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Application of GIS and Remote Sensing for Land Use and Land Cover Change in Kilite Awulalo, Tigray Ethiopia

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ABSTRACT

This study examines the application of GIS and Remote Sensing in mapping Land Use and Land Cover change in Kilite Awulalo Woreda, Eastern Tigray Zone from 1972 to 2014. For this study, LANDSAT images of 1972 (Landsat-1 MSS); 1984 (Landsat-5 TM); 2000 (Landsat-7 ETM+) and 2014 (Landsat-8 OLI_TIRS) were used and analyzed using Arc GIS 10.1 and Erdas Imagine 13. Supervised classification scheme was used to classify the images. Under land use and land cover categories Agriculture land, Settlement land, Grazing land, Forest land, Bush land, Water bodies and Bare/stony land were studied. The result shows that Bush land was decreased from 1972 to 2014 which is 1972 (58007.88 hectare), 1984 (47900.79 hectare), 2000 (45000.1 hectare) and 2014 (40573.53 hectare) and forested land was decreased from the year 1984 (21706.65 hectare) to 2014 (11916.6 hectare). Agriculture and settlement area was increased from the year 1972 to 2014. Agriculture was increasing 13138.92, 20856.78, and 23000.09 to 30402.27 hectares from the year 1972, 1984, 2000 and 2014 respectively.

1) INTRODUCTION

Ethiopia is one of the most well endowed countries in Sub-Saharan Africa in terms of natural resources including fauna and flora [1]. About 50 percent of Ethiopia is covered with mountain, because its altitude is above about 1500_m, with steep slopes. The country's highland areas comprise about 90% of its arable lands and are occupied by 90 percent of the human population and 60 percent of all livestock. The mountains of Ethiopia have natural diversity and resources and offer excellent opportunities for human development. Even though all over the highland parts of Ethiopia as they are very suitable places for living and agriculture, but know the natural resources are degraded because of the increasing of [2].

However, the country faces different problems in relation to natural resource management. From this, land cover change is one of the most serious environmental problems. According to Eric et al.[3] , summarizing a large number of case studies, and find that land-use change is driven by a combination of resource scarcity; changing opportunities created by markets; outside policy intervention; loss of adaptive capacity and increased vulnerability; and finally changes in social organization, in resource access, and in attitudes.

In the Ethiopian, serious environmental problems are associated with the overwhelming proportion of the Ethiopian population lives in rural areas (85%) and about 90% lives in the Ethiopian highlands and directly depend on subsistence agriculture which is entirely dependent on natural resources [2]. Therefore, in the country, Land use and cover changes had been particularly dynamic in the 20th Century. This was due to increasing population, expansion of the agricultural sector and climatic change [4]. On the other hand, Amare [5] explain that rapid population growth and the low economic living standard in Ethiopia have brought in their awake numerous consequences to land cover and use changes; change in climate and hydrological status in the country. Besides, land tenure policy has been changed since 1975 that also contributed for the dynamic change of land use land cover [2]. Alemayehu and Arnalds [6] also studied on Land Use and Land Cover Dynamics in the Ethiopian Highlands between 1868 to 2008. The land use and land cover change from 1980s-2000s showed continued declines of shrub lands and forest cover, but improvements in vegetation cover in some areas.

The study of Land use/cover pattern is providing information for managing dynamics of land use and meeting the demands of increasing human population [7]. On the other hand, Information on land and land cover change in the form of maps and statistical data is very vital for special planning, management and utilization of land for agriculture, forestry, pasture, urban-industrial, environmental studies, economic production etc [8].

Land use land cover change can be observed from processed aerial photographs and satellite images. Since remote sensed data from the earth orbit can be obtained repeatedly over the

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same area, they have been very useful to monitor and analyze LUCC in various regions of the earth and greatly contribute to planning and management of available resources, especially in the developing countries where other kinds of background data are often lacking**.** Although a number of studies have been conducted on land use and land cover changes, it is still crucial to generate site-specific information on land use/cover dynamics to ensure planning of sustainable and integrated management of the land resources.

Therefore, an attempt was made in the study to examine the application of GIS and remote sensing in mapping land use and land cover change that is taken place connecting from the year 1972 to 2014 and analyze the LULC changes by considering the major political and policy reforms from 1970s.

OBJECTIVES OF THE STUDY: The main objective of this study is to examine temporal changes in Land Use and Land Cover in Kilite Awulalo Woreda, Eastern Tigray Zone between 1972 and 2014 by using Remote sensing and GIS tool.

A. Quantify and map the LULC change using satellite image classifications
B. Analyze the LULC changes by considering the major political and policy reforms from 1970s.

2) SITE DESCRIPTION (LOCATION)

The study area is located in Tigray region; north part of Ethiopia within the geographical grid coordinates of 13°33'37.618"N to 13°57'29.447"N latitude and 39°18'8.606"E - 39°41'44.647"E longitude.

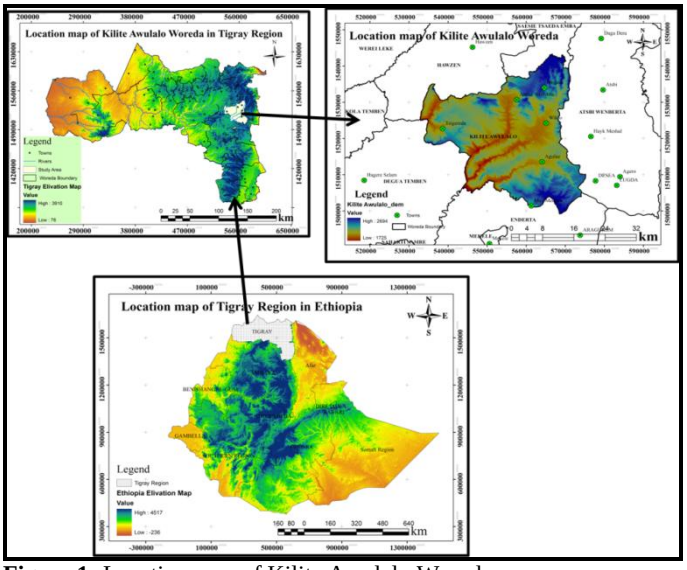


Figure 1: Location map of Kilite Awulalo Woreda

The altitude of study area varies from 1725 m (msl) at the western and central part to 2694 m (msl) at north eastern and south eastern part of the area.

3) MATERIALS AND METHODS

Satellite images used for present work are shown in **Table 1**.

Methods of data analysis: Four LANDSAT Satellite imagery covering the period 1972 (Landsat-1 MSS); 1984 (Landsat-5 TM); 2000 (Landsat-7 ETM+) and 2014 (Landsat-8 OLI_TIRS) were used. For the study of LULC, Ground Control Points (GCP‘s) were identified before interpretation of the satellite images. At each GCP location, GPS measurements were taken during a field work so as to verify and confirm the information gathered through remote sensing. The steps involved in this study has presented in figure 2.

Bands 4, 3 and 2 of Landsat MSS, TM and ETM+ were combined to make false-colour composite images while Bands 3, 2 and 1 were combined to make true-colour composite images. However, Bands 5, 4 and 3 could be combined to make false-colour composite images and Bands 4, 3 and 2 could be combined to make true-colour composite images for Landsat image 8.

Following Software were used the data processing and analysis.

a) Arc GIS 10.1 for preparation of vectorization of project area and data base generation
b) Erdas Imagine 13 for image classification
c) Google Earth to create KML files
d) Quantum GIS 2.6 for image processing

Statistical Package for Social Sciences (SPSS) & MS Excel

4) RESULTS AND DISCUSSION

Based on the prior knowledge collected from the peoples who lived in the study area and through observation of the current situation a classification scheme was developed for the study area. Using the application of image classification methods, five major land uses and land cover types were identified in Kilite Awulalo woredat. These include forest, shrub/bush, agricultural land, rock/bare land and settlement based on the characteristics of Landsat satellite images of the year 1972, 1984, 2000 and 2014.

4.1. Land Use Land Cover Classification

4.1.1. Land Use Land Cover Classification for 1972: The study area has been categorized to five land use land cover categories, which were: Agriculture, Bush land, Forest, Rocky and Settlement. The land use land cover classification for 1972 from MSS satellite image (table 3) showed that majority of the study area was covered by bush land 58007.88 hectares (ha), contributes 57.23699 % of the total area. Forest land and agriculture land cover an aerial size of 19968.48 ha (19.7 %) and 13138.92 ha (12.96431 %) respectively, whereas the aerial coverage of Rocky/Bare and Settlement land is 9747.72 ha (9.618179%) and 483.84 ha (0.47741%) from the total area of the Woreda. This shows that 76.9401% of the total area of the district was covered by bush land and forest land in 1972 and the remaining 23.0599% was covered by agricultural, Rocky/Bare and Settlement, which indicates that much of the area was covered by green vegetation in 1972.

4.1.2. Land Use Land Cover Classification for 1984: The land use land cover classification for 1984 from TM satellite image (table 3) showed that the greatest share of land use/land cover from all classes is bush land, which covers an area of 47900.79 ha (47.26 %). Forest land and agriculture land cover an aerial size of 21706.65 ha (21.42 %) and 20856.78 ha (20.58%) respectively, whereas the aerial coverage of Rocky/Bare and Settlement land is 9675.81ha (9.55%) and 1206.09 ha (1.19%) from the total area of the Woreda. There is decline of 10% bush land and converted to agricultural land because of rapid population growth in the study area. In addition to this, there was also an increase of forest and settlement from 1972 to 1984 but there is no significant change in Rocky/Bare lands (**Table 3)**.

4.1.3. Land Use Land Cover Classification for 2000

The land use land cover classification for 2000 from ETM+ satellite image (table 3) showed that even though bush land is declined from 1972 to 1984 to 2000, the greatest share of land use/land cover from all classes is still bush land, which covers an area of 45000.10ha (44.402371%). Forest land and agriculture land cover an aerial size of 12065.70 ha (11.905414%) and 23000.09 ha (22.694594%) respectively, whereas the aerial coverage of Rocky/Bare and Settlement land is 19500.81 ha (19.241774%) and 1761.8550 ha (1.74%) from the total area of the Woreda. There is decline of 9.51459% and 2.8576310 % bush land and forest land and converted to agricultural land and others like settlement, Rocky/Bare and artificial water. In other words, there was an increase of Agriculture, Settlement and Rocky/Bare lands from 1972 to 1984 (**Table 3**).

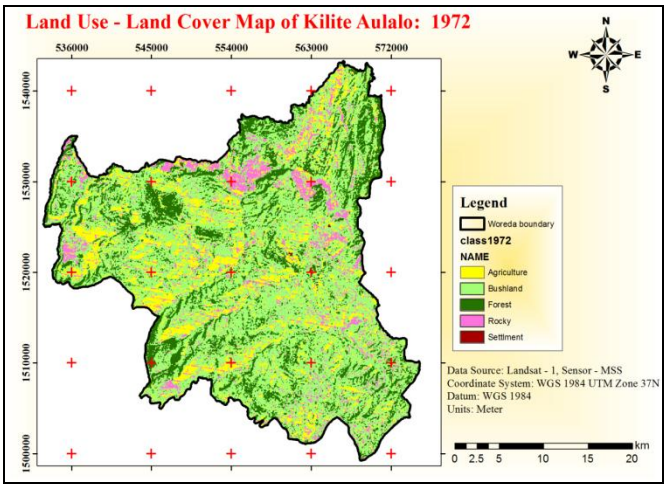


Figure 3: Land use and land cover map of the Kilite Awulalo in 1972.

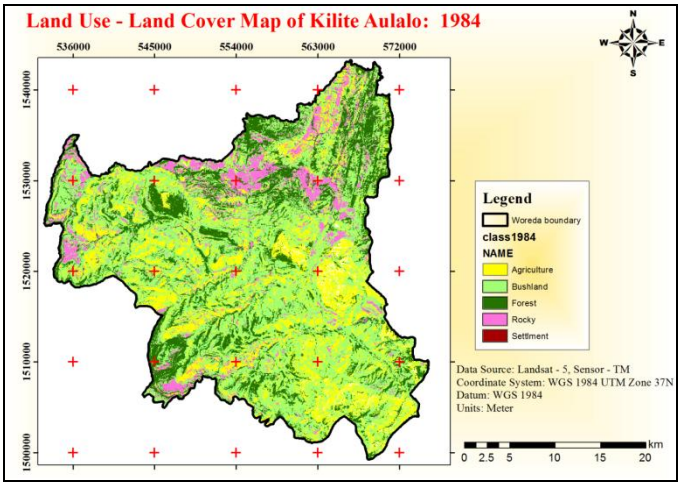


Figure 4: Land use and land cover map of the Kilite Awulalo in 1984.

4.1.4. Land Use Land Cover Classification for 2014

The study area has been defined to have six land use land cover categories, which were: Agriculture, Bush land, Forest, Rocky, water and Settlement. The land use land cover classification for 2014 from OLI_IRS satellite image (table 3) showed that majority of the study area was still covered by bush land 40573.53 hectares (ha), contributes 40.03% of the total area. Forest land and agriculture land cover an aerial size of 11916.4 ha (11.76 %) and 30402.27 ha (30 %) respectively, whereas the aerial coverage of Rocky/Bare and Settlement land is 13974.39 ha (13.78%) and 4461.48 ha (4.41%) from the total area of the Woreda. There are also artificial waters which covers 1.79 %. There is decline of forest, bush land and Rocky/Bare from 2004 to 2014 and increasing of agricultural land, settlement and artificial waters from 2000 to 2014 (**Table 3**).

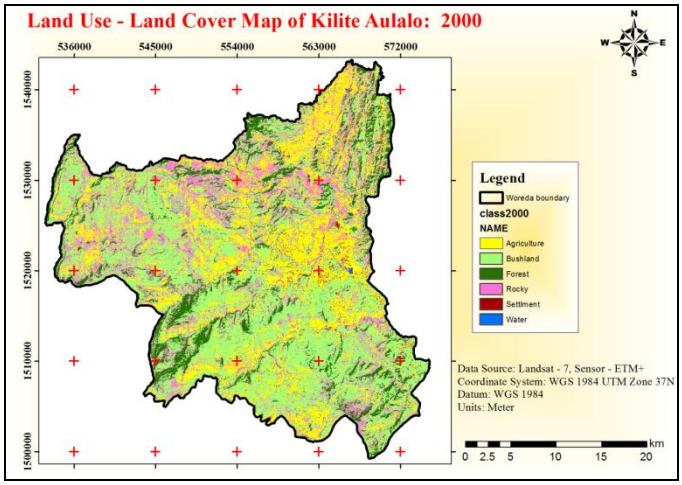


Figure 5: Land use and land cover map of the Kilite Awulalo in 2000.

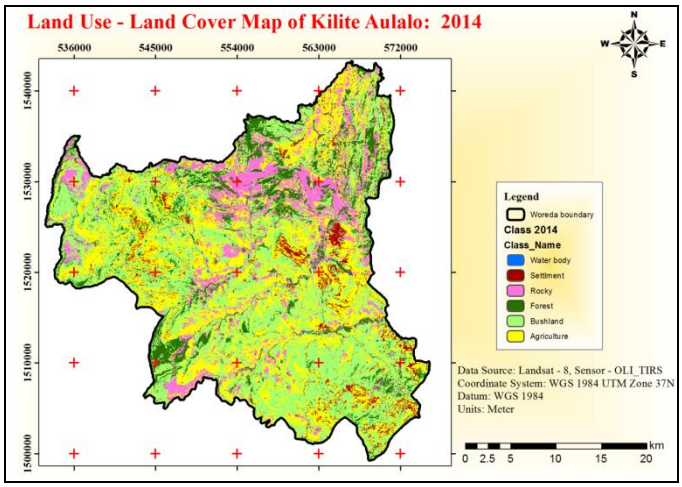


Figure 6: Land use and land cover map of the Kilite Awulalo in 2014.

4.2. Land use and land cover change detection

4.2.1. Land use/Land cover change in the area (1972-1984): The few policies that existed to stop the accelerating rate of land degradation were poorly enacted because institutions involved in land-related policies changed frequently. Three different governments have been in power in Ethiopia since 1972, and the policies implemented by each have directly affected land use. Before 1974, the relationship between land users and owners was based on a feudal system [14]. under which the ownership of land was limited to a few individuals, and most inhabitants could access farmland only through sharecropping. The population density was relatively low, and fallow land was common. After the downfall of the empirical regime, the military government called Derg took power and there was a significant change in the land use types among different land use categories. The period from 1972-1984 is the closing period of empirical regime and most of the Derg regime. As change detection is depicted in the table forest land is somewhat increase. This is due to the fact Derg has given more emphasis to mountain plantation program, and hence

most highlands were covered by vegetation. Since there was plantation program mainly in mountainous areas, the proportion of rocky/bare lands decreased during these periods, this may also be true for the case of Klite Awlalo. In addition this due to the increasing trend of population growth, there was extension of farmlands/ Agricultural lands through ploughing of Bush lands. In relation to population growth additional land for settlement was needed, hence Settlement towards bush lands and forests, and digging land/ holes for finding additional source of water /artificial lakes. As a result the two land use types (bush lands and forest lands artificial lake) had shown a declining inclination. Due to the above reasons water/artificial lake has shown not increasing rather launching tendency. Since the period was towards end of military government there was instability and drought and famine have led to the displacement or death of millions of

Table 2: Description of each land use land cover type in the study area.

No	Land use and Land cover classes	Description of each land use class
1	Forest	Areas covered by trees forming closed or nearly closed canopies; Forest; Plantation forest
2	Bush land	Land covered by small trees, bushes, and shrubs, in some cases mixed with grasses; less dense than forests
3	Agriculture	Areas currently under crop, fallow or land under preparation for agriculture.
4	Settlement	Land being used for settlement/ urban land
5	Rocky/Bare	Land covered by bare soil and exposed rocks.
6	Water/artificial lake	Lakes and ponds (natural or artificial)

Table 3: LU/LC classes, their corresponding areas for 1972, 1984, 2000 and 2014

Land use/land cover Categories	1972		1984		2000		2014	
	Area (Ha.)	**Area (%)**	**Area (Ha.)**	**Area (%)**	**Area (Ha.)**	**Area (%)**	**Area (Ha.)**	**Area (%)**
Forest	19968.48	19.70311	21706.65	21.42	12065.70	11.905414	11916.4	11.76
Bush land	58007.88	57.23699	47900.79	47.26	45000.10	44.402371	40573.53	40.03
Agriculture	13138.92	12.96431	20856.78	20.58	23000.09	22.694594	30402.27	30.00
Settlement	483.84	0.47741	1206.09	1.19	1761.8550	1.74	4461.48	4.41
Rocky/Bare	9747.72	9.618179	9675.81	9.55	19500.81	19.241774	13974.39	13.78
Water/ artificial lake	----	----	----	----	17.627545	0.017	18.09	1.79
TOTAL	101346.84	100	101346.12	100	101346.12	100	101346.12	100

Table 4: Land use land cover change detection from 1972 to 2014

LULC Categories	**Change Detection (1984-1972**		**Change Detection in (Hectares and percentage) (2000 - 1984)**		**Change Detection in (Hectares and percentage) (2014 - 2000)**	
	Area (Ha.)	**Area (Ha.)**	**Area (Ha.)**	**Area (Ha.)**	**Area (Ha.)**	**Area (%)**
Forest	+ 1738.17	-9640.95	-149.3	-149.3	-149.3	-0.14541
Bush land	-10107.1	-2900.69	-4426.57	-4426.57	-4426.57	-4.37237
Agriculture	+ 7717.86	+ 2143.31	+ 7402.18	+ 7402.18	+ 7402.18	+ 7.30540
Settlement	+ 722.25	+ 555.765	+ 2699.62	+ 2699.62	+ 2699.62	+ 2.67
Rocky/Bare	-71.91	+ 9825	-5526.42	-5526.42	-5526.42	-5.46177
Water	----	17.627545	+ 0.46245	+ 0.46245	+ 0.46245	+ 1.773

land show an increasing trend.

4.2.2. Land use/Land cover change in the area (1984 - 2000): The period from 1984 -2000 is the second half of the era of Derg, and hence most of the land use changes are results of policies and proclamations as well as Steady population changes during the military government. As it can be observed from statistics, there was an increasing trend of population number, hence Population pressure had paramount consequences on the environment and resources and life of human being. Hence, there was a shortage of agricultural and settlement land as well as additional water source was needed due to drought. The response for this pressure was expansion Ethiopian citizens, there was no conservation of uplands. As a result more lands were changed to rocky/bare lands [9, 10].

4.2.3. Land use/Land cover change in the area (2000 - 2014): In the time period from 2000 to 2014 the change detection shows that there is an increase in area coverage/proportion of Agriculture, Settlement, and Water/artificial lake; and there is a decline of Forest, Bush land and Rocky/Bare land areal coverage. When we see the contributing factors for this land use land cover change, population pressure takes the leading share.

The population of Ethiopia in general and Tigray state in particular is growing rapidly. In the first place, growing

number of population increases the demand for additional cultivable land. Farmers have no option other than cultivating forest areas and bush lands. Secondly, when population pressure increases there is a demand for settlements. This has a two way effect on the environment. On one hand there is a need for settlement area through burning of bush lands, and on the other hand there is a need for housing construction material particularly wood, and hence farmers cut trees. Thirdly, Population growth ***creases demand for biomass as a source of fuel, leading to deforestation.*** Fourthly, when population pressure increases there is a demand for additional source of water. This is mainly due to the fact that the land is degraded and farmers have large live stock population, and hence water for animals drink is needed. Since there is rainfall scarcity, the state has given more emphasis for irrigational agriculture which needs plenty of water. Hence the government intensifies digging of water holes/artificial lakes. From the above discussion we can conclude that population pressure in Tigray state particularly in the study area results in an increase of proportion of *agricultural land, settlement areas* artificial lakes. On the other hand since the land is limited resource enhancement of the above land use types resulted in the decline of forest and bush lands [9, 10, 11]. It is the Policy of the EPRDF government to give emphasis for soil and water conservation activities specially on hill areas of the country. In Tigray state that since the early 1980's soil and water conservation activities have become one of the major preoccupations of the people and the authorities. This has involved mass mobilization of labor during the dry season, as well as food-for-work and cash-for-work programmes. Originally every dry season, for four months, the farmers in Tigray state were mobilized to treat catchments by building stone bunds over entire catchments, starting with higher level fields. This required the equivalent of 2.5 to 5 months of part-time work per hectare of terracing work for a farmer and his family if tools were supplied. Each family was expected to give 90–180 man-days per year spread over 90–120 days of the year [11]. This had a serious cost implication to the household. After critical assessment, the present EPRDF government substantially reduced the number of days allocated for "voluntary" unpaid involvement in soil and water conservation activities, to twenty days. Food-for-work and cash-for-work programmes are used to mobilize additional labor for such activities.

The conservation strategy focuses mainly on the construction of physical structures, depending on the topography and land use pattern. For steep uncultivated lands, contour stone bunds, cut-off ditches and contour furrows are used. For cultivated lands, contour stone bunds, soil bunds, or grass strips, complemented by check dams for gully control are used. To complement these physical structures, biological measures, such as tree planting and enclosures for natural regeneration are used Since 2001/2002 about 600,000 ha of land has been terraced and 4,600 km of gullies treated. An average of 7–8 million person-days/year of labor was utilized [9, 10, 12, 13]. As a result of this the percentage/coverage of rocky/bare lands in the study area decreases.

5) CONCLUSIONS

The results of this study showed that there was a change in land use land cover from the year 1972 to 2014 in Kilte Awlalo Destrict of Tigray State. The change detection clearly depicts that agricultural land routinely increased throughout the periods might be due to increasing trend of population growth. The need for settlement land is another issue related with population pressure. Hence, it has resulted in reduction of forests and bush lands. Water/artificial lake from the beginning were not there but due to the above episode, that is the establishment of new settlements and expansion of agricultural lands there was a need for having additional water sources which we can call artificial lakes. Hence, it becomes the government's policy option to expand artificial water sources for home consumption as well as for agricultural use. Regarding rocky/bare lands, population increment resulted in cultivation of uncultivable lands. As a result they showed increasing trend for some times, however, the government had planned to protect the environment through research based soil water conservation strategies and hence resulted in reduction of bare land.

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