Ecosystem Services to the Community: A Situation Analysis of Mt. Kenya Conservation Area Using GIS and Remote Sensing

Margaret Wachu Gichuhi, J. M. Keriko and J. B. N Mukundi

Abstract—The purpose of this research was to look into how communities living in the Mt. Kenya conservation area benefit from the ecosystem services such as food, water, biodiversity, tourism and recreation, fuel and energy, timber and housing materials. The analysis gave an insight into the state of the natural resources and the sustainability of diminishing resources.

The objectives of the research were; to analyze the socio-economic benefits that may result from sustainable management of resources; to assess the state of the environment for the past twenty years. Geographical Information Systems (GIS), remote sensing (RS) was used to assess the state of the environment. Mt. Kenya National Park owned by the government, Il Ngwesi Community Conservancy were used as sample study sites for the eco-region. Satellite Images used were from 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. 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 conflict over water, grass and other resources.

Key Words: 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 [1].

A. Mountain Conservation Area

a. Mt. Kenya National Park

This study will focus on Mt. Kenya National Park and 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 with deeply incised u-shaped valleys in the upper parts. Mt. Kenya is a World Heritage site , Gathaara, G. [2]. There are twelve small glaciers remaining from the earlier glacial periods, and which are receding rapidly and may disappear during the next century, KWS, [3].

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 northern 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 Ithanguni and Rutundu cones.

The altitude variation on Mount Kenya gives rise to a wide variety of climate. The wettest part of the mountain is to the South - East which receives up to 2,500 mm per year. The mountain is driest to the North which receives less than 1000 mm. The altitudes with the highest rainfall are between 2,700 m and 3,100 m. 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 °c.

Mt. Kenya National Park has the following vegetation zones KWS, [3], the Nival Zone lies above 4,500 m and the vegetation is mostly mosses and lichens. The Afro-alpine zone lies above 3,500 m where the moorland is characterized by tussock grasses. The most notable adaptations are Giant groundsels, Cabbage groundsels, and Giant lobelia. High altitude Heath lies between 3,000 m and 3,500 m. 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 melanox) and St. John’s wort (Hypericum perforatum). Many
of the trees are festooned with mosses and old man’s beard trees KWS, [3].

The Bamboo zone forms a dense belt between 2,500 m and 3,200 m. The belt is thickest where it is moistest on the Southern - 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, [3]. Mt. Kenya has a wide variety of wildlife and six species of large mammal of international conservation interest occur within the forests.

b. IL Ngwesi Community Conservancy

Il Ngwesi II Group Ranch (GR) which is also known as (Il Ngwesi community conservancy), lies between 0° 16’ to 0° 25’ North and 37° 17’ to 37° 26’ East, Harrison, [4]. 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 [5] (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 5Km² 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, [4].

II. LITERATURE REVIEW

The Geographical Information Systems (GIS) constitute a considerable expansion of the capacity of humans and organizations to manage and make use of such information. [5] states that, subdivision of some formerly large ranches and communal lands have resulted to habitat fragmentation and threat to the biodiversity existing outside 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, [6]. The traditional method of representing the geographic space occupied by spatial data is as a series of thematic layers Heywood et al [7]. Spencer [8] indicates 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 (LULC).

According to Spencer, [8], GPS data when put into a GIS, gives the researcher the ability to link a spatial data to real world coordinates. Wadsworth and Treweek,[9], stated that most ecological data are collected using some form of ground survey. Jensen, [10], 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,[11], image analysis can provide quantitative information about ecological properties, which cannot be easily derived from aerial photography or field studies. UNEP,[12] 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 [13] in their study on Tarangire National Park (TNP), states 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 cover were estimated to occupy; woodland 52.82% (1515 Km²), grassland 40.24% (1154 Km²), and barren 6.94% (199 Km²) of the total national park area in 1979.

Bertwistle[14] reported that they 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,[15] 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. [15]. This report has 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.

III. METHODOLOGY

The landsat images were used to assess the land cover and land use changes for a twenty year period (1988 - 2010), and they were sourced from the Regional Centre for Mapping of Resources and Development, Kenya. 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.

IV. DISCUSSION

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). There was a problem of cloud cover and stripping in most satellite images between 2001 and 2010.

The landsat image of 1988 and 2000 indicated that there was a decrease in water by 152.9 ha, snow increased by 2855.5 ha, montane increased by 20599.3 ha, montane or upper forests decreased by 1704.6 ha, bamboo decreased by 9718.65 ha, heath or high altitude forests decreased by 15744.51 ha, agriculture increased by 3867.4 ha. There was a big increase in agricultural activities in the buffer zone 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

Il Ngwesi Conservancy land cover and land use analysis (Fig.4.52), indicated that there was 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 1073 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 decreased in area by 756 ha between 1989 and 2000 but increased to 672 ha between 2000 and 2008. Thickets decreased to 595 ha and continued to decrease to 1073 ha between 2000 and 2008. Forests decreased by 789 ha in 1989 and 2000 and by 931 ha between 2000 and 2008. Shrubs also increased by 1414 ha between 1989 and 2000 and by 1407 ha between 2000 and 2008. Riverine vegetation increased by 208 ha between 1989 and 2000 but decreased by 228 ha between 2000 and 2008 (Fig.8).

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

The land cover changes indicated that there was a decrease in forest cover of 931 ha, thickets decreased with 1073 ha and riverine vegetation with 228 ha.
V. 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 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 1988 and 2000 in mt. Kenya indicated that there was a decrease in water by 152.91 ha, snow increased by 2855.5 ha, moorland increased by 20599.3 ha, montane or upper forests decreased by 1704.6 ha, bamboo decreased by 9718.65 ha, heath or high altitude forests decreased by 15744.51 ha, and agriculture increased by 3867.4 ha. At Il Ngwesi grasslands increased by 635ha, bareground decreased by 84ha, thickets decreased by 1073ha, forests decreased by 931ha and riverine decreased by 228ha between 1988 and 2000.

It is imperative to note that communities living in the mountain conservation area benefit from rivers, rainfall as indicated in the 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, there are diminishing resources such as forests, rangeland reduction and rivers drying up as indicated by the GIS analysis. This could be due to increased droughts and impacts of climate change.

APPENDICES

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

Figure 3. Classified image of land use / land cover types for the year 1988 within Il Ngwesi conservancy and its environs

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
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7. References


ABBREVIATIONS AND ACRONYMS

ETM+     Enhanced Thematic Mapper Plus
GIS      Geographical Information System
GPS      Global Positioning System
GR       Group Ranch
KWS      Kenya Wildlife Service
LULC     Land use and Land cover
RS       Remote Sensing
TIFF     Tag Image File Format
TM       Thematic Mapper
TNP      Tarangire National Park
UNDP     United Nations Development Program
UNEP     United Nations Environmental Programme
UTM      Universal Transverse Mercator
WGS      World Geodetic System