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# Evaluation of Land Use/ Land Cover Changes in East of Lake Tana, Ethiopia

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**Abstract**
The objective of this study is to evaluate the Land use/ land cover changes in East of Lake Tana, Ethiopia. Data was gathered from two different years of satellite image (Landsat 5 TM of 1985 and Landsat 7 $ETM^+$ imagery 2011). Global positioning system and topographical maps of scale 1:50,000 were used for ground verification. The data were employed using ERDAS Imagine 9.1 and ArcGIS 9.3 software. Field observations and focus group discussions of farming households were also conducted to gather additional information. The result of this study portrayed that there is an expansion of cultivated and degraded land by 72.7% and 39.34% respectively from 1985 to 2011 at the expense of forest, shrub and grazing land. The expansion of degraded land indicated that how the conversion of forest, shrub and grazing land into cultivated land aggravated land degradation. Thus, proper implementation of land use policy is recommended.
**Keywords:** land use/land cover, change analysis

## 1. Introduction

Land use and land cover (LU/LC) change is a locally pervasive and globally significant ecological trend and has become an event of paramount importance to the study of global environmental change (Geist and Lambin 2001). It was the major element of global environmental changes of the past three centuries. Global cropland showed fivefold increase from 1770 up to 1990 and pastureland also increased by above six fold from 1700 to 1990. This increase of cropland and pastureland was at the expense of forest, natural grassland and savannas. For example, forest cover was decreased from 5000-6200 million hectares in 1700 to 4300- 5300 million hectares in 1990 (Lambin *et al.* 2003). More rapidly than the aforementioned periods, more woody vegetation cover was converted to cropland between1950 and 1980. But direction of land use and land cover change is not similar for all parts of the world. In the last two decades, the area of temperate forest was increasing by almost 3 million hectares, while the tropical forest was decreasing by 12 million hectares per year (Millennium Ecosystem Assessment 2005).

LU/LC change is increasingly recognized as an important driver of environmental change on all spatial and temporal scales (Turner and Meyer 1994). LU/LC contributes significantly to earth atmosphere interactions, forest fragmentation, and biodiversity loss. Thus, it has become one of the major issues for environmental change monitoring and natural resource management. That is why LU/LC change and its impacts on terrestrial ecosystems including forestry, agriculture, and biodiversity have been identified as high priority issues in global, national, and regional levels (Fu *et al*. 2000).

LU/LC dynamics is one of the major environmental problems in Ethiopia. In relation to this, recent watershed based LULC studies showed that land cover change is brutal and there has been agricultural land size expansion at the expense of natural vegetation cover lands and marginal areas without any appropriate conservation measures (Abate 1994; Amsalu *et al.* 2006; Gessesse & Kleman 2007; Temesgen *et al*. 2014). While, some studies conducted in the previously degraded parts of northern Ethiopia, revealed improvement of vegetation cover due to plantation and enclosure of the previously degraded hillsides in the period since the 1980s. For example, a study conducted by Woldeamlak (2002) in Chemoga watershed, East Gojjam revealed the increased of forest cover at a rate of 11 ha per annum from 1957-1998, even though it is eucalyptus plantation. Similar study by Amare (2007) and Amare *et al*. (2011) in Eastern Escarpment of Wello, Ethiopia and Munro *et al*. (2008) in Tigray highlands disclosed that vegetation cover improved since the 1980s owing to land rehabilitation efforts of the community supported by the government and multilateral donor agencies.

Therefore, LU/LC change analysis is one of the most precise techniques to understand how land was used in the past, what types of changes are to be expected in the future, as well as the forces and processes behind the changes. It also yields valuable information for the analysis of the environmental impacts of population pressure, agriculture, resettlement program, climate change, and others. Such analysis is of great use to the resource manager because it provides information that would help in resolving conflicts between human use of natural resources and the function of natural systems because it provides accurate information related to LU/LC changes (Belay 2002). Thus, the objective of this study is to evaluate LU/LC change in East of Lake Tana.

 

## 2. *Materials and methods*

### 2.1 Study area

This study was conducted in East of Lake Tana, Ethiopia particularly in Tana Mitsili *Kebele*. It is located between 13° 02' - 13° 14' N latitude and 33° 60' - 35° 10' E longitude, and its topography varies from 1779m to 1846m above sea level. The study area comprises mixed farming zones where crops are grown for food (mainly cereal and pulse crops) and for cash (mainly oil crops seeds), and livestock are kept for complementary purpose, as a means of security during food shortage, and to meet farmers' cash needs. The main soil types of the study area are Nitosols, Vertisols, Gleysols, Luvisols and Cambisols. The dominant vegetation type includes: *Eucalyptus* species, *Croton macrostachyus*, *Cordia africana* and *Ficus vasta*.

### *2.2 Data collection*

The study was conducted using two different years of satellite imagery (Landsat 5 TM of 1985 and Landsat 7 $ETM^+$ imagery 2011). Global Positioning System (GPS) and topographical maps of scale 1:50,000 were used for ground verification (Table 1). Filed observations and two focus group discussions with farming households having a group member of ten were also conducted.

**Table 1**: Types of landsat and toposheet used in the study

| Image | Path | Row | Sensor | Resolution or Scale | No of Bands | Date of acquisition | Source |
|---|---|---|---|---|---|---|---|
| Landsat5 | 169 | 52 | TM | 30 X 30 | 7 | 25/12/1985 | GLCF |
| Landsat7 | 169 | 52 | ETM + | 30 X 30 | 8 | 12/1/2011 | GLCF |
| Toposheet | | | | 1:50,000 | | | EMA |

### *2.3 Satellite Image processing*

***Present and past information on LU/LC changes for the study area were generated from satellite images. First, landsat images with 30m resolution for the year 1985 (Landsat5 TM) and 2011(Landsat7 $ETM^+$) were downloaded from Global Land Coverage Facility (GLCF). It is believed that the time gap of about three decades between satellite imagery is wide enough to show changes in LU/LC occurred in the study area.***

Then, image classification was undertaken using hybrid classification method involving both unsupervised and supervised techniques. Among different classification algorithms, maximum likelihood was used for supervised classification by taken 60 training areas for six major LU/LC class categories. The major LU/LC types were identified with the help of visual interpretation elements and the different reflection characteristics of the features in the satellite images of 1985 and 2011. These include water body, forest, shrub, grazing, cultivated and degraded land. The classification legend was made based on spectral characteristics of the land cover types (Table 2). The areal extent of LU/LC changes and the statistics of LU/LC changes were computed and summarized to detect the nature of major changes occurred between 1985 and 2011. The rate of change was calculated for each LU/LC class (Abate, 2011) as Rate of change (ha/year) = (A-B)/C

Where: A = Recent area of LU/LC in ha, B = Previous area of LU/LC in ha, C = Time interval between A and B in years

**Table 2**: Description of Land use and land cover classes (Adopted from Abate 2011)

| Land use/Land cover classes | Description |
|---|---|
| Cultivated land | Areas allotted to rain fed and irrigated cultivation, including fallow plots, cultivated land mixed with some bushes, trees and the scattered rural settlements included within the cultivated fields. |
| Forest land | Areas covered by trees forming closed or nearly closed canopies; Forest; Plantation forest; Dense (50-80% crown cover). |
| Shrub land | Land covered by small trees, bushes, and shrubs, in some cases mixed with grasses; less dense than forests. |
| Grass land | Areas of land where small grasses are the predominant natural vegetation usually used for grazing. |
| Water body | Areas covered by manmade small dams, seasonal water bodies and permanent water bodies. |
| Degraded land | Are parts of the land surface which is mainly covered by bare soil and exposed rocks. |

 

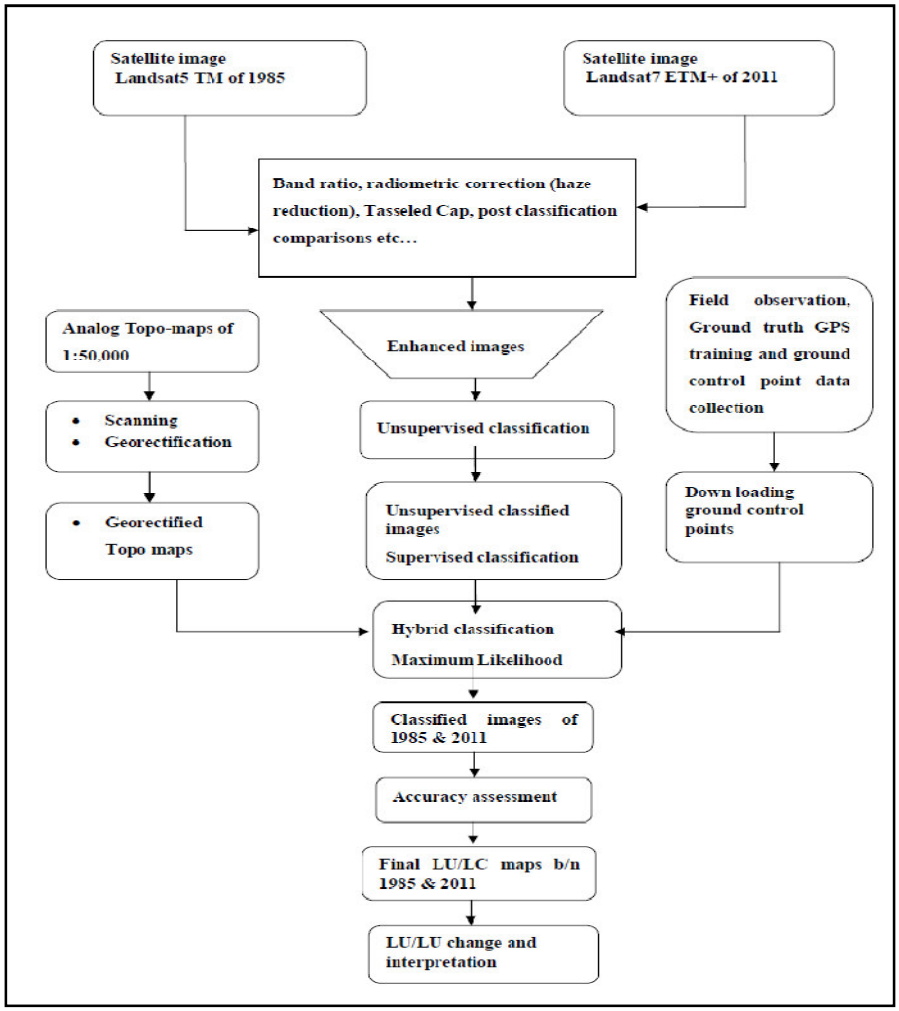


**Figure 1**: Flow chart of LU/LC classification (Adopted from Temesgen *et al*. 2014)

*2.4 Accuracy assessment*

Accuracy assessment was done for the recent satellite image of Landsat7 ETM$^+$ 2011, for which the ground truth data is likely corresponding. An overall accuracy is calculated by summing the number of pixels classified correctly and dividing by the number of pixels. Thus, an overall accuracy of 80% with a Kappa coefficient of 0.78 was achieved.

## 3. Results and Discussions

### 3.1 Land use/ land cover change analysis

In the study area, forest, shrub and grazing lands revealed negative rate of change between 1985 and 2011 while areas of cultivated land and degraded land were increased accounted for 66.73% and 2.15% respectively in 2011 (Table 3). Therefore, the figure tells us that forest, shrub and grazing lands have been under way for cultivation. In addition, it is observed that the conversion of forest, shrub and grazing land into cultivated land on steep slopes is one of the causes for presence of soil erosion and degraded land (i.e. land out of cultivation). From 2011 LU/LC map there is an increase of the size of water body in the northern side. This is actually due the construction of dam in the area in 2007. Similar to this study, a study conducted by Belay (2002), Girmay (2003), Amsalu *et al*. (2006), Gessesse and Kleman (2007), Messay (2011), Judith (2013) and Temesgen *et al*. (2014) indicated that there has been agricultural land size expansion at the expense of natural vegetation cover lands and marginal areas without any appropriate conservation measures. In addition, Gete and Hurni (2001) have also documented the expansion of cultivated land at the expense of forestland between 1957 and 1982 in Dembecha area, northwestern Ethiopia.

 

**Table 3**: LU/LC changes of the study area between 1985 & 2011

| LU/LC class | 1985 | | 2011 | | Change in ha b/n 1985-2011 | Rate of change in ha/year b/n 1985-2011 | Percentage change (1985-2011) |
|---|---|---|---|---|---|---|---|
| | Area (ha) | % | Area (ha) | % | | | |
| Forest | 1419.75 | 19.11 | 407.79 | 5.49 | -1011.96 | -38.92 | -71.3% |
| Shrub | 945.9 | 12.73 | 667.08 | 8.98 | -278.82 | -10.72 | -29.5% |
| Grass | 1885.32 | 25.37 | 1085.76 | 14.61 | -799.56 | -30.75 | -42.4% |
| Cultivated | 2870.64 | 38.63 | 4958.55 | 66.73 | +2087.91 | +80.3 | +72.7% |
| Degraded | 114.84 | 1.55 | 160.02 | 2.15 | +45.18 | +1.73 | +39.34% |
| Water body | 194.04 | 2.61 | 151.29 | 2.04 | -42.75 | -1.64 | -22% |
| Total area | 7430.49 | 100 | 7430.49 | 100 | | | |

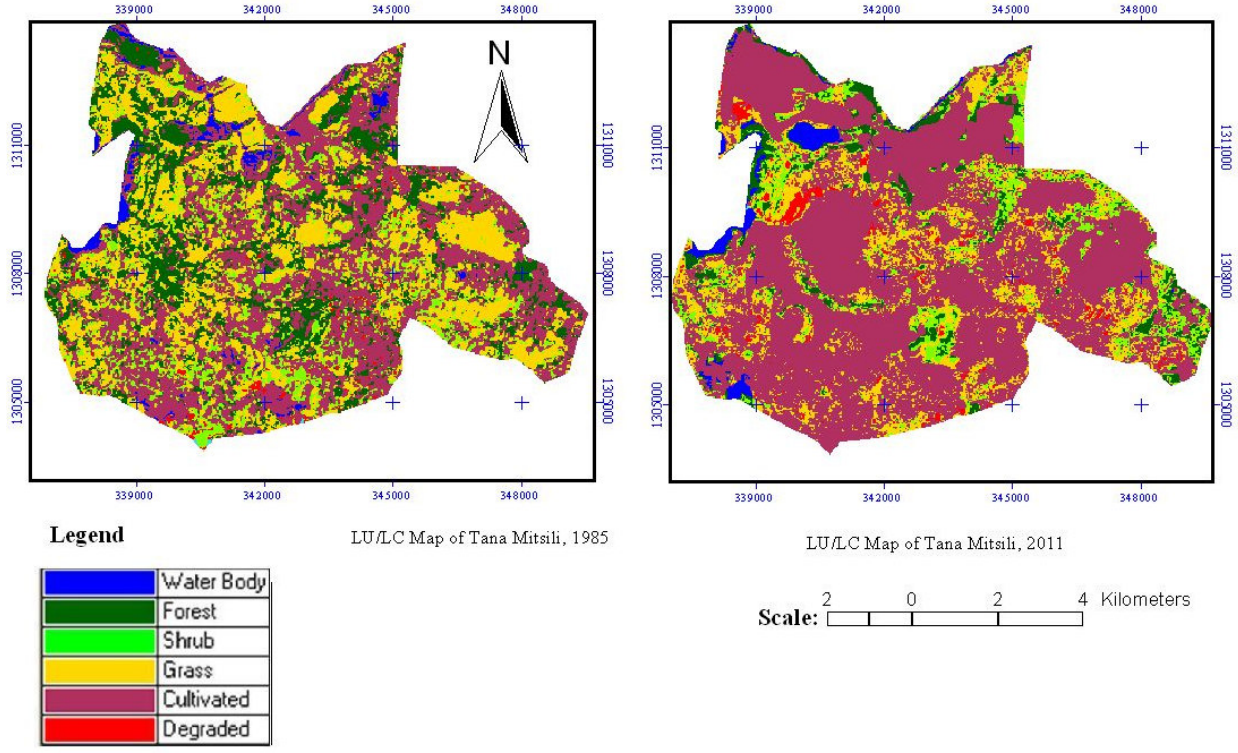


Figure 3: LU/LC Map of the study area

## 4. Conclusion

Evaluation of LU/LC changes which is carried out in East of Lake Tana, Ethiopia based on satellite image of 1985 and 2011 indicated that there is an expansion of cultivated and degraded land at the expense of forest, shrub and grazing lands in the study periods. In addition, it is observed that the conversion of forest, shrub and grazing land into cultivated land on steep slopes is one of the causes for presence of soil erosion and degraded land (i.e. land out of cultivation). This implies that the observed LU/LC changes are a cause for the presence of land degradation.

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