7	171/055
Land sat 7	ETM+	30 m	05/6/2002	1-7	171/055
Land sat 8	OLI-TIRS	30 m	03/15/2017	1-7	171/055
Source:	http://www.usgs.gov		04/1/2017		

Table 1: Land sat Images with their Registration date.

Data collection methods

Field observation and GPS point data were conducted within the study area to examine the major types of land use land cover. Such kind of data collection methods are useful for identifying land use land cover categories in the study area and accuracy assessment of the developed land use land cover category.

In addition to that, key informant interviews and FGDs were utilized to collect other ancillary data from the respondents to assists the investigator determining the effects of each land cover class in the study area.

Key informant's interviews

According to Ref. [13] key informant interviews are qualitative in depth interviews which involve the researchers in presenting the issue to the people who have knowledge about what is happening in the community.

The main objective of key informant interview is to collect detail information from specific group of people like community leaders, elderly group and professionals who have firsthand knowledge about the problems in the community. In this study the researcher has conducted key informant's interviews with natural resources experts in the field.

The qualitative data collection from key informants through interviews and FGDs especially with those who are at sites of deforestation and forest degradation are important for understanding the primary causes of deforestation and forest degradation, supplement and validates other source of information and to come up with comprehensive analysis of the issue under investigation.

Focus group discussions

FGD is an instrument of data collection which involves the investigator in gathering group of participants together to discuss a certain issue of study. The role is to introduce the problem for discussion and facilitate the group to engage deeply in discussion in a good manner [14].

The FGDs were performed within the four villages of the study area by involving the elder people who are more knowledgeable in discussions. This has helped us to aware more about the ongoing causes and consequences of deforestation in the study area.

Field works

The definitions of observation are always hard to find in many research writings. According to Gordon and Clayton [15] observation is a complex method of data collection which in its nature involves the investigator to critically observe the phenomena under its primary state using the five sense organs.

This method requires the investigator to actively engage in looking and observing at the condition and status of the phenomena and critical record the characteristics of the phenomena understudying. It has been widely used in various geographical researches [5, 16].

Field works is mainly focused on observing and capturing the various land use land covers by using digital camera and each sampling location was recorded by using GPS 72H and Google earth extension. Thus, the overall number of sampling points was (115) for all land use land cover classes which are adequate and statistically accurate for accuracy assessment as suggested in Ref. [17]. To better determine the quality of the data collected in the field then accuracy assessment has been utilized and finally overall accuracy and kappa coefficient have been calculated with the help of 2017 image.

Research design and methods

In this study explanatory sequential approach of the mixed research design has been used. According to Ref. [18] explanatory sequential approach gives more priority for quantitative data than exploratory sequential approach that gives priority for qualitative data. The purpose of mixed method design is to collect data from different

sources and applied triangulation method to enhance and improve the quality of the data during the analysis and interpretation.

Qualitative data are also carried out by the researchers in order to provide information on the causes and consequences of deforestation in the study area. This approach of mixed method design has been widely used in numbers of writings [19]. GIS and RS technique particularly the maximum likelihood of the supervised classification that has been widely used in several studies has been used to determine the change that has taken place in the study area [7,20,21].

Maximum likelihood algorithm assumes that the statistics for each class in each band is normally distributed and calculate the probability that a given pixel belongs to a specific class where each pixel is categorized to class that has the highest probability (Arc GIS 10.4 Desktop Help).

The technique was selected because it has greater probability to weight minority class that can be swamped by the large class during samples training from images.

The assumption of this technique is that the minority classes in the image have the opportunity to be included in to their respective spectral classes thereby minimizing the problem of uncategorized pixel from entering in to another class during the classification process.

A study by Ref. [22] applied supervised classification technique for determining land use land cover changes of Simiyu forest in Tanzania and suggested that in order to use supervised classification effectively then it's very crucial for the analyst to have a prior set of certain knowledge of the classes in mind and then develop the signatures accordingly.

Accuracy assessment

Accuracy assessment is useful to assess the quality of the data collected in the field and the classified images. With this method it would then be possible to find out the sources of errors. Cohen kappa with in error matric is always used to determine the error encounter during classification of satellite images [17].

Generally, accuracy assessment is very important measurement to determine how accurate the referenced data agreed with classified images of the remotely sensed data.

Error matrix

The matrix is a square table with reference data in the columns and mapped data in the rows. The reference data is obtained from the data collected in the field where it's considered to be correct while mapped data is obtained through classification of remote sensed data. Several measurements can be calculated from error matrix. User; producer and overall accuracy are the most important measurements used in accuracy assessment [23].

Overall accuracy, user and producer accuracy

According to Ref. [23] the overall accuracy can be derived by dividing the total number of correctly classified classes or pixels with total number of reference pixels.

The overall accuracy provides the percentages of how correct the classified pixels are in the error matrix [24].

When dividing the number of correctly classified pixels in each class by the number of training set pixels used for that class (column) then the user accuracy is computed. If the number of correctly classified pixels in every class is divided by the total number of pixels that were classified in that class (row total) then producer accuracy is calculated [23].

Basically, User's accuracy shows the percentage of the correctly classified pixels per land cover classes while the producer accuracy provides the percentage of correctly classified pixels per reference class [24].

Kappa coefficient

Kappa coefficient or statistics can be applied as a measure of how well the remotely sensed classification agrees with reference data [4].

This method provides more accurate measurement when compared with overall accuracy and its values always ranges between +1 and -1 [17]. According to Ref. [25] kappa statistics are the best measurements that have been widely applied in many change detection methods where it reflects the actual agreement of the remotely sensed image with the agreement expected by chance in the reference data.

Thus, kappa coefficient is calculated as follow:

$$K = \frac{N\sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \times x_{+i})} \quad Equation\ (1)$$

Where N is the total number of samples in the matrix, r corresponds to the number of rows in the matrix, x_{ii} is the number in row i and column i, x_{+i} is the total for row i, and x_{i+} is the total for column i [26].

Sample size and sampling technique

There are sixteen (16) villages in Gog district. Out of these the investigator has selected four villages namely Gog Dipach, Jangjor, Atati and Auokoyi by using purposive sampling technique. The areas were selected based on their vicinity and proximity to the forest. The investigators has also provided a structured interview with older farmers, village leaders and agricultural experts in the study area.

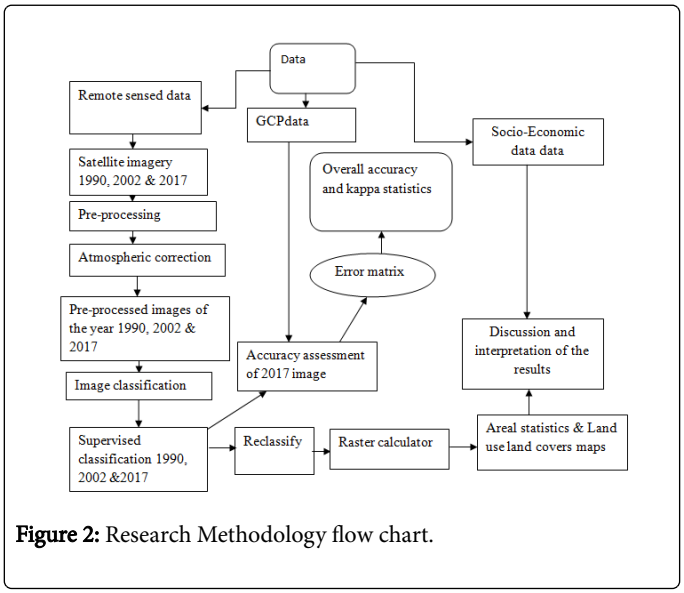

Figure 2: Research Methodology flow chart.

A key informant's interview was employed to collect information from the informants such as village leaders and agricultural experts and FGDs was utilized to obtain data from the farmers.

Overall, a group has 8-12 respondents from each village and conducted a structured interview with them. This number falls within the boundaries of ideal group size suggested for focus group interviews [27].

Four group discussions were carried out with household farmers in the study villages and in the discussion the investigator has carried out problem analysis with household farmers in the four villages to find out the prominent problems in the area and its consequences on forest resource.

Ref. [28] asserted that the group size for FGDs should not be less than eight or more than twelve individuals otherwise the group behaviors could not be easily controlled (Figure 2).

Results and Discussion

Land use land cover classification scheme

Three sets of remotely sensed images namely Landsat TM (1990), ETM+ (2002) and OLI-TIRS (2017) are used in this study to classify land use land cover categories in to difference informational classes. The informational classes categorized from the difference Landsat images include water body, bare land, farm land, bush land, grassland and forest cover classified based on the fundamental elements of image interpretation and sample trainings created during image classifications.

Twenty training samples were gathered from each land sat class of the images and maximum likelihood algorithm of the supervised classification technique was used to generate land use land cover maps in ERDAS Imagine 2014 software and finally the GCP data was used in GIS environment using ArcGIS 10.4 software to assess whether the point data agreed with classified satellite images.

The classification hierarchy used in this study is derived from field observation, document analysis of the district of agricultural office and land use land cover classification of the past study. The description provided in each land use land cover category is derived from FAO 2010 report (Table 2). The classification scheme used to classify land use land cover categories in Gog district, Gambella regional state, Ethiopia.

Class name	Description
Water	An areas of land covered with water (lakes, rivers and sea)
Forest	Land covered with trees reaching 5 m in height, 0.5 ha in area and a canopy cover of >10% without other land use.
Farmland	Areas covered with perennial and annual crops
Bush land	Areas of land covered with scattered grasses, shrubs and trees
Bare land	Areas with no vegetation cover or uncultivated farm lands consisting of exposed soil and rock outcrops
Grassland	Areas dominantly covered with grasses and shrubs

Table 2: Descriptions of Land use Land cover categories [1].

Land use land cover distribution in 1990, 2002 and 2017

The distribution of land use land cover categories in the study area are well examined in the field during March till May and based on this critical examination of the land use land covers, sample of six land cover categories were identified. This includes bare land, farm land, bush land, forest cover, grass land and water body. The land use land cover categories in Figure 3 below shows that bush land is the most predominantly land use land cover category in the study area follow by farm land, forest cover, grass land, bare land and water body.

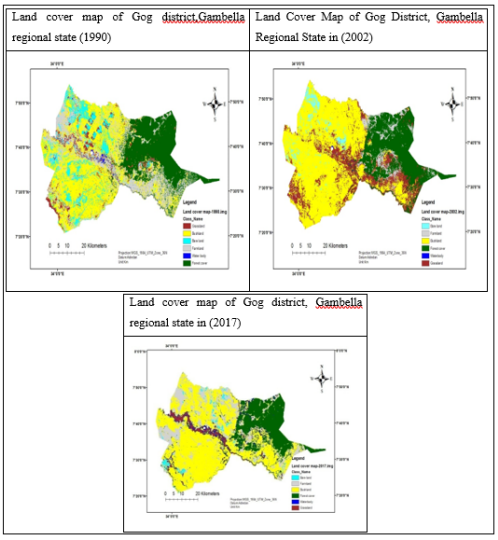

Figure 3: Land cover and land use of Gog district under different time periods. There is a significant change in land use land cover change in the last there decades in Gog district.

Temporal and rate of land use land cover change in Gog district

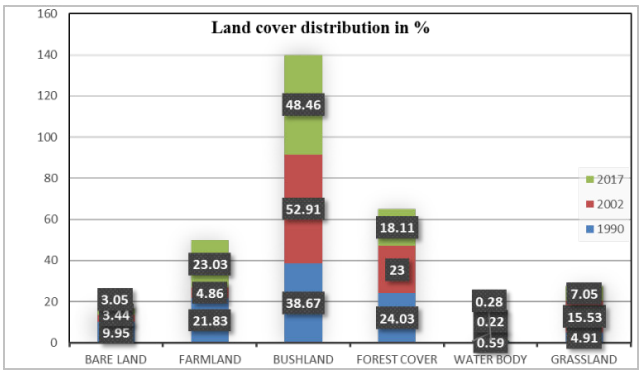

Figure 4: Percentage of land use land cover distribution in Gog district.

Temporal trend of land use and land cover change in the last three decades shows that, there a magnificent change detection has been noticed. In addition to that, the rate of forest change is large compared

to the other land use and land cover in the last three decades (Figure 4).

The distributions of land use land cover categories in the study area are well presented in table (Table 3) of different time periods of the study. The negative values represent the declined in the proportion of land use land cover categories in that particular time where positive values corresponds to the increased in the proportion of land covers class in that particular time of the study. In order to calculate and determine the area cover of each land use land cover in hectare and percentage in the study area the following formulas have been used [29].

$$Area\ in\ Ha = Count \times \frac{900}{10000}$$

$$Area\ in\ \% = \frac{Observed\ pixel\ value}{total\ number\ of\ pixel} \times 100 Equation\ (2)$$

The result from Table 3 shows that Bush land occupies the highest area 124934 ha in 1990 at (38%) of the total area of the study. In 2002 bush land dramatically increased to 170913 ha at (52%) of the study area and then later in time 2017 declined to 156538 ha (48%) of lands.

The rapid declined in bush land during the year 2017 was attributed to the expansion of farm land where many foreign and local investors obtained lands for large scale agriculture in the study area.

This has been witnessed by the respondents during the focused group discussions and key informant interviews that the expansion of farm land in recent time has triggered serious problem over other land use land cover categories in the study area. From Table 3 above, one can infer that bush land is the most predominant LULC category in the study area.

LULC	Area(Ha) (1990)	Area (%)	Area(Ha)(2002)	Area (%)	Area(Ha) (2017)	Area (%)	Annual rate of change (%)	
							1990-2002	2002-2017
Bare land	32150	9.96	11132	3.45	9860	3.05	-0.542/year	-0.026/year
Farmland	70516	21.84	15729	4.86	74399	23.03	-1.415/year	1.211/year
Bush land	124934	38.67	170913	52.91	156538	48.46	1.186/year	-0.296/year
Forest	77624	24.03	74308	23.00	58524	18.11	-0.085/year	-0.326/year
Water	1916	0.59	742	0.22	911	0.28	-0.030/year	0.004/year
Grass land	15869	4.91	50184	15.53	22775	7.05	0.885/year	-0.535/year

Table 3: Spatial distribution and trend of land use and land cover from 1990-2002-2017 in Goga district.

Forest land cover a total area of 77624 ha at (24%) of study area in 1990 and later in 2002 and 2017 it shows a steady declined from 74308 ha (23%) to 58524 ha (18.11%) respectively. The magnitude of this land use land cover category from 1990-2002 is (-3316 ha) with percentage change (-4.27%) and annual decreasing rate (-0.085/year). Similarly the percentage change of this land cover category in the second period (2002-2017) has also shown a similar trends where it decreased to (-15784 ha) at percentage rate (21.25%) with annual decreasing rate (-0.326/year) in the study area. This dramatic declined in forest cover could be best linked, according to data obtained from participants, to the expansion of farm land, forest fire, population growth, illegal logging, charcoal and fuel wood extraction and unsustainable natural resource management practiced in the study area. These wide spread human activities particularly the expansion of farm land (from 4% in 2002 to 23% in 2017) has largely contributed to the decline of forest resource in the study area. The result of this finding is also indicated in the studies conducted by Ref. [30], reported large scale agriculture is the leading cause for forest destruction worldwide. According to data obtained from FGDs and KIs reveals that rapid deforestation in the study area leads to shifting of cropping seasons (50%), soil erosion (20%), loss of soil fertility (18%) and migrations of useful animals (12%) toward other countries like Kenya. This has also been identified by Ref. [21], indicated that deforestation causes soil erosion, rapid runoff, loss of soil fertility, and to widespread deterioration of biodiversity.

Farmland occupy a total area of 70516 ha (21%) in 1990 of total study area where in 2002 decreased to 15729 ha (4%) and later in 2017 increased to 74399 ha (23%) of study area.

The magnitude of farm land destruction was about (-54787 ha) from (1990-2002) at percentage change (-77.70%) with annual decreasing rate (-1.415/year) in the study area. In the second period of the study (2002-2017) the magnitude of farm land increased by (58670 ha) at percentage change (373.00%) with annual increasing rate (1.211/year) in the study area.

Generally farm land use land cover category has alarmingly increased throughout study periods and if the trend and rate of changes continue in this way it will have negative impact on other land cover categories in the study area.

The expansion of farm land has exerted a negative impact on the other land use land cover categories in the study area particularly on the forest resource. Data obtained from the key informants and focus group discussions noticed that rapid increase in the number of the investors (818) become one of the main factor contributing for tremendous expansion in farm land in the study area.

Large scale agricultural investment was introduced in the region within short period of time (2010) as mean to reduce or improve the livelihoods of the indigenous people through the provision of public goods and services to those who are living in the area and to bring about sustainable economic development for the country. This seems quite difference when we come to ground level where agriculture take place and these have foster a great challenges on the livelihoods of the people who rely most on natural resources of the study area.

About (96%) of the respondents reported large scale agriculture is the leading cause for forest cover change in particular and land use

land cover change in general, and (4%) of them reported that small scale agriculture to be main cause of deforestation in the study area. This was also confirmed during the field work that wide spread agriculture activity was the dominant activity escalating the rate of deforestation in the study area.

Bare land cover a total area of 32150 ha (9.96%) of the total study area in 1990 and later on it decreased to 11132 ha (3.45%) in 2002 to 9860 ha (3.05%) in 2017. The magnitude of this land cover category was about (-21018 ha) at percentage change (-65.38%) with annual decreasing rate (-0.544/year) in the first period (1990-2002) and later on in the second period (2002-2017) it is magnitude of change reached (-1272 ha) at percentage change (-65.38%) with annual decreasing rate (-0.026/year) of the study area.

The proportion of bare land has shown a sign of decreasing in the study period due to several factors of which the conversion of other land use land covers in to bare land category become the prominent reasons for its decline.

Water body occupies the lowest area during the study period where in 1990 it cover a total area of 1916 ha (0.59%), in 2002 it covers a total area 742 ha (0.22%) from the total study area and in 2017 it covers 911 ha (0.28%). The magnitude of water body change from the first period (1990-2002) is (-1174 ha) at percentage change (-61.27%) with annual decreasing rate (-0.030/year) in the study area where the magnitude of changes in the second period (2002-2017) is (169 ha) at percentage change (22.78%) with annual increasing rate (0.004/year) in the study area. The greater decrease in water body in the study period is due to conversion of this land cover category in to other land use land cover categories.

Grass land covers a total area of 15869 ha (4.91%) in 1990, 50184 ha (15.53%) in 2002 and 22775 ha (7.05%) in 2017. The magnitude of grass land expansion in the first period (1990-2002) of the study is (34315 ha) at percentage changes (216.3%) with annual increasing rate (0.885/year) of the study area and later in time(2002-2017) it has decreased to (-27409 ha) at percentage changes (54.61%) with annual decreasing rate (-0.535/year) of the study area. Grass land category has shown a tremendous declined due to several reasons of which wide spread fire occurrence become the dominant factor in the study area and in addition to this hunting, slash and burn farming, charcoal and bee collections were also recognized as the main factor threatening grass land distribution in the study area. According to data gathered from Key informants interviews shows that farmers uses fires to manage and establish agricultural activities where uncontrolled use of fire for forest conversion in to agricultural activities and other activities continues to causes severe loss on other land use land cover categories.

A study by Ref. [31], shows that fire affects the functioning of the environment in several ways of either by influencing nutrient cycles, disturbing the ecological function of the ecosystems, wild life and plant species. Generally, the destruction of this LULC category leads to the disappearance of animal fodder and consequently to ever decreasing number of livestock's in the study area.

Spatial pattern and dynamic of land use land cover change from 1990-2002 and 2002-2017

The pattern of land use land cover change is one of the dynamic phenomena that need to be assessed and endorsed in every aspect of planning activities. The proper management of the natural resource coupled with endorsement in policy making allowed all the experts in the area to better sustain and conserve natural resources for next generation. Figures 5 and 6 below show the spatial pattern of land use land cover changes between the year (1990-2002 and 2002-2017).

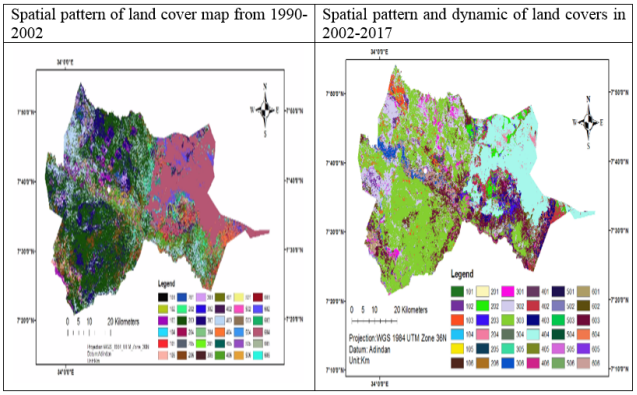

Figure 5: Spatial pattern and dynamic of land covers 1990-2002 and 2002-2017.

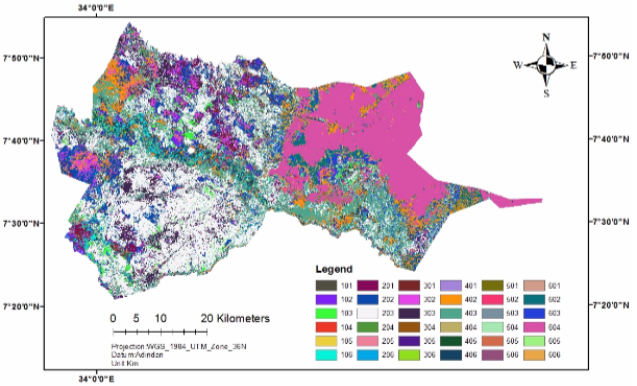

Figure 6: Spatial pattern and dynamic of land covers 1990-2017.

Figure 5 above demonstrates the land cover changes observed from the year 1990-2002 to the year 2002-2017 and the extent to which the drivers of deforestation influence the extent and distribution of forest cover of study area. The following formula is used to determine the proportion of land use land cover changes through time series analysis of Landsat images [29].

Area statistics=(Reclassified image at time1 × 100+Reclassified image at time2) Equation (3)

In Figure 5 the value 101 represents bare land, 202 represents farm land, 303 represents bush land, 404 represents forest cover, 505 represents water body and 606 represents grass land. For instant the bare land (101) in the year 1990 is still bare land in the year 2002 and the same thing is for other land cover category too. On other hand the bare land (102) in the year 1990 is converted in to farmland in the year 2002.

Bare land	Area(Ha)	Area (%)	Observed change 1990- 2002	Bare land	Area (Ha)	Area (%)	Observed change 2002-2017
101	793		Bare land to	101	667		Bare land to
102	919	6.10	Farm land	102	4224	40.35	Farm land
103	8445	56	Bush land	103	5903	56.40	Bush land
104	667	4.42	Forest	104	0.01	0.00001	Forest
105	20	0.13	Water	105	4	0.03	Water
106	5026	33.33	Grass land	106	335	3.20	Grass land

Table 4: Spatial pattern and dynamic of bare land from 1990-2017.

Table 4 shows that the area coverage of bare land in 1990-2002 was highly converted in to the bush land (8445 ha) of land and 2002-2017 with (5903 ha) followed by conversion in to grass land (5026 ha) during the year 1990-2002 and in to farm land (4224 ha) in the year 2002-2017. This could be inferred that bare land was highly converted in to bush land during the study period.

Farm land	Area (Ha)	Area (%)	Observed change 1990- 2002	Farm land	Area (Ha)	Area (%)	Observed change 2002-2017
201	3584	2.93	Bare land	201	225	2.68	Bare land
202	2885		Farm land to	202	7361		Farm land to
203	97970	80.27	Bush land	203	4922	58.81	Bush land
204	2841	2.32	Forest	204	1996	23.85	Forest
205	8	0.006	Water	205	51	0.60	Water body
206	17645	14.45	Grass land	206	1174	14.02	Grass land

Table 5: Spatial pattern and dynamic of farm land from 1990-2017.

The result from Table 5 reveals that farm land is most widely converted in to bush land (80% and 58%) between the year 1990-2002 and 2002-2017 follow by the conversion in to forest land (1996 ha) in the second period 2002-2017. This was caused by extensive human activities particularly shifting cultivation practiced in the study area where cultivators abandon the fields for certain times and later through prolong period of times natural re grown with trees and grasses.

Bush land	Area(Ha)	Area (%)	Observed change 1990- 2002	Bush land	Area (Ha)	Area (%)	Observed change 2002-2017
301	4363	68.44	Bare land	301	6449	11.62	Bare land
302	179	2.13	Farm land	302	42830	77.20	Farm land
303	25774		Bush land to	303	115432		Bush land to
304	35	0.41	Forest	304	63	0.11	Forest
305	1	0.01	Water	305	24	0.05	Water
306	1797	21.45	Grass land	306	6114	11.02	Grass land

Table 6: Spatial pattern and dynamic of bush land from 1990-2017.

This land use land cover category for the time period 1990-2002 is converted in to bare land (4363 ha) and later in 2002-2017 is converted in to farm land (42830 ha) of the total land. This could be due to expansion of agricultural land that caused wide spread lost in the bush land area (Table 6). The widespread expansion of agricultural activities in the study area have resulted in the greater loss of bush land category that was aggravated by the increasing number of investors placed in the bush land and near forest cover.

Forest cover	Area (Ha)	Area (%)	Observed change 1990- 2002	Forest cover	Area (Ha)	Area (%)	Observed change 2002-2017
401	2346	3.65	Bare land	401	311	1.67	Bare land
402	6223	9.70	farm land	402	7515	40.43	farm land
403	35598	55.50	Bush land	403	4918	26.46	Bush land
404	6369		Forest to	404	55723		Forest to
405	17	0.02	Water	405	50	0.26	Water
406	19962	31.11	Grass land	406	5792	31.16	Grass land

Table 7: Spatial pattern and dynamic of forest cover from 1990-2017.

The forest cover in the study area is most converted in to bush land (35598 ha) during 1990-2002 and in to farmland (7515 ha) during the second period (2002-2017) (Table 7).

The majority of the respondents described that the forest cover destruction in the first period (1990-2002) is mainly due to the expansion of illegal logging by the immigrants from Southern Sudan, large scale resettlement program established during Derge regime (1975-76 and 1984) where 150,000 households resettled in the study area while in the second period (2002-2017) it was attributed to expansion of large scale agriculture as witnessed by key informants during the field work. Another study conducted by Ref. [32] also found similar result which stated that large scale agriculture was the leading cause for the reduction of forest cover in the world particularly in medium and low income countries. This is also matched with study carried out by Ref. [30], identified large scale agriculture to be the greatest factor that threatens forest cover.

Generally, the recent development activity particularly agricultural investment in the study area has exerted strong pressure up on the forest resource and other land use land cover categories during the study period.

Water	Area (Ha)	Area (%)	Observed change 1990- 2002	Water	Area (Ha)	Area (%)	Observed change 2002-2017
501	31	2.53	Bare land	501	2	1.42	Bare land
502	141	11.51	Farm land	502	2	1.42	Farm land
503	332	27.10	Bush land	503	30	21.42	Bush land
504	156	12.73	Forest	504	7	5	Forest
505	690		Water to	505	602		Water to
506	565	46.12	Grass land	506	99	70	Grass land

Table 8: Spatial pattern and dynamic of water body from 1990-2017.

Grass land	Area (Ha)	Area (%)	Observed change 1990- 2002	Grass land	Area (Ha)	Area (%)	Observed change 2002-2017
601	15	0.10	Bare land	601	2206	5.40	Bare land
602	5383	36.80	Farm land	602	12468	30.46	Farm land
603	2793	19.10	Bush land	603	25334	61.90	Bush land
604	64239	43.90	Forest	604	735	1.8	Forest
605	5	0.06	Water	605	180	0.44	Water
606	5189		Grass land to	606	9261		Grass land to

Table 9: Spatial pattern and dynamic of grass land from 1990-2017 in Gog district.

This land use land cover category was changed in to grass land with (562 ha) and (99 ha) in 1990-2002 and 2002-2017 respectively. The conversion of this land use land cover category in to grass land is mainly due to greater expansion of grass land towards water reservoir (Table 8).

This land use land cover category was converted in to forest land (64239 ha) of land during the first period 1990-2002 and later in 2002-2017 was converted in to bush land (25334 ha) of land (Table 9).

LULC	Bare land	Farm	Bush	Forest	Water	Grass	Total	User (%)
Bare land	**13**	0	2	0	1	0	16	81
Farm	1	**26**	0	1	0	1	29	89
Bush	0	3	**21**	1	0	0	25	84
Forest	0	0	1	**21**	0	0	22	95
Water	0	0	0	1	**8**	1	10	80
Grass	1	1	1	2	1	**7**	13	53
Total	15	30	25	26	10	9	**115**	
Producer (%)	86	86	84	80	80	77		

Table 10: Error matrix for 2017 classification map. Overall accuracy: 0.83 Kappa coefficient: 0.82.

Table 10 highlights the accuracy assessment of the classified map (2017) where the percentage of overall accuracy and kappa statistic of the classification are (83%) and (82%) respectively. The colored diagonal number in the matrix indicated correctly classified pixel in each land use category where off diagonal depicts poor classification of either referenced data and classified image in each land use category. Apart from total accuracy and kappa coefficient, user accuracy and producer accuracy is calculated for each land cover category in the matrix.

Bare land has an overall accuracy (13) reference data where 2 referenced data for bush land and 1 reference value for water are erroneous included in to bare land category under user accuracy and 2 reference values were erroneous omitted from bare land.

Farm land has a total accuracy (26) where 1 value of bush land, 1 value of forest cover and 1 value of grass land are erroneous included in farm land category of the user accuracy and 4 reference data under producer accuracy are excluded from farm land category.

Bush land has a total accuracy (21) pixel values of which 3 farm land and 2 forest cover pixels are erroneous included in to this category of the user accuracy where 4 referenced data are erroneous excluded from the bush land categories.

Forest cover has an overall accuracy (21) referenced data where 1 referenced data is erroneous included in forest cover and 5 referenced data under producer accuracy are excluded from forest category.

Water has a total accuracy (8) reference data where 1 value of forest cover and 1 value of grass land are erroneous included in water body category and 2 pixel values are omitted from this category. Grass land has a total accuracy (7) pixels where 1 bare land, 1 farm land,1 bush land, 2 forest cover and 1 water pixel values of the user accuracy are erroneous included in water body category and 2 pixel values are excluded from grass land category.

Generally, the result of the accuracy assessment of the classified map (2017) shows that there is a strong agreement of reference data with classified map.

As indicated in Ref. [33], split the values of Kappa statistics in to three broad ranges where a value greater than (0.80) corresponds to strong agreement; a value that range between (0.40-0.80) corresponds moderate agreement and a value below (0.40) represents poor agreement. According to these ranges, the classification of land sat image (2017) in this research study had strong agreement with ground truth data collected in the field.

Local Views on the causes of deforestation in the study area

Four focused group discussions were conducted in the study area with older farmers (47) who have firsthand information on the forest cover. All the respondents participated in the FGDs acquire their daily needs from primary economic activities like agriculture and forest and most of them can be categorized under low income group.

They all rely on cultivation of crops (maize) for their livelihoods and the most common farming systems employed in their fields are shifting cultivation and slash burn farming using traditional methods of farming.

Gog is one of the well-known district in Gambella regional state for its forest cover and fertile soil. The area was covered by dense forests before some 15 to 20 years ago but now the spatial distribution of forest cover has decreases from to time to time mainly because of agriculture and forest fire. And because of these various reasons the forest cover of the study area has become sparse and degraded.

According to data collected in the field with respondents in all selected villages the most common causes for land use land cover changes in general and forest cover changes in particular were the expansion of farm land (small and large scales agriculture), forest fire, illegal logging, migration and population growth, fuel wood collection and charcoal production.

Farmland expansion is one of the major widespread factors contributing for dramatic changes in land use land cover in the study area. Human being has begun to cultivate crops for millennia without bringing any change in the production and productivity. The major driving factor for the expansion of farmland according to the perception of the interviewed respondents (97%) is agricultural activities practiced in the study area. This problem was brought by the unsustainable agricultural practices whereby small and large scale

farmers introduced shifting cultivation, slash and burn farming. Farmers in the area have begun to move in the past from one field to another new field looking for fertile land to clear. Shifting of farmlands from times to times has caused to greater extent loses of forest cover in the area.

About (85%) of respondents reported that the inability of the farmers to clear grasses in the field is one the most threaten factor that cause them to abandon their old farms from time to time and the other (15%) respondents mentioned that poor soil fertility was the case for shifting their land from time to time.

They have also described that clearing grasses in the farm is time consuming than cutting trees and this has opened the way for the farmers to practiced slash and burn farming which in the long run leads to an ongoing deforestation in the study area.

The most recent phenomena causing widespread forest cover destruction in the area is unpredictable agricultural investment that began shortly in 2010. This has been reported by respondents and key informants as being the prominent problem that put strong pressure on the remaining forests and environment. According to my personal observation in the field most of the farmlands were located near to forests where it allowed the owner of the farm to gain access to nearby forests. This issue is also in agreement with the study conducted by Ref. [34], described the land leased to investors are placed near to national parks, protected areas and forests.

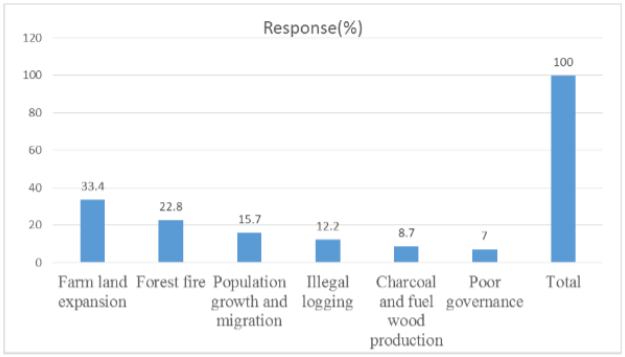

Figure 7: Respondent response to causes of forest cover change in Gog district.

Forest fire which is often referred as the chronic issue in the study area is one of the second major deteriorating factors of forest cover changes that cause widespread loss of both animal and plant species. This chronic issue is always occurring every year in the study area where people intentional sets fire on forest or burn the field during the time of cultivations (Figure 7).

Farmers are confused about the negative consequences of fire on land and forest resources where about (97%) of respondents perceived fire is importance to remove low growing underbrush, kill pests and insects that would have destroy crops.

Evidence from Ref. [35], suggests that there is a trend of expanding area burned beginning in the early eighties and continuing to expand in the nineties.

A wild fire statistics for national forest in the western United States also indicates an increase in area burned from the mid-1980s onward compared to the earlier part of the 20 century.

This consistent increase in the incident of forest fire shows unidirectional tendency where some areas suffered more than others due to increasing land use intensity.

Africa is often referred as the "fire continent" due to regular and widespread incident of fire derived by the anthropogenic forces. A report from Ivory Coast shows that more 60000 ha of forest and 108000 ha of coffee and cocoa plantations were destructed by wild fire [35].

Forest fire in Ethiopia is dated back to early 1984 where huge amount of high forest (209913 ha), bush lands (41785 ha), bamboo forest (2600 ha), wood land (20584 ha) were burned causing great loss in the country. Human being is the main driver of forest fire accounting for 100% of the total forest fire of which arson contribute to 20% and carelessness account for 80% of forest fire [36].

Migration and population grow are another factor driving land use land cover changes in the area. Historically human kind has begun to move from one place to another place due to several reasons of which economic, environmental, political and social factors are the immediate drivers that forced people to relocate to different parts of the world.

The resettlement program established during the previous and current regimes and refugee settlement are also the driving phenomena to deforestation which have brought about adverse effects on land use and land cover changes in the study area [37]. Ethiopia is one of the few African countries hosting huge amount of refugees and asylum seekers in the world. It has started to receive refugees from different neighboring countries like South Sudan, Eritrea and many other countries and displaced them in to different regional states like in Gambella, Somali, Tigray and Benishangul Gumuz regional states.

Gambella alone become the leading regional state in the country in terms of number refugees received where in the current period has received more than 60000 refugees in 2015 during the war that broke out in South Sudan in 2013.

The total number of refugees living in Gambella regional state has now increased from 236371 in 2013 to 296371 in 2016 [38].

This massive increase in the number of refugees has put strong pressure on land use and land cover categories in the study area. This is also confirmed during key informant's interview that the rapid influx of refugees in the study is the third leading causes for the degradation of the environment. Demographic factors such as population growth, density and migration are the major drivers of forest cover change in the study area. An evidence from many third world countries also revealed that population growth, density and distribution in combination with other social economic forces contributes to rapid deforestation [1].

Illegal logging is another prominent problem threatening the forest cover of the study area where inhabitants cut off huge amount of trees and timbers for sale in Pugnido town. Rapid increase of human population demanding huge amount of timbers for construction purpose in the town have also triggered series illegal logging. This has been triggered by the general increase in price of the timber in the town. Although the government has put strong rules and regulations

on preventing illegal logging people have been still involved in cutting trees in the study area.

Another cause for decline of forest resource in the study area is the frequent collection and production of fuel wood and charcoal as being sources of energy.

About (97%) of the respondents rely on collecting fuel wood and charcoal from the nearby forests and this has become so series especially during dry seasons when the price of charcoal and fuel wood reached to the peak.

The biggest problem with charcoal production is the mishandled of fire by the people where they carelessness use fire to obtain charcoal from the forest. This is true in the study area where people are more relying on the extraction of fuel wood and production of charcoals. About (97%) of the respondents depends on the collection of fuel wood as source of energy in the study area.

Lack of knowledge about the benefits of forest and forest management is another determinant challenge for the decline of forest resource in the study area. The people in the study area lack awareness about how to manage forest resource. They thoughts the forest resource is only belongs to government where they can be responsible for its management and controlling rather than by the community.

Lack of community involvement in the management of forest resource has also triggered the deterioration forest resource in the study area. Environmental law enforcement is also absent in Gog district due to lack of political will, low level of human and technical assistance, poor information systems and ineffective regulations and law with regard to natural resource management. The overall issues lead to widespread deforestation in the study area.

Conclusion and Discussion

In this is study, geospatial techniques has been used in analyzing forest cover change in Gog district using three sets of land sat images. Land use land cover change detection under different time periods have been studied.

This study has demonstrated the application of Geospatial techniques in analyzing forest cover change in Gog district by using three sets of land sat images. With the application of the various components of GIS, it has become possible to generate the quantitative data on land cover classes and land use land cover changes at different time periods where farm land and forest cover shows negative relationship in the study area.

The extent and distribution of forest resource in the study area decreased from (23%) in 2002 to (18%) in 2017 with annual destruction rate (-1.45/year). In total, between the year 1990-2017 the district lost (-0.91%) of forest per year where farm land increased from (4.86%) in 2002 to (23%) in 2017 with annual expansion rate (24.88%) in the study area. In total between the years 1990-2017 farm land expanded by annual rate (0.20%) per year. Generally the rapid expansion of farm land leads to further decrease in forest cover which in turn leads to widespread soil erosion and loss of biodiversity in the study area.

The rapid rate of deforestation is mainly occurring due to several reasons of which unsustainable large and small scale agriculture, forest fire, migration and population growth, illegal logging for construction purpose, charcoal and fuel wood production for cooking. The result of this research is similar to studies conducted by Ref. [30,32,39,40]. Overall the rapid decline in forest cover can be best explained by the interplay of the various human activities undertaken in study area of which the threatening factor for the forest cover decline is recognized as large scale agricultural investment.

Analysis of the socioeconomic data and field observation also revealed that large scale commercial agricultural has forcefully asserted environmental pressure on environment and forest covers, creating undesirable condition to the livelihoods of the community living in Gog district. The result of this finding is in line with study carried out by Ref. [41], showed that agriculture and resettlement program to be the leading causes of deforestation in South Western Ethiopia.

Similarly, a study conducted by Ref. [12] on the major causes of land use land cover changes in Abobo District, Gambella regional state and the result shows that resettlement program is the leading cause for land use land cover changes in the study area.

Finally, the finding of this research study shows that agriculture is the leading driver of deforestation in the study area. Similar condition was also outlined in Ref. [1] document that large scale agriculture is the leading cause for widespread deforestation in Africa which is mainly due to the conversion of forest land in to agriculture.

This research uses only the low resolution satellite images so future research studies must give more emphasis on the integrating of geospatial technologies with high spatial, spectral and temporal resolutions to enhance the visual interpretation of the land cover categories and apply new generation satellite images.

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