

THE PHYSICAL STATE OF FOREST COVER AND LAND USE IN KENYA: A CASE OF NANDI HILLS FORESTS IN NANDI COUNTY, KENYA

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ABSTRACT: *The Nandi Hills and Forests in the Nandi County are major water catchments for the Lake Victoria. However, these resources have faced significant decline and degradation in recent times, thereby impacting the hydrological quality and quantity in the Lake Victoria Basin. This study was informed by the observed degradation of the Nandi Hills and Nandi Forests, epitomized by the receding forest cover, drying up of previously permanent streams, instances of mudslides and rock falls, and downstream flooding. This paper sought to establish the state of and use of the Nandi Hills/Forests as water catchment area in Nandi County, Kenya. The study adopted a mixed methodological design which incorporated both qualitative and quantitative methodologies. The mixed methodological approaches used in this study were the concurrent triangulation and nested/embedded designs. A four-tier analysis was carried out once all the data had been coded and grouped. The analysis covered three categories of the population in the study area; namely the households, institutions and community groups, and analysis of Landsat images for change detection. Analysis of the Landsat images revealed a grim state of the receding natural forest cover. However the uptake of on-farm forestry by the locals is seen as a potential remedy for the dwindling forest cover.*

KEYWORDS: Land Cover, Land Use, Nandi Hills/ Forests, Water Catchment, ecosystem services, Water towers.

INTRODUCTION

Forests serve diverse ecological functions and provide numerous environmental and socio-economic benefits to society (Food and Agriculture Organization [FAO], 2009). The continuous monitoring of the state of forest cover is essential in estimating forest loss or its increase in order to take any appropriate actions to counter any loss of forest cover. Despite the importance of trees and forest resources to human existence and economic development, current trends show that forest fragmentation, degradation, inadequate regeneration, and mismanagement are threatening the supply of vital ecosystem services and provisions (Temu & Ogweno, 2007). human livelihoods depend on forest ecosystems for its essential services and any loss is a threat to human survival.

Land Cover

The Global Forest Resources Assessment 2005 (FAO, 2006) emphasized that forest area provides the first indication of the relative importance of forests in a country or region. Forest area is relatively easy to measure, and this variable has therefore been selected as one of the 48 indicators for monitoring progress towards the Millennium Development Goals agreed by the United Nations (particularly Goal 7 – Ensuring environmental sustainability). The structure and composition of forests are increasingly influenced by global phenomena such as the presence of introduced species, climate change, and anthropogenic alterations of

biogeochemical cycles (Newman, 1995; Vitousek *et al.*, 1997; Simberloff, 2000; Dale *et al.*, 2001; Honnay *et al.*, 2002). Major transformations of forest ecosystems have occurred or are underway, in many cases resulting in substantial losses of timber values or commercial extinction of valuable tree species, along with a reduction in native biodiversity (Liebhold, *et al.*, 1995; Laurance, 1999; Simberloff 2000; Hoekstra *et al.*, 2005). In addition to global influences, forests are also being shaped by regional and local forces.

Forests provide an array of economic resources, and different harvesting techniques are prone to achieve manifold yields from the same environment. The incredibly robust management techniques are those which shun open-access utilization of resources, through tenure and usufruct mechanisms allowing for long-term and exclusive access by individuals or communities (Caldecott *et al.*, 1994). They continue to elaborate that where such techniques have been embraced, the necessity for exterior intervention may be reduced to technical counsel and monitoring, to guarantee sustainable harvests. Barring such harvesting may lead to economic loss to the local people and trigger their antagonism. Alternatives in such a case may comprise traditional utilization of segments inside conservation areas, buffer zones bordering them, or community lands in a different place, which may all be accessible for particular types of persistent exploitation by locals. Moreover, forests often experience the cumulative and often fragmentary impacts of development stresses such as road-building, oil and gas development, urban and suburban encroachment, and agriculture (Forman 2000; Trombulak & Frissell, 2000; World Resources Institute, 2000; Schneider *et al.*, 2003). This combination of disturbance and developmental pressures can reduce biodiversity and diminish the capacity of forests to continue providing ecological goods and services of the same quantity and quality in perpetuity (Toman & Ashton, 1996; Costanza *et al.*, 2000). In response to these concerns, many ecologists have argued that resource managers should focus on maintaining ecological resilience, defined here as the capacity of natural systems to absorb disturbances without undergoing change to a fundamentally different state e.g., (Holling, 1973; Holling, 1986; Peterson *et al.*, 1998).

Whenever a resource is exploited, several different interests are put into conflict. Two major ones are economic interests and environmental interests. Economic factors are easy to measure. The cost of exploitation and financial return for this expenditure are the primary issues. The environmental viewpoint is often difficult to put into monetary terms and must often rely on ethical and biological arguments to temper the economic arguments. Modern forest management practices in many parts of the world involve a compromise between these two points of view (Enger *et al.*, 1992).

Global Forest Outlook

Data on the status of and trends in area of forest are crucial to decisions related to forest and land-use policies and resource allocations, but they need to be combined with information on the health and vitality of forests and their socio-economic and environmental functions and values. FRA 2005 (FAO, 2006), points out that forests cover 30% of the total land area with the total forest area in 2005 being just under 4 billion hectares (ha), corresponding to an average of 0.62 ha per capita. However, the area of forest is unevenly distributed. For example, 64 countries with a combined population of 2 billion have less than 0.1 ha of forest per capita. The ten most forest-rich countries account for two-thirds of total forest area. Seven countries or areas have no forest at all, and an additional 57 have forest on less than 10% of their total land area.

Africa accounts for just about 16.1% of the global forest cover which is around 0.64 million ha. Although the tropics boast of the largest area under forest, they are faced with the largest rate of deforestation (FAO, 2009). Forest loss caused by a complex set of social and economic pressures is a concern, contributing to losses of biological diversity, degradation of forests, and have contributed significantly to global warming (Glenday, 2006; Haili, 2007). Among the major factors contributing to forest degradation are conversion of forests to farmland and poor forest management, including inappropriate logging, forest fires, and increased harvesting of wood fuels and other forest products for household use (Glenday, 2006; World Rainforest Movement [WRM], 2006).

Progress towards sustainable forest management in Africa appears to have been limited during the last 15 years despite some indications that the net loss of forest area has decreased and that the area of forest designated for conservation of biological diversity has increased minimally and the continued, rapid loss of forest area (the largest of any region during this 15-year period) is particularly disconcerting (FAO, 2006).

Forest Status in Kenya

In Kenya, gazetted forests represent less than 2.5% of the total land area. The country has about 37.6 million ha of natural woody vegetation outside forests, consisting of 24.8 million ha of bush land, 10.8 million ha of wooded grassland and 2.1 million ha of woodland. A further 9.54 million ha of woody vegetation is found on farmland and in settlements (Kenya Forestry Department, 2001). Kenya's closed canopy forests are estimated to cover 1.24 million hectares. This is just about two per cent of the country's land area and these are largely confined to the wetter, cooler parts of the country. According to Ogwen and Oduori (2001), these forests can be classified into four types: (a) Coastal Forest (b) Afro-montane forest comprising east and west mountain forests (c) Guineo-Congolan upland forests and (d) the small outlier forests in dry zones, like the Kitui and Machakos hill tops and the Taita hills. Also to be included here are forest patches in Western Kenya and Riverine forests. Recent estimates, based on remote sensing, indicate that Kenya's forest cover now stands at a critical 1.7 per cent (UNEP, 2001). This is against, the minimum international recommended forest cover of 10 % (see figure 1).

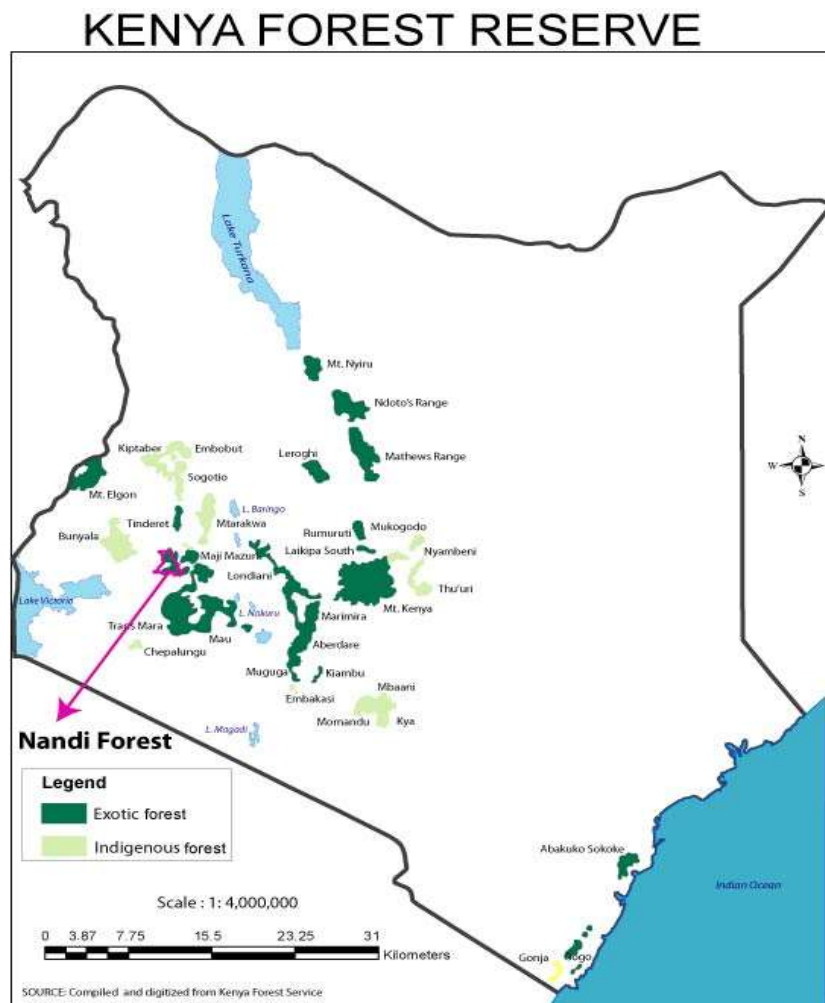


Figure 1: The distribution of forests in Kenya (Source: Kenya Forest Service, 2010)

Despite the fact that the amount of closed canopy forest cover in Kenya is low, the nation's forests are important natural assets for their economic, environmental, social and cultural values. Forestry and wood processing industries are estimated to provide direct employment to 35,000 people (Gathaara, 1999). Forests are therefore an integral part of national development. Although forest products and services in Kenya are estimated to contribute about €90 million to the economy, and although the forest sector employs 50,000 people directly and another 30,000 indirectly, the forests nevertheless tend to be undervalued (Emerton & Karanja, 2001) and are often poorly managed.

The Mau forest provides sustenance to more than 150,000 families that live in and within 2 kilometres of its boundary. Each year, these families utilize forest resources such as fuel wood, building materials, food, vegetables, honey, fodder, and other non-timber forest products. The Mau Water Tower represents the upper catchment of all but one of the main rivers west of the Rift Valley, which are the sources of over 60% of the water flowing into Lake Victoria (see figure 2 below).

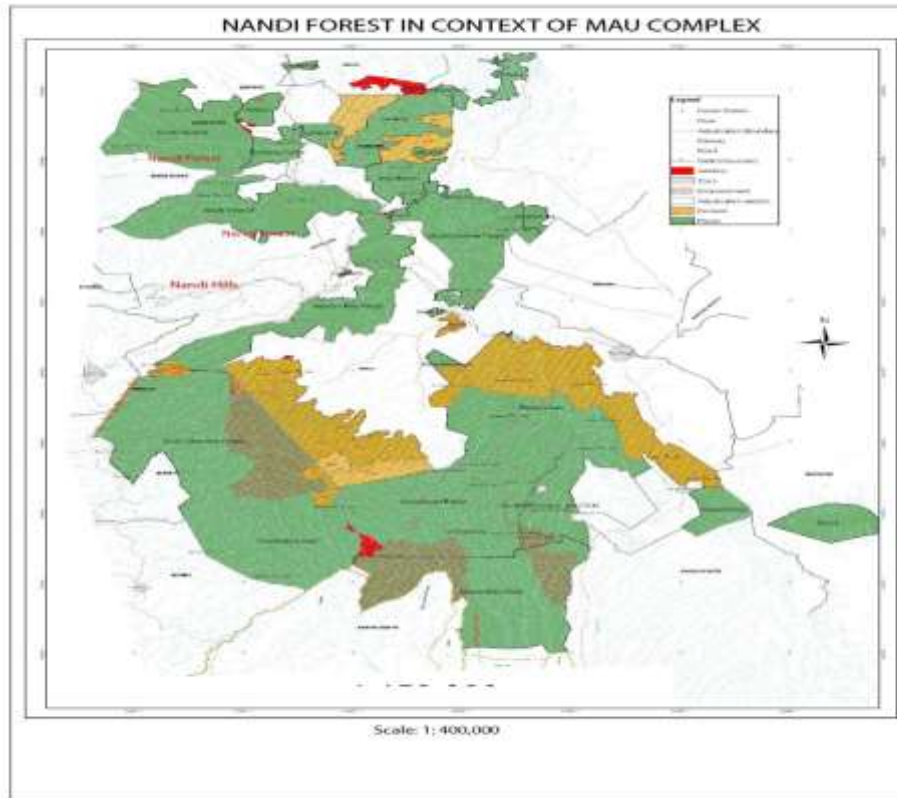


Figure 2: Nandi Forests in the Context of Mau Forest Complex (Source: Kenya Forest Service, 2010)

The Mau Forest Complex have been heavily impacted by official forest excisions, as well as the illegal, irregular and unplanned settlements; the most affected are the Eastern Mau and South Western Mau Forest Reserves where 35,301 ha and 22, 797 ha respectively have been excised representing 54.3% and 27.3% of their total area respectively (Akotsi, Gachanja & Ndirangu, 2006)

Land Use and Forest Depletion in Kenya

In spite of the fact that many Kenyans have become responsive to the aesthetic, environmental, and commercial worth of forests, thick-canopy forests have been degraded (Government of Kenya, 1999a). By the year 1981, a total forest record showed a number of documented and non-documented areas in threat of expurgation. Over a period of about 20 years forested areas have been reduced by 16%. The directory of endangered forests includes the Karura and Ngong Forests. Earlier forest degrading was the result of an effort by the government to make room for agriculture and also to create homes for the landless. A decrease in the pace of depletion of forests in the mid and early 1970s from about 18% to approximately 6% per year was the result of local efforts conservation efforts complemented by those of the global community (Matiru, 1999).

Clearing of forests has been an ecologically and spatially distinguish process changing across time and reflected the comparative power and the capability of various groups to find access

into Kenya's forest resources (Emerton & Karanja, (2001). Between the years 1990 and 1995, the cover of forests changed by 17%, mainly as a result of the settlement of landless people. Systematic analyses also show that a number of blocks of forests were illegally acquired by the then land owners (Akotsi *et al.*, 2006). Recently the decrease of forests through removal, pressures in population and change in climate is approximately at about to 5,000 hectares annually, while depletion through forest excisions and fires is estimated at almost 15,000 hectares each year (Government of Kenya, 1999a).

The case of Nandi County, Nandi Forests

Land cover change detection and its variations are required so as to comprehend global change in environment. Of deep interests are the impacts of rain forest in the tropics ramifications which changes due to the extent and strength. The growth in ramification is related either to human or natural sources (Geist & Lambin, 2001). Both biodiversity influences are immensely important in the tropics (Gaston & Blackburn, 2000). The activities of the East African BIOTA are presently concentrating on the Nandi Forest and its fragments (Kohler, 2004). Retrieval of information about land cover change and therefore forest ramification and disturbance is conducted for the larger area of Nandi Forest and connected areas of forests. Here, the findings from satellite data form a chief contribution of processing spatial-information for registering man-made influences on these forests through time. The various ecological and/or biological subprojects of East African BIOTA allow investigation of local variations in ecosystems and biodiversity in relation to global environmental change (Kohler, 2004).

The forests of the Nandi District are on an escarpment of between 200m and 300m in elevation. Recently, there has been a continuous debate on whether such islands of forests would have become a wider area of forest if not they have been owned and managed by the Guinean Congo rain forest (Kokwaro, 1988). These forests exist in one of the earth's most populated rural settings (Blackett, 1994) with an average population density of 600 per km² on land which is vigorously used for home-based agriculture. The forest reserves play a significant role in providing for their basic needs of local people such as building material and firewood (Kokwaro, 1988). An increase in illegal and legal activities since colonial times in the early 20th century to date have led to forest depletion and have resulted in only relatively small patches of compact forests are remaining, with the much tampered with Nandi Forest deemed to have decreased to only about 120 km² by the year 1980 (Kokwaro, 1988).

MATERIALS AND METHODS

The study employed a mixed methodological design which incorporated both qualitative and quantitative methodologies. The mixed methodological approaches used in this study were the concurrent triangulation and nested/embedded designs. A four-tier analysis was carried out once all the data had been coded and grouped. The sample frame of the study is for persons above 18 years in Nandi County and there was heterogeneity in the population in the sample frame due to variety of issues such as: spacio-topographical exposure to the forests, urbanization, intermarriages, migration, education levels and even economic statuses. Nandi North forest is located within Nandi North District of the western parts of the Rift Valley Province of Kenya. This forest lies on the edge of the Nandi escarpment about 5 km east of

the Kakamega Forest. It stretches for more than 30 km from North to South and is no more than 5 km wide for most of its length. The Nandi South forest falls within the Nandi South District which was carved out of the greater Nandi in 2003 (Nature Kenya, 2009). Nandi Hills is a highland area of lush green rolling hills at the edge of the Great Rift Valley in the former Rift Valley Province of Kenya and is part of the once extensive Nandi South Forest.

To alleviate some of these causes of heterogeneity to the closest achievable extent, the sampling units were hence delimited based on the administrative boundaries (largely per district and finely per division). All the districts (4 districts) in the Nandi County were sampled. Relevant stakeholders (in the management of the Nandi Forests) other than the mainstream local community were also purposively sampled to obtain data. The desired sample size of households for simple random sampling was obtained from a formula as used by Fisher *et al* (1998) which yielded a sample size of 306 respondents. Oral interview schedules, questionnaires, Digital cameras and review of documented literature were used in data collection.

RESULTS

Land Use in the Nandi Hills District of Kenya

A database on land use within the administrative boundaries of the Nandi District was generated via GIS and Remote Sensing (Landsat images of 1994, 1999, 2003 and 2008, thematic layers clipped from Kenya and Nandi District images that include forests and vegetation), ground truthing (observations and photographs taken in the field from 2007 to 2010), questionnaires completed by members of the sample of households, and key informant interviews.

Remote Sensing and GIS

Remote Sensing and GIS data were generated by obtaining Landsat images from the Regional Centre for Mapping of Resources for Development in Nairobi. Broad classes of land use/land cover were established and classified images of the land cover prepared following the supervised classification criteria. These included: forest (areas under total forest cover), shrubs (areas with continuous un-interrupted interrupted shrub cover), tea (areas with total tea vegetation cover), grasslands (areas with continuous un-interrupted and interrupted grass cover) and bare ground. The preliminary images interpretation was done in reference to the five land use and/or land cover classes. These included land use land cover typologies from 1994, 1999, 2003 and 2008 from the respective Landsat images. The results of spatiotemporal variability in land use based on false colour composite Landsat images prepared from the clipped bands 2, 3 and 4 of the 1994, 1999, 2003 and 2008 revealed the variation in land cover and land uses within the study sites. PCA was undertaken for the acquired images for purposes of change detection for the five classes of the training area.

Areas for supervised classification were computed using Idrisi Kilimanjaro GIS analysis area computation software. This classification was carried out by prompting the software to run GIS analysis for specific areas in the training site. During the supervised classification of the satellite data for change detection, the analysis software was instructed to adhere to the earlier created land use classes. The preliminary images interpretation was done in reference to the five land use and or land cover classes (created during the initial interpretation). These

included land use land cover typologies from 1994, 1999, 2003 and 2008 from the respective Landsat images (the classes were created based on observers' own image interpretation skills).

The resultant Landsat images for detection of changes of different land uses and land cover classes in the study area are presented below (processed Landsat satellite images of 1994, 1999, 2003 and 2008 in Figures 3, 4, 5 and 6 respectively).

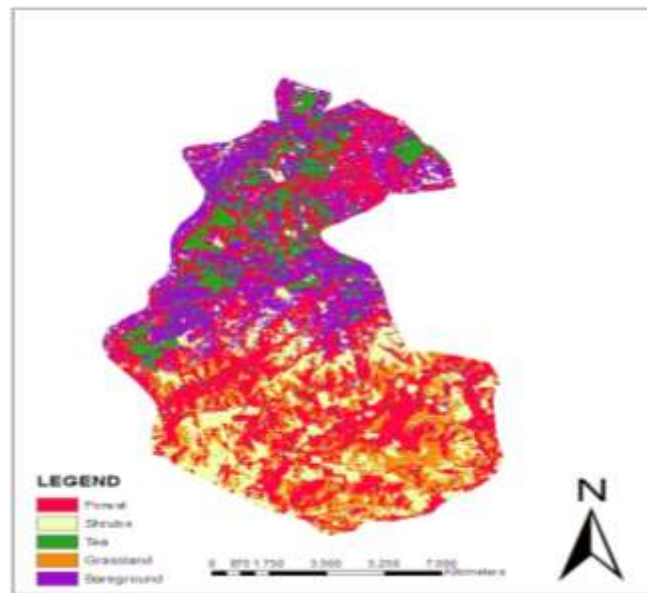


Figure 3: Processed Landsat image of the study area (1994)

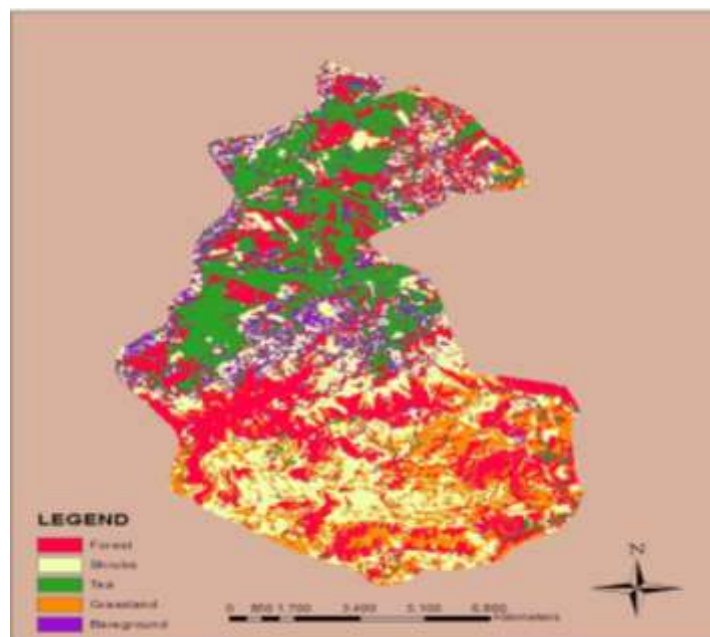


Figure 4: Processed and analyzed Landsat image of the study area (1999)

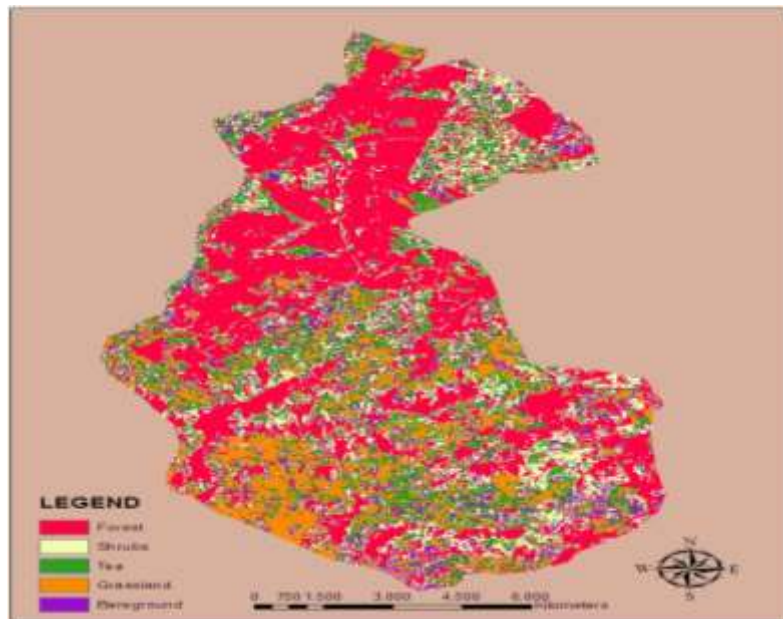


Figure 5: Processed Landsat image of the study area (2003)

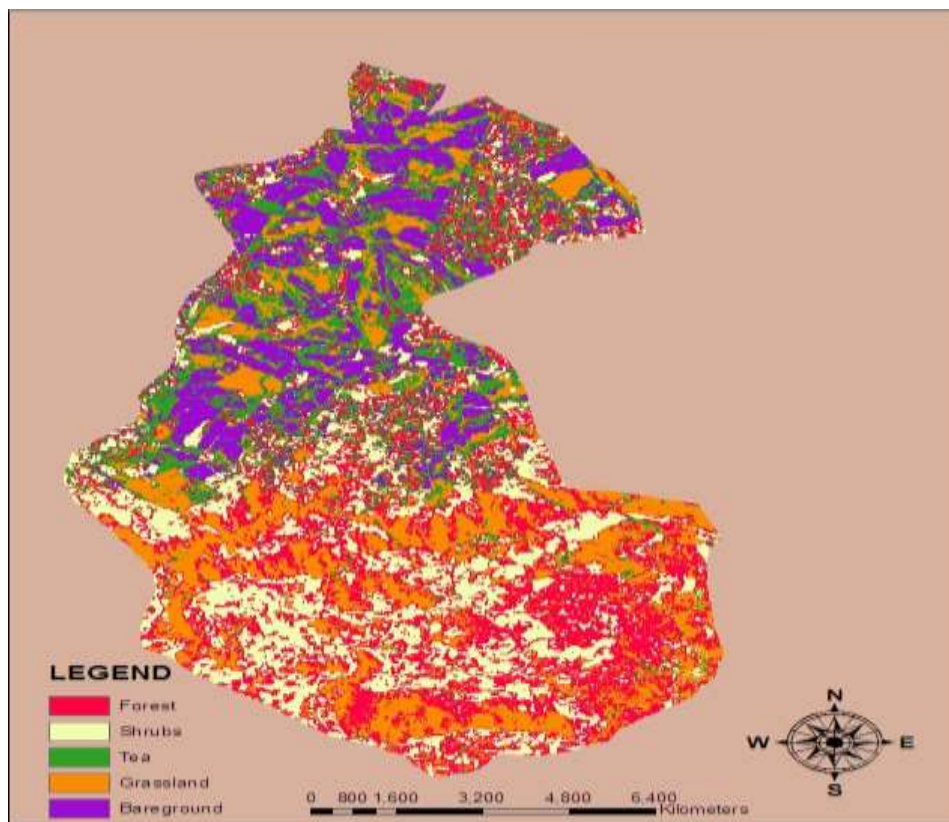


Figure 6: Processed Landsat image of the study area (2008)

The total area covered by each of the five land use/land cover types in 1994 and 2008 as mapped from the Landsat satellite images, as well as the changes that were calculated by subtracting the sum of the areas of each cover class in 2008 from their corresponding areas in 2003, 1999 and 1994, are summarized in Table 1 below.

Table 1: Representation of the spatiotemporal variation in land use between 1994 and 2008

Land use / Land cover Class	1994 Area (km ²)	1999 Area (km ²)	2003 Area (km ²)	2008 Area (km ²)
Forest	51.3477	42.8328	63.9441	42.1317
Shrubs	26.2089	37.0593	28.8207	31.0905
Tea	15.7302	32.7798	25.3332	25.4745
Grassland	23.6512	23.4234	17.4258	29.9916
Bare ground	31.1589	12.0006	12.5721	19.4085

From the results indicated in the table above it can be seen that the spatiotemporal variation in cover types that occurred in Nandi Hills forest area between 1994 and 2008 were mainly an increase in the areas under shrubs, tea and grasslands areas. Tea cultivation increased by 97.443 km² (62%) and areas covered by forest cover decreased by 9.219 km² (18%). Bare ground also decreased by a considerable value of 11.7504 km (38%), while shrubs increased by over 18% Figure 7.



Figure 7: Change in Area of Various land Uses

The rapid population growth, standing at 2.9% (Government of Kenya, 2005), has forced the local community to encroach fragile ecosystems such as hill-slopes and to some extent the

forest ecosystem including wetlands. Coupled with rapid urbanization, the immigration of foreign communities into the area has diluted the cultural stimulus of the native community, which has provided the driving factor for the effective management of the Nandi Hills Forests. Nevertheless, formal environmental approaches have attempted to re-energize effective

As noted earlier, two thirds of the forest communities is aware of the existence of the forests and have proximal knowledge of changes to the forest ecosystem, information on the reality of their progressive destruction or conservation still remains a vital aspect that requires attention. It is for this reason that an extensive GIS database was generated in this study and maps were draw to illustrate spatiotemporal variations in land use in the water catchments regions of Lake Victoria in the Nandi District of western Kenya.

CONCLUSION

It was found that the forest cover of Nandi Forest has suffered severe deforestation and degradation through heavy exploitation resulting from an escalating demand for timber and fuel wood, land for cropping and grazing. The depletion and degradation of the Nandi Forest was found to be a threat to ecosystem diversity and a fundamental influence on the declining standard of living of many households.

RECOMMENDATION

It is important to explore both the observable and perceived impacts of land use change; how both perceived and observable impacts differ across different types of socio economic classes and proximity to forest ecosystems and the reasons views may differ across groups on the utilization practices of forest resources. This will help in further disaggregating the awareness creation mechanisms relevant to the various cohorts or socioeconomic classes of the community. There's need to take appropriate actions to stop the deforestation and degradation that was found to be rampant in the area in order to ensure that the ecosystem diversity is maintained and even improved.

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