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Forest cover change detection using remote sensing and GIS in Banja district, Amhara region, Ethiopia

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Abstract: Forest cover change analysis between 1973 and 2003 was conducted in Banja district, Awi zone, Amhara region using remote sensing and geographic information system supported with field verifications. Information was extracted from various Satellite images and different digital maps. The objectives of this study were to detect the extent and rate of forest cover change over the last 30 years. Three dates of Landsat image data of the 1973, 1986 and 2003 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 6044ha in 1973 to 2855.9ha in 1986 and 2446.9ha in the year 2003. The annual rate of forest cover change between 1973 and 2003 was 120ha/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: Forest Covers Change, Remote Sensing, Geographic Information System, Satellite Image Analysis

1. Introduction

Forest cover changes is a dynamic, widespread and accelerating process, mainly driven by natural phenomena and anthropogenic activities, which in turn drives changes that would impact natural ecosystem. Understanding forest patterns, changes and interactions between human activities and natural phenomenon are essential for proper forest management and decision improvement. Today, data from satellites are very applicable and useful for forest cover change detection studies. Detecting forest conditions as well as monitoring the changes of various forest structural and biophysical variables can enable accurate understanding of forest ecosystem services. Monitoring of forest cover change is one of the main applications of remote sensing based change detection.

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Remote sensing based change detection applies comparison of a set of temporal images covering time period of interest using specific change detection algorithms. To address this issue, technology has developed and the possibilities are virtually unlimited in different areas of applications, which can be addressed through earth observation satellite data and decisions support tools such as Geographic Information System [1].

The problematic nature of forest degradation in connection with spatio-temporal change of forest cover change needs a profound and ongoing research to act accordingly. In this respect, the depletion of forest cover has become a major ecological problem Ethiopia. Regarding this, EFAP [2] stated that by the early 1950s forest cover of the country was reduced to 16% of the total area, early 1980s by 3.6% and about 2.7%

in 1989. The rate of deforestation is estimated at 150,000ha per year. This indicated that rapid deforestation and accelerated land degradation have led to deterioration of the country's environment.

In relation to the available information of forest cover in the country, EFAP [2] documented that there is no adequate information on the location, extent of the remaining forest cover of the country and the rate at which this resource is depleted. However, there were some works done to offer information on forest cover of the country. Due to massive exploitation, the forest resource of the country has confined itself to small remnants on the highlands particularly, almost all located at unreachable areas [3]. In the study area the Kathasa Priority State Forest is one of the few remnant forests which are found in Banja district. Furthermore, like in many other parts of the country, the problem of forest cover change is a very serious environmental problem in the study area and extensive areas of forest cover including shrub lands have been deforested. However, the rate and areal extent of the forest cover change is not well studied till date. Thus, for a sustainable forest resource management, it is necessary to estimate forest cover change on large spatial and temporal scales. The General Objectives of this research was to detect the magnitude of forest cover change. The Specific objectives include identifying forest cover and its spatial distribution, to analyze the spatio-temporal change, to create forest cover map of the study area for the years 1973, 1986 and 2003 and to assess the cause of forest cover change.

2. Methods

The study was conducted in Banja District, *Awi Administrative zone*, *Amhara National Regional State*, Ethiopia. Geographically, the study area lies within $10^0$52'to 11^0 3'N latitude and $36^0$38'to $37^0$8'E longitude at a distance of 440 km Northwest of Addis Ababa and 120km South of Bahir Dar, the capital of Ethiopia and Amhara regional state respectively. The altitude of the study area ranges from 1800 to 2953m.a.s.l. Most of the eastern parts of the district are 2425m.a.s.l (Fig.1).

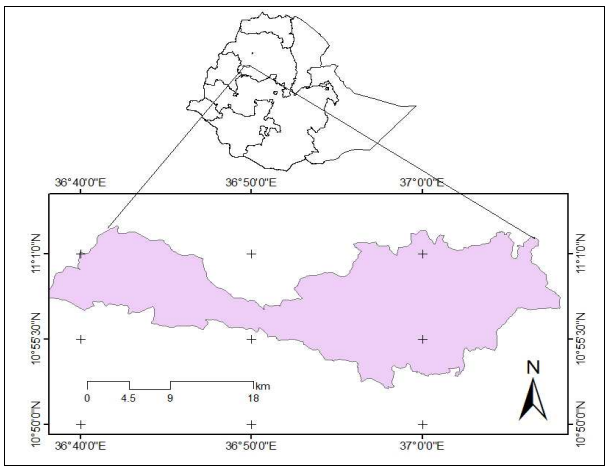

Figure 1. *Location of the study area*

Both primary and secondary data have been used in this research. The use of each data has been found to be relevant and important in the research process. Primary data used in the study were: Landsat MSS data image acquisition date of 02/01/1973 with four bands, Landsat TM data image acquisition date of 01/03/1986 with seven bands, Landsat ETM^+ data image acquisition date of 01/26/2003 having eight bands and SRTM (Shuttle Radar Topographic Mission) DEM data 90m resolution. In order to assess the causes that brought about forest cover change; questionnaires have been designed and distributed. 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 the collection of ground control points for image classification. Field observation sheet was prepared for storing all land use /land cover information types. Totally 121 ground truth points were collected. Images (MSS 1973, TM 1986 and ETM+ 2003) were projected to similar projection and datum, UTM projection and Adindan datum.

Radiometric correction, Histogram equalization haze and noise reduction were performed. The three images have different spatial resolution. Spatial resampling was performed using ENVI 4.2 software. By doing this Accordingly, the spatial resolution of all images become 28.5m by 28.5m. Furthermore, resolution merges was also conducted to increase the spatial resolution of multi-spectral images. Both unsupervised and supervised image classification techniques were applied. Unsupervised classification was done before field work. For 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 forest cover change. With the help of visual interpretation and the different reflectance characteristics of the features in the satellite images of 1973, 1986 and 2003 eight Land use/Land cover classes, namely; Forest, Shrub land, Grazing land, Agricultural land, Settlement area, Bare land, Water body and Marsh have been identified with the support of ERDAS Imagine Software. Each land use/land cover description was stated as follows:-

- Forest: It represents both natural and fragmented plantation forest areas that are stoked with trees capable of producing timber or other wood products.
- Shrub land: Areas covered with small trees, bushes and shrubs, mainly with less crown cover.
- Settlement: are those areas composed of intensive use with much of the land by rural villages, towns and roads.
- Agricultural land: are lands covered with agricultural activities.
- Grazing land: All areas covered with mainly natural pasture, but also other small sized plant species.
- Bare land: Areas under degraded grasslands and with some areas that are bare ground (rocks).

- Marshy: Lands that are seasonally under water.
- Water body: lands completely covered with water.

All the existing images were classified in to eight 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 1986 and 2003, 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:-

$$r = a - b/t \quad \text{.....Equation 2}$$

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 2003 using ENVI4.2 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.

The Kappa coefficient result values are between 0 and 1, where the latter shows complete agreement, and is often multiplied by 100 to give a percentage measure of classification accuracy. Kappa values are also grouped into three groups: a value of kappa coefficient greater than 0.80(80%) represents strong agreement, a value of kappa coefficient between 0.40 and 0.80 (40 to 80%) represents moderate agreement, and a value of kappa coefficient below 0.40(40%) represents poor agreement [4].

3. Results and Discussions

3.1. Land Use and Land Cover Results

The land use/land cover units of the study area were classified in to classes of forest, Shrub land, Grazing land, Agricultural land, Settlement, Bare land, Marsh and Water body. 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 1973, 1986 and 2003.

The dominant land use, grazing land and agricultural, takes 33,848.2ha of the total area, forest covers 6044ha, shrub land, which mainly contains small trees, bushes and shrubs, covers 4910.9ha, settlement covers 751.4, bare land covers 305.3ha, marshy and water body covers 97.2 and 29.3, respectively. Agricultural land take the highest share in the 1986 land use/land cover class covers 21,631.6ha, followed by grazing land which accounts 12,308.1. Shrub land which mainly contains small trees covers 7,989.5 ha, forest 2,855.9 ha, settlement 891.9ha, bare land 214ha and marshy 53.9ha and water body 40.9ha takes the minimum area coverage (Fig.2).The land cover classes for 2003 takes the highest share for agricultural and grazing land covering 28,545.6 and 10,157.8 respectively followed by forest 2446.9ha, shrub land 1937.9ha,settlement 1552.5ha, bare land 951.9ha, marshy346.1 and water body 47ha of land cover from the total area of the Banja district.

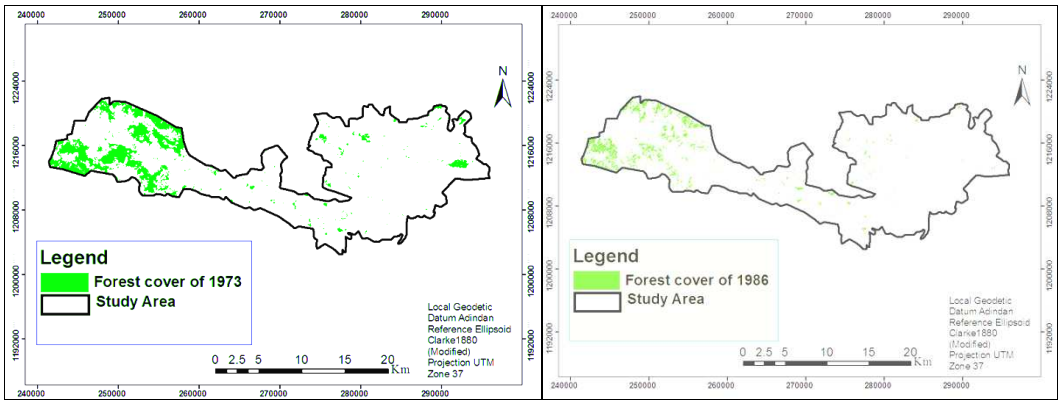

Figure 2. *Land use/Land Cover map for 1973(left), 1986(right) and 2003 (Below)*

3.2. Change Detection

Change detection method was employed to categorize forest cover changes between 1973, 1986 and 2003. 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 is presented in Table 1.

Based on the 1973 land use / land cover classes, about 48% was accounted for grazing land where as agricultural land shared 25% and forest shared 13% and shrub land takes 11% of the total area of the Banja district. The smallest share went to settlement, bare land, marshy and water body. In1986, agricultural land showed an increase in areal coverage due to the need to secure more agricultural lands. However, grazing land which was likely to be changed in to other land use / land cover unit showed change in decline. Apparently, shrub land and settlement coverage have got increment in areal coverage. Regarding 2003 land use / land cover unit, the size of three classes, namely; grazing land, forest and shrub land became reduced in areal coverage as compared to the 1973 and 1986 land cover / land use classes. But the agricultural land has been on the pace of increment, accounting for 65% of the total area.

To clearly understand the major land cover change source and destination of cover classes change conversion matrix for each period is analyzed. Change matrix has been produced on the basis of 1973, 1986 and 2003 satellite images classification and presented in Tables 2, Table 3 and Table 4.The three Confusion Matrix table show that the areal distribution of each land cover/ land use classes that have undergone transformation from one type to another or being lost their areal extents or remained intact.

The amount of land in hectare changed into other land use type obtained from other land use type. For instance, 11,176ha of grazing land, 2553.3ha of shrub land and 1503ha of forest of 1973 were converted to agricultural land. Whereas the bolded diagonal values stand for the unchanged land use / land cover that maintained its original land cover / land use unit (Table 2).

Table 1. *Rate of land covers change*

Land use Land cover categories	**1973-1986**		**1986-2003**		**1973-2003**	
	Area (ha)	**Rate of change(ha/yr)**	**Area (ha)**	**Rate of change(ha/y)**	**Area (ha)**	**Rate of Change (ha/yr)**
Agricultural land	10349.3	796.1	6914	406.7	17263.3	575.4
Grazing land	-10257.8	-789.1	-2150.3	-126.5	-12408.1	-413.6
Forest	-3188.1	-245.2	-409	-24	-3597.1	-120
Shrub land	3078.6	236.8	-6051.6	-356	-2973	-99.1
Settlement	140.5	10.8	660.6	38.9	801.1	26.7
Bare land	-91.3	-7	737.9	43.4	646.6	21.6
Marshy	-43.3	-3.3	292.2	17.2	248.9	8.3
Water body	24.4	1.9	6.1	0.4	17.7	0.6

Table 2. *Matrix of Land Cover/Land Use Changes Between1973 and1986*

	Land Cover/Land Use Units of 1986							
	Classes	**Agricultural land**	**Grazing Land**	**Forest**	**Shrub land**	**Bare land**	**Settlement**	**Marshy**	**Water body**
Land Cover/Land Use Units of 1973	Agricultural land	5841	2865.4	396.8	1916.5	53.8	187.8	14.6	5.5
	Grazing land	11176	7499.6	409.5	2785	119	563.1	12.1	1.5
	Forest	1503	680	1760	1983.1	6.8	59.7	9.7	7.2
	Shrub land	2553.1	915.7	502.6	1085	22.2	64	14.4	3.9
	Bare land	137.8	83.3	13	63.8	2.8	3.3	1.2	0
	Settlement	349.9	225.7	22.2	132.9	9.3	11.1	0.2	0
	Marshy	34.6	37.7	1.7	15.8	0.2	2.8	1.3	3.2
	Water body	2.1	0	0	7.5	0	0	0.3	19.4

Table 3. *Matrix of Land Cover/Land Use Changes Between 1986 and 2003*

	Land Cover/Land Use Units of 1986							
	Classes	**Agricultural land**	**Grazing Land**	**Forest**	**Shrub land**	**Bare land**	**Settlement**	**Marshy**	**Water body**
Land Cover/Land Use Units of 1973	Agricultural land	15252.8	4584.9	227.8	583.8	446.7	353.5	182.2	0.1
	Grazing land	6349.4	4359.6	37.7	96.3	349	1029.4	86.7	0
	Forest	887.8	82.2	1478.4	384.4	3.7	15.2	4.1	0
	Shrub land	5535	704	700.6	846.4	74.5	66.2	60.2	2.5
	Bare land	123.2	34	0.4	2.2	36.5	17	0.6	0
	Settlement	378.8	389	1.5	7.7	41.6	71	1.8	0
	Marshy	18	3.9	0.3	16	0	0.2	10.5	4.6
	Water body	0	0	0	1.6	0	0	0	39.8

The type and amount of conversion in the land use land cover from 1986 to 2003 within 17 years. Land with areas of 15252.8ha, 4359.6ha, 1478.4ha, 846.4ha, 36.5ha, 71, 10.5ha and 39.8ha classified as agricultural land, grazing land, forest, shrub land, bare land, settlement, marshy and water body respectively remain 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, agricultural land to grazing land (4584.9ha), grazing to agricultural land (6349.4ha) and shrub land to agricultural land (5535ha) (Table 3).

From 1973 to 2003 within 30 years. 7633.3, 5939.71726, 266.6, 13.1, 34.5, 0.2 and 20.1 that classified as agricultural land, grazing land, forest, shrub land, bare land, settlement, marshy and water body 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, agricultural land to grazing land was (2396.9), grazing to agricultural land (14363.7) and shrub land to agricultural land (3275.6) (Table 4).

Table 4. *Matrix of Land Cover/Land Use Changes Between1973 and 2003*

	Land Cover/Land Use Units of 2003							
Land Cover/ Land Use Units of1973	**Classes**	**Agricultural land**	**Grazing Land**	**Forest**	**Shrub land**	**Bare land**	**Settlement**	**Marshy**	**Water body**
	Agricultural land	7633.3	2396.9	254.2	301.4	233	351.5	104.2	6.5
	Grazing land	14363.7	5939.7	233.2	433.8	558.6	907.7	125	4.1
	Forest	2501.5	712.7	1726	887.3	33	126.2	50	7.6
	Shrub land	3275.6	884.8	217.3	266.6	83.7	116.2	61.6	5.1
	Bare land	207.5	53.8	4.4	9.3	13.1	15.1	2.2	0
	Settlement	508.5	143	9.3	23.3	29.9	34.5	2.9	0.1
	Marshy	52.4	27	2.4	9.9	0.6	1.2	0.2	3.5
	Water body	2.8	0	0.2	6.3	0	0	0	20.1

Table 5. *Trends and Rates of Forest cover change*

Forest cover in hectare for three years			**Rate of Change**					
			Area change (ha)	**(ha/yr)**	**Change (ha)**	**(ha/yr)**	**Area change (ha)**	**ha/yr**
1973	1986	2003	1973-1986	1973-1986	1986-2003	1986-2003	1973-2003	1973-2003
6044.4	2855.9	2446.9	-3188.1	-245.2	-409	-24	-3597.1	-120

3.3. Areal Extent and Rate of Forest Cover Change

Three Land sat satellite images of 1973, 1986 and 2003 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 1973, 1986 and 2003 is presented in Table 5.

From this result, about 6044 ha of the area were covered with forest resource in the year 1973. Meanwhile, the forest cover land of the area accounted for 2855.9ha and 2446.9ha in the year 1986 and 2003 respectively.

In the year 1973, 13% of the area was covered with forest resources while from the total area of the area about 6 % was covered with forest resources in 1986. Meanwhile, forest resources of the area were turned down in to 5% in the year 2003 from the total area.

The rate of forest cover change from year 1973 to 1986 is -245.2 ha per year (6044.4ha –2855.9ha/13 years) and from year 1986 to 2003, it was -24 ha annually (2855.9-2446.9ha/ 17years).

Besides, considering the annual rate of forest cover change between1973 and 2003, the computed result is -120ha per year (6044.4-2446.9/30). The rate of forest cover change from 1973 to 1986, 1986 to 2003 and 1973 to 2003 is presented in Table 6.

Table 6. *Total Forest Cover of 1973, 1986 and 2003*

Year	**Forest Cover unit from the total area (in ha)**	**Forest Cover In %**
1973	6044.4	13
1986	2855.9	6
2003	2446.9	5

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 1973 and 1986, 1986 and 2003 and 1973 and 2003 is presented in Table 7. 4249.5ha of forest cover land are changed into other land cover and land use units between1973 and 1986. Specifically, 48% of the forest cover is changed into Shrub land followed by forest cover transformed in to agricultural land (35%). The remaining 16%and1% of the forest cover land is converted into grazing land and settlement respectively. From the 1986 and 2003, 1,377.4ha of forest cover land are changed in to other land cover units. The conversion of forest land to agricultural land takes the lion share, about 65%. The remaining 28%, 6% and 1% of the forest is transformed into other land cover/use units of shrub land, grazing land and bare land respectively.

Table 7. *Patterns of Forest Cover Change in to Other Land Cover/ Use Units*

Forest Cover Change	B/N 1973 & 1986		B/N 1986 & 2003		B/N 1973 & 2003	
	Area(in ha)	Percentage	Area(in ha)	Percentage	Area(in ha)	Percentage
Forest to Agricultural land	1503	35	887.8	65	2501.5	57
Forest to Grazing land	680	16	82.2	6	712.7	17
Forest to Shrub land	1983.1	48	384.4	28	887.3	21
Forest to Bare land	6.8	0	3.7	0	33	1
Forest to Settlement	59.7	1	15.2	1	126.2	3
Forest to Marshy	9.7	0	4.1	0	50	1
Forest to Water body	7.2	0	0	0	7.6	0
Total change	4249.5	100	1377.4	100	4318.3	100

3.5. The Socio-Economic Results

Forest cover change is the direct reflection of the dynamics of socio-economic development. Concerning this, Badege (2001) states that forest cover change has occurred starting from an early time a small level of expansion of agriculture by deforestation of the land that covered by the natural forest. Similarly, numerous factors inspired by the action of human being are accountable for the huge changes of the forest cover land into other land cover and land use units in the study area.

In the case of forest cover change in study area is a miniature case of the general deforestation that occurs throughout Ethiopia. Out of the total sampled 99% of the respondents reported that there was a decline of forest cover compared the current forest status with forest status before 1973. The remaining was preferred the increment in the status of the forest.

Table 3 indicated that there is an increasing of agricultural land from 11,282.3ha in 1973 to 21631.6ha in the year 1986 and 28,545.6ha in the year 2003. The indication of agricultural land expansion in terms of spatial coverage means agricultural land expanded in the expense of other land cover/land use units. For instance, between the years 1973 and 1986 about 1503ha, between the year 1986 and 2003 about 887.8ha and between the years 1973 and 2003, about 2501.5ha forest cover land is drastically changed into agricultural land. This also supported by the survey 76% of respondent's views confirmed that, the expansion of various types of agricultural activities is the major sources of forest cover change in the study area. 6.1% thought that human consumption for fuel, 2.6% charcoal making, and 15.4% cutting of trees for house and fens construction as the major causes of deforestation.

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 96% of the sample households in the study area derived their energy source from fuel wood the rest from cow dung and crop residues. The major energy sources of the area presented in Table 14. Woody biomass accounts the total fuel needed for domestic cooking and heating. Fuel wood is the major source of energy since there is no shortage of biomass fuels for their energy source. According to the survey, type of domestic appliance that the family use for cooking (wet and others) and baking injera among the total sampled house hold 98% of the sample house hold responds use of open hearth the remaining answered "mitine stove" 1% and Charcoal Stove 1%. The growing demand for forest resources by rural and urban sectors is responsible for the massive scale of deforestation. 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 62% observed more erosion. It is only 13% of the respondents have observed more flooding. The rest 25 % encountered loss and decline of fertility of land (Table 8). Regarding the solutions for deforestation, about 40% of the respondents suggested strong law as a solution to control forest depletion. Providing environmental education as a solution was also indicated by 23% of the respondent. Those who said looking for another source of income was only 19%. The rest 18 percent pointed out planting trees pointed out as a solution.

Table 8. *Principal energy sources in the study area*

Energy source	Number of households	Percentage of household using
Fuel wood	137	96
Cow dung	2	1
Crop residues	4	3

4. Conclusion

Forest cover change in the form of deforestation is a major environmental problem manifested at Banja district .In the district, forest resources decreased by 3188.1ha, 409 and 3597.1ha between 1973and 1986, 1986 and 2003, and 1973 and 2003 respectively. An increasing demand for agricultural land was the cause for the change of forest resources in the district. Totally, 2501.5ha of the forest resources were converted into agricultural land between 1973 and 2003.

From the examined results, the extent of land use and land cover in general and forest cover change in particular was radically changed between 1973 and 2003.. Particularly, expansion of agricultural land and decline of both forest cover as well as shrub land were observed. In addition, the areal

coverage of forest is reduced from time to time. From the total area of the district about 6044 ha of land was covered with forest in 1973. But, this figure is declined to 2446.9 ha in the year 2003The socio-economic data analysis; anthropogenic factors were identified as major causes for forest cover change in Banja 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, farmers should be encouraged to plant fast growing trees on their farm boundaries, homesteads or on degraded lands instead of cutting trees from the existing forest, introduction of fuel saving stoves instead of using fuel wood in traditional three stone stoves, creating awareness among the society regarding to optimum utilization of the forest recourses and conservation systems by concerned bodies could play significant role in rehabilitation and minimizing of environmental degradation.

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Nomenclature

Authors declared that they have no competing interest

Acronyms

AVHRR	Advanced Very High Resolution Radiometer
BoA	Bureau of Agriculture
CSA	Central Statistics Agency
CSE	Conservation Strategy of Ethiopia
ETM	Enhanced Thematic Mapper
FCC	False color composite
EFAP	Ethiopian Forestry Action Program
GIS	Geographic Information Systems
GLCF	Global Land Cover Facilities
GPS	Global Positioning System
MSS	Multi Spectral Scanning
NDVI	Normalized Difference Vegetation Index
RGB	Red, Green and Blue
SPOT	Satellite Probatoire d'Observation de la Terre
SPSS	Software package for social scientists
UTM	Universal Transverse Mercater

Author's Contributions

AY, and FZ conceptualized the research problem, designed the study, conducted field work, collected data, data entry and analysis.

BG and SA were involved in revision of the overall research activates, data analysis, writing and drafting of the manuscript for publication.

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