A Situational Analysis of Mt. Kenya Conservation Area Using GIS and Remote Sensing: Ecosystem Benefits to Communities.

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Abstract- For quite some years, communities living in the Mt. Kenya conservation area have benefited from the several ecosystem services found within it such as; food, water, biodiversity, tourism and recreation, fuel and energy, timber and housing materials just to mention a few of them. This study analyzed the socio-economic benefits that resulted from sustainable management of these resources and also assessed the state of the environment for the past twenty years.

Both the Geographical Information Systems (GIS) and Remote Sensing (RS) tools were utilized to assess the state of the environment. Mt. Kenya National Park, owned by the government and Il Ngwesi Community Conservancy were used as sample study sites for the eco-region. Satellite Images used in the study, were from the years 1990 to 2010.

Landsat images were used to assess land use and land cover changes for the past twenty years (1988 to 2010) for a 5 Km buffer zone using ArcGIS, Idrisi and Erdas Imagine software.

Thus, the analysis gave an insight into the state of the natural resources and the sustainability of the diminishing resources. GIS and satellite images indicated land cover reduction of the feature classes such as forests, grasslands, and scrubland and shrub land. The glaciers on Mt. Kenya have reduced and this has affected the river regimes in the catchment area. This has led to an increased demand for the scarce resources leading to overexploitation and to human-human and human-wildlife conflicts over water, grass and other resources.

Key Words: Communities, Conservancy, Conservation, Ecosystem Services, GIS.

I. Introduction

Ecosystem Services are the processes by which the environment produces resources that we often take for granted such as clean water, timber, and habitat for fisheries, and pollination of native and agricultural plants. Whether we find ourselves in the city or a rural area, the ecosystems in which humans live provide goods and services that are very familiar to us **[Ecological Society of America, 1997].**

This study focused on National Park, IL Ngwesi community conservancy and communities living in the vicinity of these conservation areas. Mt. Kenya is located on the equator 180 Km North of Nairobi. It is a solitary mountain of volcanic origin with a base diameter of about 120 Km and at an altitude of 5199 m above sea level with deeply incised u-shaped valleys in the upper parts. Mt. Kenya is a World Heritage site**, [Gathaara, 1999].** There are twelve small glaciers remaining from the earlier glacial periods, and which are receding rapidly and may disappear during the next century **[KWS, 1992].**

The mountain is a water catchment area with several rivers flowing in different directions. Some of the rivers have curved deep valleys with steep gorges such as the Sirimon gorge. The **N**orthern part of the mountain is exceptional to this general description. The ground is more gently undulating with fewer streams. There are a number of volcanic cones and craters such as **the** Ithanguni and **the** Rutundu cones.

The altitude variation on Mt. Kenya gives rise to a wide variety of **climatic zones.** The wettest part of the mountain is to the South - East which receives up to 2,500 mm **of rain** per year. The mountain is driest to the North which receives less than 1000 mm **of rain per year**. The altitudes with the highest rainfall are between 2,700 m and 3,100 m **above sea level**. Rainfall decreases with altitude and above 4,500 m, most precipitation falls as snow or hail. Temperature also varies considerably with altitude but the average temperature at 4,750 m is **x** **ºC**.

Mt. Kenya National Park has x vegetational zones **[KWS, 1992],** the Nival Zone lies above 4,500 m **above sea level** and the vegetation is characterized by mostly mosses and lichens. The Afro-alpine Zone lies above 3,500 m **above sea level** whereas the Moorland is characterized by tussock grasses. The most notable adaptations are **the** Giant groundsels, Cabbage groundsels, and Giant lobelia. High altitude Heath lies between 3,000 m and 3,500 m **above sea level**. The habitat is characterized by shrubs with small leaves. These include Heathers (*Calluna vulgaris*), African Sage (*Salvia aethiopis*), Protea (*Protea cynaroides*), and Herichrysum (*Helichrysum petiolare*). The Upper forest zone lies above the Bamboo zone and is characterized by smaller trees scattered in glades. The dominant species are East African Rosewood (*Dalbergia melanoxy*) and St. John's wort (*Hypericum perforatum*). Many of the trees are festooned with mosses and old man's beard trees [KWS, 1992].

The Bamboo zone forms a dense belt between 2,500 m and 3,200 m **above sea level**. The belt is thickest where it is moistest on the South - Eastern side of the mountain. It is absent entirely on the Northern side. The Montane forest descends as low as 2,000 m and the characteristic species are pencil Cedar and Podo. The threats and damages to Mt. Kenya forest were recorded as charcoal production, cultivation of marijuana (*Canabis sativa*), fire occurrences, Shamba (mixed farming) system practices in the forests, grazing of livestock and logging of Camphor, Wild Olive and East African Rosewood **[KWS, 1992]**. Mt. Kenya has a wide variety of wildlife and six species of large mammal of international conservation interest occur within the forests such as elephant, black rhino, leopard, giant forest hog, bongo and black-fronted duiker.

Il Ngwesi II Group Ranch (GR) which is also known as (Il Ngwesi community conservancy), lies between 0º 16´ to 0º 25´ North and 37º 17´ to 37º 26´ East [Harrison, 2001]. This group ranch consists of 8,645 ha of community managed land located in Mukogondo Division, Laikipia District, North of Mount Kenya, [Ojwang *et al,* 2010] or (Plate 3.21). Il Ngwesi meaning "People of Wildlife" was among the first community- led conservation initiatives established in Northern Kenya. The ranch was established in 1995 with the aim of producing extra income from tourism and regenerating wildlife populations with the assistance of Lewa Conservancy. The Group Ranch is split up into a settlement area and a conservation area. The core area has a radius of 5 Km^2 while the buffer area totals 6,000 Ha. Grazing in the buffer area is regulated and is not permitted after the rains to allow good grass growth. The highlands to the West are largely occupied by the upland-dry forests of the Mukogondo Forest Reserve and the grassland plains of Anadanguru. The medium altitudes of the plains are characterized by wooded grassland savanna, a mixture of grasses, dense thorn-shrub thickets [Harrison, 2001].

The Geographical Information Systems (GIS) constitute a considerable expansion of the capacity of humans and organizations to manage and make use of such information. [Ojwang *et al,2010*] states that, sub-division of some formerly large ranches and communal lands have resulted into habitat fragmentation and threat to the bio-diversity existing outside the protected areas. Increasing intensive crop cultivation and loss of vegetation cover in areas adjacent to the protected areas resulted in unchecked land use conflicts. The complexity of the biological, ecological, and physical processes, which comprise natural systems, makes modeling a potentially valuable tool for anticipating responses to management options [Toxopeus, 1996] or [6]. The traditional method of representing the geographic space occupied by spatial data is as a series of thematic layers [Heywood *et al.,* 1998]. [Spencer, 2003] indicated that, GPS for ground truthing is used to create, correct, interpret, assess accuracy or somehow modify existing geospatial data. Two common uses for geo-referencing aerial or satellite images and classifying satellite images is by deriving land use and land cover (Leica Systems, (2006).

According to [Spencer, 2003], GPS data when put into a GIS, gives the researcher the ability to link a spatial data to real World coordinates. [Wadsworth and Treweek, 1999], stated that most ecological data are collected using some form of ground survey. [Jensen, 2000], observed that remote sensing has the capability to provide synoptic views over very large areas very quickly. Most ecological studies make use of data collected by sensors working in the visible and near-infrared parts of the spectrum.

According to [Johnson, 1998], image analysis can provide quantitative information about ecological properties, which cannot be easily derived from aerial photography or field studies. [UNEP, 2009], states gaps in vegetation cover caused by fragmentation can isolate populations of certain species and lead to their demise while land and water degradation render habitats unhealthy thus threatening species survival.

Deus and Gloaguen [2011] in their study on Tarangire National Park (TNP), stated that, the three main land-cover categories namely barren, woodland and grassland have been identified and mapped successfully using four sets of landsat images; MSS 1979, MSS 1988, ETM+ 1999 and TM 2009. The land covers were estimated to occupy; woodland 52.82% (1515 Km^2), grassland 40.24% (1154 Km^2), and barren 6.94% (199 Km^2) of the total national park area in 1979.

Bertwistle [2001] reported having evaluated land cover data for the Albemarle-Pamlico peninsula to delineate landscape characteristics preferred by black bears and white-tailed deer. Data from surveys, monitors, and modeling were analyzed separately and results were spatially combined.

Clark *et al.,* [2008] stated that, the creation of the habitat map consisted of the following two steps: defining a set of land cover

classes (hereafter termed 'habitat classes') known to exist in the study area, and then using a remote sensing technique to classify the ortho- rectified imagery based on the pre-defined set of classes. A GIS could also be useful for yellow-eyed penguin habitat restoration and tourism management, Clark *et al.*, [2008]. This report described how the preferred vegetation cover for nest sites can be easily determined with a GIS. This information could be valuable for determining the type, amount and spatial layout (such as distribution and density) of vegetation that should be used in habitat restoration programs.

3. RESEARCH ELABORATIONS

The landsat images sourced from the Regional Centre for Mapping of Resources and Development, Kenya were used to assess the land cover and land use changes for a twenty-year's period, between 1988 and 2010. The remote sensing images used were in TIFF formats which were imported to Erdas Imagine platform. The supervised classification analysis identified the following feature classes; Agriculture, settlements, grasslands, bare ground, thickets, shrubs, Forests, mixed forests, swamps, riverine vegetation, water and snow. All classes were assigned unique symbols for easier identification.

1. RESULTS AND FINDINGS

Two landsat images of 1988 and 2000 images of a ten year period were used to analyse the land use and land cover of Mt. Kenya National Park, (Fig. 1 and Fig. 2). However, there was a problem of cloud cover and stripping in most satellite images between 2001 and 2010.

The landsat image of the years 1988 and 2000, indicated the following; a decrease in water bodies by 152.91 ha, area covered by snow decreased by 1,494.45 ha, Moorland increased by 20,599.3 ha, Montane or upper forests decreased by 1,704.6 ha, area covered by bamboo decreased by 9,718.65 ha, heath or high altitude forests covered area decreased by 15,744.51 ha, and land on agricultural activities increased by 3.867.4 ha. The big increase in agricultural activities in the buffer zone was due to illegal logging in the forests, forest fires and impact of climate change on the mountain vegetation (Fig. 3).

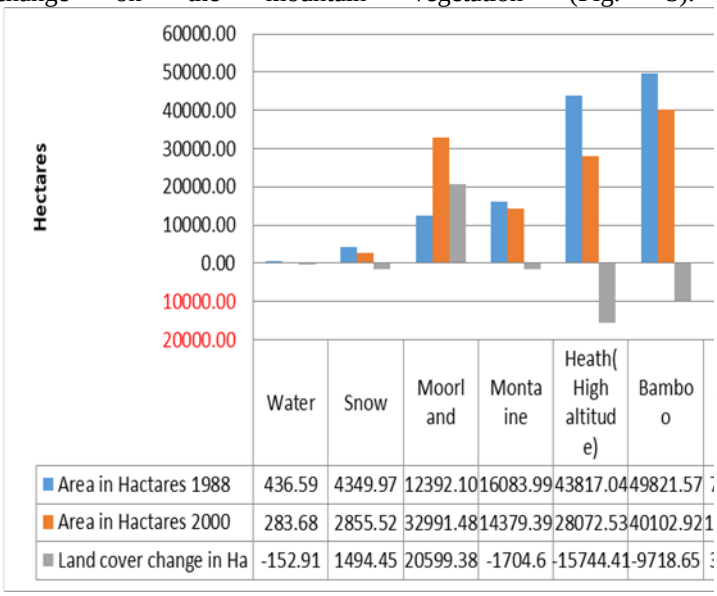


Figure 3. Land use / land cover chart for 1988 and 2000 images within Mt. Kenya National Park and its environs.

The land cover changes indicated an increase in agricultural activities of 3,867.4 ha. The diminishing resources could be linked to a decrease in; water of 152.9 ha, montane 1704.6 ha, bamboo 9718 ha and heath 15,744 ha.

The Landsat images of 1988, 2000 and 2008 were used for land use and land cover analysis for Il Ngwesi Conservancy (Fig. 4, 5, 6 and 7).

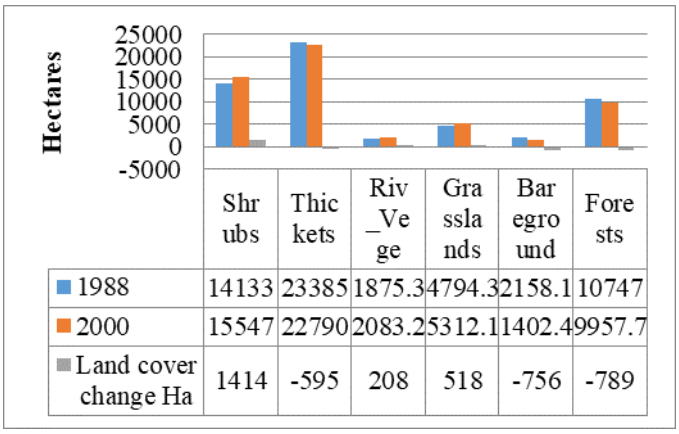
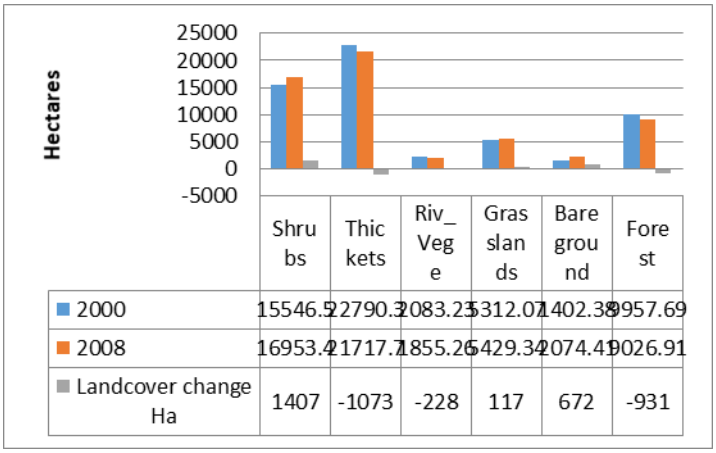


Figure.7. Land use / land cover chart of 1988 and 2000 images within Il Ngwesi conservancy and its environs.

Il Ngwesi Conservancy land cover and land use analysis (Fig.7), indicated a decrease in forest cover between 1989 and 2000 by 789 ha which continued to decrease by 931 ha between 2000 and 2008 within the park. Thickets decreased by 595 ha between 1989 and 2000 and continued to decrease to 1,073 ha between 2000 and 2008. Grasslands increased in area by 518 ha between 1989 and 2000 and continued to increase between 2000 and 2008 to 117 ha. Bareground area decreased by 756 ha between the years 1989 and 2000 but increased to 672 ha between the years 2000 and 2008. Thicket-covered area decreased to 595 ha and continued to decrease to 1,073 ha between the years 2000 and 2008. Forest cover decreased by 789 ha in the years 1989 and 2000 and by 931 ha between the years 2000 and 2008. Area covered by shrubs also increased by 1,414 ha between the years 1989 and 2000 and by 1,407 ha between the years 2000 and 2008. Area under Riverine vegetation increased by 208 ha between the years 1989 and 2000 but decreased by 228 ha between the years 2000 and 2008 (Fig. 8). It was noted that the land cover changes indicated a decrease in; forest cover by 931 ha, thickets area by 1073 ha and riverine vegetation by 228 ha.



	Shrubs	Thickets	Riv_Vege	Grasslands	Bareground	Forest
2000	15546.5	22790.3	2083.25	5312.07	1402.38	8957.69
2008	16953.4	21717.1	1855.26	5429.34	2074.41	9026.91
Landcover change Ha	1407	-1073	-228	117	672	-931

Figure.8. Land use / land cover chart for 2000 and 2008 images within Il Ngwesi conservancy and its environs.

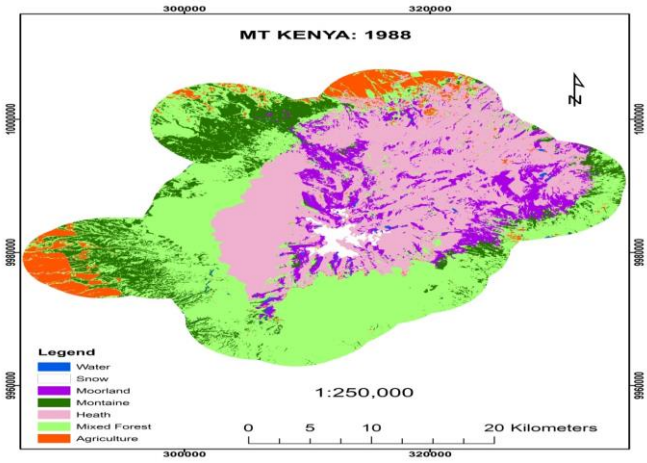


Figure 1. Classified image of land use / land cover types for the year 1988 within Mt. Kenya National Park and its environs.

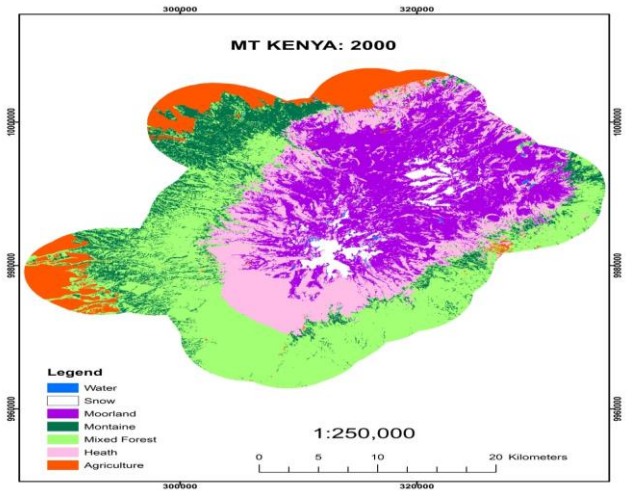


Figure 2. Classified image of land use / land cover types for the year 2000 within Mt. Kenya National Park and its environs.

2. CONCLUSIONS

The GIS analysis indicated that there was a general decrease of land cover and land use in hectares. There was a general decrease in areas under; forests, shrubs and bare land due to illegal logging in the forests, forest fires and impact of climate change on the mountain vegetation. The Landsat image of the years, 1988 and 2000 in Mt. Kenya indicated a decrease in the water bodies by 152.91 ha, area under snow increased by 2,855.5 ha, Moorland area increased by 20,599.3 ha, Montane or upper forests area decreased by 1,704.6 ha, area under bamboo decreased by 9,718.65 ha, heath or high altitude forests area decreased by 15,744.51 ha, and the land under agricultural activities increased by 3,867.4 ha. At Il Ngwesi, grassland area increased by 635 ha, bareground decreased by 84 ha, thicket area decreased by 1,073 ha, forests cover decresed by 931 ha and riverine area decreased by 228 ha between the years 1988 and 2000.

It is imperative to note that, communities living in the mountain conservation area benefited heavily from rivers waters, heavy rainfall as indicated by the types of crops grown in the high altitude areas, keeping of livestock, timber, firewood and eco-tourism. This is an indicator of the benefits of ecosystem services to the communities living in the conservation area. However, the study noted diminishing resources such as; foret cover, rangeland and heavy river water flow as indicated by the GIS analysis. This could be due to increased droughts and compounded by the impacts of climate change.

3. APPENDICES

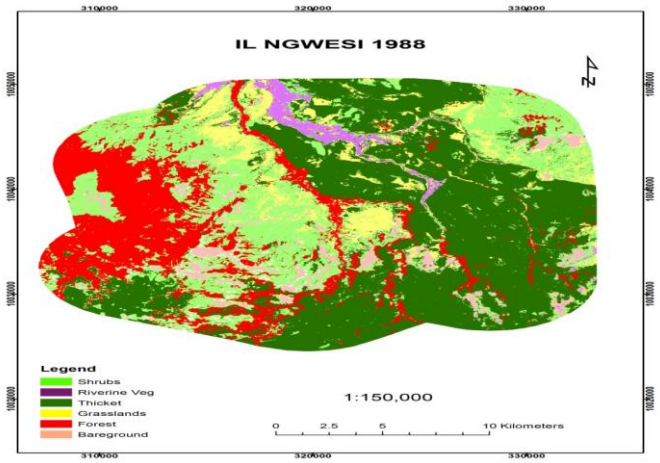


Figure.4. Classified image of land use / land cover types for the year 1988 within Il Ngwesi conservancy and its environs

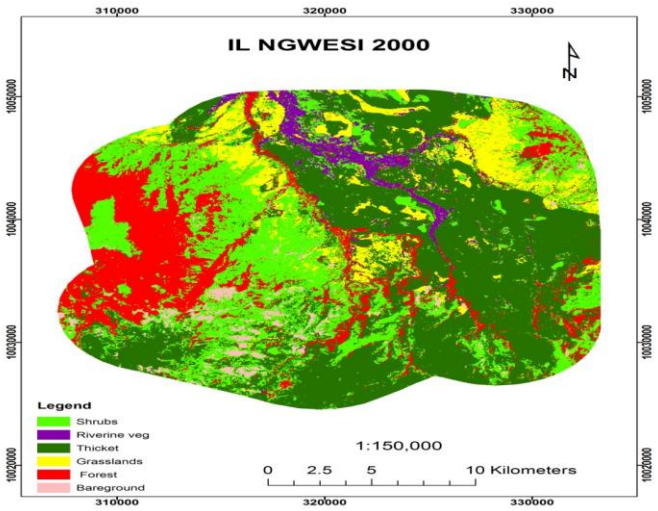


Figure 5. Classified image of land use / land cover types for the year 2000 within Il Ngwesi conservancy and its environs

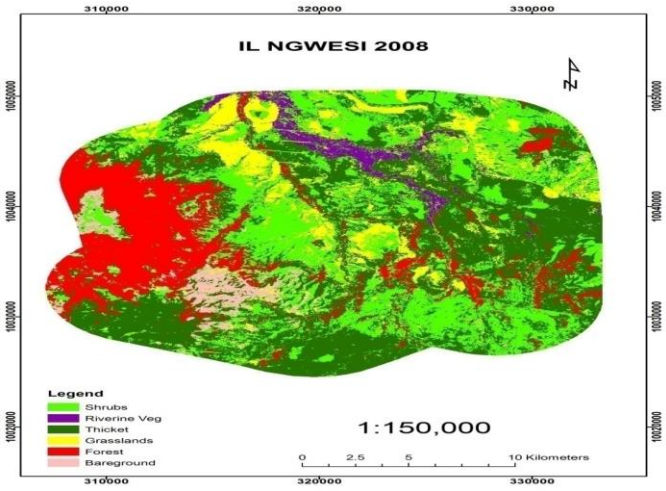


Figure 6. Classified image of land use / land cover types for the year 2008 within Il Ngwesi conservancy and its environs

4. ACKNOWLEDGEMENT

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