ISSN 2348-313X (Print)
International Journal of Life Sciences Research ISSN 2348-3148 (online)
Vol. 5, Issue 1, pp: (28-36), Month: January - March 2017, Available at: www.researchpublish.com

ASSESSING THE ENVIRONMENTAL IMPACTS OF POST EATEC WATTLE TREE PLANTATIONS IN ELDORET MUNICIPALITY

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Abstract: **The study area which lies within Eldoret Municipality has experienced environmental problems as a result of the sale, land subdivisions for settlement and subsequent clearing of the wattle tree plantations that were owned and managed by EATEC. The extents of environmental consequences due to the clearing of the plantations are not fully understood and the necessary mitigation measures to manage these challenges have not been put in place.**

The objective of this research study was to carry out an environmental assessment of the impacts of the clearing of the wattle tree plantations by the use of remote sensing and GIS techniques. The study sought to characterize the environment before and after the project implementation, assess and quantify the major environmental changes between 1995 and 2015 and identify the major environmental impacts and then propose mitigation measures to address the negative impacts.

Remote sensing Satellite images for the years 1995, 2000, 2003, 2010 and 2015 were classified and integrated with other data within GIS for assessment of the land use and land cover change.

The results reveals that the study area has experienced significant changes due to the clearing of the wattle tree plantations and increase in human settlement resulting in environmental challenges including decreased wetlands, decreased wattle tree plantations, and increased cropland and bare land. The research findings indicate that human activities have had a profound effect on the natural environment and are the main agent of environmental degradation. This study has proposed mitigation measures which if undertaken could address environmental challenges affecting the study area.

Keywords: **Remote Sensing, GIS, wattle tree plantations, environmental assessment.**

1. INTRODUCTION

Wattle trees are fast growing but short-lived, with hard, strong wood useful for fuel, poles, fencing posts and tool handles.[1] further described them also as suitable for bee forage and the bark used in the tanning process and in the production of gum. They are widely cultivated in many parts of the temperate world, as ornamental and agro-forestry trees. Wattle trees were introduced in East Africa for their tannin-rich bark, and for use as fuel wood.

[2] in his findings stated that wattle trees, were regarded as a weed in many parts of the world as they out competed other crops for nutrients and light and capable of invading native vegetation from grassland to dense forests he termed them as invaders in many parts of the world, though in South Africa, they are invaders with a commercial use, animal fodder and soil stabilization. [3] Noted that wattle trees were not listed as a noxious weed by any state or government authorities in Kenya, Tanzania or Uganda.

Wattle tree plantations in Eldoret Municipality were owned and managed by the East African Tanning Extract Company (EATEC). They covered an area of about 35,000 acres within the municipality and with a workforce of over 3,000 employees. [3] In their research found out that wattle trees were grown for their bark. The extracted tannin was largely used for tanning leather, as well as in making adhesives, preserving ropes and nets, making dyestuffs, corrosion inhibitors and as pharmaceutical products. They were also used for both fencing and building poles.

The sale of this land and subsequent subdivision into small parcels of land led to an influx of people to the area in search of land for settlement and other socio economic activities. The increased human settlement led to the clearing of the wattle tree plantations that has caused environmental concern and deprived the thousands of people formally employed by the company of their source of income. The parcels have further been subdivided into smaller uneconomical units that have had negative impacts on human health as a result of informal settlements coming up and due to lack of piped water and solid waste disposal mechanisms.

The need for EIA was succinctly expressed in Principle 17 of the 1992 Rio Declaration on Environment and Development which afforded the strongest evidence of international support for EIA in the following terms; "Environmental impact assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant impact on the environment and are subject to a decision of a competent authority. [4]

Remote sensing, which, in combination with Geographic Information Systems (GIS) and fieldwork, is an effective management tool that is increasingly important in the detection, description, quantification and monitoring environmental changes [5].

Subjecting projects to environmental assessment through spatial information technology involving GIS and remote sensing are crucial for sustainable development. Geospatial technologies also play a leading role in monitoring the environment as a result of the clearing of the plantations and the rapid population growth.

This study was therefore undertaken to assess the impact of the clearing of the wattle tree plantations formally owned by (EATEC) within Eldoret Municipality. This would enable the government make informed decisions on the state of the environment and mitigate the negative impacts to ensure sustainable development.

2. METHOD

2.1 Study area:

The study area borders Eldoret town to the south and located in the high-agricultural potential highlands of Uasin Gishu County. It lies at an altitude of 2,085 metres above sea level and traverses latitude 0˚ 31'North and longitude 35˚16' East. It is located about 312km northwest of Nairobi on the main Kenya-Uganda highway. The study area borders Sosiani River and rises southwards from1800m above sea level to about 2120m above sea level in the extreme south east.

The study area receives bimodal rainfall which falls between the months of April and May. The municipality enjoys two rainy seasons with an annual rainfall ranging between 900 to 1200 mm. Sited on a plateau; the municipality has a cool and temperate climate, with annual temperatures ranging between 8.4 °C and 27 °C. The wettest season is experienced between the months of April and May while the driest season comes between January and February. There is a dry spell in June followed by increasing rainfall in July and August and tails off in September and October. A long dry period of 4 to 5 months then follows. The average day temperatures are 24˚C with average night temperatures being 10˚C.

Geologically, Eldoret falls under the tertiary volcanic period. The rocks are mainly of alkaline type including basalts, phonolites, nephelinites, trachytes, alkali rhyolites and their pyroclastial equivalents. The rock formations indicate that the rock slopes, run along the escarpment and most of the volcanic effusion was by way of vents and fissures. The soils are the red to strong brown friable clays with laterite horizon and grey mottled clays.

The study area comprises of Langas location, Kapsoya location and Saroiyot sub location and has had a population increase from 55,387 in 1995 to a projected population of 178,535 people in 2015 [6]. However the rate of physical development has superseded the provision of potable water. Liquid waste disposal in the study area is normally by pit latrines while water wells close by, supplement the sources of water.

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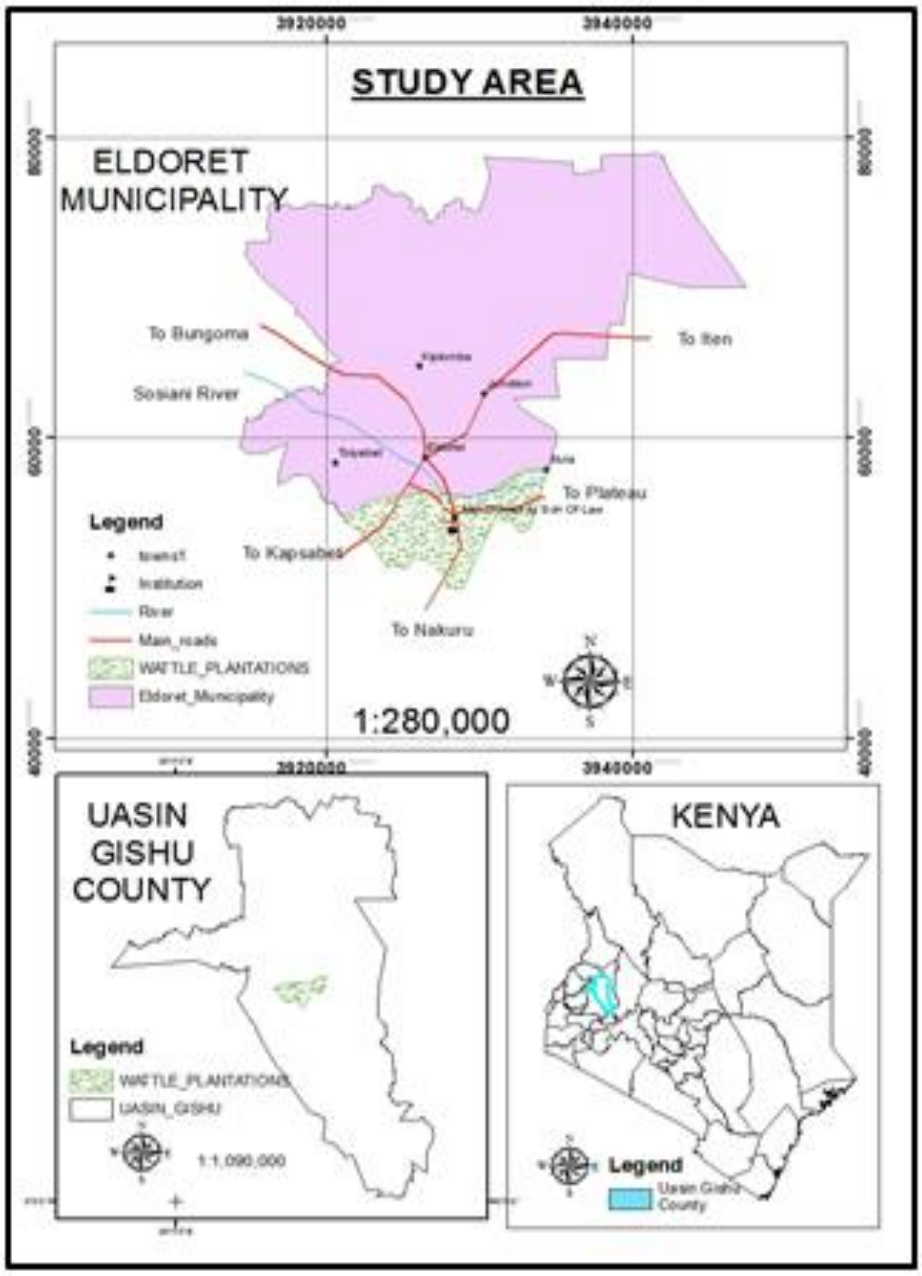

Fig 1: Study area

2.2 Data:

The first step was to identify the variables needed to assess the environmental impact of the Study area on the clearing of the wattle tree plantations. The variables consisted of environmental information, including the amount of Crop land, Human settlement, Wetlands, Forests, Population, rainfall, hydrological data and land subdivision data.

These variables were obtained from secondary sources such as government documents. The Variables obtained covered the period from 1995, 2000, 2003, 2010 and 2015.

The study also relied on datasets from The United States National Aeronautical and Space Administration. The satellite data used consisted of 5 scenes of Satellite images for the separate periods of 1995, 2000, 2003, 2010 and 2015 for the study area.

This paper used a mix scale approach involving the integration of primary and secondary data provided through government sources and data bases from other organizations. The raw spatial data and satellite images that were used in the research came from the United States National Aeronautical and Space Administration.

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TABLE 1: Primary and Secondary data

S/no	Data type	Source	Year
1	Landsat 5 (TM) image	USGS	January 1995
2	Landsat 7 (ETM+) image	USGS	February 2000
3	Landsat 5 (TM) image	USGS	March 2003
4	Landsat 5 (TM) image	USGS	February 2010
5	Landsat 8 (OLI) image	USGS	February 2015
6	Population data	Kenya National Bureau of Statistics	1979, 1989, 1999 and 2009
7	Rainfall data	Kenya Meteorological Department	1995, 2000, 2005, 2010 and 2015
8	Hydrological Data	Water resources Management Authority	1995, 2000, 2005, 2010 and 2015
9	Land subdivision data	Survey of Kenya	2001, 2003, 2010 and 2015

2.3 Research approach:

The methodology adopted for this study is summarized in Figure 2 and involved Remote sensing data processing, land cover mapping, change detection, environmental assessment and identification of mitigation measures

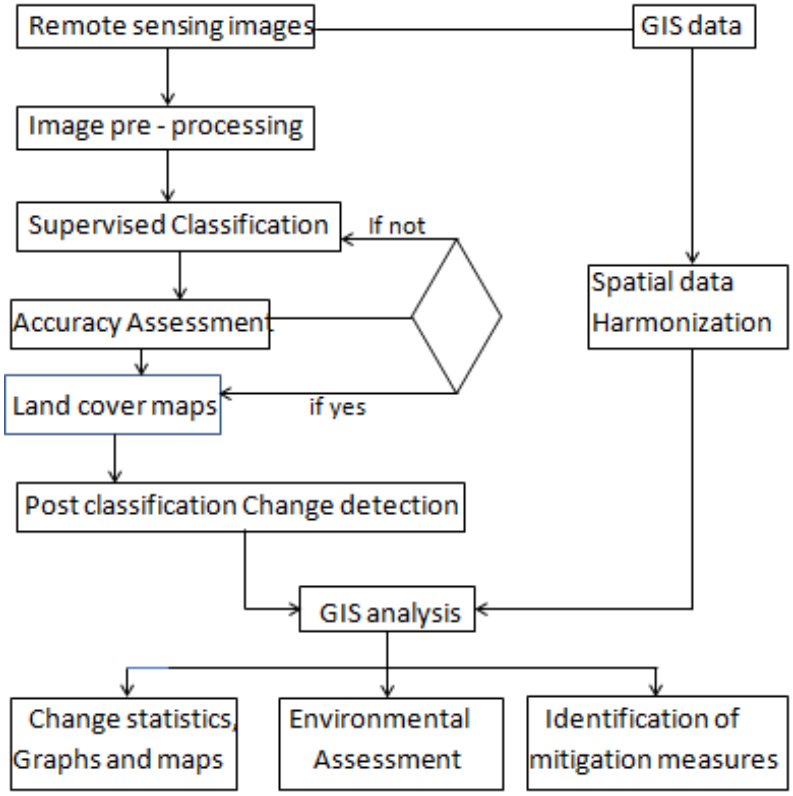

Fig 1: Methodology flow diagram

2.4 Land cover mapping:

Due to acquisition system and platform movements, remotely-sensed data are generally geometrically distorted. Pre-processing entails, geometric correction, radiometric correction, noise removal and geo referencing.

The satellite images were imported into ERDAS 2010 software in an image format for geometric correction. The images were then geo referenced and subset on the basis of Area of Interest (AOI).

Supervised classification was used in this research and involved the training stage, feature selection, Selection of classification algorithm, Post classification smoothening and Accuracy assessment.

Spectral signatures for the respective land cover types derived from the satellite imagery were recorded by using the pixels enclosed by these polygons. A satisfactory spectral signature is the one ensuring that there is 'minimal confusion'

among the land covers to be mapped. Supervised classification was performed by applying maximum likelihood algorithm on the images. Land cover maps with six classes were generated from each satellite image.

Accuracy assessment was essential for individual classifications if the classification data was to be useful in change detection. For the accuracy assessment of land cover maps extracted from satellite images, stratified random method was used to represent different land cover classes of the area. The accuracy was assessed, based on ground truth data and visual interpretation. The comparison of classification results and reference data was carried out statistically using error matrices.

2.5 Change detection:

Change detection was done by overlay of classified maps. It was done by comparative analysis of map-to-map comparison. This approach required very good accuracy in both classifications because the accuracy of the change map was the product of the accuracies of the individual classifications. It was thus important to do an accuracy assessment of each land cover map.

Change detection in terms of the acreages of the land cover classes were obtained for each classified map and compared. The classes involved were wetland, forestland, cropland, settlement, grassland and bare land.

2.6 GIS Analysis:

GIS analysis is described by [7] as a methodological framework that may be applied to a very wide range of spatial analysis problems and projects.

GIS brings to the EA process a new way of analyzing and manipulating spatial objects and an improved way of communicating the results of the analysis, which can be of great importance during the public participation process where the results from the public consultation and social surveys can be imported into a GIS for spatial and non-spatial analysis, and display in a format that is easily understood by all stakeholders. The process of Environmental analysis is described by [8] as using either or combination of checklists, overlay, matrices and network methods.

2.7 Mitigation measures:

They are measures put in place to counter the negative impacts on the environment that may arise from the project. Impact may be defined as 'any alteration of environmental conditions or creation of a new set of environmental conditions adverse/beneficial, caused or induced by the action or set of actions under consideration [9]. In this study, the negative impacts found were mainly due to human actions. They included increased settlements, decreased forest cover, and increased bare land, decreased wetlands and other environmental challenges.

3. RESULTS AND DISCUSSION

3.1 Population:

The population of the study area encompassing Pioneer location, Kapsoya and Saroiyot sub location was obtained from the Kenya Bureau of Statics in their Eldoret office. The census data obtained was for the census years 1989, 1999 and 2009. The data was interpolated to obtain the population for the study years 1995, 2000, 2003, 2010 and 2015 (Table 2). The results showed that the population increased from 55,387 in 1995 to 178,535people in 2015. These figures represented an increase of 222.34%.

TABLE 2: Projected population data

Location/ Sub location	1995	2000	2003	2010	2015
Pioneer	34,099	43,703	60,281	97,617	118,521
Kapsoya	18,218	22,735	28,302	35,284	44,514
Saroiyot	3,070	3,859	5,794	10,635	15,500
Total Projected Population	**55,387**	**70,297**	**94,377**	**143,536**	**178,535**

3.2 Rainfall:

Rainfall pattern between the years 1995 and 2015 did not show a predictable trend, Instead of a decrease, there appeared to be a non-uniform increase in the rainfall pattern. These may be attributed to the existence Kaptagat and Ainabkoi forests to the East of Eldoret Municipality.

TABLE 3: Rainfall (Kapsoya gauge station within the study area)

Year	1995	2000	2005	2010	2015
Total rainfall (mm)	985.9	855.9	955.3	1348.6	1121.2

3.3 Hydrological data:

Hydrological pattern agrees well with the rainfall pattern of the study area. The effect on the Study area was minimal.

TABLE 4: Hydrological data (gauge heights on River Sosiani)

Year	1995	2000	2005	2010	2015
Mean Gauge Height (m)	0.62	0.55	0.59	1.02	0.97

3.4 Land subdivisions:

The information obtained from Survey of Kenya County Office indicated that, on first Registration in 2001, there Were 3,537 parcels of land ranging from 0.01ha to 40ha.Registration as at 28th June, 2015 stood at 14,591 parcels. This is an increase of 11,054 parcels, representing an increase of 312.5% over a period of 15years. It is worth noting that the increase in subdivision of parcels is not uniformly distributed across the entire study area. The parcels along Eldoret to Nakuru road have been converted to Commercial; Residential and Institutional uses among them are Moi University school of Law. Similarly, informal Settlements have cropped up, notably Rehema informal settlement, which is referred to as Block 27 of EATEC registration. (Table 5) shows the number of parcels created after subdivision since 2001 to 2015.

TABLE 5: Land Subdivisions

Year	1995	2001	2005	2010	2015
No of Parcels	0	3537	5120	8948	14277

3.5 Land use/ Land cover Change detection:

The results of the land cover maps (Figure 3) of 1995, 2000, 2003, 2010 and 2015 are presented in (Table 6). Settlement areas increased from 144.72 ha in 1995 to 763.29 ha in 2015 representing an overall increase of 427.43%, cropland increased from 7959.33 ha in 1995 to 19257 ha in 2015 representing an increase of 141%, similarly there was an increase in other land from 15311ha in1995 to18695.1 ha in 2015 representing an increase of 22.1%. Forestland posed a decrease from 1467.09ha to 1356.03, grassland from 24675.3ha to 9200.7 ha and wetland decreased from 293.84ha to 82.62 ha representing a decrease of 7.57%, 60.29% and 71.82%.

TABLE 6: Results of the land cover maps 1995, 2000, 2003, 2010 and 2015 maps and percentage change between 1995 and 2015

Classes	Area (Ha) 1995	Area (Ha) 2000	Area (Ha) 2003	Area (Ha) 2010	Area (Ha) 2015	% change 1995 - 2015
Cropland	7959.33	29705.3	18734.4	25269.4	19257	**141.94**
Forestland	1467.09	4441.98	3738.69	2904.75	1356.03	**-7.57**
Settlement	144.72	505.037	557.91	644.13	763.29	**427.43**
Wetland	293.84	156.3553	73.33	49.68	82.62	**-71.82**
Grassland	24675.3	4512.02	15582	9200.7	9798.39	**-60.29**
Bare land	15311.00	10728.4	10382	11883.7	18695.1	**22.10**

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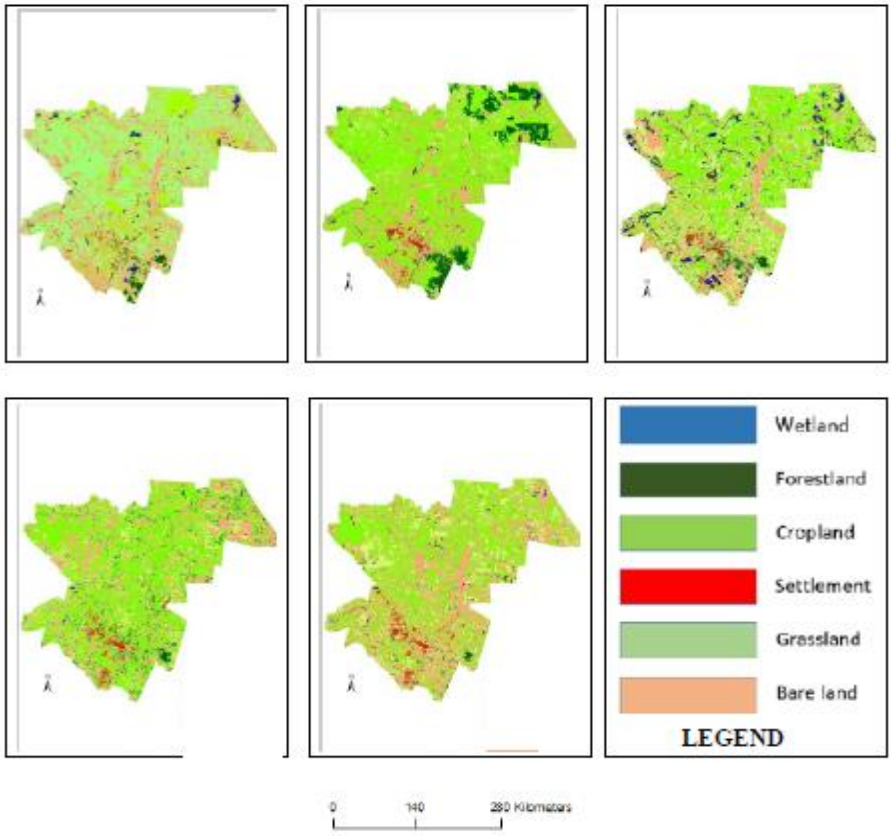

Fig 3: Land Cover maps for the period 1995, 2000, 2003, 2010 and 2015

Dynamics of land cover changes beginning from 1995 to 2015 in terms of areas and percentages were obtained. Six land cover classes of settlement, forestland, wetland, cropland, grassland and bare land were decided upon based on knowledge of the study area.

Harmonization of the spatial data sets composed of decomposing the data sets so as to graphically determine the relationship between them. Since the data sets were in different units of measurement, it was necessary to normalize the data into one unit of measurement.

From the analysis, it was possible to obtain, change statistics, graphs and maps. Similarly, it was possible to do an environmental assessment from the land cover change detection and the harmonized GIS data. The major environmental drivers in the study area were identified from the analysis (Figure 4). This formed the basis of mitigating their effects on the environment.

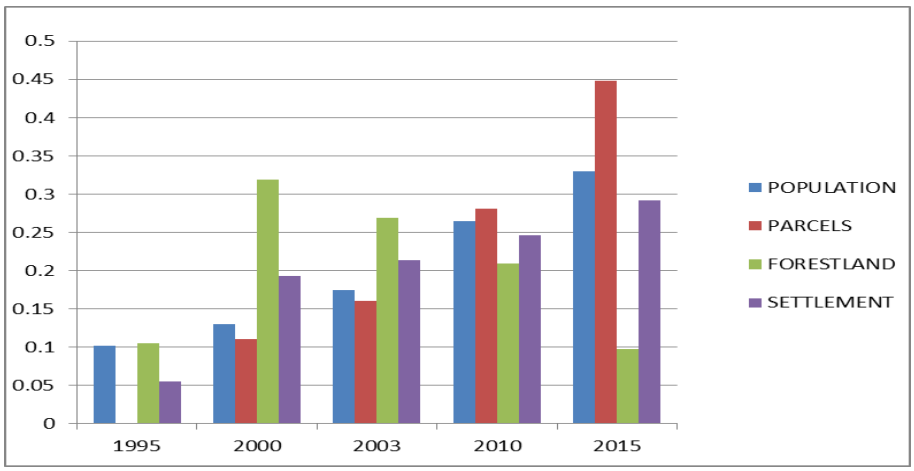

Fig 4: Environmental drivers

3.6 Environmental drivers in the study area:

The results, analysis and data obtained from government sources showed the following drivers as responsible for environmental Change within the study area, Increase in human Settlements, increase in population, decline in forest cover, increase in Land subdivisions and Environmental policies and regulations that are ineffective and lack the enforcement aspect.

These trends possess challenges to the environment and Policy makers in the local Government and needs urgent confrontation to tackle the impending environmental degradation.

3.7 Mitigation measures:

On increase in human settlements and population, the Government could promote sustainable land use Planning and management by making provisions for environmental infrastructure such as water, sanitation, drainage, hazardous and solid waste management.

On eradication of poverty, creation of productive employment and social integration, the Government could formulate and implement human settlement policies that ensure equal access to basic services like education, food security and basic health that would include family planning and reduction of the burden of investment on curative health. Similarly, the Government could develop and enforce appropriate norms and laws for land use, buildings and planning standards to reduce any impacts that may arise due to natural and human-made disasters. The Government could also provide adequate financial and legal support for the effective protection, conservation and rehabilitation of the historical and cultural heritage [10].

On decline in forest cover the Local Government could create responsible partnerships, for enhanced private sector participation in forestry development and to promote tree planting and agro-forestry activities. Similarly, the Local Government could enact legislation to ensure that all sub-divisions of land are tied to land use sizes specified for different ecological zones and put in place a system to determine economically viable minimum land sizes for various zones, promote conformity of land subdivisions with the set minimum economically viable land sizes [11]

4. CONCLUSIONS

The clearing of the wattle tree plantations that were being managed by the East African Tanning Extract company (EATEC), subsequent subdivisions and increase in human settlement has had serious environmental challenges on the study area within Eldoret Municipality. The continued population growth has resulted in environmental problems such as decreased wetlands, loss of the wattle tree plantations (forest), increased bare land, increased cropland and many other issues. There was an urgent need to undertake an environmental assessment to determine the extent of the impact of these changes on the environment and mitigation measures to manage these challenges.

The objective of this research study was to carry out an environmental assessment of the impacts of the clearing of wattle tree plantations within Eldoret Municipality by the use of remote sensing and GIS techniques. The study sought to characterize the environment before and after the project implementation, assess and quantify the major environmental changes between 1995 and 2015 and identify the major environmental impacts and then propose mitigation measures to address the negative impacts

This study used a mix scale approach involving both primary and secondary sources of data and analyzed with descriptive statistics, GIS techniques and remote sensing.

Results reveal that the study area experienced some significant changes in its environment as a result of the clearing of the wattle tree plantations, increased human settlement, decreased wetlands, increased agricultural intensification and other environmental variables. The other factor was the rapid increase in population and its implication on the environment.

To deal with these challenges, the project offers some mitigation measures as part of the conservation strategies for the study area. The mitigation measures consist of participatory approach, periodic assessment, land use management strategies, land subdivision strategies and strengthening the laws and regulations dealing with environmental issues.

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