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TREE COVER TREND ANALYSIS FOR THE SEMI-ARID LANDS OF SOUTH EASTERN KENYA: THE CASE OF MATUNGULU SUB-COUNTY, MACHAKOS COUNTY

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ABSTRACT

89% of Kenya, inclusive of Matungulu Sub-County, is arid or semi-arid, with serious socio-economic, environmental and developmental challenges. Rapid population growth has led to an increasing demand for land, over-exploitation and degradation of local natural resources. The objective of this study was to identify and analyse tree cover trends that have taken place in Matungulu Sub-County between 1987 and 2017, with a view to providing data that can be used to mitigate the situation. Satellite images from mid 1980s and 2000s were used for a time series analysis of the land use/cover change in the study area with emphasis on the forest resource change. Changes were assessed by applying cross tabulation of the sequence maps of land use for the various periods used in the study based on the image classifications. Results showed that forest cover reduced by 64% over the 30-year period (from 17,044 ha to 6,136 ha) while all other land uses increased (farming by 34%, shrubs by 9%, water by 245% and urban settlements by 600%) in the same period. The study recommends institutionalization of land use planning and indigenous knowledge in climate change adaptation interventions for long-term sustainable development in Matungulu Sub-County.

Keywords: Tree cover change, sustainable development

1. INTRODUCTION

The study was conducted in Matungulu Sub-County, Machakos County, South Eastern Kenya to assess tree cover trends in the study area for the thirty-year period between 1987 and 2017. The area is mainly savannah landscape and was chosen for this study due to its scanty tree cover, low farm yields, degraded ecosystems, high levels of poverty and rising public concern over scarce and expensive wood-based products. These negative attributes were definitely being compounded by effects of climate change. Globally, some 129 million hectares of forest – most of it in the tropics, especially in Africa and South America - have been lost since 1990 (FAO, 2016). Over the years natural land cover has been changing due to increased human population, growth in infrastructural development and changing climate leading to even more stress on the

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available resources (**Hansen***et al., 2013).* Studies on land-use/land cover (LULC) changes through remote sensing techniques represent vital tools for generating rational information for sound decision making on natural resources management (Teka*etal*., 2018). Migration of people to the arid lands from high production areas particularly has had a big impact on the land cover. This coupled with the effect of climate change makes continued study and monitoring the dynamics of these changes important so as to develop coping mechanisms and adaptations to these changes (**Hansen***et al., 2013).*Trees play a critical role in regulating the earth's climate through the carbon cycle; removing carbon from the atmosphere as they grow, and storing carbon in leaves, woody tissue, roots and in more recalcitrant forms as organic matter in the soil (UNFCCC, 2011). Tree planting at farm level can reduce vulnerability and mitigate climate change (Insaidoo*etal*., 2014). De Leeuw*etal*. (2018) recently observed that resource exploitation and frequent fires in lowland savannahs and lowland tropical forests were partly responsible for the degradation of tree cover in the dry-land counties of Kenya.

2. RESEARCH METHODOLOGY

2.1 Image classification method

Proper classification forms the main basis to place all pixels in an image into the right LULC classes to extract the needed thematic information. In this case a combination the Infrared band (NIR 4), Blue (2) and Red (3) were used since it gives the best indicator of vegetation cover. This provided information on vegetation health by showing areas with healthy green vegetation remaining high in their NIR wavelength reflection and made it easy to establish trend in land cover change over the intervening period. In the classification, several classification algorithms were used but maximum like hood classifier was found to generate the best outputs and thus was adopted. The classification as previously indicated resulted in mainly four classes by aggregation on the basis of the small area covered by the study. These include: Forest, agriculture, shrubs/herbaceous, urban and water. Three decades multi- temporal imageries (Landsat imageries of 1987, 2004, 2014 and 2016) were used for the study with land use and tree cover changes established between the intervening periods. Results from the validation of Google Earth enabled improvement of the classification where the latest series of interpreted images was used as the basis for adjustments of the other older categories of images.

2.2 Land use/Land cover Change Analysis

In determining the various changes over time in the intervening periods, change analysis was conducted by using post classification change comparison method. To analyze tree cover trends between 1987 and 2017, ERDAS IMAGINE 2013, ArcGIS 10.1 and QGIS 1.8.0 were used to classify and reclassify the satellite images, produce various thematic images and to generate land use/ land cover maps. Tree cover changes in the study area were estimated from satellite images selected to reflect a time series pattern spanning about the period 1987 – 2017 (thirty years). The images were analyzed and interpreted using GIS technology. The method is taken as one of the most accurate procedure to present changes of land use (Mas, 1999) and has been taken to minimize difficulties of analysis of images at different periods. Changes were assessed by

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applying cross tabulation of the sequence maps of land use for the various periods used in the study based on the image classifications.

2.3 Secondary data

This was obtained from the internet, office reports, development plans, research theses, pamphlets and other materials found in public offices, libraries and documentation centers.

3. RESULTS AND DISCUSSIONS

3.2 Tree cover changes in Matungulu Sub-County between 1987 and 2017

3.2.1 Land use classification

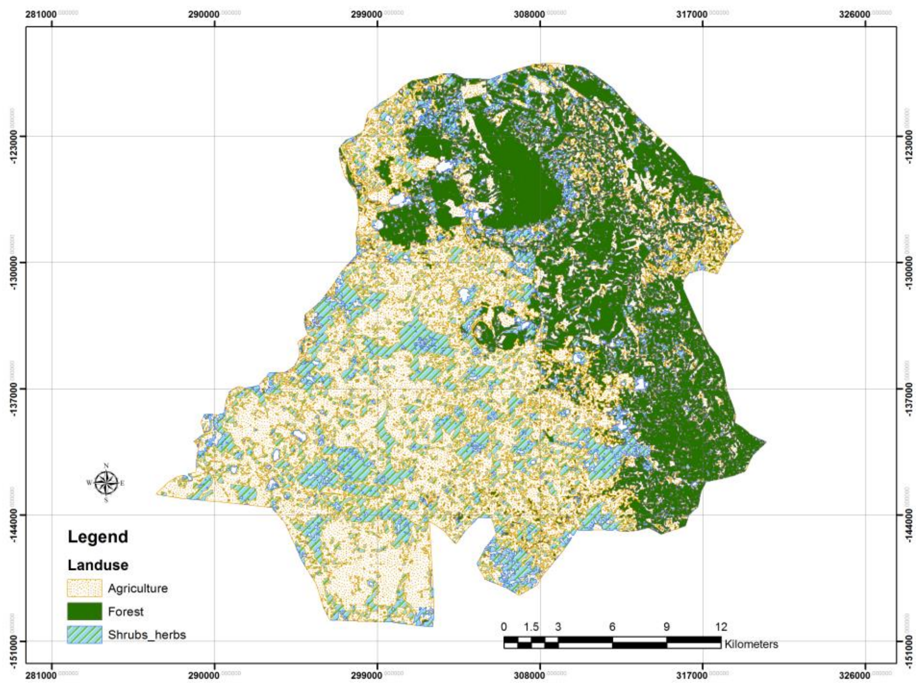

Figure 3.1: LU/LC Classification map of the study area for the year 1987

The study area was found to mainly comprise of four major Land use/Land cover (LULC) categories, that is, forestland or tree cover, farmland, shrub/herbland, built up area (urban) and water.From the visual observation, it is apparent that in 1987 agricultural area covered the largest portion, about 46%; forested or tree cover area was second with quite a significant percentage of about 28%, followed by shrubland with about 26% of the total area in Matungulu Sub-County (Figure 3.1). This was colloborated by farmers when they confirmed that most of land had belonged to white settlers who had conserved their farm/ ranch tree cover zealously. As a result the region was a critical wildlife dispersal area for Nairobi and Donyo Sabuk National Parks, teeming with all manner of wildlife such as gazelles, impallas, wilderbeasts, zebras, artebeasts, giraffes, hyenas and ostriches. Areas covered by water and urban centres were insignificant, probably because the Sub-County was largely a wild, semi-arid and sparsely populated.

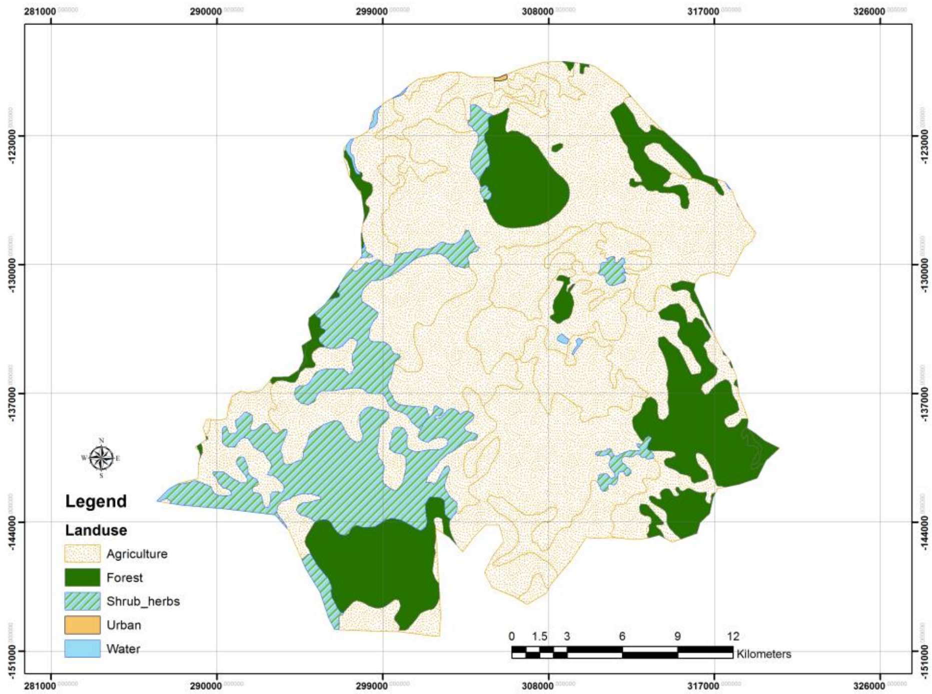

Figure 3.2: LU/LC Classification map of the study area for the year 2004

Figure 3.2 above shows details of the land cover in the year 2004. Agricultural land had increased from about 46% in 1987 to about 68% of the total area in 2004, meaning a large area had been cleared for farming in only 17 years. Forest land decreased from about 28% in 1987 to about 18% in 2004, while shrub/herb land also decreased from about 26% in 1987 to about 15% in 2004. From Figure 4.5, it is evident that forests had become highly fragmented and scattered due to increase in agricultural activities and human population and settlements in the area. Forest and shrub lands appear to have been taken up by agriculture, water and urban developments as new settlements took hold and the new settlers engaged in farming and urban businesses. Farmers explained that the white farms had been bought by Africans and the last white settler had departed by 2004. This was followed by rapid sub-division of the large farms among thousands of new shareholders, followed by uncontrolled heavy tree and bush clearing for farming and settlement.

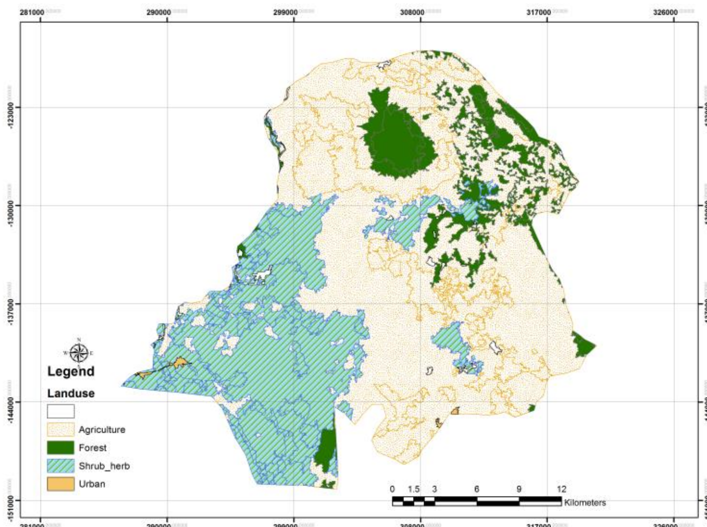

Figure 3.3: LU/LC Classification map of the study area for the year 2014

Figure 3.3 above shows the status of the various land uses in Matungulu Sub-County in the year 2014. Agricultural land had reduced from about 68% in 2004 to about 61% in 2014, as more people gave up their farming activities to try their hand elsewhere. Meanwhile, forest land further decreased from about 18% in 2004 to about 10% in 2014; shrub land increased from about 15% to about 28% in 2014. From these results it is clear that forests were the only land use that decreased consistently between 1987 and 2014. The forest reduction in 1987-2004 was 37 % followed by a 43% reduction in 2004-2014. This is because of constant clearing, exploitation and frequent fires common in the African savannah, all fuelled by climate change (Loehman*etal*., 2017).The total shrub land area reduced by 44% in 1987-2004, then increased by 93% (2004-14). The initial shrinking of shrub area could be attributed to rapid clearing, exploitation or degradation and effects of climate change, or a combination of two or more of these. The sharp increase in shrub-land between 2004 and 2014 can be attributed to bush recovery after deforestation and abandonment of cleared agricultural land due to un-favourable farming conditions. Clearly, forest land was converted to other uses like shrubs, agriculture and urban settlements. The new and expanding settlements needed new water sources for agriculture, domestic and urban use. By 2014 and as shown in Figure 4.6, forested areas had all been cleared except around the OlDonyoSabuk area which is a protected area. This free-for-all wanton clearing of forest cover, within public and riverine areas, numerous plains and hilltops, left Matungulu Sub-County largely devoid of forest cover worth of any mention. This is the situation the research team observed in the area during the study.

Looking at the general LULC classes for the period 1987 - 2014, the gross changes in area coverage varied from one LULC class to another with bush-land experiencing the most increase and crop farming having increased then decreased significantly. Tree (forest) cover decreased consistently over the same period, from one decade to the next. The forest cover reduced from 17, 044.45 ha 1987 to 6, 136.24 ha in 2014 – loss of about 10,908.21 (64.0%). The mapping data shows that the built up area increased in Matungulu Sub-County by about 600% in the 2004-2014 period.

Table 3.1: Summary of the major land cover type changes in Matungulu Sub-County during the 1987-2014 period

	Area (Ha)			% Change	
Land use	**1987**	**2004**	**2014**	**1987-2004**	**2004-2014**
Farming	27,777.39	41,303.61	37,349.29	48.70	-9.57
Forest	17,044.45	10,763.90	6,136.24	-36.85	-42.99
Shrubs	15,713.55	8,857.93	17,107.48	-43.63	93.13
Urban	-	15.28	106.34	-	595.94
Water	-	98.7	340.08	-	244.56

From the results, there has been significant conversions from one land cover category to another with the most significant being conversions from tree cover to bush-land and cropland. The significant growth in shrub land might be interpreted to show an increased degradation of the land which could be attributed to both abandoned agriculture due to poor yields and probably as a result of changes in climate making the land to become hostile to crop farming. Cleared forests could also give way to shrubs. The growth of built up area on the other hand could be attributed to increased urbanization that occurred in Matungulu Sub-County over the same period. The significant increase in water bodies however might require much more in depth analysis which was beyond the scope of this study. A similar study on the impacts of urban expansion on land use in neighbouring Kiambu County revealed that tree cover reduced from 4749 ha in 1986 to 2660 ha in 2014 mainly due to charcoal burning, farming and human settlements (Njiru, 2016). Like in the case of Matungulu Sub-County, migration of people from high production areas to Semi-Arid and Arid Lands (ASALs) in such of land for livelihood and development has had a big impact on the tree cover.Global tree cover loss reached a record 29.7 million hectares (73.4 million acres) in 2016, most of it in the tropics (Weisse and Goldman, 2018). The loss is 51 percent higher than the previous year, totaling an area about the size of New Zealand (Weisse and Goldman, 2018). According to Kenya's Ministry of Environment and Forests (2018), forest plantations in Kenya are in decline because the rate of replanting has failed to offset the rate of felling - giving way to grasslands and shrubs. Tree resources are being depleted in areas of rapid agricultural expansion, but degradation is less severe where traditional land-use systems are still firmly entrenched (Legilisho-Kiyiapi, 1995). According to UN-Environment (2012), in the ten year period of 2000-2010, for example, deforestation in Kenya's water towers was estimated at 50,000 ha, translating to a depletion rate of about 5,000 ha per annum. This translates to reduction of water availability of 62 million cubic meters per year, with a subsequent yearly loss of over USD 19 million (UN-Environment, 2012). This has the potential to roll back steps towards attainment of Vision 2030 and the current Government's Big Four Agenda of food and nutritional security, affordable and decent housing, universal healthcare and manufacturing (Ministry of Environment and Forests, 2018). Modeling studies show that tree cover loss increases annual discharges, surface runoff and peak flows while low flows decrease (Guzha*etal*., 2018).

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