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Land use land cover change Analysis using Multi Temporal Landsat data in Gilgel Gibe, Omo Gibe Basin, Ethiopia

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ABSTRACT

Land use land cover change is the general term for human and natural modification of the earth's terrestrial surface at a variety of spatial and temporal scale. This change lends the need of knowing the type of change, when and where they occur with their extent and rates. Hence, effective information regarding the environmental responses of land use land cover changes are important to hydrologists, land use planners, watershed management and decision makers to formulate and implement effective and appropriate response strategies to minimize the undesirable effects of future land use land cover change. Consequently, this study was aimed at assessing the land use land cover changes of Gilgel Gibe catchment between 1987, 2001 and 2010. Particularly, the study have analyzed land use land cover changes that were assumed to take place in the Catchment for the past 24years. The Land use maps of 1987, 2001 and 2010 were derived from satellite images and processed using ERDAS Imagine 9.1 and ArcGIS10.1 software. Change detection analysis and accuracy assessment was done after Image processing and classification with spatial analysis tools. The outcome of land cover change analysis shows an increment of agricultural land from 54.51% to 56.54%, Urban and built up area from 2.22% to 4.06%, range land from 30.02% to 31.55% while decreasing proportion of forest land from 12.82% to 7.63%, Water body from 0.42% to 0.22% for the recent period between 2001 and 2010. The accuracy assessment of land cover classification indicates an overall accuracy of 83.87%, 82.18%, 89.29% and kappa coefficient of 0.7848, 0.7691, and 0.86 respectively for 1987, 2001 and 2010 map.

Key words: *Environmental Response, ERDAS Imagine, Land Use Land Cover Change, Watershed Management*

1. INTRODUCTION

The need of producing more food and maintaining ecosystem services were undermining the environment by altering the availability of different biophysical resources. The strong relationship between land use and land cover from these systems has contributed great concern to the basic planet characteristics and process. Productivity of the land, diversity of plant and animal species, hydrological cycles, ecological and environmental conditions are some of the anxieties. This was basically depending on the fact that, land use change is the proximate cause of the land cover change (Sherbinin, 2002).

Expansion and intensification of agricultural lands, development of urban areas and the need of extracting timber and other products are accelerating over time to meet the needs of an increasing population. Under such circumstance, handling the land and water resources in achieving high productivity would be difficult to be realized without degrading the resources. This results in the land use land cover change leading to a decreased availability of the products and services of the livelihood. The severity of the dynamic land use changes as a result of population increment, expansion of the agricultural sector and climatic conditions were increasing in Ethiopia (Getachew and Melesse,2012).

Despite a strong potential for increased agricultural productivity, south-western Ethiopia is environmentally challenged mainly due to resource degradation, soil erosion and nutrient depletions. Gilgel Gibe catchment is one amongst such land resources which are subjected to the land use land cover dynamics (Amsalu, 2010). The catchment is occupied and cultivated by large number of smallholding farmers. Poor land management practices coupled with the rugged topography, erosive rainfall regime in the area and nutrient depletions posed major threats in the catchment (Tefera, 2006). In addition, the increased demand of resources by the alarmingly growing population has resulted in biophysical resource degradations which would lead to a decreased availability of different products and services for human, livestock, agricultural production and damage to the environment as well (Dereje, *et al.*, 2009). As a result, the life span of Gilgel Gibe Reservoir is under question unless the threats are alleviated. Alleviating this multifaceted problems of the basin requires proper, coherent and organized land developments for which the land use land cover situation of the area was an input.

However, the quantitative data on the land use land cover change and clear insight into the local contributions of the change in the Gilgel Gibe catchment were absent. Therefore, the need of scientific research in analyzing the LULC change evolution and developing technical tools to quantify the extent of the change in Gilgel Gibe basin were imperative. Systematic and careful planning, the development of new patterns of land cover and land use can enhance the well-being of the community and ecosystem (Millennium Ecosystem Assessment, 2005).

Modeling and prediction of land use change is essential to assess the consequent environmental impacts of the LULCC event. Simulation of plausible human influenced land use changes following different scenarios may reveal strategic policies that should be modified to improve the environmental effects of the LULCC. Hence, the most important goals of catchment modelling are to quantify and predict the effects of global change at catchment scale, particularly for future water resource development and extreme events (Houet and Hub ert-moy,2006).

The estimation and understanding of the land use land cover Change requires accurate assessment of the type and direction of changes occurring in the catchment through change detection analysis of multi-temporal remotely sensed image. Various quantification methods were used with the spatial data handling capabilities of geographic information systems (GIS) to process data. This was done by integrating ERDAS imagine 9.1 with Arc GIS 10.1 to process, quantify and detect the land use land cover changes. Finally, accuracy assessment was done to reveal information on the status of land use classification.

2. DESCRIPTION OF THE STUDY AREA

The study area was situated on the upstream of the large Omo Gibe basin in the South-Western part of Ethiopia, in Oromia regional state at some 260km from Addis Ababa and about 70 km North-East of Jimma. Gilgel Gibe lies between 7º 19′ 07.15″ and 8º12′09.49″ North latitudes and 36º31′42.60″ and 37º25′16.05″ East longitudes with the catchment area of 4225km^2.The basin is generally characterized by high relief hills and mountains with an average elevation of about 1700m above mean sea level and by a wet climate with an average annual rainfall of about 1550 mm and an average temperature of 19ºc.

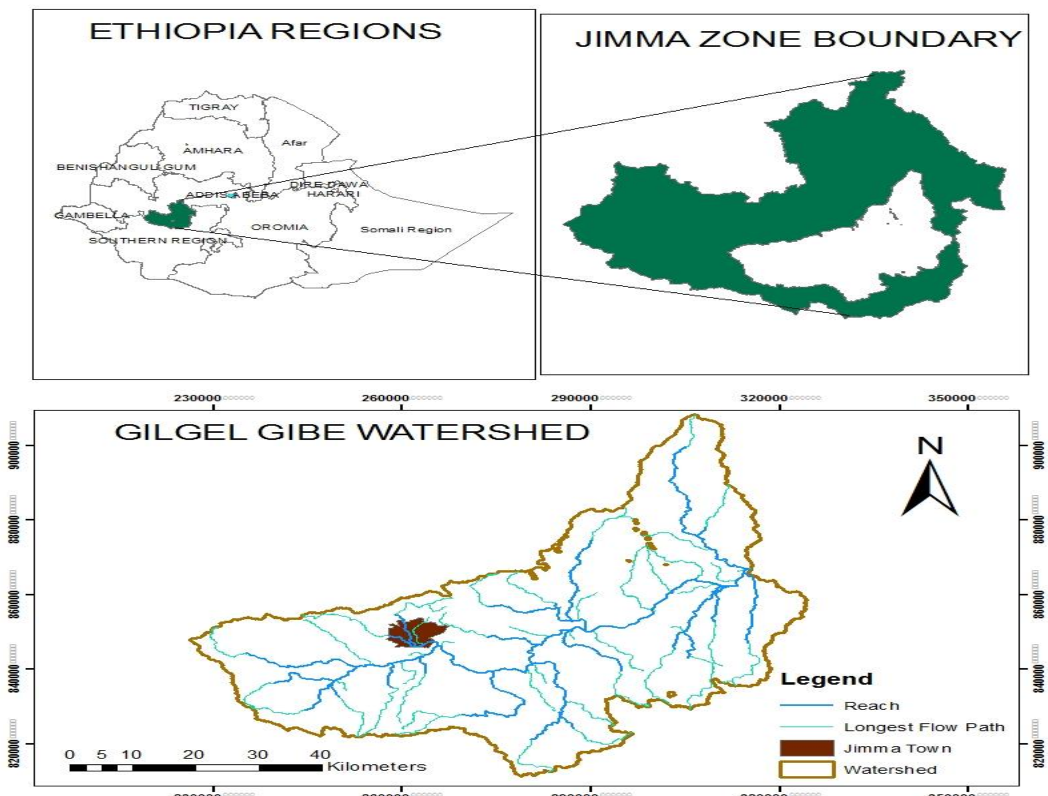

Figure 1. Location map of Gilgel Gibe catchment

3. MATERIALS AND METHODS

3.1. Digital Elevation Model (DEM)

A digital elevation model (DEM) of 30m by 30m was downloaded from the United States Geological Survey (USGS) website by path and row search of the study area via a dataset of a digital elevation of Shuttle Radar Topography Mission (STRM) with 1 acre. A path-row search of 169_054, 169_055, 170_054 and 170_055 were mosaicked and used for delineation and topographic characterization of the basin.

3.2. Land use land cover data classification schemes

Based on the prior knowledge of the study area and additional information from previous research, physical site observation and interviewing the concerned body in the study area, five different types of land use and land cover have been identified for Gilgel Gibe catchment. These are forest lands, urban and built up areas, range land, agricultural land and water body (table 1). In this study land use land cover classification system developed by Anderson, *et al.,(*1976) was used as basis of the classification.

Table 1: Land cover categories of Gilgel Gibe catchment

Land cover class	Description
Forest land	Areas covered with dense growth of trees that include: ever green forests, mixed forest land, deciduous forest lands. Plantations of indigenous specious of trees were also considered here.
Range land	Sparsely located trees with brush and shrub form types, bushes, wood lands, mixed range lands and transitional forests(less dense forests) were included.
Agricultural land	Areas used for crop cultivation (both annual and perennials), scattered rural settlements, some pastures and plantations around settlements. Sparsely located settlements were included here as it was difficult to separate them from agricultural lands.
Urban and built up	Residential, commercial and services, recreational sites, public installation, infrastructures. Due to their similar reflectance, bare lands were considered here.
Water body	Rivers, streams, reservoirs

3.3. Site Observation

Site observation and field works by GPS was conducted on selected weredas in the catchment to get a physical characteristics and land use features of the catchment and for ground truth verification of the mapped features and accuracy assessment. Based on the result of previous study held in the catchment by Kissi, 2010 and Tamene, *et al.*, 2013, some parts of Kersa wereda, Seka and Dimtu has required special attention so as to know the factors deriving the changes. Information on these areas were obtained through discussion with key informants and group discussions. Elders who are longtime residents of the areas and guards of the forests (on protected areas) were selected for the study discussion. During the discussion and interviews, the main focus were to obtain the past and present trend of land use land cover information and the factors contributing to the changes.

3.4. Landsat Images and Image Processing

For this study, two sets of Landsat TM imagery (for the period of 1987 and 2010) and one set of ETM+ image (for the period of 2001) were obtained from Global Land Cover Facility (GLCF) for the analysis of LULC change. Due to the presence of cloud cover on the Landsat 1987 imagery from GLCF, it was replaced with the data obtained from USGS only for 1987 data. Due to the extent and quality concern, full images for a given year covering the whole catchment is not available; as a result the Landsat images were assembled around a given year as closely as possible. To minimize the impacts of a seasonal variation in vegetation pattern and distribution throughout a year, the selection of dates of the acquired data were made as much as possible in the same annual season of the acquired years. The images were identified by the Landsat grid describing path (p) and row(r) and consequently two paths and two rows were used to get the Landsat images covering the whole catchment as shown in table 2.

Table 2: TM and ETM+ satellite data characteristics

Index	Sensor	Path_Row	Spatial resolution(m)	Acquisition date	Producer	Used bands
Around 1987	TM	169_054	30	30-12-1986	USGS	1-5,7
		169_055	30	30-12-1986	USGS	1-5,7
		170_054	30	06-01-1987	USGS	1-5,7
		170_055	30	22-01-1987	USGS	1-5,7
Around 2001	ETM+	169_054	30,15	22-11-2000	GLCF	1-5,7,8
		169_055	30,15	22-11-2000	GLCF	1-5,7,8
		170_054	30,15	05-02-2001	GLCF	1-5,7,8
		170_055	30,15	05-02-2001	GLCF	1-5,7,8
Around 2010	TM	169_054	30	27-11-2009	GLCF	1-5,7
		169_055	30	30-01-2010	GLCF	1-5,7
		170_054	30	05-11-2010	GLCF	1-5,7
		170_055	30	05-11-2010	GLCF	1-5,7

*in the table above, spatial resolution of 15m is used for the panchromatic band 8.

Source: Author, 2015

Due to their low spatial resolution (120 and 60 m) the thermal bands (band 6, bands 6.1 and 6.2) from TM and ETM+ were not used in this study. For the ETM+, the 30 m multispectral image was fused with the 15 m panchromatic band (band 8) using the Principal Component Analysis (PCA) method found in ERDAS to improve the visualization and interpretation of the image.

After completing the pre-processing of the image, to view, discriminate and interpret the surface features of the study area clearly for the future classification, all the input satellite images were composed with the standard RGB "false color composition (FCC)" of the satellite image for the study area. The choice of band combinations were selected depending on the applicability of each band as each band is a set of data file for specific portion of the electromagnetic spectrum in identifying the features of the study. The characteristics of each bands with their application is tabulated as in table 3.

Table 3: TM and ETM+ bands, wavelength and application

Band	Name	Band width(**μm**)	Application
1	Blue	0.45-0.515	-soil and vegetation discrimination -bathymetry and coastal mapping -cultural/ urban features
2	Green	0.525-0.605	-green vegetation mapping and cultural/urban features
3	Red	0.63-0.69	-vegetated and non-vegetated mapping -cultural/urban features
4	NIR-1	0.75-0.90	-delineation of water body -soil moisture discrimination
5	MIR	1.55-1.75	Vegetation moisture discrimination -soil moisture discrimination -differentiation of snow and ice
6	TIR	10.4-12.5	-vegetation and soil moisture analysis -thermal mapping
7	NIR-2	2.09-2.35	-discrimination of minerals and rocks -vegetation moisture analysis
8*	Panchromatic	0.52-0.9	-on Landsat 7 only, has 15 m resolution, used to "sharpen" images

Source: Erdas field guide, 2010

Based on the above information, the following band combinations were used to display images with the order of the bands corresponding to the red, green, and blue (RGB) color guns. Bands 3, 2, 1 create a true color composite and bands 4, 3, 2 create a false color composite for both Landsat TM and ETM+ of satellite imageries.

Landsat TM 1987 **Landsat ETM+2001** **Landsat TM 2010**

Figure 2: Band combination of mosaicked images in FCC for Landsat TM and ETM+

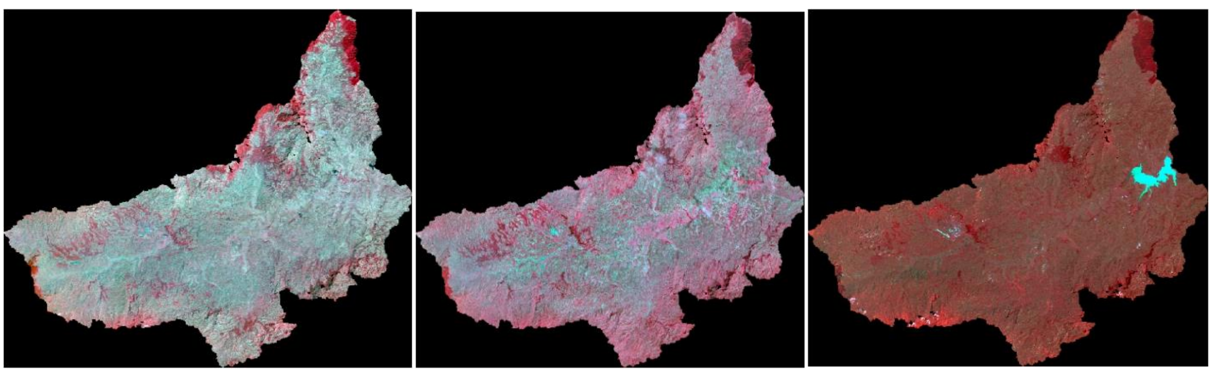

Image of 1987 **image of 2001** **image of 2010**

Figure 3: Band combination of AOI (subset) images in FCC for Landsat TM and ETM+

3.2 Image Classification

This operation has involved the investigation of multispectral image and the application of statistically based decision rules to determine the land cover identity of each pixel in an image. First, pattern recognition with the enhanced image to sort certain textures and colors into category based only on spectral radiances were considered as spectral pattern recognitions classification system. On the other hand decisions depending on geometric shape, size and patterns of the image data was done. In the two situation above, the determined classification system was aimed to categorize all pixels in a digital image into a classes of land cover. These category results are then used to produce thematic maps of the land cover present in an image and produce statistical summary of the areas covered by each land cover type.

The classification scheme has to have classes that can be used for the study and discernible from the available data. For this purpose Anderson, *et al.*, 1976 classification scheme was applied for the land use land cover classification.

There are two types of image classification systems: supervised and unsupervised classification. Unsupervised classification uses ISODATA (Iterative Self-Organizing Data Analysis Technique) clustering method which applies spectral distance as in the sequential method to classify pixels iteratively (ERDAS Field Guide, 2010). Because the ISODATA method is iterative, sometimes there exists miss classification of the land use. For example, water body might be classified as forest land.

Therefore, in this study unsupervised classification was used only to generate and compare a basic set of classes, and then supervised classification was used for further definition of the classes and thematic map preparation.

For this study, the land cover map was produced based on the pixel based supervised classification through the steps of: First, selecting of the training sites which are typically representative for the land cover classes. Training data sets were generated from the processed and after sub-setting images with the aid of ground truth. To make training sites clear and representative, personal experience and the physiographical knowledge of the area were supported with field works. In addition, image enhancement and composition were applied for better discriminating the land cover classes. Different color combinations were also applied to identify the feature classes clearly.

With a Polygon sampling approaches a 120 training sites were collected from each images (images of 1987, 2001 and 2010). For a single class a minimum of 20 training sites were taken to create signatures. After established training sites each training sites were stored in signature editor and color desired for the particular feature class. The extracted signatures were evaluated using histogram technique and different trials were taken until unimodal distributions of each band is achieved. Then, signatures of the same class were merged by selecting all the signatures of the each class. Finally, it is the cumulated (merged signature) which the supervised classification has used for the land cover map production.

To avoid the disturbance of the classes having nearly similar reflectance, different band combination for each class were compared. From the parametric and non-parametric decision rules in supervised classification system, parametric decision rule was selected as it depends on the statistical descriptors (mean and covariance matrix) of the pixels assigned as a training sample for the Land Cover class. Minimum distance and maximum likelihood parametric classifiers were compared and the maximum likelihood decision rule was selected as it results in a better result for this study. Hence, maximum likelihood classifier parametric rule found in the supervised classification of ERDAS 9.1 was used to reclassify each pixels on the basis of known ground truth. The reclassified images was developed based on the selected area of interest. Finally the AOI was extracted from the images as vector data and its areal extent was derived from the shape file.

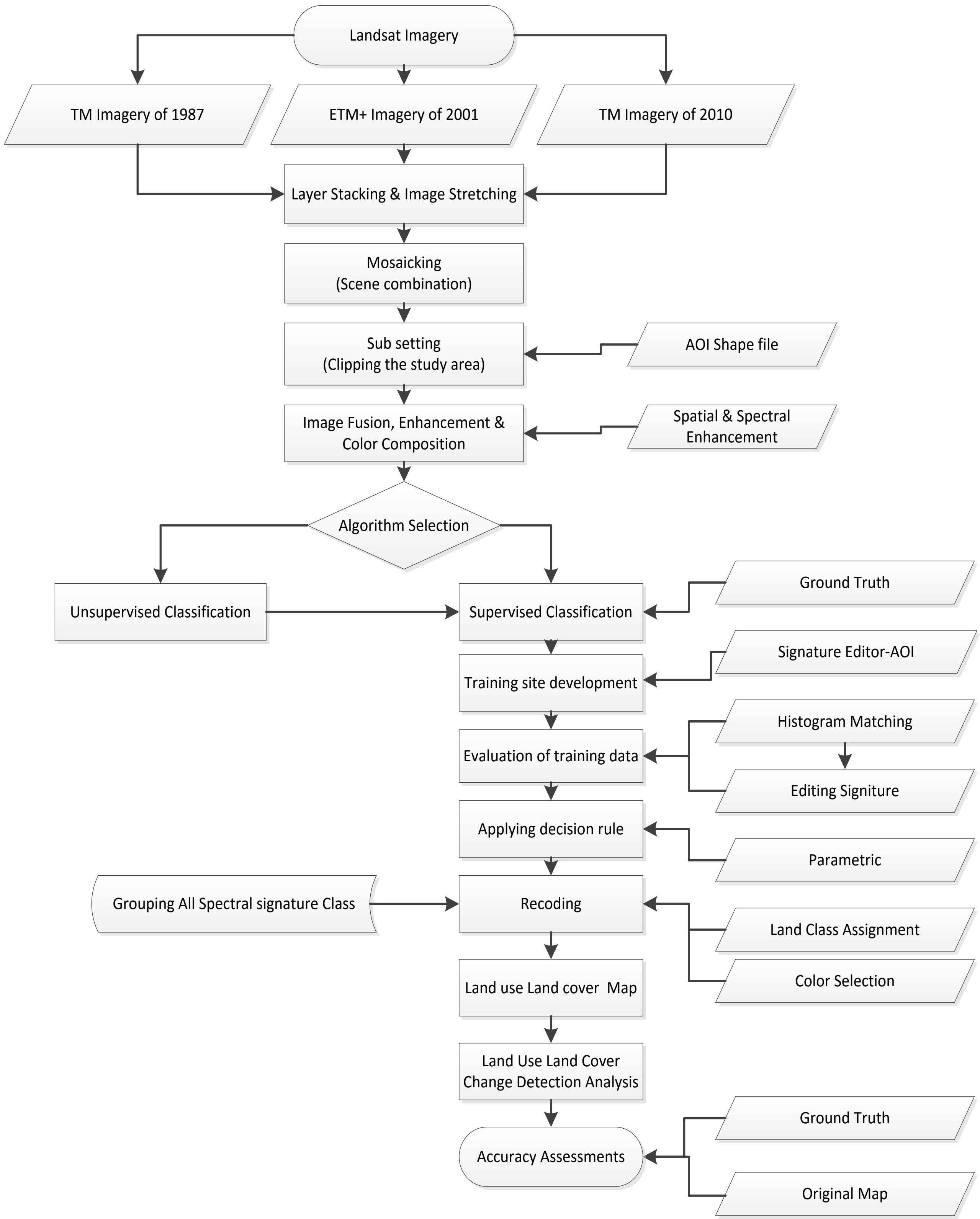
Landsat Imagery
TM Imagery of 1987
ETM+ Imagery of 2001
TM Imagery of 2010
Layer Stacking & Image Stretching
Mosaicking
(Scene combination)
Sub setting
(Clipping the study area)
AOI Shape file
Image Fusion, Enhancement &
Color Composition
Spatial & Spectral
Enhancement
Algorithm Selection
Unsupervised Classification
Supervised Classification
Ground Truth
Training site development
Signature Editor-AOI
Evaluation of training data
Histogram Matching
Editing Signiture
Applying decision rule
Parametric
Grouping All Spectral signature Class
Recoding
Land Class Assignment
Color Selection
Land use Land cover Map
Land Use Land Cover
Change Detection Analysis
Accuracy Assessments
Ground Truth
Original Map

Figure 4: Steps for the land use land cover classification

3.3 Accuracy Assessment

The process of doing an accuracy assessment involves generating a set of points from the classified imagery and comparing the positions of points whose location were determined by the ground truth data and corresponding coordinates from the original maps. Random selection of reference pixels were used to reduce the biases of using same pixels for testing classification that were used in training samples as they were the basis of the classification.

Confusion matrix and kappa coefficients were used as a means of evaluating image classification accuracy. The results of Kappa coefficients were interpreted according to Anthony, *et al.,(2005)* Kappa value characteristics. Kappa value greater than 0.8 denotes a strong agreement, value between 0.4 and 0.8 denotes a moderate agreement and a value below 0.4 represent poor agreement.

Steps followed to evaluate the accuracy assessment were:

1. Reference data were collected by GPS from the field through careful site visiting and reviewing study documents on the area. In addition, google earth was used to collect ground truth for land use class assessment.
2. The collected reference data were then, compared to the classified map with the class types assigned from the reference data. At this stage the original imagery (before undergoing preprocessing phase) were used for classification result comparison.
3. In this study a sample size of 113,101 and 93 points were collected for Landsat images of 1987, 2001 and 2010 through systematic sampling.
4. Finally, the data were summarized and quantified by using error matrix and kappa coefficient.

4. RESULT AND DISCUSSION

4.1. Land Use Land Cover Maps

The study from the ground truth data and classified Landsat images of 1987, 2001 and 2010 has revealed that, the catchment has undergone numerous land use and land cover changes over time. Figure 5, 6 and 7 shows the land use land cover map of Gilgel Gibe catchment for the period of 1987, 2001 and 2010 respectively.

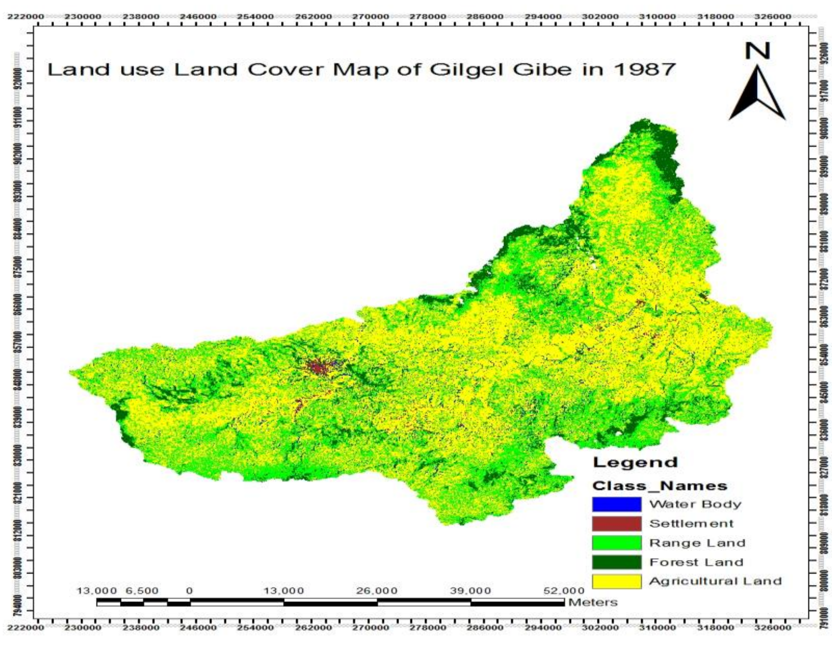

Figure 5: Classified land use and land cover map of Gilgel Gibe basin in 1987

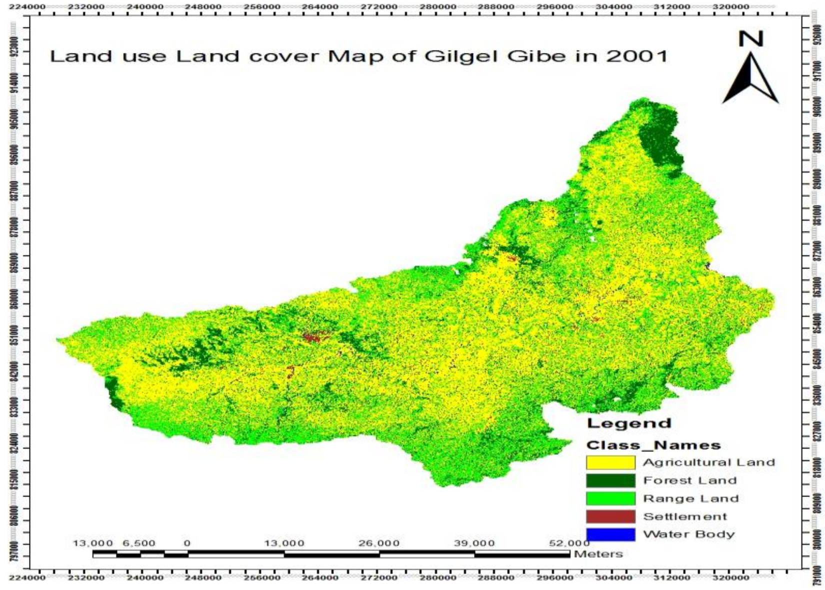

Figure 6: Classified land use and land cover map of Gilgel Gibe basin in 2001

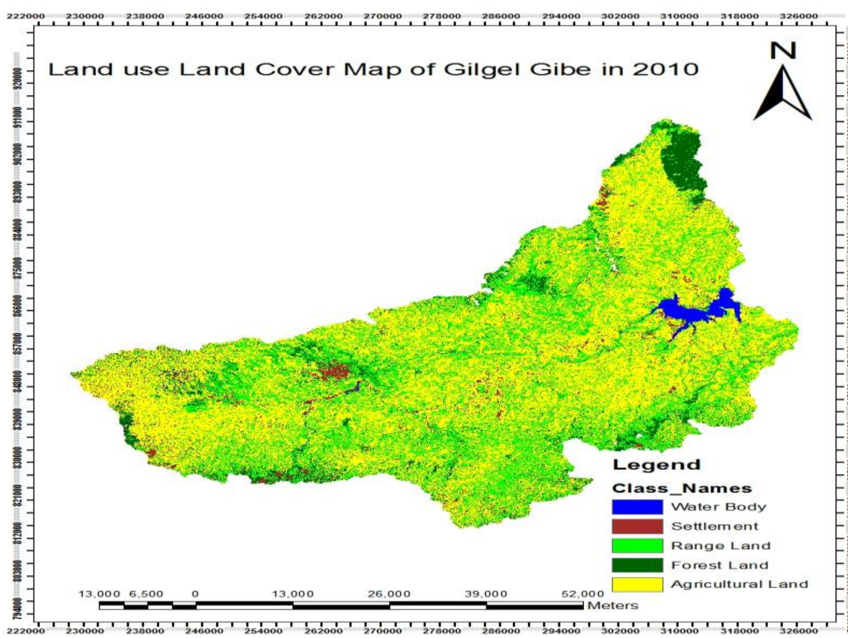

Figure 7: Classified land use and land cover map of Gilgel Gibe basin in 2010

Due to the creation of the Gilgel Gibe I reservoir in 1996, the coverage of water body has increased in the catchment for the LULC study of 2010. When the coverage percent of the land cover types are compared with the results of 1987 and 2001, the increment in water body would lead in to unreasonable result. There fore the surface area of the reservoir has required special consideration in order not to lead in wrong conclusion for the change of water body.

As there exists a LULCC in the surface area of the reservoir, the reservoir area was separated from the whole catchment for a particular analysis. Independent LULC maps were prepared to the reservoir areas of the water body for 1987,2001 and 2010 sepaeately. Then, the area was substracted from the whole catchment for change detaction analysis in study area.

To avoid the effect of varying land use map preparation for the whole catchment and the reservoir area, the follwing technique was developed. First, map of the whole catchment was prepared for the study periods of 1987, 2001 and 2010. From the map result of 2010, shape file for the reservoir area was prepared by digitizing surface area of the water body. This shape file was then used to subset the reservoir area for 2010, 2001 and 1987 maps. The areal coverage of landcover types was quantified for the resrvoir area. Finally, the reservoir area was substracted from the whole catchment for change detaction analysis. The figure 8 below shows the land use maps of the reservoir area for 1987,2001 and 2010 respectively.

A

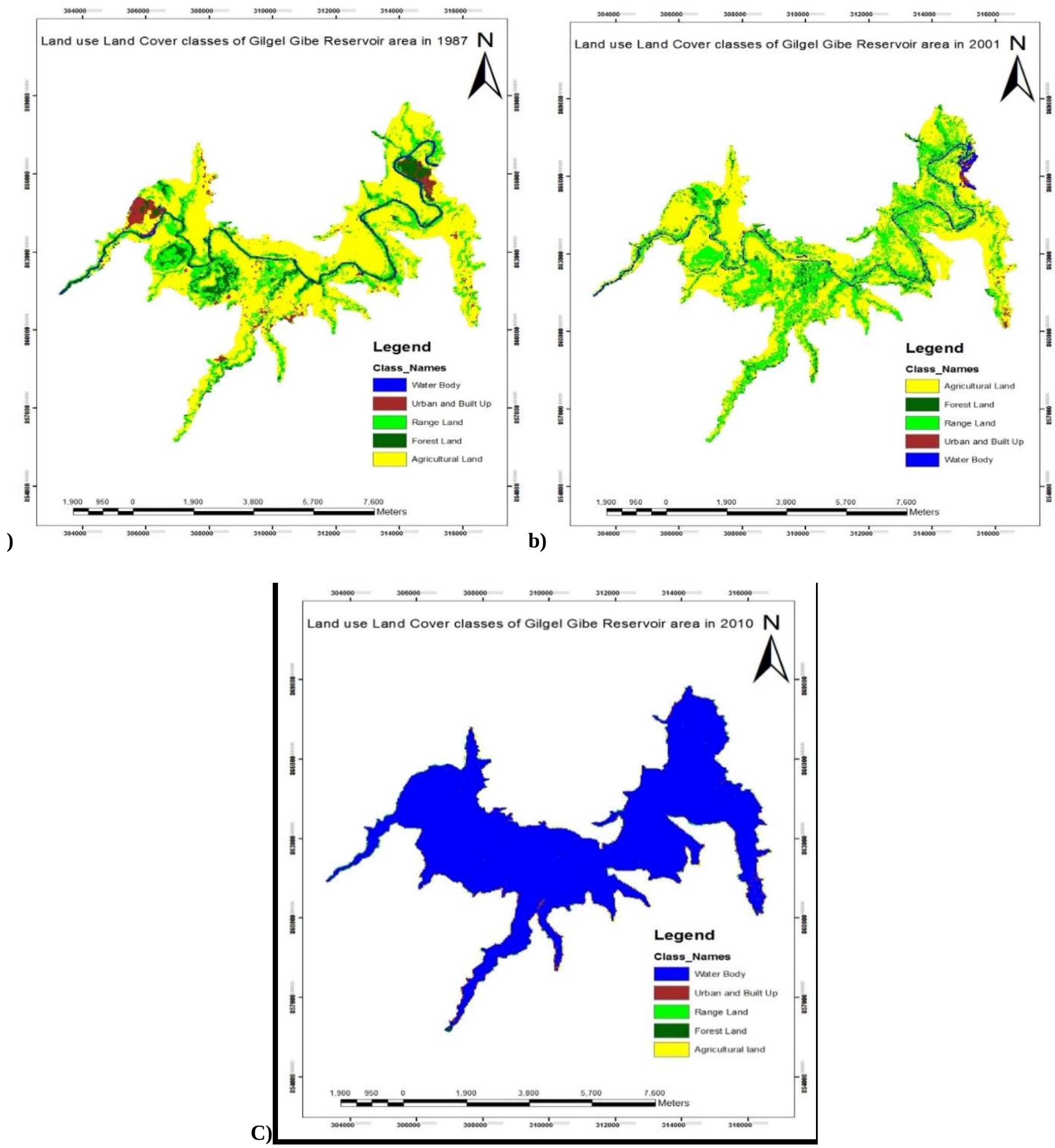

Figure 8: A, B, C: Land use land cover map of the reservoir area of 1987, 2001 and 2010 period respectively.

The result of the land use land cover change and the actual percentages covered by the classes in the catchment shown in table 4 below was developed by excluding the area of the reservoir.

Table 4: Land use land cover change percentages

LULC Class categories	1987		2001		2010	
	Area(ha)	%	Area(ha)	%	Area(ha)	%
Agricultural land	223626.78	54.37	224374.36	54.51	232553.28	56.54
Forest land	39824.86	9.68	52781.158	12.82	31383.24	7.63
Urban and built up	6666.3	1.62	9131.7629	2.22	16700.8	4.06
Water body	2924.43	0.71	1729.425	0.42	893.01	0.22
Range land	138251.25	33.61	123576.92	30.02	129763.23	31.55
Total	**411293.62**	**100**	**411593.63**	**100**	**411293.56**	**100**

The distribution of the LULC change was summarized as in figure 9 below. This was important for the development of LULCC scenario. The result indicates agricultural land and urban and built up area has shown continues increment. Whereas, water body is getting decline throughout the study period (over 23 years). This could be resulted from the need of an increasing population to get the resources. Resources like water and land are finite, whereas the need to use these resources are increasing from time to time. In addition to their limited existence, human and natural process are imposing pressure on the resources. As a result, the coverage of these fresh resources are getting diminished. On the other way, population growth persuades land use changes through the use of more land for cultivation reducing the land occupied with natural ecosystems. An increase of urban areas would be as a result of migration of population from rural to the urban areas.

This indicates, unless the mode of utilizing and handling of the resources are changed, we loss the resources in short period with which sustainable development would not be achieved. This would necessitates human intervention at different level (governmental and non-governmental involvements), for proper utilization of the resources without damaging the resources so that the future generations will get it.

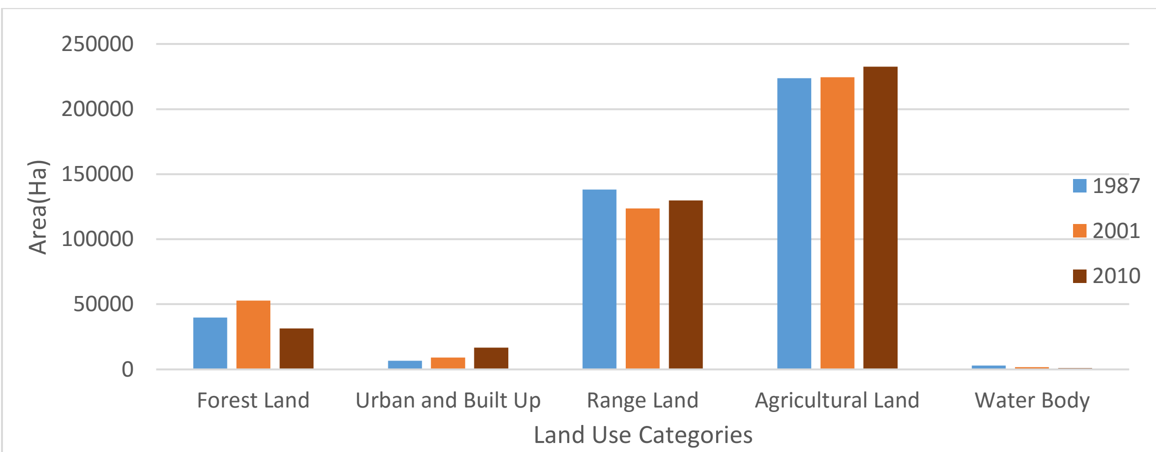

Figure 9: Land use land cover distribution of 1987, 2001 and 2010

From the study result, there is a significant LULCC in the catchment where, agricultural land covered 54.37% in 1987 has increased to 54.51% in 2001 and increased to 56.54% in 2010. Even though, it shows an increment in both cases, the rate of an increment is different (the latter is at a greater rate). This increment could be related to a high population demand for different cultivation practices. The area covered by urban and built up has shown a maximum rate of increment. This could be attributed to the increase in population that has increased the need for built up lands and infrastructure (road, and urban areas) developments in the catchment. The forest land has shown an increment from 9.68% in 1987 to 12.82% in 2001 whereas, the range land has shown a decrement from 33.61% in 1987 to 30.02% in 2001. The result of the ground truth and interview analysis has shown that the reason of an increment was due to the conversion of range land especially shrub lands to forest in 2001. On the other hand from 2001 to 2010 forest cover has decreased from 12.82% to 7.63%. This could be brought due to the cutting of forests for the increased need of an agricultural land and the need of urban and built up expansions. Water body has shown a decreasing rate of 0.71% to 0.42% for 1987 and 2001 periods and from 0.42% to 0.22% in 2010. The range land has increased for the period of 2001 to 2010, this could be due to the plantations of Ethiopian millennium at different areas especially in Bada Buna, limmu, kersa, Seka and forests are converted to range land as a result of cutting of trees.

4.3. Land Use Land Cover Change Scenarios

The LULC change scenario was developed for the change detection analysis to understand and quantify the trend of the land use land cover change from 1987 to 2001, from 2001 to 2010 and from 1987 to 2010.

Table 5: Land use land cover change scenario

LULC categories	Land use land cover			LULCC					
	1987	2001	2010	1987-2001		2001-2010		1987-2010	
	Area-ha	Area-ha	Area-ha	%	Rate-ha/yr	%	Rate-ha/yr	%	Rate-ha/yr
Agricultural land	223626.8	224374.4	232553.3	0.26	52.71	3.72	909.96	3.99	387.94
Forest land	39824.9	52781.16	31383.2	32.44	925.36	-40.50	-2377.5	-21.20	-367.08
Urban and built up	6666.3	9131.77	16700.8	36.88	176.09	83.02	841.04	150.53	436.29
Water body	2924.4	1729.42	893.01	-40.91	-83.56	-48.33	-92.93	-69.46	-88.32
Range land	138251.3	123576.9	129763.2	-10.68	-1047.75	5.08	687.91	-6.14	-369.07
Total	**411293.6**	**411593.6**	**411293.6**						

The result over 1987 to 2001 has indicated that agricultural land, forest land and urban and built up are has increased while range land and water body was decreased. This was resulted from the increased demand of land through conversion of swamp areas to agricultural lands reducing water body coverage and range lands to forest. The result from 2001 to 2010 also shows an increase in agricultural land, urban and built ups and range lands where as forest land and water body has get declined. This could be due to the need of land for agricultural land and settlement, forest was cleared.

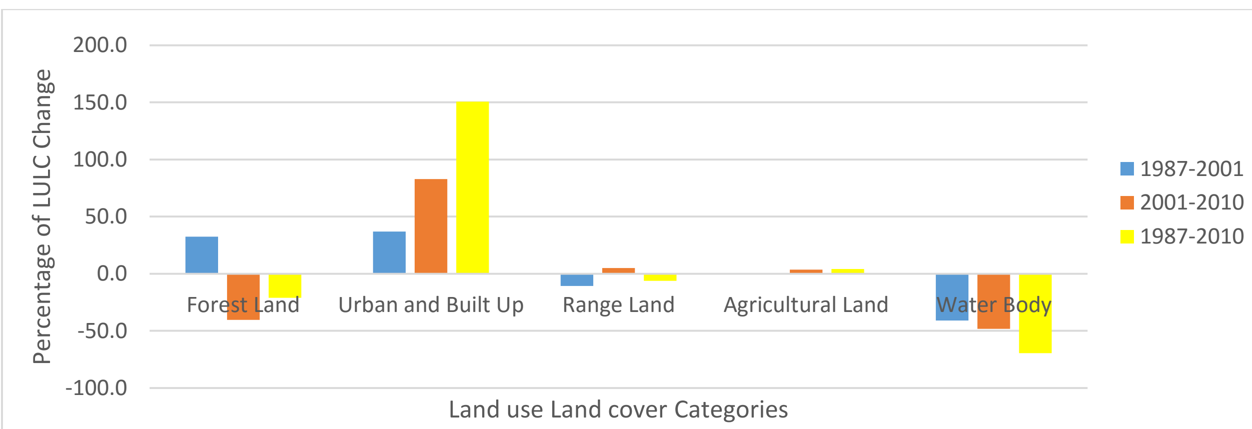

Figure 10: Percentage of land cover change over the period of time

4.4. Land Cover Classification Accuracy Assessment

Confusion matrix and kappa coefficients were developed for the certainty of the classification result. 113,101 and 93 points were identified from each class of the land cover classification for the 1987, 201 and 2010 land use maps. Each classified point was compared with these field data to ascertain the classification accuracy. The result of the overall land classification reveals a good result as shown below. The terms used in the analysis of accuracy assessment were:

Producer's accuracy-it was calculated by dividing the number of correctly classified pixels in the category by total number of pixels of the category in the reference data. The lowest values of the producer's accuracy was resulted from misclassification due to the spectral similarity of the land cover classes. Swampy lands with forest land, agricultural land with range lands were some among these.

Overall accuracy- it was calculated by dividing the total number of correct pixels by the total number of pixels in the confusion matrix. From the result, the application of the map will determine the level of the accuracy to accept.

User's accuracy-it is the ratio of pixels correctly belonging to a class (diagonal portion) and the total number of pixels assigned to the same class by the row total.

Kappa coefficient-it describes the proportionate reduction in error generated by the classification process compared with the error of a completely random classifications. For example 0.8657 kappa index implies that the classification process is avoiding 86.57 percent of the errors that a completely random classification would generate.

Table 6: Confusion matrix and kappa index of the 1987 land use classification

		Reference data							
		Al	Fl	Rl	Ua	Wb	Total	User's accuracy	Kappa index
Classification data	Al	31	0	2	5	1	39	79.49%	0.6821
	Fl	1	15	2	1	1	20	75%	0.7019
	Rl	1	0	16	0	0	17	94.12%	0.9240
	Ua	0	0	0	4	0	4	100%	1.000
	Wb	0	0	1	0	12	13	92.31%	0.9094
	Total	33	15	21	10	14	93		
Producer's accuracy		93.94%	100%	76.2%	40%	85.7%		Overall accuracy 83.87%	0.7848

Note: Al-agricultural land; Fl-forestland; Rl-range land; Ua-urban and built up; Wb-water body

Table 7: Confusion matrix and kappa index of the 2001 land use classification

		Reference data							
		Al	Fl	Rl	Ua	Wb	Total	User's accuracy	Kappa index
Classification data	Al	29	0	2	5	0	36	80.56%	0.7154
	Fl	1	18	5	0	1	25	72%	0.6509
	Rl	1	2	14	0	0	17	82.35%	0.7772
	Ua	0	0	0	11	0	11	100	1.000
	Wb	1	0	0	0	11	12	91.67%	0.9094
	Total	32	20	21	16	12	101		
Producer's accuracy		90.6%	90%	66.7%	68.75%	91.7%		Overall accuracy 82.18%	0.7691

Note: Al-agricultural land; Fl-forestland; Rl-range land; Ua-urban and built up; Wb-water body

Table 8: Confusion matrix and kappa index of the 2010 land use classification

		Reference data							
		Al	Fl	Rl	Ua	Wb	Total	User's accuracy	Kappa index
Classification data	Al	15	0	0	1	0	16	93.75%	0.9231
	Fl	0	24	2	0	1	27	88.89%	0.8570
	Rl	3	1	21	0	1	26	80.77%	0.7580
	Ua	2	0	0	20	0	22	90.91%	0.8881
	Wb	1	0	0	0	20	21	95.24%	0.9407
	Total	21	25	23	21	22	112		
Producer's accuracy		71.4%	96%	91.3%	95.24%	90.9%		Overall accuracy 89.29%	0.8657

Note: Al-agricultural land; Fl-forestland; Rl-range land; Ua-urban and built up; Wb-water body

5. CONCLUSION

The advancement of computational power and the availability of spatial and temporal data has made GIS and remote sensing being attractive tools to examine and analyze how the LULC process of the catchment takes place. Particularly, in this study ERDAS Imagine was found to be useful tool for investigating land use land cover dynamics at various spatial and temporal scales.

The result of land use land cover dynamics shows that agricultural land and urban and built up area is getting increased for the study period. Whereas water body and forests are getting decreased for the recent study period (2001 to 2010). This increment is contributing to the increased runoff which disturbs the ecological functioning of the area.

Accuracy assessment of land use classification by confusion matrix and kappa index shows, an overall accuracy of 83.87%, 82.18%, 89.29% and kappa coefficient 0.7848, 0.7691, 0.86 respectively for 1987, 2001 and 2010 map. The result indicates the availability of data for recent map is accurately mapped than the others.

The study acknowledges that the out looks into future sustainable land and water resources of Gilgel Gibe catchment shall depend on the spatial planning of land use with the objective of optimizing the environmental benefit through surface runoff control, erosion protection, flood protection and water availability. Therefore, educating the community the effect the unplanned land use practices had on the environment, natural resources and ecosystem is of paramount importance for the catchment management.

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