Land Cover Change and Deforestation in Gazetted Maji Mazuri Forest, Kenya

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Abstract: ***Loss of forest cover and forest degradation are of global and national concern. Among other things, such changes can lead to reduction in stream discharges, increased erosion and loss of biodiversity, which may alter the functioning and values of affected ecosystems. This study used three Landsat images acquired in 1975, 1986 and 2005, to determine land cover changes and likely environmental impacts in Maji Mazuri forest in Kenya. The results of the analysis showed that between 1975 and 2005, natural forest decreased by about 42.31%. The likely environmental impacts include loss of biodiversity, soil erosion, and changes in forest hydrology. All stakeholders should be involved in policy formulation and implementation for better management of this important ecological resource.***

Keywords: Gazetted forest, Forest Cover, GIS, Deforestation, Kenya

1. Introduction

Forests are important key components of the environment (FAO, 1997). They provide a wide range of essential goods and services good for development opportunities and improvement of human well-being. The environmental functions of forests include protecting catchments, purifying water and regulating river flows (UNEP, 1992). Forest services are critical in conserving coastal areas, wetlands, and fresh water systems.

According to the FAO forest assessment for 2005, forests globally occupy an estimated 3,870 million hectares, equivalent to 30 percent of the land area. As part of the forestry assessment, FAO estimated forests to occupy 650 million hectares or 21.8 percent of the land in Africa. This accounts for 16.8 percent of the global forest cover. FAO (2005) also estimated that forests and woodland occupy 17,096,000 hectares or 3 percent of the total land in Kenya. According to Nelson (2008), Kenya's gazetted forest cover a total of 1.4 million hectares representing about 1.7 percent of total land area. This compares unfavorably to the internationally recommended minimum of 10 percent of country forest cover. Worse still, this 1.7% is experiencing deforestation through a number of unsustainable activities (GOK, 2002).

Forest degradation through forest clearing and emissions of toxic gases are major drivers of global warming and climate change (FAO, 2005). The world's forests, especially in the tropics, are rapidly shrinking (Apan, 1999). The trend shows that the tropical forests are being destroyed more and more despite their ecological, social and economic importance. Satellite Remotely sensed data and GIS for land cover, land use and its changes is a key to many diverse applications such as environment, forestry, hydrology, agriculture and geology, natural resource management Erdas Field Guide (2002).

The gazetted Maji Mazuri forest is a threatened ecosystem due to uncontrolled and unsustainable human activities. The forest cover is decreasing. Degraded patches are also readily observable. This may lead to serious degradation of the forest.

The overall objective of this study is to determine the rates of land cover change between 1975-1986, 1986-2005 and 1975-2005 in the Maji Mazuri gazetted forest. It is located in the Baringo County in the Mau East region of the Rift Valley in Kenya within longitudes 35^0 30' and 35^0 15' East and between latitudes 0^0 10' South and 0^0 05' North.

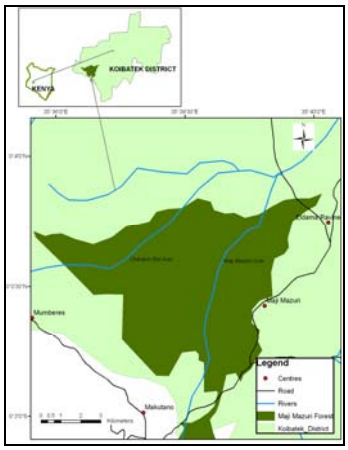

Figure 1: Location of the study area

2. Materials and Methods

GIS and remote sensing techniques were used to determine the rate of forest loss. Landsat -MSS (1975), Landsat -TM (1986) and Landsat -ETM (2005) for the

same season were used. Land cover classification system was developed for this study. Secondary data sources such as maps and documented literature aided this exercise. Four land cover classes were obtained namely natural forests, planted forests, non-forest vegetation and bare ground for 1986 and 2005 images and three land cover classes for 1975 image namely forests, non-forest vegetation and bare ground.

Digital image processing involved three major operations: image restoration, image enhancement and image classification. First, unsupervised classification was done to identify dominant land cover types. Field survey followed, aided by Global Positioning System (GPS). This was used to obtain accurate coordinate data for each land cover class to be included in the classification scheme as well as for the creation of training sites during image pre-processing. The clipped Landsat images representing the study area were then enhanced to make them visually suited for interpretation. This was performed through the creation of false color composite images. The false colour composition was band 4 (red), band 3 (green) and band 2 (blue) for 2005 and 1986 satellite images and band 3 (red), band 2 (green) and band 1 (blue) for 1975 satellite image.

Training sites for each land cover types were created in all the three images. They were used to perform a supervised classification using the Maximum Likelihood Classifier (MLC). The overall testing accuracy for the classification of Landsat 2005 was 83%. Finally, a cross tabulation was performed from 1975 to 2005 to determine the land cover changes.

3. Findings

Three land cover maps were generated but only two are shown in this report (Figure 2a and 2b). One could easily see distribution of different land cover types on the figures after classification.

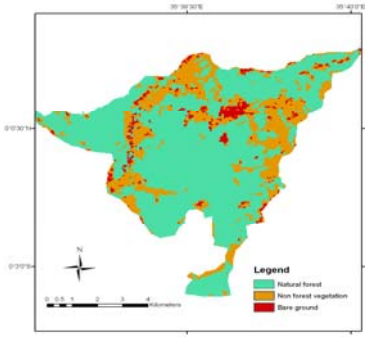

Figure 2a: Classified Landsat image 1975

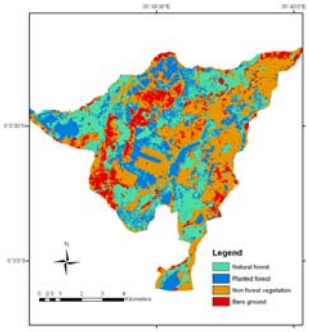

Figure 2b: Classified Landsat image 2005

Percentage land cover composition in 1975, 1986 and 2005 were determined. The results for differences in land cover composition are shown in Table 1. The composition is given in hectares (ha) and percentages for each of the three years of study.

Table 1: Variation of land cover classes over time

	1975		*1986*		*2005*	
Land cover classes	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Natural forest	4360	71	2328	37	1781	29
Planted forest	-	-	1814	29	1300	21
Non forest veg.	1526	24	1681	27	2287	37
Bare ground	249	4.3	311	5	768	12
Total	6135	100	6135	100	6135	100

Some of the forest area was converted to non forest vegetation or bare ground by 2005. Natural forest recorded the highest percentage of land cover type in the three years studied. Even though there was deforestation, non forest vegetation covered a fairly high percentage 24.7% in 1975.

4. Summary of the land cover types for 1975, 1986 and 2005

Some land cover types increased while others reduced between 1975 and 2005. The estimation of forest cover and other classes revealed that there had been major changes in the Maji Mazuri Forest. While the planted forest cover remained relatively constant between 1986 and 2005, there was a drastic decrease in that of natural forest from 1975 to 2005 (Table 2). There was therefore a general forest decrease between 1975 and 2005.

Table 2: Land cover changes of the Maji Mazuri Forest between 1975 and 2005

	1975- 1986		*1986 – 2005*		*1975 - 2005*	
	Change		*Change*		*Change*	
Land cover classes	*Area (ha)*	*%*	*Area (ha)*	*%*	*Area (ha)*	*%*
Natural forest	- 2031	- 32	- 254	- 48	- 2579	- 42.3
Planted forest	+ 1814	+29	-514	+8	+1300	+21.2
Non forest veg.	+ 155	+9	+606	+9	+761	+12.4
Bare ground	+ 62	+2	+456	+7	+518	+8.4

NB: (+) indicates increase, (-) indicates decrease. Areas above were calculated in % based on the total Forest area (ha), 6135 ha.

It was further found that, 12.8 % of planted forest was converted to non-forest vegetation and bare ground respectively. There was insignificant change from bare

ground to natural forest and planted forest between the same periods (Table 3). The type of deforestation and their area were also computed as shown in the table 3.

Table 3: Types of deforestation and their area

Type of deforestation	*Area (ha)*	*Percentage*
Natural forest to non forest vegetation	38.3	12.7%
Natural forest to bare ground	28.8	14.5%
Planted forest to non forest vegetation	24.9	11.3%
Planted forest to bare ground	38.5	12.8%

The results showed a deforestation rate of 1.8% per year. This rate might increase if proper measures are not put in place to avert the environmental threats in Maji Mazuri Forest. However, in recent times, non-sustainable extraction of forest resources such as fuel wood has caused forest loss and degradation (UNEP, 1992). It was also found that most of the exotic forest plantations comprised of cypress and pinus species.

The natural forest areas decreased between 1975 and 1986 (4360.7 ha to 2328.9 ha) as planted forests increased (Table 4.1). Even though there was deforestation, there was replacement of natural forest and bare ground by planted forest in this period.

Bare ground increased during the study period (Table 4.2). It is suggested that there could be many possible causes for this. One of reason could be excessive tree harvesting. Others were being over-grazing which can cause extensive loss of grass cover in the forests. This is because forests play an important role in the provision of fodder for livestock rearing and serve as grazing grounds. The above findings were similar to a study done in Central Ethiopian Rift Valley (Muzein, 2006).

The study suggests that there were no disturbances that would have led to excessive forest deforestation in 1975. In a similar study carried out in South West Mau, natural forest covered 60% of the area in 1970, 45% in 1990 and 10% in 2000. Other land cover types included crop plantation which was 19% in 1970, 33% in 1990 and 43% in 2000. By 2000, encroached area was 50% from 10% in 1970 (Okemwa, 2005). In a study carried out by Kapkiai (2006) mapped forest cover of North Nandi forest in Kenya using GIS and remote sensing reported 13%, 15% and 26.1% between 1967-1991, 1991- 2000 and 1967-2000, respectively within the area mapped.

Johansson and Svensson (2002) showed significant change in land use from forest to agriculture as evident in Lake Baringo area. The study showed that, the Bare ground increased in the forest between 1970 and 1989 but to a large extent they consisted of ploughed fields in 2002.

5. Conclusion

This study has shown that the land cover in Maji Mazuri Forest, changed at a high rate, 42.3% between 1975 and 2005 at a rate of (113ha) 1.8% per year. Unfortunately, uncontrolled human activities have resulted in extensive losses in forest cover and current pressures such as deforestation; threaten to further reduce this resource. There is need for a comprehensive assessment of human activities in Maji Mazuri Forest and the adaptation of sustainable forest management practices.

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