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LAND USE/ LAND COVER CHANGE ANALYSIS IN NESHI WATERSHED, SOUTH-EAST BLUE NILE BASIN, ETHIOPIA.

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ABSTRACT

Land cover changes are one of the contributing factors for the variability of ecologic regimes. Hence, good understandings on the trend of land cover changes are crucial for sustainable natural resources management. However, investigations on such trends are little in Ethiopia both at national and watershed scale. Therefore, this study was designed to deal with the change in land use/land cover pattern of Neshi watershed, South-East Blue Nile Basin, Ethiopia. The land use/ land cover change was identified from 1972, 1986 and 2005 multi spectral Landsat satellite images. The rate and extent of land use/ land cover change of the area was manipulated from the images by Geographic Information System and Remote Sensing techniques. From land use/ land cover change analysis, a decreasing trend was observed in forest and wetland coverage, while an increasing pattern for woodland and agricultural lands was observed.

KEYWORDS: Land, Land cover, Land Use, land cover change, satellite.

INTRODUCTION

Forest destruction, pressure on land and other natural resources, unsustainable pattern of land use for agriculture, degradation of land and depletion of resources are the environmental consequences of uncontrolled population growth (EPA, 1997). Thus, natural land cover modifications for subsistence livelihood support and extensive development of infrastructure following this fast growing population are becoming the common environmental challenges which are rapidly increasing in developing countries at present time (Enrico *et al*., 2002). Subsequent to these modifications, land covers particularly forests have undergone dramatic decrease with a fundamental result of alteration in ecosystem processes. These changes have accelerated in pace, scale and magnitude in recent decades and potentially alter water, energy and biogeochemical cycles is important but not fully understood ways (Bradford, 2010).

It is clear that misuse of land resources has caused adverse watershed conditions like depletion of land productivity, disruption of people's routine activities, conversion of arable lands into semi arid or dessert conditions (Chang, 2003). Currently, suspicions are increasing that the quality, quantity and flow regularity of streams in downstream areas are under serious threat than any time due to extensive land use/ land cover changes in the upstream areas (Jeans *et al*., 2006). These issues pressurize the hydrological resources to be the recently recognized conservation and monitoring priority in global condition.

As one of the developing countries, uncontrolled population growth is one of a challenging problem for Ethiopia nowadays. Thus, natural land cover modifications at the expense to have a subsistence livelihood support for this fast growing population are a long term act in Ethiopia. Consequently, land degradation induced by deforestation and poor management of land resources is becoming a serious problem for Ethiopia at present time. For example, a report from (UNEP, 1983 as cited in Badeg, 2001) reveals rapid population growth, extensive forest clearing for cultivation, over grazing, movement of political centers and exploitation of forests for fuel wood and construction materials without replanting reduce Ethiopia's forest area to 16 percent in the 1950s and to 3.1 percent by 1982. The Ethiopian Forestry Action Plan outlines the pattern of deforestation and states that the rate of deforestation in the 1990s is 150,000 ha per year

(EFAP, 1994). Additionally, Leonard (2003) reported that with steady growth in population, clearing of woodland for agriculture has been a continuous process at an estimated rate of 62,000 ha a year. Recently, the forest cover of Ethiopia showed an increasing trend. For example, FAO (2005) shows that 11% of the countries land mass is forested area which is about 0.13 million Km^2 and this cover shows 1.1% annual rate of decline.

Although, it is not yet quantified and well documented, Neshi watershed experienced a long term land use/ land cover change condition like expansion of settlement and agricultural land in both formal and informal ways. The watershed is part of Nile basin which has a transboundary issue requiring clear information on the land use/land cover and hydrologic conditions of the upstream areas like this watershed. More recently, Ethiopian electric power corporation has also started the Neshi hydropower dam constructions in order to full fill the increasing hydropower demand of the country. The dam is also purposed as additional irrigation water source for expanding Finchaa state farm. These all requires a detailed study on the land use/land cover conditions of the area. A study by Tefera and Graaff (2010) on Finchaa watershed has revealed the expansion of agricultural land even to a steeply sloped areas and the severity of soil erosion and sedimentation in the area. This study is, therefore, intended to understand and estimate the extent of land cover change in general.

2. MATERIALS AND METHODS

2.1 Description of the study area

According to Awulachew *et al*. (2008) and Abbay River Basin Integrated Development Master Plan Project (ARBIDMPP, 1998), the Abbay river basin in Ethiopia is divided into 16 reasonably homogeneous areas named basin units or sub basins, representing each the catchment of one tributary or of several minor ones with similar behavior. Out of these Finchaa sub basin from the south eastern part is the one to which this study was carried out. This area is selected based on the accessibility of data for more than 30 years and since the watershed is sought to be one of the potential future development areas where currently some water resources development projects like Finchaa multipurpose hydropower project and Finchaa sugar farm Irrigation projects are in progress. In addition to these issues, Neshi hydropower dam construction is the ongoing water resources development related project specific to the study site. Moreover, information concerning to this basin as one of sub basin that contributes water to the Blue Nile River helps to know the land cover change status from the upstream area. Specifically, the study was carried out in Neshi watershed under Finchaa sub basin of Blue Nile, Horro Gudurru Wollega Zone in west central Ethiopia having a drainage area about $336km^2$. The area is bounded by escarpments from east, west and north within the general boundaries of latitudes 9° 30'N to 9° 45'N and longitudes 37° 15' to 37° 30'E at an altitude between 2,588m and 2,202m above sea level at about 312km north-west of Addis Ababa. The area can be reached following the main highway from Addis Ababa to Gedo (192Km west of Addis Ababa) and thereafter by means of an all weather gravel road from Gedo via Finchaa Dam , 95km + 25km from Gedo in the Northwest direction (Bayissa, 2007).

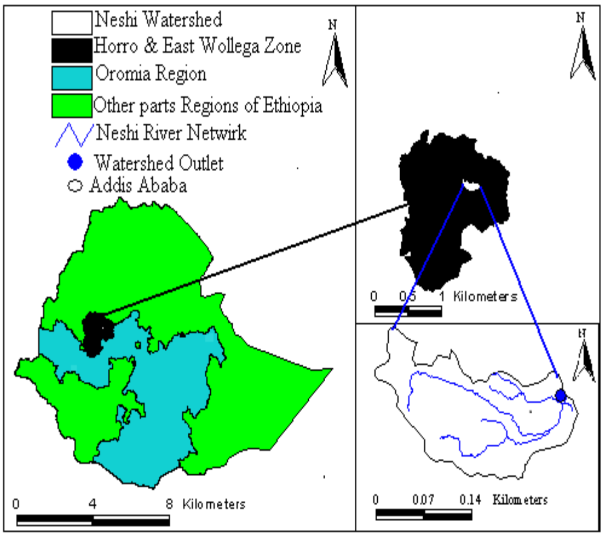

Figure 1: Map of the study area.

The principal vegetative cover of upper hilly areas consists of various species of trees which comprises Kerrero (*Acokanthera schimperi*), Wanza (*Cordia Africana*), Agamsa (*Carissa spinarum*), Girar (*Acacia etbaica*), Woira (*Olea europea*), Sesa (*Albizia gummifera*), Zigiba (*Podocarpus falcatus*) and Bisana (*Coroton macrostachys*). The principal agricultural crops in the area include barely (*Hordeum vulgare*), oats (*Avena sativa*), Wheat (*Triticum vulgare)*, and Teff (*Eragrostis teff*) (Burayu, 1995 as cited in Bayissa, 2007).

Grasses are the principal vegetation on the low elevation areas. The principal agricultural crops in the area include barely (*Hordeum vulgare*), oats (*Avena sativa*), Wheat (*Triticum vulgare),* and Teff (*Eragrostis teff*) (Burayu, 1995 as cited in Bayissa, 2007).

2.2 Data Collection

This study has used both primary and secondary data types. The primary data includes all data which was collected in the field. These are ground truthing points which were collected by GPS, direct observation about the current land use/land cover types of the area and informal interviews. Questions about the historic land cover conditions of the study area were asked for elders who were found during ground truth point's collection and general field observation. The data obtained from their response were used as support for historic land cover classification especially, for those land cover types which are around the watershed boundary and difficult to differentiate. While the secondary data types include all data types related to the study area description which was obtained from different sector offices of the area, and land use/land cover change related data.

It is evident that the analysis of a long term land cover change requires a 25 or more year's data. For this study 33 years land use/land cover change data were used. Based on this, the period since 1972 to 2005 is preferably selected by considering the availability of data in the area.

Landsat satellite images such as Multispectral Sensor (MSS) for the year 1972, Thematic Mapper (TM) for the year 1986 and Enhanced Thematic Mapper (ETM) for 2005 which completely cover the watershed were obtained from Addis Ababa University. Additionally, four topographic maps having a scale of 1: 50,000 for the year 1982 obtained from Ethiopian Mapping Authority were used. In addition to these, the 2006 land cover shape file of the area was taken from this project.

2.3 Data Analysis

The geographic location of the watershed on the map was laid on the joints of four areas topographic maps such as *Alibo (0937 A1)*, *Lemlem Bereha (0937 A2)*, *Shambu (0937 A3)* and *Finchaa (0937 A4)*. Therefore, these topographic maps with the scale of 1:50,000 were used for the sake of watershed boundary delineation and land cover type identification. These maps were scanned, geo-referenced and rectified to UTM projection system, WGS84 datum and zone37. Extraction and joining area of interest (AOI) for the maps were undertaken by ERDAS imagine 9.2 through the process of mosaic. Having this mosaic image, watershed boundary digitization was made by ArcGIS 9.2.

The radiometric corrections and systematic errors for all images were removed from the data set providers. Around 310 ground control points (GCP) were used for training and accuracy assessment. The image for the year 2005 was geo-referenced using ground control points and 1:50,000 scale topographic map of the area. The root mean square error (RSME) of the first order polynomial function or affine transformation for geo-referencing this image was found to be 0.20 pixel or 6 m on the ground. The 1986 and 1972 images were then rectified to the geo-referenced image by image to image registration method which is the process of making an image to conform with other image and involves georeferencing with the reference image that is already rectified to a particular map projection system (Lillesand and Kieffer, 2004). The registration gives 0.34 Root Mean Square Error (RMSE) of registration which is about 19.38m on the ground for the 1972 and 0.22 pixel or 6.6m on the ground for 1986 images, respectively. To have the same resolution, spatial resampling was done using spatial resampling algorithm in ENVI4.2 software. Following this, the spatial resolution of all images becomes 29.7m which is important to perform change detection.

The basic premise of remote sensing is that different objects do have different reflectance properties at different Electro Magnetic Spectrum (EMS) interacting with them since all objects vary with internal structure, morphology and chemical composition (Paul, 2004; Robert, 2007). Different color composite images were prepared in order to select the best band combination that enhance the raw satellite images for the identification of the different land cover classes in the study area. In this study the false color composite (FCC) of the image made using bands 4-2-1(R-G-B) for Landsat MSS, bands 7-4-2(R-G-B) for Landsat TM and ETM+ were found to be best for the identification of major land cover classes of the area.

A hybrid classification approach was used in this study. Unsupervised training is first performed on the image to delineate relatively homogenous areas for potential supervised training sites .Finally, land cover map of the three periods were developed using the supervised; maximum likelihood classification algorism based on the signatures developed as those of (Dessie and Kleman, 2007; Yu-Pin *et al.,* 2008).

As this method needs training points and the analyst's knowledge of the study area, ancillary data obtained from field observation of the land cover types, ground control points taken from areas which are difficult to interpret from the image, informal interviews with local peoples and topographic maps were used as an input. Otherwise, it was hardly possible to distinguish agricultural (crop) lands from grass lands as well as those of the forest and woodland areas from imagery alone since they have similarity in their color designation. By interpreting the various FCC of the images and making inter band comparisons with the help of the above ancillary data together with the researcher's field knowledge, About 70 sampling points for each class were identified from the1972, 1986 and 2005 images. Care was taken in training sites development so as to minimize the spectral variations which would affect the classification performance and accuracy.

Finally, five-land use/land cover classes, mainly Forest land, Shrubby woodland, Grassland, Agricultural land and Scrub wetland cover types were identified. Then, image re-sub setting into the area of interest i.e. separating the study area from the large classified image was made by masking the recoded and classified images of each year to the digitized watershed boundary of the area.

3. RESULT AND DISCUSSION

3.1 Land use/Land Covers Change Detection

In this study relative locations like upstream, midstream and downstream are used based on the steepness of the slope and altitudes of the study area. The 1972, 1986 and 2005 years land use/land cover maps obtained from analysis of Landsat MSS, TM and ETM satellite images are presented in Figure 2. The forest cover of the area showed a decreasing trend and a spatial shift throughout the study period (Figure 2). During the year 1972 about 5,235.55ha of the middle and downstream part of the watershed was covered by forest. This coverage became

5,180.65ha in 1986 revealing a decrease by 54.9ha and a spatial shift to upstream hilly areas. Though the decrease in this period seems not as such large, the trend continuous to the second period (1986 to 2005).

Besides this, Visual interpretation from the map and the change detection matrix revealed forest land in the 1972 to 1986 period was converted into woodland, grass and agricultural lands. This implies that there is a force that induces this decrease. Forest cover was decreased from 5,180.65ha to 4,164.21ha for the period 1986 to 2005 showing a decrease by 1,016.44ha. The annual decreasing rate of forest cover in the area for the period 1972 to 1986 is 3.92ha/yr while in the second period (1986 to 2005) the rate was severely raised to 53.49ha/yr. In the overall study period (1972 to 2005), the area under forest cover is decreased by 1,071.34ha.

This result supports the findings of many scholars in Ethiopia which almost all of them revealed that agricultural lands are expanding at the expense of forest land reduction (Zeleke and Hurni,2001; Emiru, 2009; Dessie and Kleman , 2007). Besides, fuel wood consumption and charcoal production may also be considered as reasons for forest cover decrease in Neshi watershed.

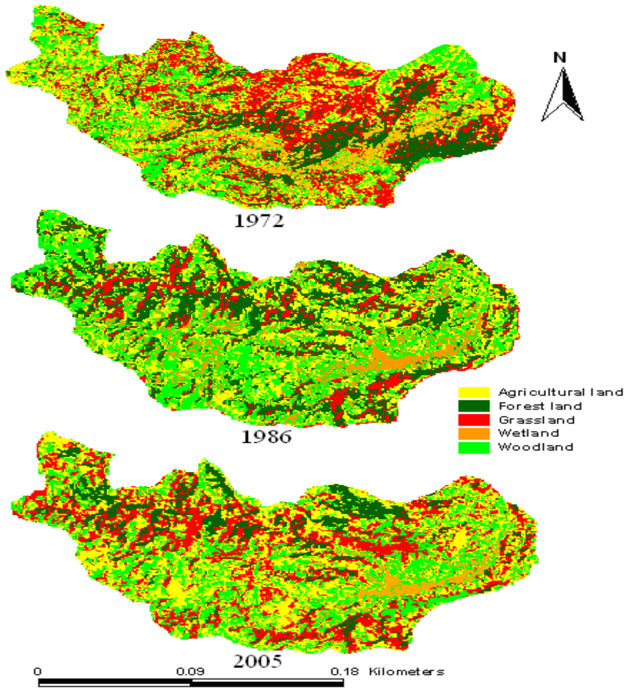

Figure 2: Land Cover Map of Neshi Watershed for the years 1972, 1986 and 2005.

Table 1: Land Use/Land Cover Change in Neshi Watershed between 1972 and 2005.

Land Use Land Cover types	Area coverage in 1972		Area coverage in 1986		Area coverage in 2005	
	ha	%	ha	%	ha	%
Forest land	5,235.55	14.57	5,180.65	14.21	4,164.21	11.58
Woodland	8,151.67	22.68	9,421.35	26.21	9,423.6	26.22
Grassland	9,223.54	25.66	9,429.32	26.24	9,428.49	26.23
Agricultural land	9,385.41	26.11	9,665.37	26.84	10,880.39	30.27
Wetland	3,937.6	10.95	2,237.01	6.22	2,037.01	5.66
Total	35,933.7	100	35,933.7	100	35,933.7	100

Woodland which was 8,151.67ha of the total watershed in the year 1972 was increased to 9,421.35ha in 1986 revealing a 1,269.68ha additional area. Even if the magnitude is slight, this land cover type continued its increment from 9,421.35ha to 9,423.6 for the period 1986 to 2005 showing a 2.25ha expansion. The annual rate of change for Woodland cover in the area is 2.25ha/yr for the period 1972 to 1986 and 0.11ha/yr for 1986 to 2005. Woodland area increment for the period 1972 to 1986 is mainly contributed from wetland (1,229.31ha) and forest land (40.37ha). Even if it is not as such noteworthy, the 1986 to 2005 increment in Woodland was mainly contributed from grass land recovery and wetland. The result is in contrast with Garedew *et al.* (2009) who found an increasing trend in wood land area from central rift valley.

Table 2: Rates of change in land use/land cover in Neshi Watershed.

Land Use/Land Cover types	Periods			
	1972-1986		1987-2005	
	Change in ha	Annual rate ha/yr	Change in ha	Annual rate ha/yr
Forest land	-54.9	-3.92	-1,016.44	-53.49
Woodland	1,269.68	90.69	2.25	0.11
Grassland	205.78	14.69	-0.83	-0.04
Agricultural land	279.96	19.99	1,215.02	63.94
Wetland	-1,700.59	-121.47	-200	-10.52

The Grassland coverage of the study area for the year 1972 was 9,223.54ha but it was increased to 9,429.32ha in the year 1986. Although the increasing trend is not as such a great deal, it was mainly contributed from the wetland (198.79ha). In the second period the area under grass cover depicts a decreasing trend. Similar to the previous period increment the decreasing magnitude in grass land coverage of the area in this period is not as such severe with 14.6 and -0.83ha/yr annual rate of change for both 1972 to 1986 and 1987 to 2005 periods, respectively (Table 2).

Of the total area (35,933.7ha), agricultural land occupies about 9,385.41, 9,665.37 and 10,880.39ha in the years, 1972, 1986 and 2005, respectively. In the first period (1972 to 1986), agricultural land increased by 279.96ha with 19.99ha/yr annual rate.

Furthermore, it was augmented to 1,215.02ha in the second period showing 63.94ha/yr annual rate of expansion (Table 1 & 2). The first period expansion in agricultural land was mainly contributed from wetland (272.49ha) while the second period raise was added from the forest land (1,015.59ha) and wetland (194.49ha).

The result supports most reports from Ethiopia and other places throughout developing world where often rapid and continued agricultural land expansion was reported at the expense to other land covers especially forest land cover reductions. Wetland areas revealed a diminishing trend from 3,937.6ha of the total area in the year 1972 to 2,237.01ha in 1986 then to 2,037.01ha in 2005. It showed a 1,700.59ha and 200ha decrease with 121.47ha/yr and 10.52ha/yr annual rate for both the first and second periods, respectively. The overall state of change in land use/land cover through 1972 to 2005 was interpolated from 1972, 1986 and 2005 areal coverage of each cover types. Thus, the temporal trend for the overall study period is depicted graphically in Figure 3. The graph confirms that forest cover and wetlands has a reduction trend, while those of woodland, grass and agricultural lands depicts a linear increasing pattern for the entire study period.

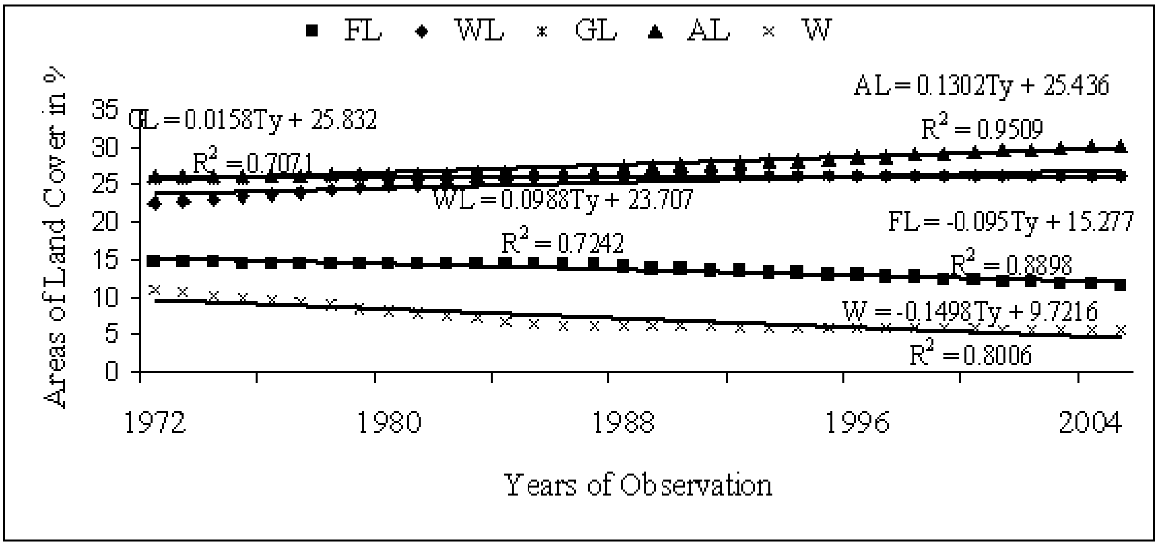

Figure 3: Linear Trend in Land cover Change for 1972 to 2005 Period.

Note: FL = Forest land, WL = Woodland, GL = Grass land, AL = Agricultural land, W = Wetland and Ty = Time in years.

As it is observed from the graph, R^2 value is greater than 0.7 for all land cover types. This implies that the relation between the change in the land cover type of the area and time is strong. Importantly, this strong relation indicates that the change either increasing or decreasing is continuous as time increases.

The accuracy of land cover maps and accompanying statistics derived from remote. Sensing analysis, the confusion matrix must be quantitatively explained. The most common and typical method used by researchers to assess classification accuracy is the use of an error matrix (Congalton *et al*., 1999 as cited in Sherefa, 2006). To assess the accuracy of the classified image, a confusion matrix was constructed by using ground control points which were not used in the training classification. Totally, 150 ground control points were used to validate the classified images. The overall accuracies obtained for the year 2005 map is 84.1% with 0.79 kappa coefficients that indicate the agreement of the classification with the actual classes from the fields is a very good. On the other hand, the average accuracy and reliability assessments which were generated from the procedures accuracy and user's accuracy give a value greater than 80%. This implies that the Landsat data and the methodology employed for this study allowed for the land cover identification of the majority of the reference as belonging to one of the classified classes.

Table 3: Confusion matrix of LU/LC classification for the year 2005 image.

		Reference data					
	Land cover types	**FL**	**WL**	**GL**	**AL**	**W**	**Procedure Accuracy**
Classified data	FL	32.31	4.6	0.8	0.0	2.4	0.82
	WL	3.1	35.11	0.7	0.5	0.0	0.89
	GL	0.6	0.0	40.51	6.3	0.1	0.85
	AL	0.0	0.1	5.0	27.62	1.8	0.79
	W	2.0	3.0	0.0	0.0	34.71	0.87
	User's Accuracy	0.86	0.83	0.86	0.81	0.89	170.26

Note: FL = Forest Land, WL = Woodland, GL = Grass land, AL = Agricultural land, W = Wetland.

3.2 Change detection matrix

The change detection for the time period between 1972 to 1986 and 1987 to 2005 was compared on a pixel by pixel method using a change detection matrix and the area of changes extracted. The matrixes reveals what land cover type was changed to what other land cover types. The rows of table 5 represent the initial stage and the columns represent the final stage of each land cover types. The diagonal values of the table shows the unchanged area of that cover type when the time goes from the first year of study to the second one. The class total values of the rows indicate the area of each land cover class during the first period while the column totals depict the area coverage of each land cover types in the second period. On the other hand, the cell values in each row tells as how much area of a certain land cover type in the first period is transformed to other respective cover type in the second year.

Table 4: Land cover conversion matrix in (ha) for 1972 to 1986 period.

		1986					
	Land cover types	**FL**	**WL**	**GL**	**AL**	**W**	**1972**
1972	FL	5,180.65	40.37	6.7	7.83	0.007	5,235.55
	WL	0.03	8,149.67	0.9	0.7	0.001	8,151.67
	GL	0.25	0.7	9,222.53	0.21	0.05	9,223.54
	AL	0.04	1.3	0.30	9,384.09	0.002	9,385.41
	W	0.01	1,229.31	198.79	272.49	2,237	3,937.6
	1986	5,180.65	9,421.35	9,429.32	9,665.37	2,237.06	35,933.7

Note: FL = Forest land, WL = Woodland, GL = Grass land, AL = Agricultural land, W = Wetland

For instance, the first row of Table 4 showed, out of the 5,235.55ha area of forest land in the year 1972, 54.90ha was converted into 40.37ha woodland, 6.7ha grass land, 7.83ha agricultural land and 0.007ha of wetland. For the period 1972 to 1986, the conversion of forest cover was not as such sever and most of it was transformed into woodland area revealing that the reason for the forest cover reduction of the area during this period might be usage of forest trees for fuel wood and charcoal production as well as living house construction. On the other hand, wetland is the cover class which was rigorously converted in to wood land and some part to agricultural land. For the period 1986 to 2005, substantial area of forest and wetland areas was converted into agricultural land (Table 5). This tells us the main reason for forest and wetland area reduction in this period is expansion of agricultural land at the expense to feed an ever growing population of the area.

Table 5: Land cover conversion matrix (ha) for 1986 to 2005 period.

		2005					
	Land Cover types	**FL**	**WL**	**GL**	**AL**	**W**	**1986**
1986	FL	4,163.21	1.5	0.35	1,015.59	0.001	5,180.65
	WL	0.87	9,412.65	2.45	5.35	0.003	9,421.35
	GL	0.129	4.3	9,423.0	1. 84	0.06	9,429.32
	AL	0.001	2.3	1.02	9,662.9	0.004	9,665.37
	W	0.05	2.85	1.67	194.49	2,037.0	2,237.01
	2005	4,164.21	9,423.6	9,428.49	10,880.39	2,037.01	35,933.7

Note: FL = Forest Land, WL = Woodland, GL = Grass Land, AL = Agricultural Land and W = Wetland

4. CONCLUSION AND RECOMMENDATION

Currently, the watershed concept has become appropriate approach in the science of studying and managing land resource degradation. Having this concept in mind, this study focused on the land cover change analysis which was carried out in Neshi watershed, South-east Blue Nile basin for the period 1972 to 2005. The generalized satellite images obtained for the three periods (1972, 1986 and 2005) suggests that aggregated area of Woodland and agricultural lands expanded in expense to the reduction in forest and wetland areas.

In Neshi watershed it was observed the expansion in agricultural land at the expense to the reduction in forest and wetland area coverage's. Therefore, it is recommended that introducing farmers with improved agricultural packages which could enable them to have satisfying product with small plots of land as well as creating awareness will reduce the deforestation rate and wetland encroachment. In addition, favoring the community with other alternative energy sources thereby reducing their dependency on forest for fuel wood and charcoal production could also reduce the problem. It is also advisable to mobilize the community for volunteer and owner sensed afforestation program to recover the deforested areas.

Analysis of community knowledge and studies of socio-economic circumstance are basic in filling the gap in the physical data analysis and for revealing the extent of impacts on livelihood. In the future, these issues need due consideration and research works in Neshi watershed.

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