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GIS AND REMOTE SENSING BASED FOREST COVER CHANGE DETECTION AND ITS IMPACTS ON THE INCOME OF THE RURAL COMMUNITIES: THE CASE OF GESHA DISTRICT, KEFFA ZONE, SNNPRS, AND ETHIOPIA

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ABSTRACT*: Deforestation is a complex phenomenon that has serious environmental, economic and social impacts on the income of the community. As such, it is important to investigate and understand the causes, which play major roles in forest cover change and its impacts on the income of the communities. The objectives of this study to detect the extent, rate and pattern of LU/LC change in general and forest cover change detection in particular over the last 30 years of Gesha district. Three dates of Landsat image data of the 1988, 2002 and 2018 were used to produce land cover map in general and forest cover map in particular. Normalized difference vegetation index (NDVI), image differencing and post-classification comparison change detection methods were employed. In addition to this, socioeconomic data were used in explaining the drivers of forest cover changes in the study area. The results showed that during the last 30 years, forest cover declined from 96913ha in 1988 to 83209.2ha in 2002 and 69019.8 ha in the year 2018. The annual rate of forest cover change between 1988 and 2002 was 929ha/year. The socioeconomic factors like population growth, the demand for the expansion of agricultural land, fuel wood and construction materials were the major driving forces for the observed forest cover changes. Therefore, in order to reduce the problem of forest cover change, remedial actions are recommended.*

KEYWORDS: land use/land cover, forest cover change, landsat image, accuracy assessment, Gesha district

INTRODUCTION

Forests are important for sustenance of life on Earth. Forests offer numerous goods and services that comprise of fuelwood, timber, food and fodder. They are vital for the conservation of ecosystem, maintenance of water quality, prevention and reduction of natural hazards such as floods, erosion, landslides, avalanches, and drought and hence in regulating the climate on the regional level. A wide range of socioeconomic benefits are also provided by the forests. These include forest products, employment and areas that hold cultural value (FAO, 2005).Natural resources such as forests and wildlife were abundant on the earth but much concern was not given about its wise use. As human population continues growing rapidly, resources are becoming scares. Obviously, these resources are changed or exhausted unless wisely used. In order to mitigate the scarcity or complete loss, mankind has started to become concerned about conserving natural resources, of which one is forest resource (NTFP, 2008).

Globally six million hectare forest lands are changed due to logging, agricultural, mining and other human activities (Verburg, P.H et. al., 2006). According to the United Nations Framework Convention on Climate Change (UNFCCC), the main cause of deforestation was agriculture. 32% of deforestation is due to commercial agriculture; 48% of deforestation is due to existed farming; 14% logging is responsible for deforestation and 5% of wood collection is responsible of deforestation (Billing ton, C., et.al., 1996).

The presence of forest in Ethiopia is relevant at several levels. Apart from its intrinsic value for many indigenous and other forest-dependent people, forests are their livelihoods. Forests provide them with edible and medicinal plants, bush meat, fruits, honey, shelter, firewood and many other goods. Whether it is private or public property, forest is the nationally and globally mutual treasure. The value of forest resources to the world's human population is becoming increasingly evident (Tadesse, et. al., 2011).

One way of assessing changes in land use is based on the measurement of changes in vegetal and non-vegetal cover (Bochco, 2001). Technological progress allows a comprehensive understanding of any region of the earth's surface from satellite images (Chuvieco et al, 2002). These images of the Earth have been widely used for change detection, specifically to the mapping and monitoring deforestation. This has favored international efforts to establish permanent programs (Violini, S. (2013).

Gesha district, despite its economical and biological importance both nationally and globally, the area is now under serious threat due to unsustainable use of the natural resources. The forest cover of the area has been deteriorating time to time and endemic tree species are under anthropogenic impacts. This situation poses a great challenge on the function of the ecosystem and the livelihoods of the people who depend up on it for their existence. The majority of rural people of the woreda live in forest or near the forest boundary. Their livelihood depends on the forest for fuel-wood, fodder, beekeeping and timber and generates income from forest to maintain their daily needs. The general objective of this study is to examine the extent, rate and pattern of LU/LC change in general and forest cover change detection in particular of Gesha district. The Specific objectives including identifying LULC classes and their spatial distribution , to identify the main cause of forest cover change ,to investigate the impact of forest cover change on the income of the communities and to detect the rate and temporal extent of forest cover change by using GIS and remote sensing for the years 1988, 2002 and 2018.

METHODS

The study was conducted in Gesha District, Keffa zone, SNNPRS of Ethiopia. Geographically, the study area lies within 7° 30′ 00" to 8° 10′ 00" E longitude and 35°30′ 00" to 36°00′ 00"N latitude at a distance of 538km km Northwest of Addis Ababa the capital of Ethiopia and 126km from the capital of the zone, Bonga.The altitude of the district ranges from 1500-3000 m.a.s.l. (Fig.1).

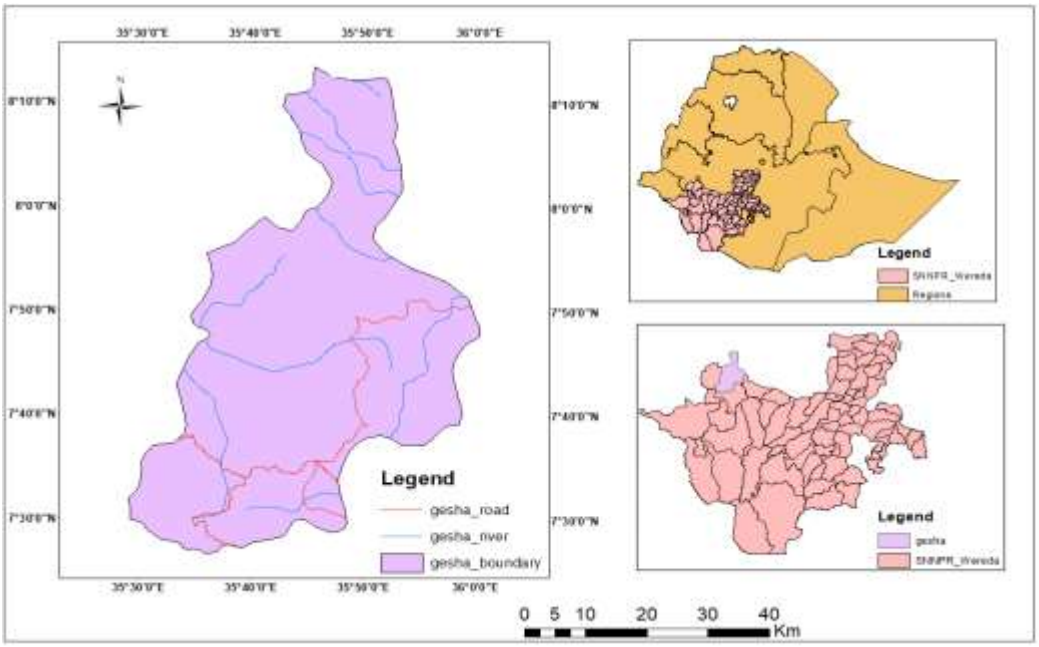


Figure 1. Location of the study area

To achieve the intended objectives, Both primary and secondary data have been used in this research. Primary data used in the study were: Landsat 5 TM data image acquisition date of 02/01/1988 with seven bands , Landsat ETM+ data image acquisition date of 01/26/2002 having eight bands, Landsat 8 Operational Land Imager (OLI) data image acquisition date of 06/26/20018 and SRTM (Shuttle Radar Topographic Mission) DEM data 90m resolution. In order to assess the causes that brought about forest cover change; questionnaires, FGD and interviews have been designed. The survey instruments used for collecting data were structured and semi-structured questionnaires. The research findings from the primary data have been supplemented by secondary data sources such as published and unpublished materials. Garmin GPS was used for collecting of ground control points for image classification. Field observation sheet was prepared for storing all land use /land cover information types. Totally 100 ground truth points were collected. Images (land sat 5 TM 1988, ETM+ 2002 and land sat 8 OLI 2018) were projected to similar projection and datum, UTM projection and WGS datum.

Geometric correction, radiometric correction, resolution merge, removal of stripes, Sub setting of Study area images and layer stacking were performed. By doing this accordingly, the spatial resolution of all images become 30 m by 30m. Furthermore, resolution merges was also conducted to increase the spatial resolution of multi-spectral images. supervised image classification techniques were applied. The supervised image classification training areas were established based on the ground truth taken during field work. Among different algorithms in the supervised classification maximum likelihood was utilized. Having applied the techniques of image classification methods, land use / land cover types were identified in order to detect land use land cover change in genera and forest cover changing in particular. With the help of visual interpretation and the different reflectance characteristics of the features in the satellite images of 1988, 2002 and 2018 five Land use/Land cover classes, namely; Dense forest, Grazing land, Farm

land, Settlement area, Light vegetation, have been identified with the support of ERDAS Imagine Software.

All the existing images were classified in to five Land use/Land cover types. To detect the changes of forest cover over time, NDVI and Post-classification Change Detection comparison methods were applied. NDVI is calculated using the following equation: NDVI = (NIR - RED) / (NIR + RED).

Where, NIR and RED is the reflectance in the near infra-red and red bands, respectively. NDVI is a nonlinear function that ranges between -1 and +1. Healthy vegetation has high positive NDVI values because of their relatively high reflectance in NIR and low in visible wavelength. Having conducting NDVI analysis of the year 1988,2002 and 2018, the mean and standard deviations values are summarized to evaluate the trends of vegetation cover change. Change detection involves the use of multi-temporal data sets to differentiate areas of land cover change between dates of imaging. This kind of change detection method identifies where and how much change has occurred. In the meantime, four conditions of forest cover change detection characteristics such as, detecting the changes that have occurred, identifying the nature of the change, measuring the areal extent of the change, and assessing the spatial pattern of the change are explored. Besides, change detection matrix has been produced to explore the trends and patterns of land use/land cover change in general and forest cover change in particular. For the current study, the rate of forest cover change was also calculated using the formula below:-

r =a –b/t .....Equation 2

Where, r = Rate of forest covers change

a = Recent year forest covers in ha

b = Initial year forest covers in ha

t = Number of years between a and b

To validate and crosscheck the result of the Landsat image classification with known ground truth data, accuracy assessment was done for the year 1988,2002 and 2018 using ERDAS 2015 software. Accuracy assessment evaluation includes an error matrix which is a report of the overall proportion of correctly classified pixels. Finally, Kappa Statistics was calculated for the different areas that were classified.

RESULTS AND DISCUSSIONS

Land Use and Land Cover Results

The land use/land cover units of the study area were classified in to classes of Dense forest, Grazing land, Farm land, Settlement and Light vegetation. The statistics of land use /land cover change in general and forest cover change in particular were computed and summarized to detect the nature of the changes based on the years 1988, 2002 and 2018. The dominant land use, dense forest and light vegetation takes 96913ha and 93102ha of the total area in the first study period(1988) , farm land land covers 25644.3ha, grasse land covers 25480.85ha, and settlement covers 6759.85ha. The land cover classes for 2018 takes the highest share for Light vegetation and dense forest covering 85841.5ha and 69019.8ha respectively followed by farm land 56898.5ha, settlement 56898.5ha,grass land 10153.5ha, of land from the total area of the Gesha district.

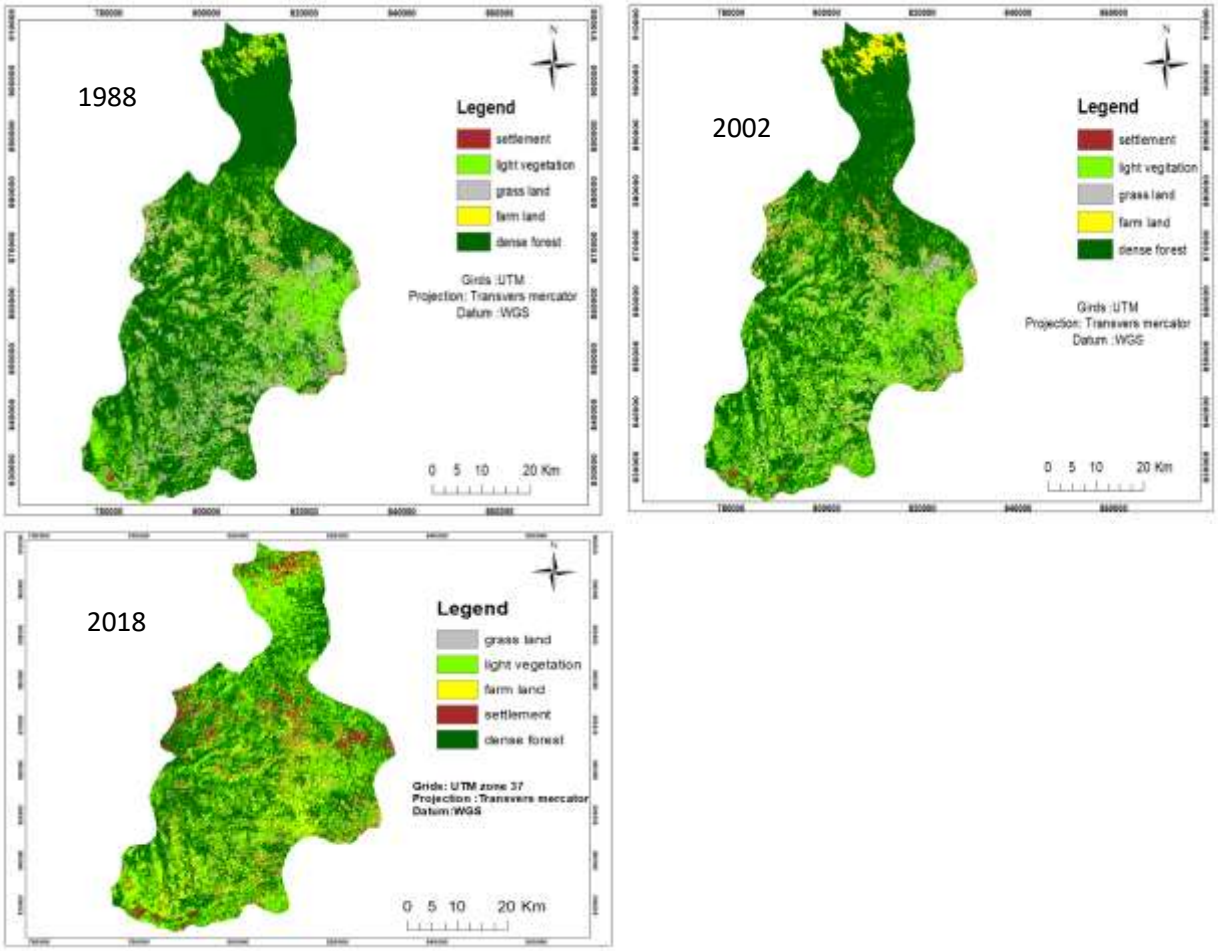


Figure 2. Land use/Land Cover map for 1988, 2002 and 2018

Change Detection

The land use/land cover change scenario was developed for the change detection analysis to understand and quantify the trend of the land use land cover change in general and forest cover change in particular for each three periods of the studies. In addition, the forest cover change in the form of maps and statistics has been assembled to examine the specific nature and extent of the forest cover changes between the stated dates of imageries in the study area. The rate of land use/ land cover is presented in (table 1).

The area covered by farmland and settlement has shown a maximum rate of increment in the three consecutive study periods. Farmland covered 10.34 %) in 1988 has increased to 16.25% in the 2002 and increased to 23% in 2018. The settlement category result showed there was a change in coverage of settlement expanding from 1988 to 2018. Statistically, the area used for settlement in 1988 was 2.7% and has increased by 5.1% in 2002. In 2018, the area covered by settlement reached 10.4 %. The temporal forest degradation is observed between 1988 and 2018 .The area under dense forest declined from 39.1% in 1988 to 33.56% in 2002 and finally remained at 27.8% in 2018. The light vegetation covered 37.56% in 1988 and getting declined to 36.5% in 2002 then to 34.7% in

2018. Similarly for grazing land in which it shows continuous decline from 1988 to 2018. The grazing land decreased from 10.3% in 1988 to 8.6% in 2002 then to 4.1% in 2018. To clearly understand the major land cover change source and destination of cover classes change conversion matrix is analyzed. Change matrix has been produced on the basis of between 1988 and 2018, satellite images classification presented in (Tables 2). The Confusion Matrix table show that the areal distribution of land cover/ land use classes that have undergone transformation from one type to another or being lost their areal extents or remained intact. For instance, the farmland has expanded at the expense of light vegetation (12331.65ha), dense forest (14731.65ha) and grazing land (6434ha) classes. Whereas the bolded diagonal values stand for the unchanged land use / land cover that maintained its original land cover / land use unit in (Table 2).

Table 1. Rate of land covers change

LULC class	Rate land use /land cover change					
	1988-2002		2002-2018		1988-2018	
	Hectare	rate of change(ha/ye)	Hectare	rate of change(ha/ye)	Hectare	rate of change(ha/ye)
Farm Land	+14641	+488.03	+12613.2	+420.4	+31254.2	+1041.8
Grass land	-4174.87	-139.16	-11152.48	-371.75	-15327.35	-510.9
Dense forest	-13703.8	-456.79	-14189.4	-472.98	-27893.2	-929.78
Light vegetation	-2699	-89.9	-4561.5	152.05	-7260.5	-242.02
Settlement	+5936.67	+197.9	+13290.18	+443.06	+19226.85	+640.9

Table 2. Matrix of land cover/land use changes between 1988 and 2018

Year	2018						
1988	Lu /lc class	Farm land	Grass land	Settlement	Dense forest	Light vegetation	Total
	Farm land	**23400**	518	1004	354	368.3	25644.3
	Grass land	6434	**8346**	5699.55	2182.3	2819	25480.85
	Settlement	1.2	0.00	**6700**	9.85	48	6759.85
	Dense forest	14731.65	90.95	6534	**65472**	10084.4	96913
	Light vegetation	12331.65	1198.55	6049.15	1001.65	**72521.7**	93102

From 1988 to 2018 within 30 years. 23400, 8346, 6700, 65472 and 72521.7 that classified as farmland land, grazing land, settlement, dense forest and Light vegetation respectively remained

unchanged. On the other hand, the conversion of land takes place from one types of land use in to other land use types. For instance, farmland to grazing land was (518ha), grazing to agricultural land (6434ha) and Light vegetation to agricultural land (12331.65) (Table 2).

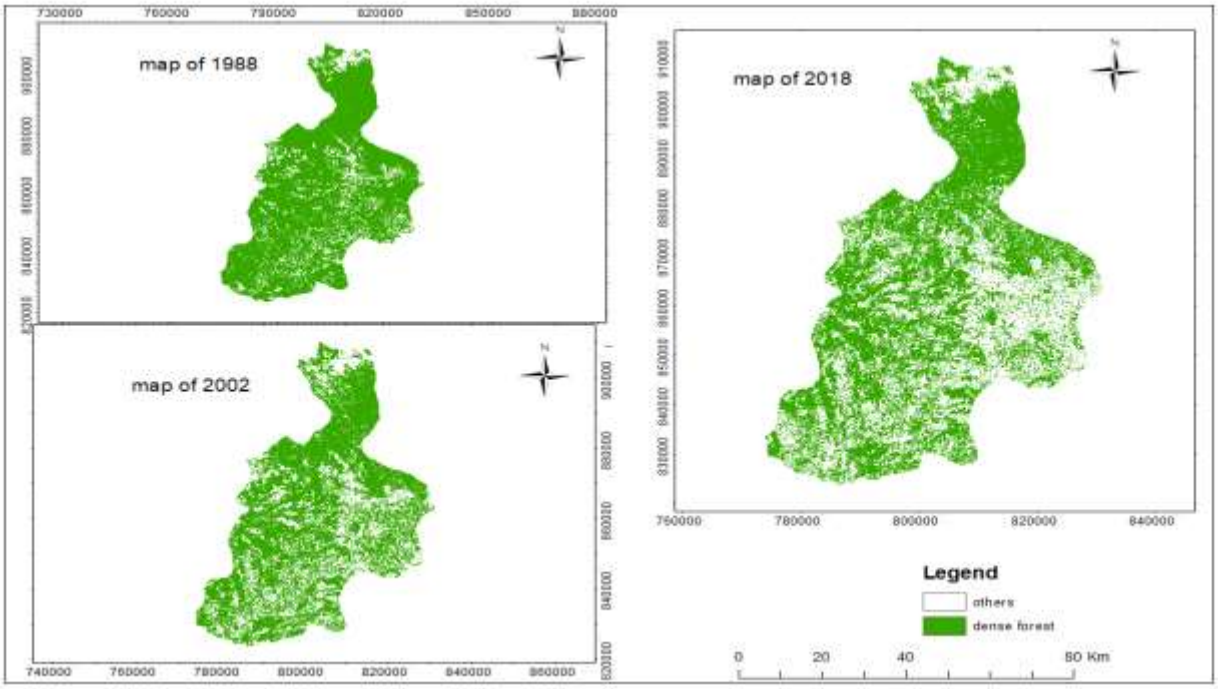
Table 3. Trends and Rates of Forest cover change

Forest cover in hectare for three years			Rate of Change					
			Area change	(ha) (ha/yr)	Area change	(ha) (ha/yr)	Area change	(ha) (ha/yr)
1988	2002	2018	1988-2002	1988-2002	2002-2018	2002-2018	1988-2018	1988-2018
96913	83209.2	69019.8	-13703.8	-978.8	-14189.4	-886.8	-27893.2	-929.8

Areal Extent and Rate of Forest Cover Change

Three Land sat satellite images of 1988, 2002 and 2018 were used to monitor the areal extent and rate of forest cover change within time series. Throughout the analysis stage, digital image interpretation of forest cover area for each year was performed and total area of the forest cover in hectare and its percentage from each date of satellite interpretations were calculated and summarized. Forest cover map and total forest cover of 1988, 2002 and 2018 is presented in Table 3. From this result (table, 3) about 96913 ha (39.1%) of the study area was covered with forest resources in the year 1988. Meanwhile, the forest cover land of the district was accounted for 83209.2 ha (33.56%) and 69019.8 ha (27.8%) in the year 2002 and 2018 respectively. From 1988 up to 2002 only 5.54% from total forest area were deforested whereas from year (2002-2018) about 6% of total forest area were deforested and currently only 27.8% of dense forests were remaining. The rate of forest cover change from year 1988 to 2002 is -978.8ha per year (83209.2 -96913 /14 years) and from year 2002 to 2018, it was -886.8 ha annually (69019.8-83209.2ha/ 16years). Besides, considering the annual rate of forest cover change between1988 and 2018, the computed result is -929.8ha per year (69019.8-96913/30).

Figure 3. Forest cover map of 1988, 2002 and 2018



3.4. Patterns of Forest Cover Change

The result shows the areal share of forest cover lands and also gives information about the amount of forest cover land that was converted into other land cover and land use units of the three periods. The pattern of forest cover change into other land use/ land cover units between in the year 1988 and 2018 is presented in Table 4.

27893.2ha of forest cover land are changed into other land cover and land use units between1988 and 2018.

Specifically, 47% of the forest cover is changed into farmland followed by forest cover transformed in to light vegetation (32%). The remaining 20.7% and 0.3percentage of the forest cover land is converted into settlement and grazing land respectively.

Table 4 .Forest Cover Change

Forest Cover Change	B/N 1988 & 2018	
	Area(in ha)	Percentage
Forest to farm land	14731.65	47
Forest to settlement	6534	20.7
Forest to light vegetation	10084.4	32
Forest to grass land	90.95	0.3
Total change	31506	100

The Socio-Economic Results

Forest cover change is the direct reflection of the dynamics of socio-economic development. Forest is important in many ways. People depend on the forest resources, mainly for their economic, environmental and enjoyment purposes. For instance, wood from forest trees provides lumber, to

make furniture and various hand tools, serve as the chief source of fuel for cooking and heating, for construction purposes (Birhan, 2007). Forest resource is one of the income source of the communities of the study area to ensure availability of energy resources needed for their daily lives. In land use/land cover change analysis however, it was observed that natural forest is declining at the expense of agricultural land. Out of the total sampled 98% of the respondents reported that there was a decline of forest cover compared the current forest status with forest status before 1988. Rural households are totally dependent on biomass for energy. Regarding this, the Ethiopian Forestry Action Program (1994) estimated that in 1990/91 Ethiopia was used about 15 million tons of energy, of which 95% was wood, dung, crop residue and charcoal. For instance, as indicated in the current survey 98% of the sample households in the study area derived their energy source from fuel wood the rest from cow dung and crop residues.

Deforestation in the study area is happening as a result of expansion of agricultural activities, wood consumption for fuel, construction and other uses. This section helps to understand respondents' observed about the impacts of forest destruction on their locality. All the respondents were asked the impact of the destruction of forest resource on their locality. Accordingly, the majority of the respondents (37%) agreed with decline in agricultural productivity as the main impacts of forest land cover change, (32.4 %)of respondents said climate change, (13.9%) of respondents said reduction of household income, (9.3%)of the respondents said soil erosion, only small percent (7.4 %) associate extinctions of biodiversity(table 5).

Regarding the solutions for deforestation, about 50% of the respondents suggested strong law as a solution to control forest depletion. Providing environmental education as a solution was also indicated by 27% of the respondent. Those who said looking for another source of income was only 13%. The rest 10 percent pointed out planting trees pointed out as a solution.

Table 5. Impact of forest Cover Change on the income of the community

Impacts of forest cover change	Frequency	Percent
Decline in agricultural productivity	40	37
Climate change	35	32.4
Soil erosion	10	9.3
Extinctions of biodiversity	8	7.4
Reduction of household income	15	13.9
Total	108	100

CONCLUSION

From the examined results, the extent of land use and land cover in general and forest cover change in particular was radically changed between 1988 and 2018. Particularly, expansion of agricultural land and decline of both forest cover as well as shrub land were observed. In the district, forest resources decreased by 13703.8ha, 14189.4ha and 27893.2ha between 1988and 2002, 2002 and 2018, and 1988 and 2018 respectively. An increasing demand for agricultural land was the cause

for the change of forest resources in the district. Totally, 14731.65ha of the forest resources were converted into farmland land between 1988 and 2018.

In addition, the areal coverage of forest is reduced from time to time. From the total area of the district about 96913 ha of land was covered with forest in 1988. However, this figure is declined to 69019.8ha in the year 2018.The socio-economic data analysis; anthropogenic factors were identified as major causes for forest cover change in Gesha district. To the alarming rate of population growth resulted in expansion of agricultural land, demand for fire wood, Charcoal production and for hose construction. This conditions leads to further depletion of forest resources in the area. Consequently, the forest cover reduced which highly contributed to land degradation in the district. Hence, to preserve the forest resources from further destruction and to use the forest resources in a sustainable manner, effective and strong natural resource management and utilization policy have to be implemented by district's forest and natural resource conservation office with the participation of local community and the regional government to insure the sustainability of proper utilization and use of natural resources.

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Nomenclature

Authors declared that they have no competing interest acronyms

ARDO: Agriculture and Rural Development Office
AOI: Area of Interest
CSA: Central Statistical Authority
DEM: Digital Elevation Model
NIR: Near Infra-Red
NTFP: Non-timber forest product
NDVI: Normalized difference vegetation index