Land Use Land Cover Change Detection by Using Remote Sensing Data in Akaki River Basin

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Abstract— *Land use land cover change (LULCC) is the result of the long time process of natural and anthropogenic activities that has been practiced on the land. GIS and remote sensing are the best tools that support to generate the relevant land use/cover change in the basin. This study was conducted in the Akaki River basin to detect land use land cover changes within the 30 years period (1985-2015) by using landsat imagery data acquired from the GCF. Supervised maximum likelihood algorithm classification were deployed to classify land use/cover into four prominent land use groups and data's were processed by using ERDAS imagine 2014 and ArcGIS10.1 software. In the basin dominant LULC was agricultural land use which accounts around 56.28% and the second largest is built-up area by 31.51% and the rest, forest(11.9%) and water body(0.31%) coverage were takes third and fourth position(as 2015 data). The rapid expansion of Addis Ababa city consumes more fertile land near to the city. According to the projected LULCC for 2030 the proportion of agricultural and built-up area near to each other, i.e., agricultural land reduced to 42.33% and urban or built-up area increased to 41.63%. One good thing observed in the basin was an increment of the forest land in between 2011 and 2015 by 23.85% whereas in between 1985 and 2015 the annual rate of change was by 4.2. This may be due to the implementation of green-economy building strategy of the government and other stakeholders to rehabilitate the degraded lands in order to achieve MDG and SDG goals. Urbanization, industrialization, commercial center enlargement and population explosion in the main city Addis Ababa grabs more fertile and productive lands which supports more semi-urban communities. Hence, the government should consider the dramatic and drastic horizontal expansion of the urbanization which resulted due to lack of appropriate master plan for the city and towns in the basin to protect the loss agricultural productive lands.*

Keywords— Akaki River basin, LULCC, GIS, Remote sensing.

I. INTRODUCTION

Land is a mother for every living and non-living entities on the earth. LULCC is the result of the long time process of natural and anthropogenic activities that has been practiced on the land. There are various natural events which alter the LULC such as weather, flooding, climate fluctuation, and fire and ecosystem dynamics (). Daily activities of human being load a great pressure on the land resources availability and usability. Population growth and land demand for settlement, commercial and industrial expansion and its impacts on environment has been a popular issue in the world roundtable debates for the centuries (Mesfin, 2009). Population expansion or growth is the main challenge in the land resources management since it leads to abandoned of land after some years and general land degradation, climate change and socio-economic crisis due to scarcity of resources to satisfy their basic needs (Solaimani et al., 2010). In developing countries like Ethiopia the rapid industrialization and urbanization process is a big challenge

in land use planning. This is due to unexpected expansion of urban centers and lack of proper master plans for the various sectoral land uses. According to UNFPA (2008), the total number of population resides in the towns and cities will make-up 81% in developing countries of the world by 2030. Furthermore, in the case of Ethiopia urban population is expected to grow on average by 3.98% per year and by 2050, about 42.1% of the total population is expected to be inhabited in urban centers (UN-HABITAT, 2007) and among this 23% lives in Addis Ababa whereas other 900 urban centers holds the remaining percent (Lueliseged et al., 2011). This accelerated rate of population extension causes deforestation, degradation, hydrological system disturbances and global climate change. This general environmental deterioration and degradation enhances the socio-economic and political instability.

Hence, to apprehend the severe effects associated with the LULCC the development of sound land use planning is very essential. To do this action the foremost thing is identifying and determining the existing land use land cover and its changing rate or conversion rate from one convenient land use to another over time. Based on the avail data and resources, developing an effective landuse management plan is an easy ways to tackle or overcome the above stated critical problems.

Understanding the changing rate and cover status of the watershed is very paramount important to develop sound policies in order to manage watershed in sustainable basis and appropriate decision-making (Mesfin, 2009). From the areas experiencing with rapid or dynamic land use changing place the prominent one is Akaki river basin where the capital city Addis Ababa incorporated. Detection of land use land cover by the traditional land marking mechanisms or direct field assessment is very boring and consumes more energy, money, time and cumbersome to generate relevant data since the feature of the earth's surface is too complex. Currently satellite remote sensing techniques are in use to increase efficiency in land use determination and reduce cost expense to cover extensive areas land use land cover change. In this project area, Akaki river basin, the rapid and dynamic expansion of Addis Ababa and other small towns have great pressure on the agricultural and forest lands of the surrounding areas. This becomes as a source for conflict and crisis in the some part of the basin areas due to frustration of the community towards brisk land grabbing and the loss of land property ownershipness (Lueliseged et al., 2011). In order to resolve antiquates related with multidimensional land resource issues, an effective determination and evaluation of LULCC rate is very crucial. It has an immense importance in developing sound and effective landuse management and planning and as well develops confidence in policy and decision-makers. This study is a pillar to know the dynamic land use land cover change in the basin by using remote sensing data and contributes its own role in solving the environmental problems due to LULCC.

1.2 Objectives

The main objective of this project is to determine the existing land use land cover change in various years by using remote sensing data.

Specific objectives:

- To identify the land use land cover change of the Akaki River Basin.
- To evaluate the changing pattern of land use land cover over the time/years.
- To develop land use land cover map of the Akaki river basin.
- To determine the trend, rate and magnitude of land use land cover change.
- To generate data on land consumption rate and land absorption coefficient and projecting land uses mainly focus on Addis Ababa city expansion

II. METHODOLOGY

2.1 Description of the study area

Akaki River basin is situated in the Western Ethiopian highlands of the Shewan plateau, and partly in the western margin of the Ethiopian Rift valley floor. It is located on latitude 8^0 45'20'' to 9^0 13'17'' N and 38^0 34' 3''to 39^0 4'10'' with an area of about 1611km^2. Addis Ababa, the capital city of Ethiopia and other small towns are found in this basin. The basin is bounded by Mt. Entoto in the northern, Mt.Yerer in the eastern, Mt.Wochecha in western and Mt.Furi in the southern parts. Akaki river basin covers an area of 1611.73km^2 and with an altitude in the range from 2040 to 3,200m above sea level (Abdulshikur, 2007; Ebisa, 2006)

Climatic feature of the area is categorized into the warm temperate with a mean annual temperature of 16.32^{0}C and the mean annual rainfall of 1100.5mm. Even though the land use and land cover was diverse enough, the area is generally categorized into four landuse land cover classes: forest, urban or built-up areas, agricultural or open lands and water body as according to BCEOM- Seureca (2000).

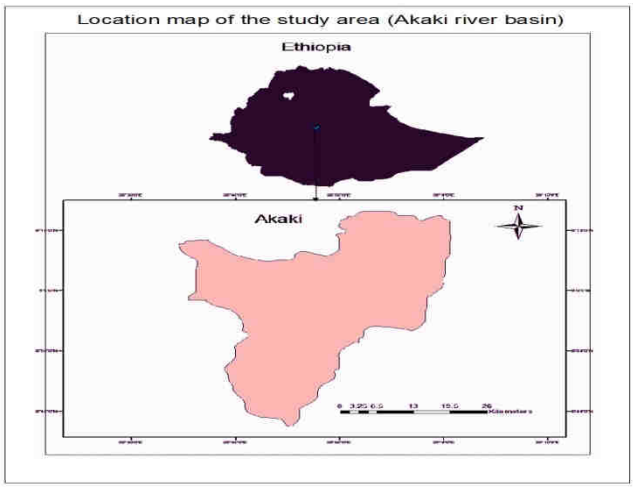


Fig.1: Location map of the study area (Akaki river basin)

2.2 Methods of data acquisition, processing and analysis

In order to assess the land use land cover change dynamics in the basin, Landsat-TM and Landsat-MSS images taken in 1985, 2011, and 2015 were accessed and downloaded from NASA's Global Land Cover Facility (GLCF). The shapefile of the Akaki River basin were drawn from the topographic map of Ethiopia. As part of pre-processing georeferencing, radiometric calibration, atmospheric and radiometric rectification were conducted to reduce misapprehension and to increase the real area feature visibility (Solaimani et al., 2010).

To classify the land use land cover two types of classification methods are most widely deployed in different investigations which are supervised and unsupervised classification systems (ERDAS Imagine, 2014). For this study supervised classification was selected due to it enables researchers to specify the parameters based on their priori knowledge of the area. Hence, conventional supervised Maximum Likelihood Classification Alogorithm was used to extract information from the satellite data and image analysis were carried out to detect the change in the basin. The interface in change of image from the 1985, 2011 and 2015 land use land cover were compared by using ERDAS imagine and ArcGIS software. The satellite image was processed and classified by using ERDAS imagine and other map finalizing activities were done by deploying ArcGIS software.

On the other hand the classification of the existing land use land cover data land consumption rate and absorption coefficient were developed for the capital city Addis Ababa by using the following empirical formula:

$$L.C.R = \frac{A}{P}$$ Where, A = areal extent of the city in hectares P = population

$$L.A.R = \frac{A_2 - A_1}{P_2 - P_1}$$

Where A_1 and A_2 are the areal extents (in hectares) for the early and later years, and P_1 and P_2 are population figure for the early and later years respectively (Yeates and Garner, 1976)

L.C.R = A measure of compactness which indicates a progressive spatial expansion of a city.

L.A.C = A measure of change in consumption of new urban land by each unit increase in urban population

The number of Addis Ababa city population was projected by using the central consensus agency data of the 2010 and by taking the assumed urban population growth rate for the city for the year 2030. In order to do the projection of population the following empirical formula was employed (Zubair, 2006):

$P_n = Po + (n * t)$, where n=r/100*Po

Pn=estimated population Po=base year population r = growth rate (3.8%) n = annual population growth

t = number of years projecting

Future land use land cover projections were made by using the percentage change of land during the selected study period multiplied by the number of years that the land use land cover intended to be projected plus the original projecting years. That means every yearly percentage increment or decrement of the land use times the number of years for projection plus the original projecting year.

III. RESULTS AND DISCUSSION

GIS and remote sensing are the best tools to address basic spatio-temporal information capturing and analysis on the area there is no detailed ground based data. Furthermore, the method is very cost effective and generates reliable data with good image mapping. Based on the supervised classification the land use land cover is categorized into four groups and maps and tables were produced in order to show the change rate and magnitude of urban expansion impact on the surrounding semi-urban areas.

Table1: Description of the LULC features of Akaki River basin

LULC	Description
Water body	All water bodies, marshes, swamps, artificial lakes and ponds
Forest	Areas covered by dense forest with relatively darker green colures, deciduous forest, mixed forest lands, scrub and others
Agriculture land	Cropland, Pasture and Other agricultural land
Built-up land	Residential, commercial and services, industrial, transportation, roads, mixed urban, and other urban

3.1 Landcover maps

The data generated shown that the landcover in three different times showed significant changes in area coverage for the classified land groups. The urban area coverage was raised from 25.71% in 1985 to 31.51% in 2015 with expense of agricultural land reduction from 64.27% in 1985 to 56.28% in 2015. The expansion rate of urbanization has great impact on the socio-economic conditions of the surrounding semi-urban community; those are dependent on the agricultural activities and production.

3.2 Existing LULCC distribution and Land use conversion/change rate

The land use conversion was depicted in the table below for the year 1985, 2011 and 2015 for the Akaki River basin.

Table2. The LULC distribution of Akaki River basin in 1985, 2011 and 2015

LULC groups	1985		2011		2015	
	Area(km^2)	Area (%)	Area(km^2)	Area (%)	Area(km^2)	Area (%)
Water body	5.11	0.32	5.91	0.37	5.03	0.31
Forest	156.34	9.70	146.45	9.08	191.75	11.90
Agriculture	1035.94	64.27	1001.19	62.12	907.12	56.28
Built-up area	414.35	25.71	458.18	28.43	507.83	31.51
Total	1611.73	100	1611.73	100.0	1611.73	100

Source: Derived from landsat image of 1985, 2011&2015

The built-up or urban area increased from 25.71% (414.35km^2) in 1985 to 31.51% (507.83km^2) in 2015. Within this 31 years period the urbanization process is shown as dramatic and rapid growths. In the last 27 years (1985–2011) period the urbanization expansion increased by only 2.72% (28.43%–25.71%) but for the last four year (2011–2015) the expansion was increased by 3.17%(31.51%–28.43%). This indicate that the rate of urbanization was very fast after 2011 and this may be due to the economic growth of the country and the construction of high density condominiums, real state houses and cooperative based groups housing development in the city (Lueliseged et al., 2011). The expansion of the built-up area is predominantly at the expense of agricultural land.

The surrounding agricultural areas were reduced from 64.27% in 1985 to 56.28% in 2015 due to the conversion of the land mass into the urban areas. Basically to observe the changing rate variation in between 1985 and 2011; it lost or decreased only by 2.15%, however, within the last four years, i.e., from 2011-2015 the areas reduced by 5.74% which is a drastic and dramatic change. This shows the lack of clear policies and administrative orders that regulate the rate of change of agricultural and cultivated land to other uses (ORAAMP, 2001). If the rate of conversion within a year by 14.99km^2 continuous on this way up to 2030 the agricultural land will be reduced to 682.27km^2, i.e., it reduced from 56.28% to 42.33% (Table2&7). This abrupt change may bring great socio-economic crisis on the semi-urban dwellers or communities unless effective and sound policies introduced and intervened to cop-up the change will happen in the society or environment. Hence, it needs alternative economic and environmental development policies to use the existing resources in proper manner in order to ensure sustainable and inclusive development in the basin.

The pattern of land use land cover distribution in the three different year's maps has shown below that the percentage coverage of agricultural land was very wide in comparing with other land use/cover portions. Its coverage takes the lion share and the next one was built-up area. It is one of the real evidence for the country as an agrarian based economy since the basin incorporates the largest Africa's diplomatic and market city Addis Ababa. Effective land use planning has immense benefit to increase production and productivity of the land by allocating in proper way to achieve the designed goals. Timely reconnaissance of land use land cover status is mandatory to monitor and evaluate the efficiency of land allocation for various sectors and to guarantee the sustainable development and stabilization of the community.

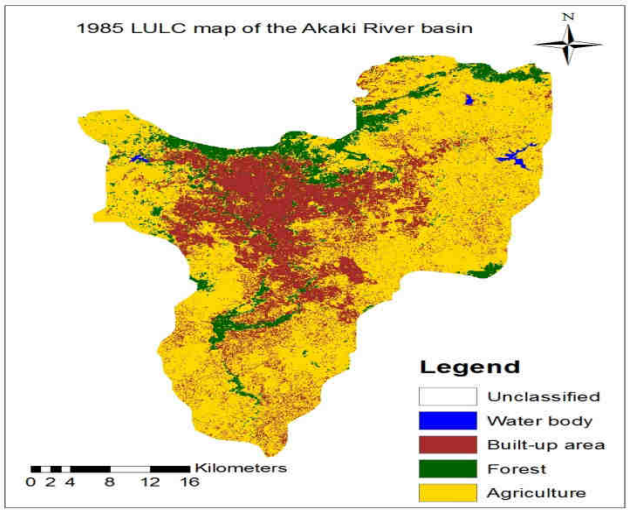


Fig.2: 1985 LULC map of the Akaki River basin

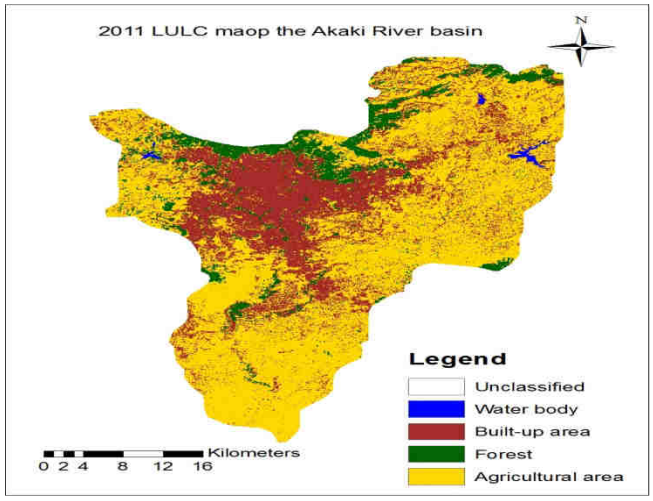


Fig.3: 2011 LULC map of the Akaki River basin

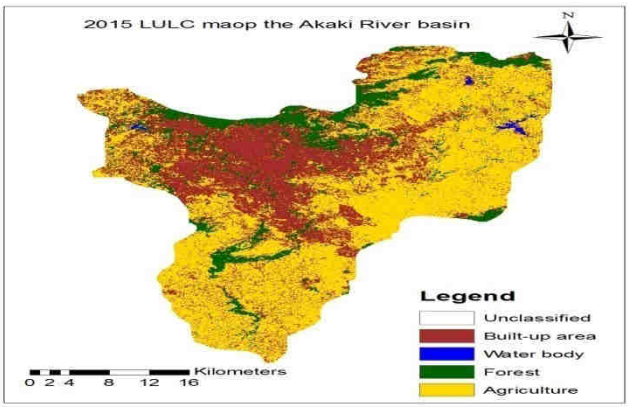


Fig.4: 2015 LULC map of the Akaki River basin

Another good thing observed in the study area was the increment of the coverage status of forested land. The coverage of forest land increased from 9.7% in 1985 to 11.9% in 2015; however, there was reduction from 1985-2011 by 0.62%. The improvement of forest status from 2011-2015 by 2.82% was due to massive movement of population in green based economic development Moto of the government and the great emphasis given to rehabilitate the degraded areas by various GO's, NGO's and other stakeholders. According to the study area result the green-economy principles is working in paramount way in the country eventhough it needs intensive research in the analogous areas to come up with the overall status conclusion.

The water body has shown increment from 1985 to 2011 by 0.05%, but it reduced by 0.06% from 2011-2015. This reduction was may be due to the ElNino effect of the year 2015. As observed in Ethiopia ElNino brought great drought and food shortage in some parts of the country and its effect was moving to worsen condition. It is the main cause for the surface water storage decrement and dryness of the small rivers, streams and brooks. Hence, the loss of water body by 0.88km^2 in 2015 was due to the lack or shortage rainfall and experienced climate change in the Eastern Africa, particularly in Ethiopia.

3.3 Land Consumption Rate and Absorption Coefficient

The land consumption rate was the measure of the compactness that indicates the progressive spatial expansion of city in time period. Based on the current study the land consumption rate was high during 1985/2011 and it being similar with progress in the 2011/2015 in the Addis Ababa city. On the other hand, a land absorption coefficient being a measure of consumption of new urban land by each unit increase in urban population was significant between 2011 and 2015 since the urban population was growing in 3.8% per annum. The rapid growth of urban dwellers and migrants to the city seeks more land for various aspects.

Table3: Land consumption rate and absorption coefficient for built-up areas

YEA	LAND CONSUMPTION RA	YEAR	LAND ABSORPTION COEFFICIENT
198	0.029	1985/2011	0.002
201	0.013	2011/2015	0.009
201	0.013		

Table4: Projected or assumed population figure of Addis Ababa city in 1985, 2011 and 2015

YEAR	POPULATION FIGURE	SOURCE
1985	1,423,182	Projected from 1984 CSA data
2011	3,510,440	Own estimate
2015	4,044,026	Own estimate from 1998 CSA data

1.4 **Land Use Land Cover Change: Trend, Rate and Magnitude**

Table5: Land use land cover change: Trend, Rate and Magnitude in Akaki River Basin

LULC type	**1985–2011**			**2011–2015**			**1985-2015**		
	Area (km^2)	**%age change**	**Annual rate**	**Area** (km^2)	**%age change**	**Annual rate**	**Area** (km^2)	**%age change**	**Annual rate**
Water body	0.8	0.896	0.233	-0.88	-0.46	-0.02	-0.08	-0.031	-0.009
Forest	-9.89	-11.08	-2.88	45.3	23.85	0.95	35.41	13.74	4.12
Agriculture	-34.75	-38.93	-10.1	-94.07	-49.54	-1.98	-128.82	-49.97	-14.99
Built-up	43.83	49.10	12.76	49.65	26.15	1.04	93.48	36.26	10.88
Total	89.27	100		189.9	100		257.79	100	

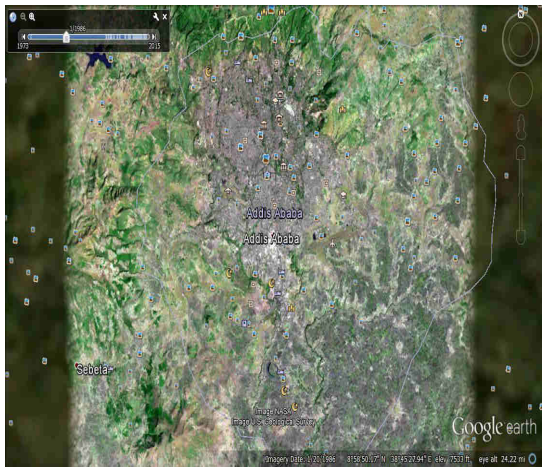
Note: Annual rate of change.

Table 6: Land use and land cover change in rate in Akaki River basin from 1985 to 2015

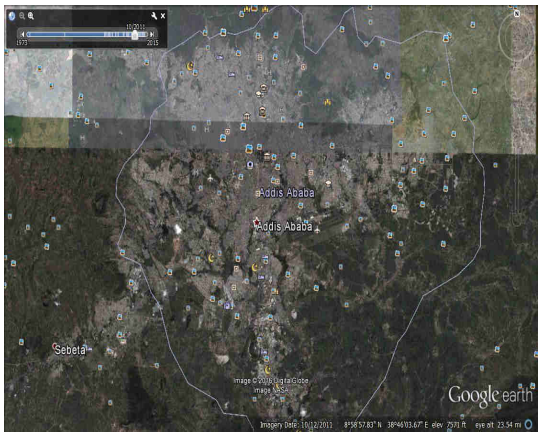
LULC type	1985-2011	2011-2015	1985-2015
Water body	0.031	-0.22	-0.003
Forest	-0.38	11.33	1.18
Agriculture	-1.34	-23.52	-4.29
Built-up area	1.68	12.41	3.12

In the above table the negative sign in waterbody has shown us the decrement of water body in the period between 2011 and 2015. This reduction of water body storage may be associated with the climate change effect such as the prominent ElNino related drought in the country. Dynamic and abrupt change observed on the agricultural land and its conversion rate very higher in comparing with others. It indicates the more displacement of rural dwellers in the past 30 years and that requires careful analysis on the horizontal expansion of the cities and towns in the basin. According to the Leuliseged et al (2011), the peri-urban people face with the problem due to rapid expansion of Addis Ababa city. Industrial, commercial, service rendering centers and other facility construction booming in the Addis Ababa and that consumes more fertile agricultural land. Society dependant on agricultural products not secured by having the other alternative income generating sources which designed as livelihood copping strategy to solve their problem (Lueliseged et al., 2011).

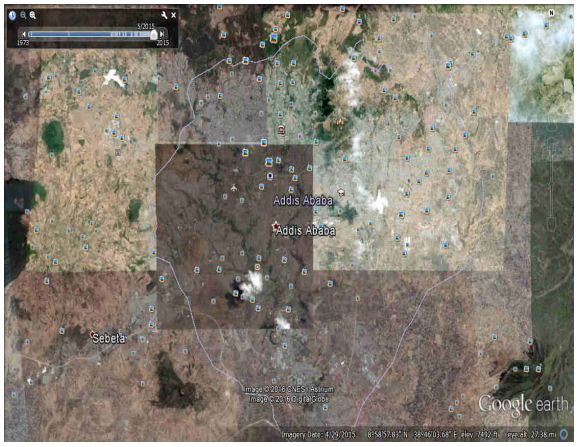
The land consumption rate becomes decrease in between 1985 and 2011 which reduced from 0.03 to 0.01 and the magnitude seems constant rate in between 2011 and 2015 (0.01). In the reverse the land absorption coefficient was increased from 0.002 (1986-2011) to 0.009 (2011-2015) which shows the expansion of the towns in the basin. Land absorption coefficient change will indicates the increment of urban expansion and population pressure results on the landmass that reduces the other part of landuse due to industrial, urbanization and commercial center expansion.



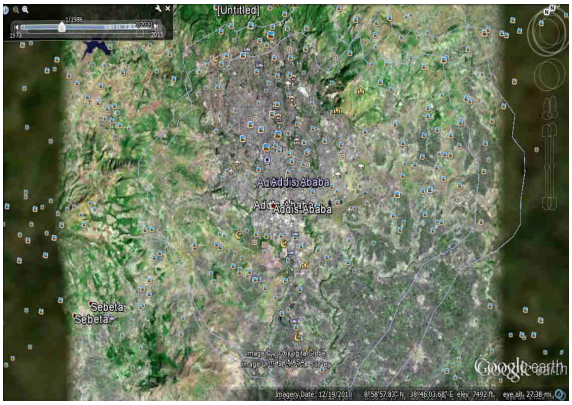
Imagery map of the Addis Ababa city administration in 1985



Imagery map of the Addis Ababa city administration in 2011

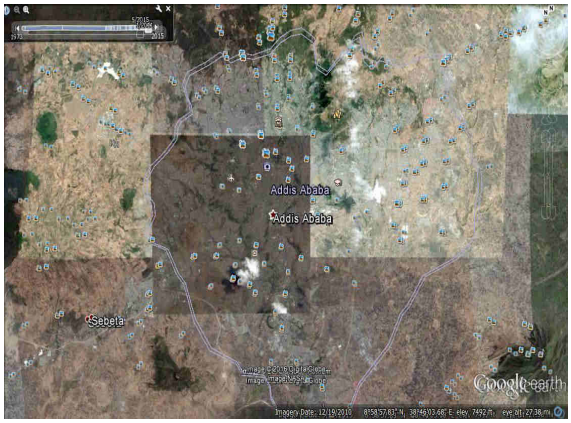


Imagery map of the Addis Ababa city administration in 2015



Map of Addis Ababa city in comparison between 1985 and 2011 imagery

As shown in the map above the expansion of the Addis Ababa city was dramatic and abrupt which indicates the extent of surrounding land consumption from the nearby agricultural fields. The inside demarcation layer in the overlay map is 1985 and the outer side indicates 2011 coverage of the city boundary. The extension of the city was very high within the 27 years period as expressed in the table above; the land use type which sacrificed for this devastative growth is agricultural areas.



Overly map of the Addis Ababa city administration in 2011 and 2015

When comparing with overlay map of 1985&2011the area coverage of the built-up areas in 2011&2015 overlay was very high and visible while the green and agricultural sites are reduced suddenly. As Leuliseged et al.,(2011), the agricultural fields in the city was reduced in very hasten manner when comparing with the other fields of the land use and that's also proved on this figure. Majority of the land surface is covered by the building and dry features were increased in contrast with the overlay of 1985&2011.

3.5 Land Use Land Cover Projection for 2015

Table 7. Projected Land use land cover for 2030

LULC classes		Forest	Water body	Built-up area	Agricultural
2030	Area in Km^2	253.45	4.98	671.03	682.27
	Area in %age	15.73	0.31	41.63	42.33

As indicated in the table above the agricultural land cover holds the first place in 2030, but the built-up area approaches closely to it. The reduction of agricultural land per a year is around 23.52% as calculated from the value of agricultural land coverage from 2011 and 2015 imagery data. But the forest land increased by 11.33% for the last four years as

observed from the 2011 and 2015 imagery data and its areal increment may continue on this rate it would cover 15.73% of the river basin in 2030. However, the rate of forest area expansion may not seem as the projected one as the real situation of the basin characteristics, i.e., the estimation/projection value is over and it not be real. Because the historical forest coverage expansion rate in the country level may not depicts such kind of paradigm growth rate. The trend in between 1985 and 2011 shows reduction in the forest land by 0.37km^2/year(156.34km^2 in 1985 to 146.45km^2 in 2011) and after 2011 is has shown rapid increment(11.33km^2/annum) up to 2015 (in 2015 the area coverage reached to 191.75km^2). The water body coverage will be reduced and it indicates the needs of great care to maintain sustainability of the basin.

IV. CONCLUSION AND RECOMMENDATION

Land use land cover change is a long time effect of the natural and anthropogenic process on the watershed or river basin. It demands continuous monitoring and evaluation system to use the land resources effectively and efficiently to address the contemporary need of the society. GIS and remote sensing have imminent value in addressing the land use land cover of the area and it supports to the future planning and management of the basin.

The result of land use land cover change detection of the Akaki river basin for various years indicated that the agricultural land holds the dominant portion of the basin. However, the expansion of urbanization and industrialization consumes more part of the land in alarming rate. The annual rate of change agricultural land reduction in between 1985 and 2015 continue for up to 2030 the area of coverage reduced from 907.12km^2 in 2015 to 682.27km^2 in 2030. The loss of farming land is very drastic and dramatic in the basin in comparing with other land uses.

The rate of urbanization and industrialization in the basin was very high and it consumes more agricultural lands mainly. As projection made based on the annual rate of change the urban land will becomes nearly equivalent with agricultural lands in 2030. Addis Ababa city situated in the basin has shown very spectacular expansion rate and plays great role in the reduction of the farming field. The horizontal and unplanned expansion grabbed more peri-urban areas and that imposes great pressure on the livelihood of the community dependant on the agricultural activities.

The rate of deforestation was observed in between 1985 and 2011 but the amazing afforestation and re-afforestation resulted was shown on the imagery data in between 2011 and 2015. This may be the result of community mobilization of the GO's and NGO's to achieve the MDG's goals and to ensure green economy building process in the country. The coverage of forest land increment was in promising rate.

Water body has shown increment in area coverage in between 1985 and 2011. Eventhough it has indicated decrement in between 2011 and 2015 image which may be due to the El Nino effect of the 2015. Hence, it needs great management activities on the basin to protect such rapid loss to this precious resource.

Continuous monitoring and evaluation of the land use land cover change is very essential to use the land resources in sustainable manner and designing sound watershed or river basin plan highly demanding in the Akaki river basin. Since the area faced with dramatic and abrupt urbanization and industrialization process observed site. Therefore, the government should take great role takeover the cumbersome problem of unplanned urban expansion rate and its influence challenge on the semi-urban people's livelihood. Developing proper and organized land use planning and management have great opportunity to solve the problems may face in the basin.

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