Assessment Of Land Use- Land Cover Changes in Kabras Division, Western Kenya (2013-2021)

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Abstract- Land-use Changes in Kenya's forest ecosystems indicate changes that are at precedented rates due to natural and human factors. These changes could negatively affect the environment and human life at large. Kabras division of western Kenya is endowed by two forest ecosystem which include the Malava forest and Kisero forest. This study analysed trends in land use–land cover changes in Kabras division for the last eight years. Landsat imageries downloaded from the United States Geological Survey archives were used to assess land use–land cover changes between 2013 and 2021 by the use of supervised classification using Arc GIS 10.8.1. The major Land Use-Land Cover (LULC) classified were natural forests, agriculture, settlements and bareland. The landsat images had an average overall classification accuracy of 87.12% and kappa coefficient (K) of 0.84. The kappa coefficient was rated as substantial and the classified images qualified for further analysis. There was an inverse relationship between the size of land under agriculture verses the size of land under natural forest. Natural forests declined by 6.4% while agricultural land increased by 37.01%. Settlements also reported major declines of about 30 % with majority of the land from forests and settlements being transformed to agricultural land. The main crop cultivated in the region is sugarcane. These findings reveal that the agroforestry program in the region may not have achieved much within the last eight years. These changes in land uses and land cover require an urgent sustainable management plan so as to protect and conserve the forests in Kabras division. Sustainable land management strategies to be used in the future may include education on the significance of the forest ecosystem, community participation in sustainable utilisation of forest eco-services and the introduction of sustainable alternative sources of livelihoods.

I. INTRODUCTION

Land use change is a process by which man transforms the natural environment into built environment for the purpose of increasing economic benefits. Land cover refers to the physical and biological cover on the surface of the earth. Land cover includes, vegetation cover, bare soil, water bodies and artificial structures. Land use and land cover (LULC) change plays a critical role with regards to the transformation of the global environment (Qian *et al* 2007). Increase in (LUCC) have been reported to be the main source of global environmental changes such as habitat and biodiversity loss (Ceballos *et al.*, 2015). Garcia-Vega and Newbold (2020) reported that over three quarters of the earth surface has been modified by anthropogenic activities such as agricultural farming, development of urban areas, development of infrastructure, afforestation and industrialization. This indicates that further increase in land use changes would aggravate biodiversity loss. Decline in biodiversity could negatively affect the ecosystem services and thus pose a major threat to human life (Cardinale *et al.*, 2012).

According to Masek *et al*., 2008, land use and land cover changes are mainly caused by demographic political, cultural, and environmental factors. The current increase in population across the globe could simply point to a further increase in LULC changes. In Kenya, land resources are strained with approximately 75% of the population engaging in agriculture on the country's 20% arable land. This has accelerated the changes in the ecosystem and in particular led to a decline in forest ecosystems.

Kenya's indigenous forests are home to many communities whose livelihoods depend on the forests natural resource. These regions are habitats for indigenous flora and fauna. With the growing population, expansion of agriculture has been achieved at the expense of the indigenous forests. According to the World Resources Institute, the world has lost about half of its forest cover. For instance, Africa lost 34 million hectares of forest cover between 2000 and 2010 (Stefanic & Stefanic,2017)). This could therefore have great negative effects on forest adjacent communities who majorly depend on forests for livelihood.

To date, Nyanza and Western provinces engage in agriculture for livelihoods. Unfortunately, the region has some of the highest levels of poverty and the lowest human development indices in Kenya (SID, 2004), indicating that though the region is endowed with fertile soils and natural resources such as forests, these has had little or no significant positive impact on the livelihoods of the residence. Out of a population of about 4.3 million people in western province, about 1.8 million are considered poor (Waswa *et al.,* 2012). This could point to the fact that changes in land uses and especially from forest land to agriculture has minimal impacts on the food security and economic status of the community. Forest value can be difficult to identify in quantitative terms though it is a source of non-monetary value in terms of ecosystem services and livelihoods. *Ecosystem Services* are the resources and benefits that we get from the environment. They include clean water, honey, medicinal, aesthetic, cultural and ritual values, timber, and pollination of native and agricultural plants. The forest provides most of the goods and services, which form the basis of man's subsistence.

Kabras division is endowed with two forest that are believed to be fragments of the larger Kakamega forest. These forests are the Malava forest and Kisero forests. The Forests harbors immense and unique biodiversity (Mutungah *et al.,* 1994). The forests are dominated by central African lowland species, but due to its elevation (predominantly between 1500- 1600 meters) and proximity to the Rift Valley escarpment, it also contains highland/montane species. The forest is of great importance in provisioning of ecosystem services and livelihoods of the local community. The rate of forest cover change on Malava and Kisero forest are yet to be documented. Detecting land use land cover changes in Kabras division is needed as part of an understanding of global environmental change.

The use of remote sensing data and analysis techniques provides an accurate, efficient, timely and detailed information for detecting and land use land cover changes in the country. Therefore, the main aim of this study was to carry out land use, land cover change analysis of Kabras division, western Kenya. This was to aid in the assessment of the changes in the land cover in the years between 2013 -2021 a period of 8 years. Understanding land use changes is therefore very critical in biodiversity conservation.

II. STUDY AREA

The research took place in Kabras division of Kakamega County which is located in western Kenya (Figure 1). The Malava forest is situated to the North of Kakamega town and West of Nandi escarpment. It is located at an elevation of 1,524 meters above sea level). The forest is situated approximately 25km North of Kakamega Town along Kakamega-Webuye road. It lies at latitude 0º28´54´´N to 0º29´44´´N and longitudes 34º50´15´´E to 34º52´26´´E (Figure1). The forest is a state forest managed by Kenya Forest Service (KFS) having been gazetted under proclamation no.14 of 13th February, 1933. It is part of Kakamega Forest Ecosystem together with Kakamega, Kibiri, Bunyala and Kisere Forests. It covers an area of 717.3 ha including 4.5 ha for Malava Girls' High School to the south of the forest (Agevi, 2016).

It is the only lowland rainforest remaining in Kenya and it is a major target for the protection of biodiversity in East Africa, ranked 3rd highest priority for conservation among forests in Kenya by the World Conservation Union (Wass, 1995). The forest experiences high rainfall all the year round. The annual rainfall ranges between 1500-1800 mm. The rainfall pattern is bimodal, providing for two cropping seasons per annum. The long rain season (March-July) receives 650- 750 mm and the short rain season (August-November) 500-600 mm of rainfall enabling the farmers to have two growing seasons. The division has high temperatures all the year round with mean maximum temperature of about 22-29°C. The high temperature and rainfall are useful for crop development all year round and therefore agricultural development.

The forest is mainly composed of natural trees such as *Olea capensis*, *Diospyros abyssinica*, *Maesopsis eminii*, *Croton macrostachyus* and *Prunus africana*. A few of the exotic tree species available in the region include *Cupressus lusitanica*, *Pinus patula*, *Eucalyptus saligna* and *Bischofia javanica*.

III. DATA COLLECTION AND ANALYSIS

Data was collected by use of satellite imageries, observation and secondary theoretical data. Satellite imageries were downloaded from the USGS website. Landsat 7 Enhanced Thematic Mapper Plus (ETM+) images (Path/Row 170/59) were used for both 2013 and 2021 images. The images were taken on 19^{th} April 2013 and 7^{th} June 2021 respectively. Landsat images for 2013 and 2021 consisted of seven spectral bands with a spatial resolution of 30 m for Bands 1–5. Acharya and Yang (2015) reported that Landsat™ satellite images are a good tool for mapping vegetation.

Pre-processing involved clipping and compositing. The administrative state boundary map for the area of study was also brought to Universal Transverse Mercator project in zone 37 and later the satellite imageries were clipped with the administrative boundary of Kabras division (Figure 1). The different False Colour Composite (FCC) of the Kabras division for the different stated periods were prepared. The preparation ensured that the pixel grids of the images for the year 2013 conform to the corresponding images of the year 2021.

Ground-truthing on land uses changes was carried out for seventy points obtained in the field with a Garmin Etrex30x Global Positioning Systems (GPS). A supervised multispectral classification was performed using Arc GIS 10.8.1 to distinguish between the four possible classes which included natural forests, Agriculture, Settlements and Bareland. Some seventy (70) training samples were created for each land use. Change analysis was run between 2013 and 2021 imageries which created change maps. Change analysis was done by use of ArcGIS 10.8.1 software. These maps showed the changes that have occurred over the periods under study.

An accuracy assessment via ground-truthing and the use of Google Earth Pro was done from the change maps so as to verify any land use change that may not have been clear. The accuracy of the classification system was evaluated by use of 70 reference test pixels identified and widespread on the 2013, and 2021 landsat images of the research site. Validation was then performed, by comparing data from Google earth and ground check. The accuracy of land use classification was assessed by using Kappa accuracy assessment, consisting of overall accuracy (OA), Producer's accuracy (PA), user's accuracy (UA) and Kappa statistic (Congalton and Green, 1999). It is stated that Kappa values of more than 0.80 indicate good classification performance. To validate data from satellite images, secondary literature of previous scientific studies on Mt. Elgon ecosystem were used. The assessment showed an overall accuracy derived from the stratified random sampling method for the 2013 classified images was 90% with an overall kappa statistic of 0.85. As for the 2021 Landsat image, the overall accuracy was 88.57% and the kappa statistics was 0.86. Figure 1 shows map of study area.

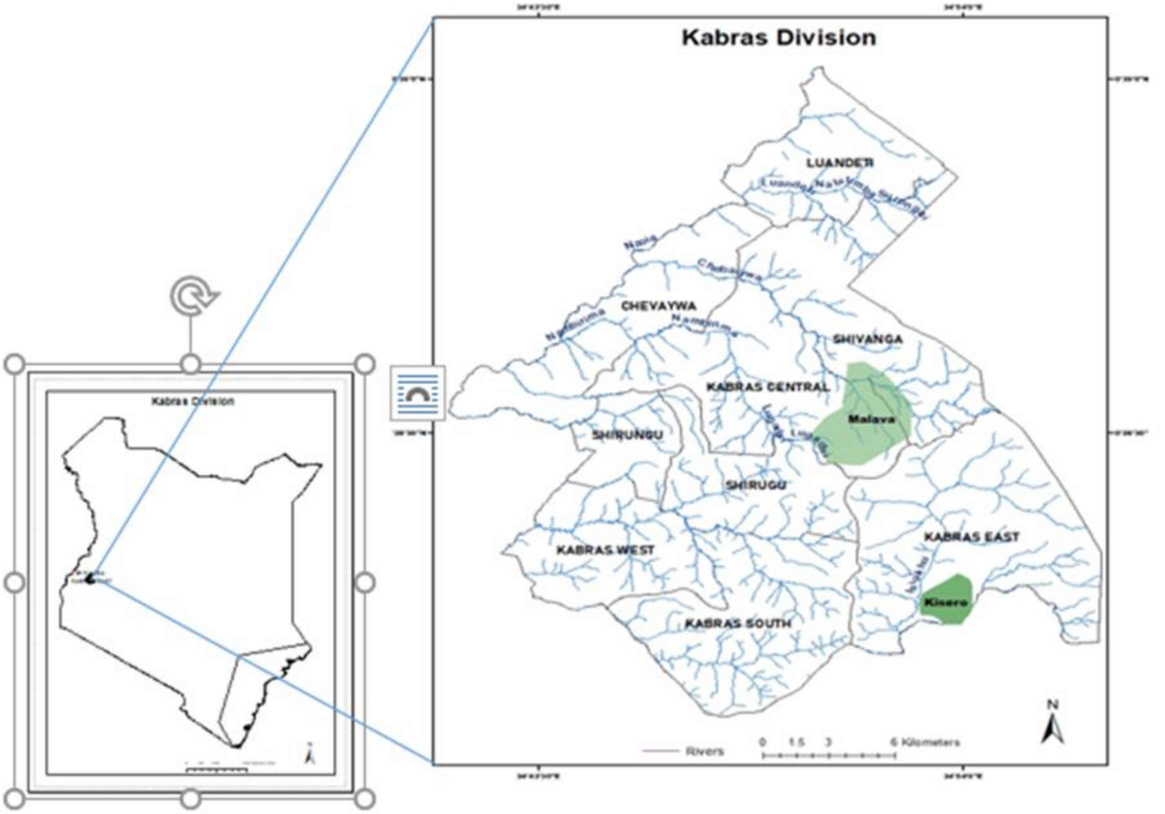
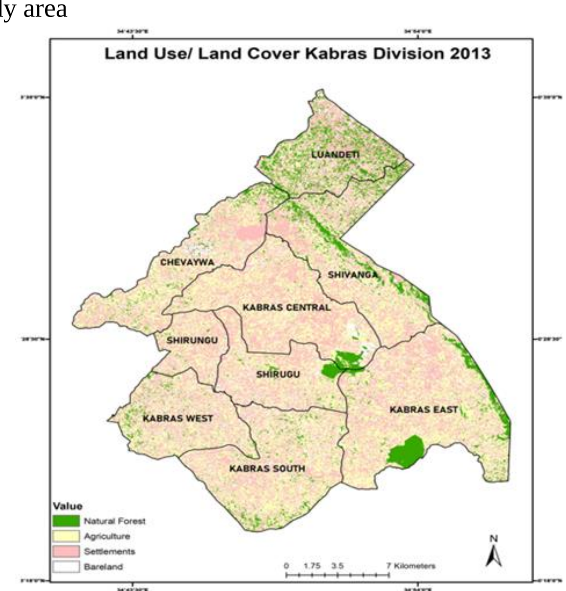


Figure 1: Study area

IV. RESULTS AND DISCUSSION

Results from Landsat images for 2013 to 2021 an 8-year period were processed and analysed for land use and land cover changes. The study area land cover was classified into four classifications namely, natural forests, Agriculture, settlements and bare lands as illustrated in the figure 2 below shows the progression of the land cover of the four classifications from 2013 to 2021.



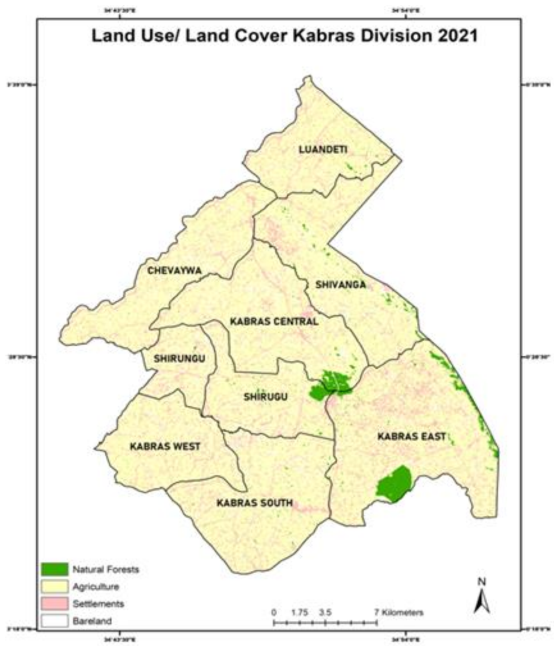


Figure 2: Landsat of Kabras division 2013 and 2014

There was an inverse relationship between the size of land under agriculture verses the size of land under natural forests. The land cover for agriculture increased from 40.91% in 2013 to 77.92% in 2021 while that for natural forests decreased from 8.77% in 2013 to 2.37% in 2021. This revealed a 6.4% decline in natural forest cover and a 37.01% increase in land under agriculture. The major cash crop grown in the region is sugarcane. The region mainly engages in monocultural sugarcane farming. This region hosts two sugarcane factories i.e., West Kenya sugar company and Butali sugar Factory. The Sugar industry in Kenya directly or indirectly supports 5 million people representing about 16 percent of the entire population. Sugarcane growing is also a major source of income to over 150,000 shareholders (Makina, & Oundo, 2020) The region however also engages in the growth of subsistence crops such as maize, beans, sweet potatoes, cassavas and horticultural crops. Kanianska *et al.* (2014) confirmed that transformation in land-use practices have enabled world grains harvest to double from 1.2 to 2.5 billion tonnes per year between 1970 and 2010. Settlements declined from 42.21% in 2013 to 12.99% in 2021. Similarly, bare land declined from 8.11% in 2013 to 1.39% in 2021. Agevi (2016) confirmed that globally forest-cover is declining, going from about 6 billion ha to approximately 4 billion ha in the last millennia.

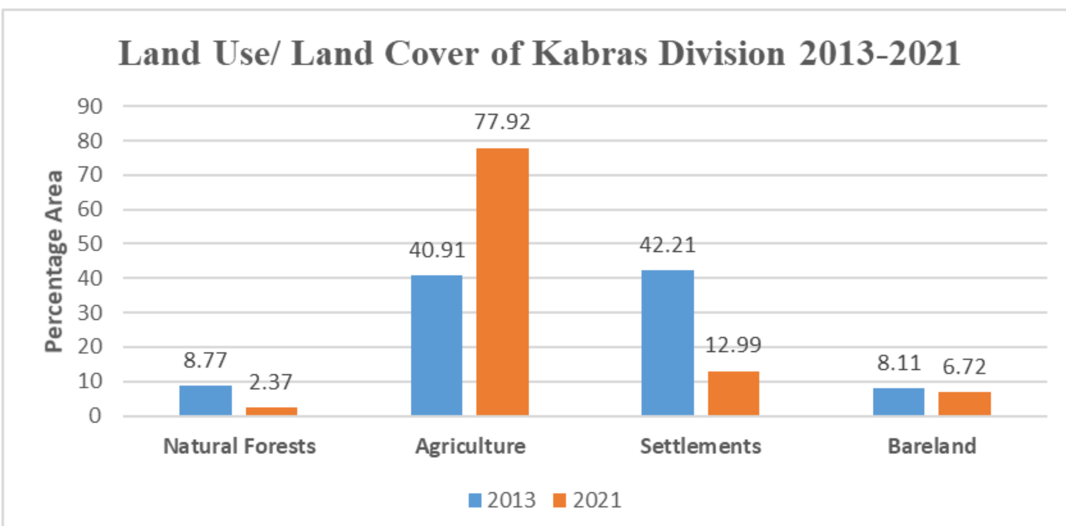


Figure 3: Changes in land use in 2013 and 2014

Further analysis of the landsat images revealed that about 6.19% of the natural forest was transformed into agricultural land between 2013 and 2021. On the contrary only 0.18% of agricultural land and 0.11% of settlements were transformed into natural forests. This gain could be as a result of afforestation programs are being carried out in Malava forests (Agevi 2016). Land-use changes such as afforestation could be associated with the improvement of atmospheric condition and increase in biodiversity. Pejchar *et al.* (2005) observed that plantation forests play an important role in biodiversity conservation and restoration of forest species and that enhanced biodiversity outcomes are expected with plantations that utilise indigenous tree species. About 31.19% of settlements were also turned into agricultural land as compared to 3.88% of agricultural land that was transformed into settlements. About 5.95% of bareland was transformed into agricultural land. About 3.16% of settlements were transformed into bareland.

V. ROAD NETWORK IN KABRAS DIVISION

Field observation revealed that road network has could be having an effect on Malava forest and consequently the flora and fauna of the Malava forest ecosystem. Analysis of Secondary digital data confirmed that Kakamega-Webuye road passes right into the Malava forest. This could be having a great effect on both the flora and fauna of the region. In particular, field observation revealed that monkeys that are often hit by the motorists are the most affected by the road network within the forest. Nyumba *et al.*, 2021 confirmed that the most severe but rarely reported effects of transportation infrastructure is destruction and loss of habitat for wildlife. Forest ecosystem are key habitats for wildlife. Figure 4 shows road network in Kabras division.

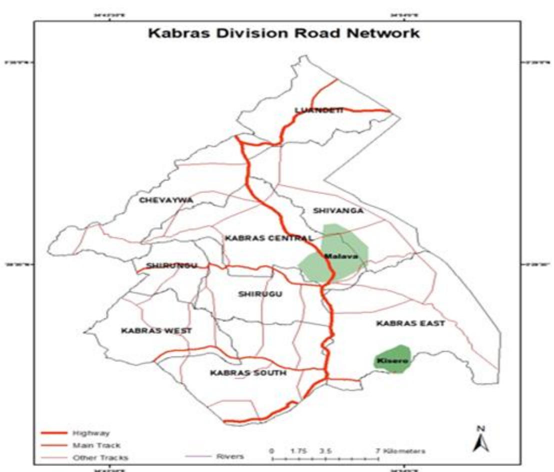


Figure 4: Road network in Kabras Division

VI. AGRO ECOLOGICAL ZONES OF KABRAS DIVISION

This study established that Kabras division is located in a region lying in very many agro ecological zones. These zones range from Lower highland zone 1, lower highland zone 2, lower midland zone 2, Upper midland zone 2-3, Upper midland zone 3-4 and Upper Midland Zone 4. In particular, Kisero forest is located in Upper Midland Zone 1 and Upper midland zone 2-3. On the contrast, Malava forest is located in zones ranging from Upper Midland Zone 1, Lower Highland Zone 2 and Upper mid land Zone 2-3, and Upper midland Zone 3-4(figure 5). The variability in agro ecological zone could imply that the forests are located in regions that support the growth of variation of crops. This could be one of the factors influencing the degradation of the forest ecosystem in Kabras Division.

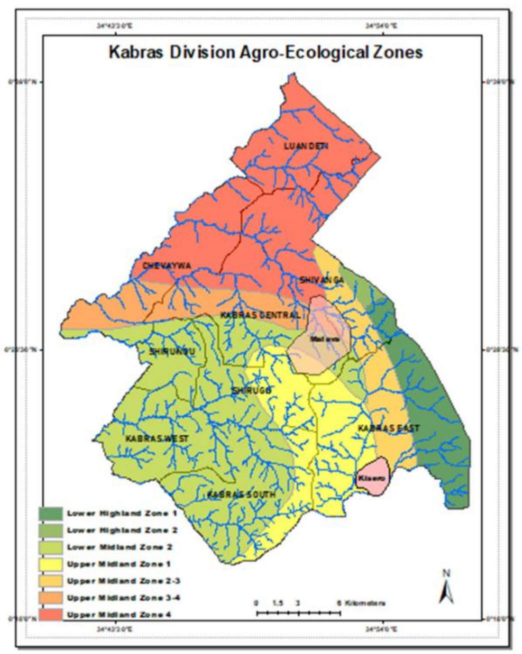


Figure 5: Agro-ecological Zones of Kabras Division

CONCLUSION

The 2013-2021, an 8year period saw a change in the land use in the area with a 37.01% increase in agricultural land. The research established a 29.22% decline in settlements, 6.40% decline in natural forest and 1.39% decline in bareland. Majority of the land under natural forest and settlements were transformed into agricultural land. The establishment of a road within the Malava forest ecosystem and the variability in agro-ecological zones could be among the factors that have aggravated the degradation of the forest ecosystem within Kabras division.

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