An Assessment of Land Use and Land Cover in and Around Kakamega Forest in Kenya Using GIS and Remote Sensing

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Abstract
Kakamega is an important forest in Kenya and in the East African region being the only Gueneo-Congolean tropical rainforest in Kenya. It is also one of the major tourist attractions in Kenya. Kakamega forest is threatened by uncontrolled degradation and conversions to other forms of land use due to high population density in adjoining areas. The uncontrolled exploitation of this resource may in the long run cause damage to the physical environment and to human livelihoods. It is against this backdrop that the study was conducted in Kakamega forest and its environs to determine the changes in land use in the areas around the forest and their implications for its conservation. The land use activities in and around Kakamega forest were identified and mapped. The land use and land cover changes were determined from three sets of aerial photographs acquired over a 28-year period using remote sensing techniques. The aerial photographs were of 1963, 1974, and 1991 at a scale of 1:25000. All the spatial data were analysed using geographical information systems software for comparison of land cover/land use over time. Three land use and cover maps 1963, 1974 and 1991 meant to compare temporal trends were produced. Land use/cover change maps were also produced to document the changes of particular land uses over time. The results obtained show that the indigenous forest has been converted to other land uses over time, resulting in substantial change in the size of the indigenous forest. They also show that communities living around the forest are highly dependent on in several ways. To enhance the conservation of the forest, the study recommends that continuous monitoring should be done in order to establish the present trend in ecological and other changes taking place to provide necessary data for planners and decision makers.

Keywords: land use, land cover, kakamega forest, remote sensing, geographic information systems

INTRODUCTION
In the scenario of rapidly expanding world population, changes in land use and declining forest cover, remote sensing has the role of an emerging discipline and provides essential tools of trade to the field forester. Land use includes man’s activities on land, which are directly related to the land (Clawson & Stewart, 1965). Examples include agriculture, forestry, range, urban and communication corridors (Anderson et al., 1976). In contrast, land cover describes the vegetation and artificial coverings of the land surface and thus, forms an attribute of the land or terrain (Barley, 1961). It includes vegetation, permanent snow and ice fields, water bodies or structures. Remote sensing is the science of deriving information about the earth's land and water areas from images acquired at a distance. It usually relies upon measurement of electromagnetic energy reflected or emitted from the features of interest (Campbell, 1987). It is the technology of acquiring data and information about an object or phenomena by a device that is not in physical contact with it. It is a system, which provides unique data that cannot be obtained by any other source; but much more often the collected data facilitates fieldwork and enables tasks to be completed at a lower cost and more quickly (Barrett & Curtis, 1992).

Remote sensing and Geographic Information Systems (GIS) can be applied in several fields such as forestry, geology, infrastructure, agriculture, wildlife, settlement and urban planning among others. Remote sensing as a technology has been applied in doing several studies in Kenya and other parts of the world of which a few are now mentioned. Agatsiva and Mwendwa (1982) have also used remote sensing techniques to prepare a land use map of Kenya where they used aerial photographs as the main source of data. In Tanzania, a land use and environmental survey of the immediate catchment area of an irrigation project was done. The main objective was to determine land use and consequent environmental impacts and their effects on development in the area (Mwaliosi, 1989). Remote sensing has also been used for erosion survey in Hunters valley New South Wales using aerial photographs (Haggison, 1973). Another erosion survey was done in central Pahang where aerial photographs and field survey were used. The results revealed the relationship between the
severity of erosion and the type of land use (Morgan, 1986).

David et al. (1969) conducted an analysis of earth resource in Phoenix, Arizona. Their study revealed that space photographs could be effectively used to evaluate urban development, land use patterns and other cultural development. Remote sensing studies by aerial photography have been used for several decades in the field of forestry (Barrett & Curtis, 1992). The technology can be used to collect urgently needed data, especially for monitoring changes in forest cover, assessing land use and forest degradation and providing information for forest inventory and also for direct input into forest management and strategic planning. Satellite remote sensing has stimulated a 'one world concept' and it repeatedly draws attention to problems associated with deteriorating national, regional and world environments (Howard, 1990).

Forests have common qualities and structures that allow us to establish regularities of their structure, state and development. This can be realized by remote sensing which record elements of the natural situation covering large territories. The importance of monitoring forest change over time was fully recognized during the advent of continuous forest inventory in the 1960’s particularly in Finland, Sweden and the USA (Howard, 1990). Remote sensing can be used to delineate vegetated from non-vegetated regions or forested from open lands. Such distinctions have great significance in some contexts especially when data are aggregated over large areas or are observed over long period of time (Campbell, 1987). The Global Environmental Monitoring System (GEMS) co-operated with FAO in global inventories and in the development of methods for future worldwide monitoring of forest cover. In the 1981 FAO/UNEP world forest resource appraisal, remotely sensed data was used for the first time to provide information on the forest cover and the forest vegetation types of several African countries. This was supplemented with information from national forest departments, universities and documents of bilateral and multilateral aid organizations. Estimates were made of forest change during the period 1976-1980 and extrapolated to the end of 1985 (Howard, 1990).

A complex programme for the investigation of forest resources is elaborated in the Soviet Union with remote sensing playing an important role in forest monitoring. It was used in the study of forest resources in the Taiga region, for example in Siberia, where most forests are almost inaccessible for direct observation and cover vast territories (Isaev, 1986). A Geographic Information System (GIS) has also been used for analysis of timber harvest, planning, critical wildlife habitat protection and planning of route location or scenic roadways. For instance GIS technology has been used in North America to manage forest inventory. The inventory was then used to assess the existing forest resource and assist in developing harvest schedules and treatment programs, protect future timber supplies and other operational planning activities (Hart et al., 1985).

Tateishi (2003) used remote sensing to detect land cover change in Mediterranean burnt forest areas and also addressed the problem of forest fires caused by arsonists in Italy. It was noted that remote sensing techniques can be successfully applied to detect land cover changes in forest areas. It can provide public authorities with information about the major changes that occur over burnt forest areas, so that more detailed ground surveillance can be focused on areas that show anomalies from satellite imagery. Sithong (2001) examined a land cover and land use change detection and the effects of roads and rivers on the changes using remote sensing and GIS in the Northern Lao PDR between 1995 and 1997. The Lao section of the Ca River Basin showed a clear relationship between distance from roads, forest cover and land use. It showed areas close to roads and rivers display a higher percentage of agricultural activity than other areas, while forest cover increases progressively away from roads or rivers. The forest cover is fragmented and scattered slightly along the roads and rivers but it is dense in the steep and difficult areas that are hard to access. The analysis showed that digital techniques are very useful for investigating land use and land cover in terms of time and investment.

The Department of Resource Surveys and Remote Sensing (DRSRS) generated land use/cover data for the Kakamega forest area in 2000. The existing land use information was reviewed to obtain current land cover/use patterns around Kakamega forest. GIS has gained remarkable acceptance and constantly expanding application because it has the capability of combining remote sensing with other data. Remote sensing methods have become increasingly important for mapping land use and land cover because image interpretation is faster and less expensive especially when large areas are to be mapped which is often the case in mapping land resources. The method also solves the problem of surface access that often hampers ground surveys. The images also provide objective data sets that may be interpreted for a wide range of specific land uses and land covers such as forestry or agriculture. Images also provide perspective that lacks in ground surveys. In remote sensing, images can be acquired with a spatial resolution that matches the degree of detail required for the survey and large areas can be imaged quickly and repetitively. Remote sensing, unlike other methods, can be used to quantify land use and land cover changes over time and the changes are
presented in maps where they can be visualised easily.

Land use and land cover information have become important for land use planning and resource management. Using or relying on ground surveys and sampling alone requires manpower, expenditure and time. Recent developments in remote sensing technology indicate that, if these methods are carefully combined with reliable ground based data, it is possible to compile detailed inventories of, and to monitor natural resources. Such analyses include the relationships between changes in forest zones and socio-economic development factors. Remotely sensed data obtained by sensors from a high altitude platform would be a good alternative to the ground survey approach. Another shortcoming of ground surveys apart from the ones mentioned above is that the respondent may guess the motives of the researcher and consequently modify the answers accordingly. However, field collected data provide more accurate and precise results but the collection is very slow. A designed spatial information system is therefore urgently required not only in view of the international rainforest discussion, but particularly in the interest of the local community and socially and environmentally compatible economic development. Remote sensing and GIS techniques have become popular and highly accepted throughout the world.

While the causes of biodiversity loss and forest destruction are reasonably well known and documented, the land use and land cover changes in and around the Kakamega forest and their implication for the conservation of the forest have not been studied. Some mapping of Kakamega forest have been done, e.g. the one done by the Department of Resource Surveys and Remote Sensing (DRSRS) described above but the land use and land cover changes over time have not been studied. The main human impacts on the tropical rain forests are logging and deforestation. For deforestation to take place, forest has to be cleared so it can be replaced by another land use practice. This has the merit of requiring a clear physical change in vegetation cover that can be monitored by satellites and other remote sensing techniques.

Need for Land Mapping of Kakamega Forest
The importance of forests need not be overemphasised. Forests play a vital role in environmental conservation, protect the underlying soil from the direct impacts of rainfall and increase the amount of humus in the soil. The presence of organic material, which is an important binding agent of the soil, makes it resistant to both wetting and water drop impact. Forests play an important role as part of the human life-support systems by regulating local climates and nutrient cycles. In addition, forests play an environmentally critical role in regulating stream flow regimes. They also act as habitat for wild animals, which may face extinction if their habitats are depleted.

The importance of Kakamega forest in particular includes its economic value (forest products, tourism etc); scenic value (visitors, tourism etc); natural value (bio-diversity, unique flora and fauna etc); traditional value (cultural uses e.g. prayers, circumcision etc); and environmental value (erosion protection, water regulation, carbon sink etc). To the local community the forest provides food, fuel wood, charcoal, timber, herbal medicine, a grazing area for animals, employment and act as venues for cultural practices. Over the years man has had great influence on plant life than on any other component of the environment. Forests world-wide are being threatened by uncontrolled degradation and conversion to other forms of land uses; influenced by increasing human needs; agricultural expansions and environmentally harmful mismanagement including: lack of forest fire control and anti-poaching measures, unsustainable commercial logging, overgrazing, airborne pollutants, economic incentives and activities of other sectors of the economy.

Through the changes brought about by man on plant cover, he has modified soils, influenced climates, affected geomorphic processes and changed the quality and quantity of some natural waters. Environmental change is occurring at an unprecedented rate where deforestation is creating local and global environmental problems threatening the survival of the world’s plant and animal species. This will result in desertification and probably climate changes through the green house effect. Scientific records indicate that the earth has warmed by about half a degree centigrade since 1850, and if this continues the world will be warmer within a few decades than at any other time in the last 100,000 years (Howard, 1990; Grainger, 1993).

Kakamega forest, which is a major tourist attraction because of its richness in biodiversity, is being depleted at a high rate. The forest is being turned into other land use such as settlement and farming among others. Over the last three decades the forest has become smaller and of poorer quality because of large destructions. These destructions include the clearing of forest areas for cultivation or commercial use without replanting and destruction through unsustainable use by local people such as overgrazing, felling of indigenous trees, pit-sawing and charcoal burning. Great pressure is being placed on the indigenous forest resources and their utilization appears to be unsustainable. The unplanned felling of forest trees might eventually leave the land susceptible to erosion which may result in the silting of water bodies and this could lead to environmental degradation and subsequent shortage
of wood and food. Kakamega forest is threatened with degradation and its impressive biodiversity is endangered (KIFCON, 1992). Clearing an indigenous forest is the final step in losing all its rich biodiversity forever. It cannot be replaced. This indeed provides a genuine need for research in this area of forestry.

The threat to this invaluable natural resource from human activities demands that research be carried out to establish the land use and land cover changes in and around Kakamega forest and their implications for the conservation of the forest. It is essential to do the study above in that for forest depletion to occur, the forest has to be cleared and replaced by other land uses. This paper therefore provides an insight into the need to conserve the forest resource and other natural resources for the community living around the forest and other interested parties. The communities adjacent to the forest depend so much on agriculture and therefore if the forests are depleted, erosion will increase, climate will change and thus there will be a threat to food production. The results and recommendations from this study will therefore be intended to guide them into making sustainable utilization of the natural resources in the forest.

LIMITATIONS OF THE STUDY
The study did not cover the whole of Kakamega forest because the aerial photographs that were available were for the southern part of the forest only. Moreover, the study period solely depended on the availability of photographs. The photographs of the years later than 1991 were not available at the time of the study. In addition, photographs of years with same time interval would have been most preferable for the study but unfortunately these were not available. Despite these limitations, the study findings as discussed in this paper provide a test case for the adopted framework as well as the possible findings when they are generalised.

MATERIALS AND METHODS
Acquisition of Data from Remotely Sensed Data and Topographic Maps
Stereoscopic pairs of black and white aerial photographs covering the study area were obtained from the Survey of Kenya and Photomap (Kenya). These photographs were taken at three different times spread over a period of 28 years i.e. 1963, 1974 and 1991 at a scale of 1:25,000 each. A crucial factor in determining the success of land mapping lies in the choice of an appropriate classification system designed for the intended purpose (Lo, 1986). Classification system is the process of assigning individual image pixels to defined categories, generally on the basis of spectral reflectance (Sabins, 1997). The Anderson et al. (1976) classification system is the commonly used system. This classification system is multilevel and has been devised because different degrees of detail can be obtained from different aerial and space images, depending on the sensor system and image resolution. It is designed to use four ‘levels’ of information two of which are detailed and require substantial amounts of supplemental information in addition to what is obtained from medium scale images and large scale for level III and IV, respectively. Levels I and II are not as detailed as the other two and are designed for use with low to moderate resolution satellite data and small-scale aerial photos respectively (Lillesand & Kiefer, 2000).

Field reconnaissance was done before the interpretation of the aerial photographs. Each set of photographs was first assembled for pre-view so as to prepare a temporary classification system. The Anderson et al. (1976) classification system was modified resulting in 15 classes of land use and land cover types namely:- indigenous forest, planted forest, riverine vegetation, glade, bare land, bush land/woodland, agriculture/bush land, built, grassland, agric/woodland, bush land, agric/settlement, tea, grassland/settlement and bush land/grassland.

The classification system above was then used in the interpretation of photographs. By use of a mirror stereoscope, a total of 82 photographs were stereoscopically interpreted run by run. Features were identified by basic photo image characteristics namely tone, texture, shape, size, site and pattern. These image characteristics together with feature association and local knowledge of the study area formed the basis of interpretation. The delineation of land and land cover types from each stereo pair was done recorded on a transparent sheet of paper superimposed onto the photographs. Due to the limitations of the scale of the photographs (1:25000), the land use/cover types could only be classified up to level I and II using the modified Anderson et al. (1976) classification system. The transparent sheets of paper for each photo were then assembled on a light table and compiled into a “composite” map of land use/cover types.

After compiling a draft map, a field check or ground truthing was undertaken during which the compiled interpretation of land use and land cover types were cross checked for verification and recording of the polygons which were not clear from the photographs. This was done to verify accuracy of photograph interpretation and aid in further identification of doubtful cases marked during interpretation. Ground truthing involved selecting various sites at random on the latest land use/cover base map and then visiting each site to check and verify whether the land use/cover indicated on the base maps is actually what is on the ground. Also all doubtful cases marked during interpretation were searched, located and identified. All features were identified and
corrections were made on the base maps. Final drawings of the land use/cover maps of the three years were completed including the changes and corrections observed from the field.

A topographic map (sheet number 102/4) for 1970 at a scale of 1:50000) was acquired from the Survey of Kenya. The map was used to derive the control points which were then used to geo-reference the base maps. This process involved identifying features or areas appearing on the land use/cover map and the topographic map and then their co-ordinates were recorded to obtain the control points. The analogue data in form of maps was then ready for digitization. The features to be digitized were assigned codes and digitized in Cartalinx software. Cartalinx is a purely vector-based package that does not enable data analysis. Digitization was done on a 34360 Calcomp Drawing Board III Digitizer configured to work in a discrete mode. The digitization generated a GIS Database from which analysis could be done. Digital data produced were edited using both interactive and batch modes. The resultant data was then coded before being exported to Idrisi software for analysis. Idrisi is a raster based package that can accept vector images.

GIS Analysis

After the interpretation of aerial photographs and digitizing the resulting maps, the data were now ready for analysis. The main land use classes considered in the analysis were: indigenous forest, planted forest, riverine vegetation, glade, bare land, bush land/woodland, agriculture/bush land, built, grassland, agric/woodland, tea, bush land, agric/settlement, grassland/settlement and bush land/grassland. The existing topographic maps (base maps) prepared by the Survey of Kenya were used to check the validity of the original source photography. The forest boundaries on both maps and photographs were compared to determine their consistency. The land cover and land use maps derived from the aerial photographs covering the study area were used as the input data for this study.

A geographic information system was used to compare the land cover and land use maps produced for the different dates that is 1963, 1974 and 1991 so as to detect any changes in land use/cover types. By use of Idrisi 32 software, the maps were compared and manipulated through overlays to quantify the changes, obtain their percentages and determine the nature, extent and amount of change. A cross-classification analysis, which involves the running of the cross-tab command from Database Query of Analysis in Idrisi for windows, was done so as to identify Land use and cover changes. The total areas covered by each land use/cover type were computed and expressed in both square kilometres and as a percentage of the study area. Thematic maps that were printed for presentation were compiled using MapInfo.

RESULTS AND DISCUSSION

Land Use and Land Cover Mapping

The areas covered by the various land use categories are as shown in the table and maps below. The maps show the distribution of the main land use categories in and around the forest. The table shows the changes in the areas occupied by the various land use and land cover categories over time.

From Table 1 and Figures 1, 2 and 3, it is apparent that there have been changes in land use and land cover. The land use/land cover categories that have changed significantly between 1963 and 1991 include the indigenous forest which reduced by 7.7 km², planted forest increased by 1.5 km², agriculture/settlement increased by 68.8 km², agriculture/woodland decreased 22.5 km² and bushland/grassland which increased by 21.3 km². The main factors behind these changes include high population growth rate, poverty, retrogressive traditions, government policies (e.g. excisions and the Nyayo tea zones), and poor forest management. The human population of Kakamega District has been going up steadily over time. This has in turn led to encroachment on the forest land due to the scarcity of land for both agriculture and settlement as the average land holding is 0.9 acres per household.

Table 1: Areas of Land Use/Cover Categories of part of Kakamega Forest and its surroundings in 1963, 1974 and 1991

<table>
<thead>
<tr>
<th>Land use</th>
<th>Area (km²)</th>
<th>1963</th>
<th>1974</th>
<th>1991</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigenous forest</td>
<td>57.6</td>
<td>50.1</td>
<td>49.9</td>
<td></td>
</tr>
<tr>
<td>Planted forest</td>
<td>6.6</td>
<td>13.3</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>Riverine vegetation</td>
<td>2.5</td>
<td>2.6</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Glade</td>
<td>1.7</td>
<td>0.6</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Bare</td>
<td>0.2</td>
<td>8.8</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Bushland/woodland</td>
<td>16.5</td>
<td>10.5</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Agric/bushland</td>
<td>1.7</td>
<td>44.3</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Built</td>
<td>0.1</td>
<td>0.6</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Grassland</td>
<td>0.6</td>
<td>0.4</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Agric/woodland</td>
<td>22.5</td>
<td>11.9</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Bushland</td>
<td>2.3</td>
<td>0.1</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Woodland/grassland/bushland</td>
<td>0.0</td>
<td>3.2</td>
<td>0.7</td>
<td></td>
</tr>
<tr>
<td>Agric/settlement</td>
<td>0.1</td>
<td>2.0</td>
<td>68.9</td>
<td></td>
</tr>
<tr>
<td>Tea</td>
<td>0.0</td>
<td>1.2</td>
<td>4.7</td>
<td></td>
</tr>
<tr>
<td>Grassland/settlement</td>
<td>2.3</td>
<td>0.3</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Bushland/grassland</td>
<td>35.5</td>
<td>0.6</td>
<td>14.2</td>
<td></td>
</tr>
</tbody>
</table>

Source: Researcher (2001)

It is evident enough on the maps that most of the indigenous forest had been converted to agriculture, bushland, grassland and settlement. With respect to land size distribution of respondents in the study area,
38(47.5%) had less than half an acre, 31(38.5%) had land ranging between 0.5 and 1.5 acres, 4(5%) had land ranging from 1.6 to 5 acres, another 4(5%) had 5 acres and above while 3 (4%) gave no response, probably because they had no land at all and survived by encroaching into the forest.

The results above show that the planted forest has increased and this is because the government has been trying to reclaim the forest by developing exotic plantations. What actually happens is that, as the communities clear the indigenous forest for whatever use the government later comes in with ways of trying to restore the forest by planting trees. Agriculture/woodland also recorded a substantial decrease and this could be attributed to the 'shamba system'.

This implies that at some point in time the locals were allowed to cultivate on forest land as they took care of trees and when the trees had grown big enough they had to stop cultivating and hence all that could be seen on the aerial photographs were the tree plantations (planted forest). The tea category increased by 4.7 km² in the period between 1963 and 1991. In addition to the encroachment and establishment of tea plantations by the communities adjacent to the forest, the government also contributed a lot to the increase in tea plantations by introducing the Nyayo tea zones.

The increase in the area covered by bushland/grassland is due to the felling of trees by the adjacent communities leaving the bushes and grasslands only. In summary, all the changes mentioned above can be attributed to poverty, attitude, education level (ignorance), unemployment and population pressure.
Rate of Change in Land Use and Land Cover
Types per Year
The rates of change per year were determined for the three periods these are, 1963 to 1974, 1974 to 1991 and 1963 to 1991 (Table 2).

Table 2: Rate of Change

<table>
<thead>
<tr>
<th>Land use</th>
<th>Rate of change</th>
<th>km² p.a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigenous forest</td>
<td>-0.68</td>
<td>-0.27</td>
</tr>
<tr>
<td>Planted forest</td>
<td>+0.61</td>
<td>+0.03</td>
</tr>
<tr>
<td>Glade</td>
<td>-0.10</td>
<td>-0.05</td>
</tr>
<tr>
<td>Bushland/woodland</td>
<td>-0.55</td>
<td>-0.59</td>
</tr>
<tr>
<td>Agric/bushland</td>
<td>+3.87</td>
<td>-0.06</td>
</tr>
<tr>
<td>Built</td>
<td>+0.04</td>
<td>+0.004</td>
</tr>
<tr>
<td>Grassland</td>
<td>-0.02</td>
<td>+0.01</td>
</tr>
<tr>
<td>Agric/woodland</td>
<td>-0.96</td>
<td>-0.80</td>
</tr>
<tr>
<td>Woodland/Grassland/</td>
<td>-0.29</td>
<td>+0.02</td>
</tr>
<tr>
<td>Bushland</td>
<td>+0.18</td>
<td>+3.93</td>
</tr>
<tr>
<td>Tea</td>
<td>+0.01</td>
<td>+0.17</td>
</tr>
<tr>
<td>Bushland/Grassland/</td>
<td>-1.18</td>
<td>-1.76</td>
</tr>
</tbody>
</table>

NOTE: Positive sign means increase while negative sign means decrease in area.
Source: Researcher (2001)

The rate of change per year was calculated by using the following formula:

\[ R = \frac{Y - X}{T} \]

Where:
- \( R \) is the rate of change.
- \( Y \) is the area in square kilometres of the study area in the final year.
- \( X \) is the area in square kilometres of the study area in the initial year.
- \( T \) is the time difference in years.

CONCLUSION AND RECOMMENDATIONS
From the findings of the study, it is apparent that there have been changes in the land use and land cover types in and around Kakamega forest over time. The indigenous forest has been converted to other land uses such as agriculture, settlement, planted forest, grassland among others. The forest has been reducing in area over time because of some socio-economic factors such as population pressure and density, unemployment, low education level, poverty and ignorance. Apart from the changes in indigenous forest, there have also been changes in the other land use and land cover types as well. It is therefore recommended that in order to implement conservation strategies of Kakamega forest successfully, the needs of the local communities should be embraced since they also utilize the forest and its land cover. Moreover, continuous monitoring in Kakamega forest should be done in order to establish present trends in ecological and other changes taking place to provide necessary data to planners and decision makers.

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