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GOVERNMENTS POLICY REFORMS FROM 1970S ONWARD AND IT'S IMPLICATIONS ON LAND USE AND LAND COVER WITH THE HELP OF GIS AND RS TECHNIQUES IN EASTERN TIGRAY, ETHIOPIA

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ABSTRACT

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. To do this, the studies analyze the LULC changes by considering the major political and policy reforms from 1970s. For this study, four LANDSAT images covering over a period of 1972 (Landsat-1 MSS); 1984 (Landsat-5 TM); 2000 (Landsat-7 ETM+) and 2014 (Landsat-8 OLI_TIRS) was used and analyzed using Arc GIS 10.1 and Erdas Imagine 13. Supervised classification system was used to classify the images of different land use categories. Generally Farm land, Settlement land, Grazing land, Forest land, Bush land, Water bodies and Bare/stony land was identified. The result shows that there is decreasing of Bush land from the year 1972 to 2014 and forest land from the year 1984 to 2014. And there was increasing of Agriculture and settlement from the year 1972 to 2014.

Keywords: Policies, Landsat MSS, TM, ETM+, OLI_TIRS, Land use/land cover, GIS, RS.

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Contribution/ Originality

This study contributes in the existing literature for the contribution of government policy reforms from 1970s on land use land cover. This study is important to understand government policy reforms on natural resource management in general and land cover change in particular.

1. INTRODUCTION

Ethiopia is one of the most well endowed countries in Sub-Saharan Africa in terms of natural resources including fauna and flora. However, the country faces different problems in relation to

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natural resource management. From this, soil erosion is one of the most serious environmental problems (Million and Kassa, 2004; Gete, 2010). The major causes of soil erosion are associated with various factors. Some of these factors are: low adoption of introduced SWC technologies due to the benefits are too long term, the increasing of population, institutions and policy issues (Gizachew, 1994; Gizaw *et al*., 2009). The causes of soil erosion is also related to surface run-off draining to neighboring countries by transboundary rivers (EPA, 1998) in this Ethiopia is 'the country largest export' to Egypt (Woldeamlak, 2003) land cover change (Woldeamlak, 2002; Eric *et al*., 2003; Haile and Assefa, 2012) civilization expansion into new areas for better soil (Hurni, 1988), Land degradation was largely neglected by policymakers until the 1970s (Genanew and Alemu, 2010) and by the components of climate (such as rainfall and wind) (Bezuayehu *et al*., 2002). In the 21st century, global environmental changes are increasingly on top of the international scientific and political agenda (Efrem, 2010) in doing of this, the Ethiopian government and international donors have initiated a number of programs that promote yield-enhancing and dissemination of soil and water conservation technologies (Mahmud and Kohlin, 2009). According to Zenebe (2009) there are three categories of SWC extension program in Ethiopia, i.e. the 1957- 1968 (emphasized industrialization and large scale commercial farming), between 1968 and 1991 (small scale farming and focused only physical SWC activities) and post-1991(a number of strategies was applied such as ADLI, food security strategy, poverty reduction strategy, natural resource conservation strategy, resettlement policy).

In due course, the national SWC and afforestation efforts were induced in response to the 1972/73 drought and its consequences through Food-For-Work (FFW) incentive (Woldeamlak, 2003). The main conservation activities were (1) farmland bunding (terracing), (2) afforestation and reafforestation programme, (3) area closure and (4) gully control (EEA/EEPRI, 2002). For the afforestation programme, *Eucalyptus* species became the centre of endeavor throughout large-scale plantation schemes in the country: commonly quite extensively in Gojjam area (Feyera *et al*., 2010). The efforts make in to practices in soil conservation was started since the 1970s and 1980s through Food-For-Work payments for motivating farmers (Abera, 2003; Ludi, 2004) and supported by donor and non-governmental organizations in areas where the problem of soil erosion is destructive and food deficit is widespread (Bekele and Holden, 1998; Gete, 2010). From the year 1971- 1993, a massive soil conservation programme was launched in Ethiopia through FFW incentive. During this period, 15% of the Ethiopian highlands that required conservation efforts were covered (Hurni, 1988). In terms of physical works: about 600 km of earth and stone bunds were constructed on cultivated lands; about 300,000 km of hillside bunds were built for the afforestation of steep slopes; about 100,000 hectare of hilly land were closed for regeneration of natural vegetation; thousands of tree seedlings were raised in nurseries and transplanted on the afforestation sites and thousands of check dams have been constructed in gullies (Hurni, 1988).

Alemayehu and Arnalds (2011) 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.

1.1. Statement of the Problem

The study of Land use/cover pattern is providing information for managing dynamics of land use and meeting the demands of increasing human population (Yadav *et al*., 2010). 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 (Roy and Giriraj, 2008).

Therefore, this study was intended 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 by considering the major political and policy reforms from 1970s.

1.2. Objectives of the Study

1.2.1. Main (General) Objective of the Study

The main objective of this study is to examine the Implication of Policy Reforms from 1970s on Land Use and Land Cover Change analysis in Kilite Awulalo District, Eastern Tigray Zone, Ethiopia.

1.3. Specific Objectives of the Study

1.3.1. The Specific Objectives of this Study are to

A. Analyze the LULC changes by considering the major 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. The District is bounded with Saesie Tsaedaemba District in the north, Hawzen District in the North West, Enderta District in the south, Degua Temben District in the South West and Atsbi wenberta District in the East.

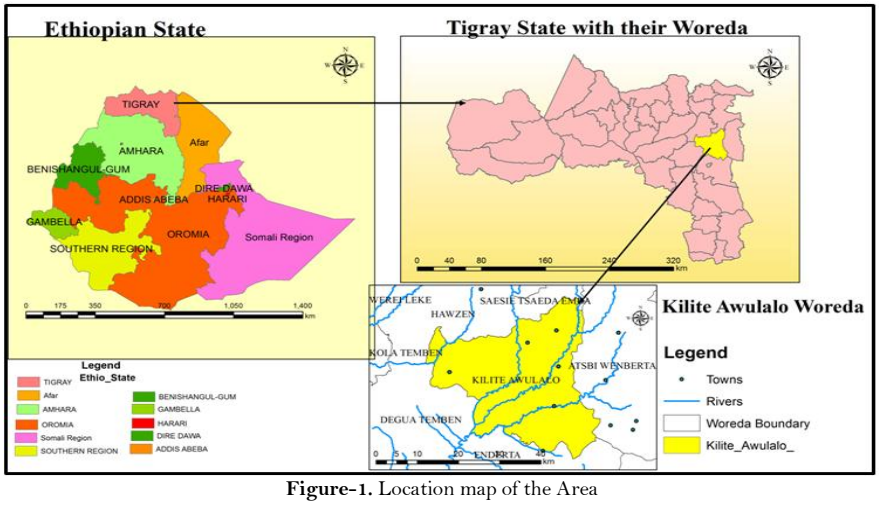


Figure-1. Location map of the Area

3. MATERIALS AND METHODS

Table-1. Source and Satellite Images data collection processing

Satellite/ craft_ID	Sensor ID	Path/row	Date of acquisition	Spatial resolution/ Cell Size (m)	Sun Elevation	Cloud Cover
Landsat-1	MSS	181/050	1972-11-02	60M	50.860	-1
Landsat-5	TM	169/050	1984-11-22	30m	46.140	-1
Landsat-7	ETM+	168/050	2000-02-05	30m	47.3496	0
		168/051	2000-02-05	30m	48.1988	0
		169/050	2000-01-27	30m	45.8008	0
Landsat-8	OLI_TIRS	168/50	2014-03-07	30m	56.46464	0.60
		168/51	2014-03-23	30m	61.10639	3.90
		169/50	2014-03-30	30m	62.39484	0.48

For the study of LULC, Ground Control Points (GCP's) were identified before interpretation of the satellite images. For this study supervised image classification was done**.** Which means, the analysts trains the computer to recognize patterns in the data by selecting pixels that represents patterns or land cover features that recognizes, the signature files thus created are then used in the classification process where each pixel is categorized into the land cover class it mostly resembles.

Coefficient of variation (CV) was used to measure the reliability of the experiment. The theoretical framework is that if an attempt is made to compare two experiments based on mean value then the comparison may be biased since measurements may be done on same scale. On the other hand if variance is used for comparison, experience showed that variance is highly related to mean and if mean is large variance tends to be large invalidating the comparison. Therefore, to compare two similar experiments, a ratio of variance by mean is selected as this quantity has no unit of measurement and since it remains constant throughout.

$$\text{Coefficient of variation (CV)} = \frac{Standard\ Deviation}{Mean} * 100 \quad (1)$$

3.1. Software Used

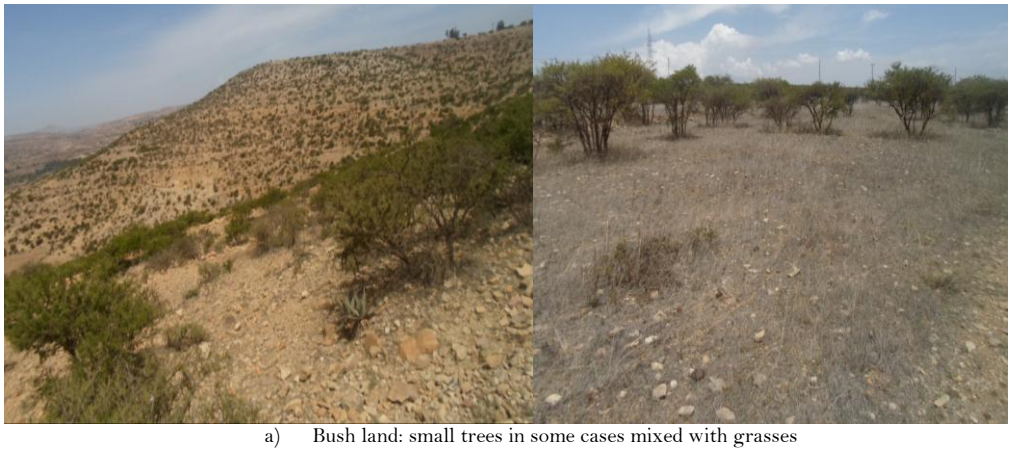
Certain parameters/algorithms of the following software would be used for the processing and/or analysis of data/images.

- **a)** Arc GIS 10.1: Preparation of Location of the project area, Data base generation and for Image classification
- **b)** Quantum GIS 2.6 for changing DN values to reflectance

4. RESULTS AND DISCUSSION

Based on the priori knowledge of the peoples those lived in the study area and through observation and image classification methods, five major land uses and land cover types were identified in Kilite Awulalo District. 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.



a) Bush land: small trees in some cases mixed with grasses

b) Water

c) Rocky/Bare land

d) Settlement and Forest

e) Agriculture

Figure-2. Photograph, land uses and land cover types of the study area (a- e Taken in 2014)

4.1. Land Use Land Cover Classification

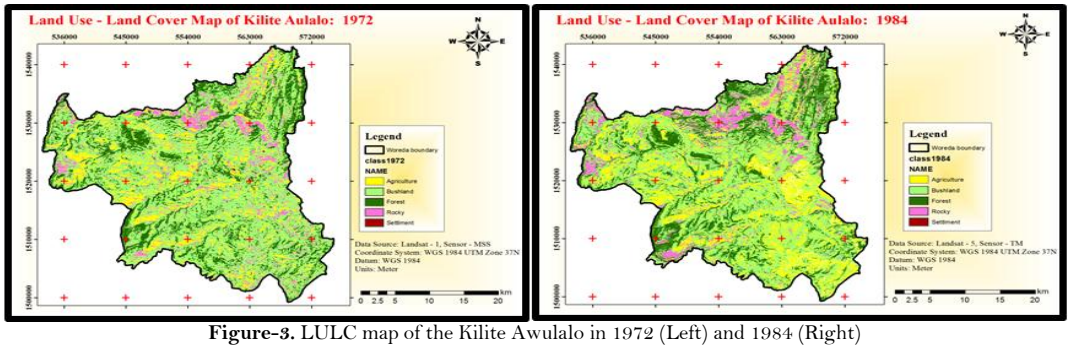


Figure-3. LULC map of the Kilite Awulalo in 1972 (Left) and 1984 (Right)

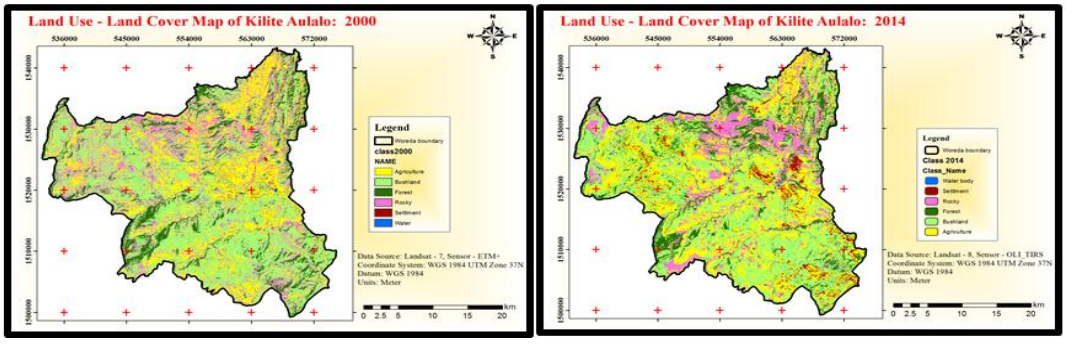
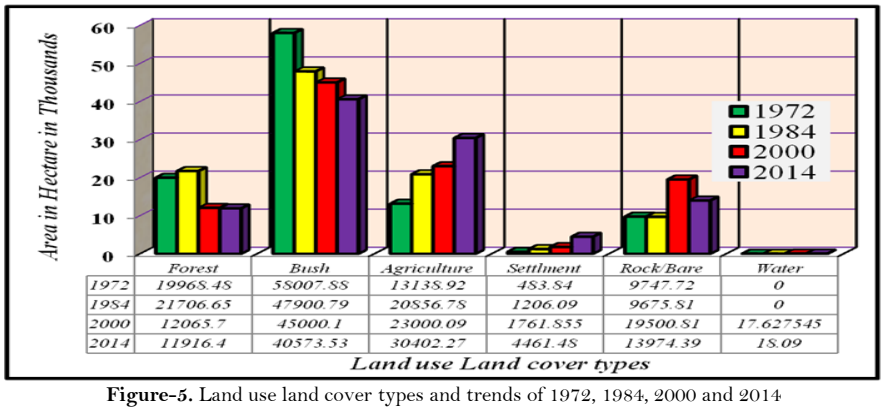


Figure-4. LULC map of the Kilite Awulalo in 2000 (Left) and 2014 (Right)



	Forest	Bush	Agriculture	Settlment	Rock/Bare	Water
1972	19965.45	58007.55	13138.92	483.84	9747.72	0
1984	21706.65	47900.79	20856.78	1206.09	9675.81	0
2000	12065.7	45000.1	23000.09	1761.855	19500.81	17.627545
2014	11916.4	40573.53	30402.27	4461.48	13974.39	18.09

Figure-5. Land use land cover types and trends of 1972, 1984, 2000 and 2014

4.2. The Implication of Policy Reforms for Land Use Land Cover Change for Different Years

4.2.1. Land Use/Land Cover Change in the Area (1972-1984)

Three different governments have been in power in Ethiopia since 1972, and there policies implemented by each have directly affected on land management system in general and land use land cover in particular. Before 1974, the relationship between land users and owners was based on a ***feudal system*** under which the ownership of land was limited to a few individuals or land

lords, and most inhabitants could access farmland only through sharecropping. 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 (Figure 5) forest land is somewhat increase from 1972 to 1984. This is due to the fact that Derg has given more emphasis to mountain plantation program (afforestation and reafforestation), 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 Kilite Awulalo. In addition to this due to the increasing trend of population growth, there was extension of agricultural lands through plowing of Bush lands. In relation to population growth additional land for settlement was needed, hence settlement land (Figure 5) show an increasing trend from the year 1972 to 1984.

Table-2. For mapping and monitoring land use land change unique values

No		1972 value	1984 value
1	Building/Settlement	**1**	**25**
2	Green area/Forest	**2**	**5**
3	Bush land	**3**	**10**
4	Rocky/Bare land	**4**	**15**
5	Agriculture	**5**	**20**

Source: Study

Table-3. Land use land cover change

	Land use changed to	Value 1984	values 1972	New values Change (1984 - 1972)	Explanation
1	Building or Settlement	25	1	24	Settlement to Settlement
		25	2	23	Settlement to Forest
		25	3	22	Settlement to Bush land
		25	4	21	Settlement to Rocky
		25	5	20	Settlement to Agriculture
2	Green area or Forest	5	1	4	Forest to Settlement
		5	2	3	Forest to Forest
		5	3	2	Forest to Bush land
		5	4	1	Forest to Rocky
		5	5	0	Forest to Agriculture
3	Bush land	10	1	9	Bush land to Settlement
		10	2	8	Bush land to Forest
		10	3	7	Bush land to Bush land
		10	4	6	Bush land to Rocky
		10	5	5	Bush land to Agriculture
4	Rocky	15	1	14	Rocky to Settlement
		15	2	13	Rocky to Forest
		15	3	12	Rocky to Bush land
		15	4	11	Rocky to Rocky
		15	5	10	Rocky to Agriculture
5	Agriculture	20	1	19	Agriculture to Settlement
		20	2	18	Agriculture to Forest
		20	3	17	Agriculture to Bush land
		20	4	16	Agriculture to Rocky
		20	5	15	Agriculture to Agriculture

Source: Study

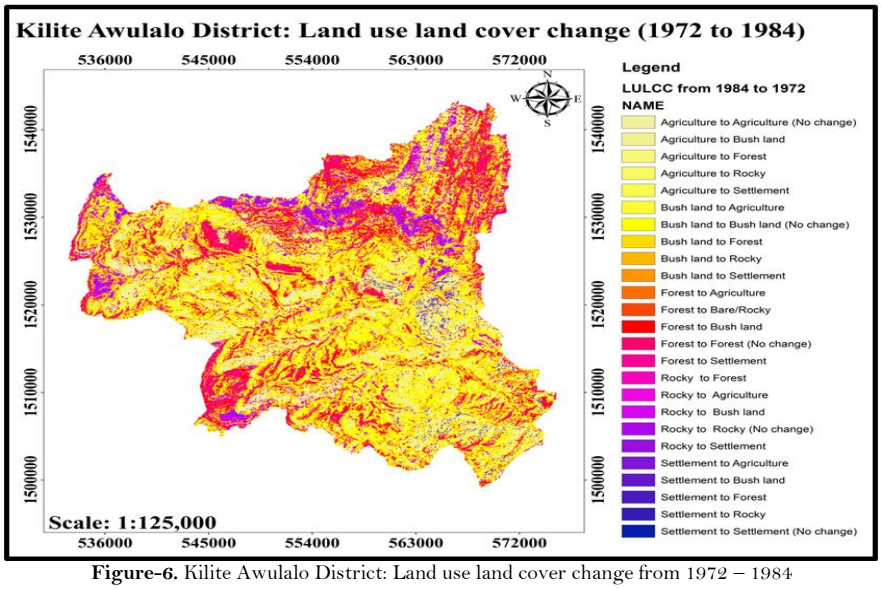


Figure-6. Kilite Awulalo District: Land use land cover change from 1972 – 1984

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 military government (Derg), and hence most of the land use land cover changes are results of policies and proclamations changes. As it can be observed from result (fig. 5), there was an increasing trend of population number and hence resulted 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 towards bush lands and forests. As a result the bush and forest lands had shown a declining from 1972 to 1984. 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 Ethiopian citizens, there was no conservation of uplands and which resulted more lands were changed to rocky/bare lands (Selome and Assefa, 2010).

4.2.3. Land Use/Land Cover Change in the Area (2000 - 2014)

From the year 2000 to 2014, there is an increase of agriculture, settlement, and water/artificial lake; and there is a decline of forest, bush land and rocky/bare land areal coverage (fig. 5), the contributing factors for this land use land cover change is population pressure. The population of Ethiopia in general and Tigray state in particular is growing rapidly from year to year. When population pressure increases, they need more land and resulting agricultural expansion. From fig. 5 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 (Selome and Assefa, 2010).

The Policy of present government is gives more emphasis for soil and water conservation activities especially on hill areas in the highland parts of Ethiopia. To do this there is mass mobilization soil and water conservation in the dry season through free labor workers 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.

The soil and water conservation strategies in the highland parts of Ethiopia were mainly focuses on the construction of physical structures depending on the topography and land use pattern. For steep and 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. As a result of this, the coverage of rocky/bare lands in the study area decreases from the year 2000 to 2014 (Central Statistical Agency [Ethiopia] (CSA), 2007; Ministry of Finance and Economic Development (MoFED), 2010; Selome and Assefa, 2010).

Table-4. For mapping and monitoring land use land change unique values

No		2000 value	2014 value
1	Building/Settlement	**1**	**25**
2	Green area/Forest	**2**	**5**
3	Bush land	**3**	**10**
4	Rocky/Bare land	**4**	**15**
5	Agriculture	**5**	**20**

Source: Study

Table-5. Land use land cover change

	Land use changed to	Value 2014	Value 2000	New values Change (2014 - 2000)	Explanation
1	Building or Settlement	25	1	24	Settlement to Settlement
		25	2	23	Settlement to Forest
		25	3	22	Settlement to Bush land
		25	4	21	Settlement to Rocky
		25	5	20	Settlement to Agriculture
2	Green area or Forest	5	1	4	Forest to Settlement
		5	2	3	Forest to Forest
		5	3	2	Forest to Bush land
		5	4	1	Forest to Rocky
		5	5	0	Forest to Agriculture
3	Bush land	10	1	9	Bush land to Settlement
		10	2	8	Bush land to Forest
		10	3	7	Bush land to Bush land
		10	4	6	Bush land to Rocky
		10	5	5	Bush land to Agriculture
4	Rocky	15	1	14	Rocky to Settlement
		15	2	13	Rocky to Forest
		15	3	12	Rocky to Bush land
		15	4	11	Rocky to Rocky
		15	5	10	Rocky to Agriculture
5	Agriculture	20	1	19	Agriculture to Settlement
		20	2	18	Agriculture to Forest
		20	3	17	Agriculture to Bush land
		20	4	16	Agriculture to Rocky
		20	5	15	Agriculture to Agriculture

Source: Study

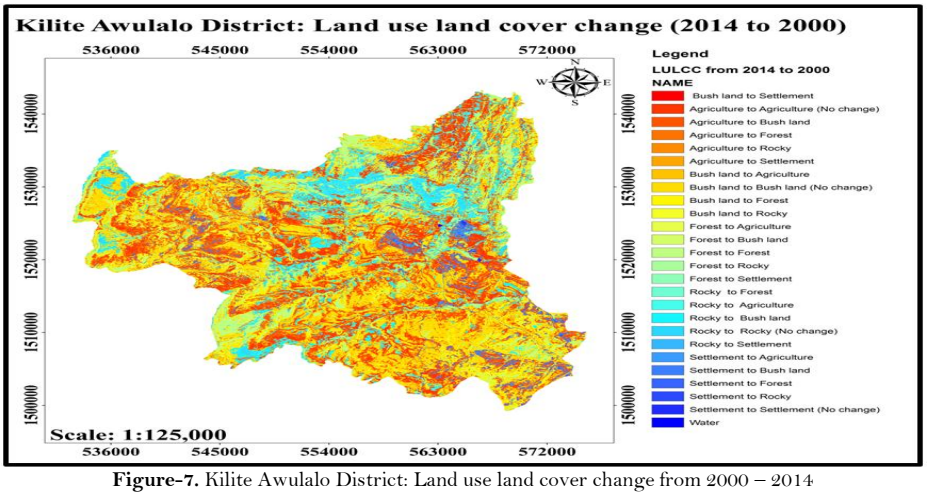


Figure-7. Kilite Awulalo District: Land use land cover change from 2000 – 2014

From table (Table 6) Coefficient of Variance (CV) for each land use land cover is calculated and Settlement have largest Coefficient of Variance (CV) which means the change of Settlement is higher than other land use land cover types which is followed by bare/rocky land, Agriculture land, Forest land, Bush land and water body.

Table-6. Statistics for Land use and land cover change for Kilite Awulalo District

LULC Types	1972 in hectare	1984 in hectare	2000 in hectare	2014 in hectare	Mean or average (M)	Standard deviation	Coefficient of variance
Forest	19968.48	21706.65	12065.7	11916.4	16414.3075	5156.95	31.41744576
Bush land	58007.88	47900.79	45000.1	40573.53	47870.575	7399.37	15.45704727
Agriculture	13138.92	20856.78	23000.09	30402.27	21849.515	7102.42	32.50611052
Settlement	483.84	1206.09	1761.855	4461.48	1978.31625	1736.13	87.75945636
Rocky/Bare	9747.72	9675.81	19500.81	13974.39	13224.6825	4641.68	35.09861807
Water/	----	----	17.627545	18.09	17.8587725	0.32	1.83106127
TOTAL	101346.84	101346.12	101346.12	101346.12			

7. CONCLUSIONS

Satellite image represents a powerful and attractive data that can be used for investigation of land use land cover. From image analysis, the results of this study showed that there was a change in land use land cover in the study area. 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 lands.

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REFERENCES

Abera, B., 2003. Factors influencing the adoption of soil conservation practices in Northwestern Ethiopia: Discussion Paper No. 37. Institute of Rural Development. University of Goettingen.

Alemayehu, M. and O. Arnalds, 2011. Synthesis of research on land use and land cover dynamics in the Ethiopian Highlands. Geophysical Research Abstracts, 13, EGU2011-10829,2011.

Bekele, S. and S. Holden, 1998. A farm household analysis of resource use and conservation decisions of smallholders: An application to Highland farmers in Ethiopia. Discussion Paper No. 3. Department of Economics and Social Science. Agricultural University of Norway.

Bezuayehu, T., A. Gezahegn, A. Yigezu, M.A. Jabbar and D. Paulos, 2002. Nature and causes of land degradation in the Oromiya region: A review of socio-economic and policy research Working Paper No. 36. Nairobi, Kenya: ILRI (International Livestock Research Institute): 82.

Central Statistical Agency [Ethiopia] (CSA), 2007. Statistical abstract 2006. Addis Ababa, Ethiopia: CSA.

EEA/EEPRI, 2002. A research report on land tenure and agricultural development in Ethiopia. Addis Ababa: Ethiopian Economic Association/ Ethiopian Economic Policy Research Institute. pp: 157.

Efrem, G., 2010. Land use and land cover dynamics and rural livelihood perspectives, in the semi-arid areas of central rift valley of Ethiopia. Doctoral Thesis; Swedish University of Agricultural Sciences.

EPA, 1998. National action programme to combat desertification, federal democratic republic of Ethiopia. Addis Ababa: Environmental Protection Authority.

Eric, F., J. Helmut and L. Erika, 2003. Dynamics of land-use and land-cover change in tropical regions. Annual Review of Environmental Resource, 2003(28): 205–241.

Feyera, S., S. Aseffa and W. Tadesse, 2010. Eucalyptus species management, history, status and trends in Ethiopia. Proceedings from the Congress Held in Addis Ababa. September 15th-17th, 2010.

Genanew, B. and M. Alemu, 2010. Investments in land conservation in the Ethiopian Highlands: A household plot-level analysis of the roles of poverty, tenure security, and market incentives. Discussion Paper Series 10-09. Environment for Development (EfD). Ethiopia.

Gete, Z., 2010. A study on mountain externalities in Ethiopia (Final Report). Sustainable Agriculture and Rural Development, Mountain Externalities in Ethiopia. Addis Ababa, Ethiopia.

Gizachew, A., 1994. Rural land issue and policy: Overview. In Dessalegn, Rahamto (Eds). Land tenure and land policy in Ethiopia after the derg. Processing of the Second Workshop of the Land Tenure Project. Working Paper on Ethiopian Development. University of Trondheim. pp: 21-33.

Gizaw, D., A. Klik and H. Hurni, 2009. Assessment of soil erosion and soil conservation practices in Angereb Watershed, Ethiopia: Technological and land user context. Conference on International Research on Food Security, Natural Resource Management and Rural Development. University of Hamburg.

Haile, G. and M. Assefa, 2012. The impact of land use change on the hydrology of the Angereb Watershed, Ethiopia. International Journal of Water Sciences, 1(4): 1-7.

Hurni, H., 1988. Options for conservation of steep lands in subsistence apicultural systems. In Moldenhauer, W. and Hudson, N. (Eds). Conservation farming on steep lands: Soil and water conservation society world association of soil and water conservation Ankeny, Iowa. United States of America (USA). ISBN 0 - 935734.

Ludi, E., 2004. Economic analysis of soil conservation: Case studies from the Highlands of Amhara Regions, Ethiopia. Switzerland: Geographical Bernensia Institute of Geography, University of Berne. A18:416.

Mahmud, Y. and G. Kohlin, 2009. Market imperfections and farm technology adoption decisions - A case study from the Highlands of Ethiopia. Working Papers in Economics No. 403. Sweden: University of Gothenburg.

Million, T. and B. Kassa, 2004. Factors influencing adoption of soil conservation measures in Southern Ethiopia: The case of Gununo area. Journal of Agriculture and Rural Development in the Tropics and Subtropics, 105(1): 49-62.

Ministry of Finance and Economic Development (MoFED), 2010. The federal democratic republic of Ethiopia: Growth and transformation plan (GTP) 2010/11-2014/15 Draft Addis Ababa.

Roy, P.S. and A. Giriraj, 2008. Land use and land cover analysis in Indian context. Journal of Applied Science, 8(8): 1346-1353.

Selome, B. and H. Assefa, 2010. Population dynamics and environment in Ethiopia: Ethiopian Environment Review Published By Forum for Environment Addis Ababa, Ethiopia.

Woldeamlak, B., 2002. Land cover dynamics since the 1950s in Chemoga Watershed, Blue Nile Basin, Ethiopia. Mountain Research and Development, 22(3): 263-269.

Woldeamlak, B., 2003. Towards integrated watershed management in Highland Ethiopia: The Chemoga watershed. Tropical Resource Management Paper No 14 (PhD Thesis). Wageningen University.

Yadav, P., M. Kapoor and K. Sarma, 2010. Land use land cover mapping, change detection and conflict analysis of Nagzira-Navegaon corridor, central India using geospatial technology. International Journal of Remote Sensing and GIS, 1(2): 90-98.

Zenebe, G., 2009. Soil water conservation program in tigray: Processes, technology packages and approach. In Fitsum Hagos, Menale Kassie, Tsehaye Woldegiorgis, Yesuf Mohammednur and Zenebe Gebreegziabher (Eds). Proceedings of Collaborative National Workshop on: Sustainable Land Management Research and Institutionalization of Future Collaborative Research. EEPFE, EDRI, EfD, Mekelle University. pp: 37-50.

BIBLIOGRAPHY

Amare, S., 2013. Population and environment interaction: The case of gilgel abbay catchment, North Western Ethiopia. E3 Journal of Environmental Research and Management, 4(1): 153-162.

Gizaw, D., 2010. Conceptualizing rill erosion as a tool for planning and evaluating soil conservation in Angereb Watershed, Ethiopia: Methodological development. Research Report for Q505 Project Supported by Eastern and Southern Africa Partnership Program (ESAPP). Amhara Region Agricultural Research Institute (ARARI).