SPATIAL-TEMPORAL CHANGES IN LAND USE LAND COVER AND IMPACTS ON WILDLIFE CONSERVATION IN MERU CONSERVATION AREA

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Abstract
Habitat conversion is a major threat to biodiversity. Recent and current levels of human activities on landscapes appear to be overriding the natural changes to ecosystems brought about by climate variations in the past several thousand years. The impact of anthropogenic activities on wildlife habitat and species vary depending on the spatial and temporal scales considered and the persistence of the activities in the landscape. The study carried out in Meru Conservation Area (MCA) examined land use land cover changes (LULC) that have taken place within and around the Protected Area (PA) between 1985 and 2015 with an emphasis of anthropogenic activities that have altered wildlife habitat and species depending on spatial and temporal scales. The distribution of land use types within and around MCA has produced land use patterns which the study seeks to establish their extent and effects in relation to wildlife conservation. To establish the land use land cover changes (LULC), Landsat satellite images of medium resolution were acquired and interpretation done using ArchGIS as the basic tool for analysis. In this study, four satellite images with a span of 10 years from 1985 to 2015 were acquired for analysis as a post-classification comparison for change detection. The results revealed significant changes in MCA ecosystem over the 30 year study period, accounting for 9.9% and 6.1% increase in grassland and bareland respectively. This could be an indication that agricultural activities are encroaching towards the protected areas in the land that was formerly used as wildlife corridors and dispersal areas. It is also an indication that there is a significant change in the forestland and shrubland which has respectively reduced accounting to 2.3% and 15.7% decline resulting to bareland and grassland. The results of the study provide a threat to the future survival of wildlife in their ecosystems due to decline in ecosystems productivity as well as socioeconomic livelihood of communities living around MCA. This therefore calls for an integrated planning approach towards management of protected areas to meet wildlife and human needs in view of the changing climate regimes.

Key Words: *Land Use, Land Cover, Wildlife, Ecosystems, Planning, Climate Change*

Introduction
Habitat conversion is a major threat to biodiversity (Smucker, 2002, Olson et al, 2004, Syombua, 2013). Recent and current levels of human activities on savanna landscapes appear to be overriding the natural changes to ecosystems brought about by climate variations in the past several thousand years (WCED,

1987, Ojima et al. 1994, Parmesa, 2006). Land cover changes may occur as a result of natural factors such as fire, drought and climate variations. However, in this case the changes may be temporary and irregular and the ecosystem tends to recover from them. The most destructing land cover changes are as a result of human alterations which have high a degree of resistance and consistency that minimize chances of ecosystems to recover.

Landscapes such as vegetation cover are modified by land use activities (Esikuri, 1998). Such modifications can lead to an increase or decrease in habitat quality and quantity for various species of wildlife native to an area (Dublin and Hamilton, 1987; Guy, 1989). For instance, expansion and intensification of agriculture is now recognized as one of the most significant human interactions of the global environment (Matson et al. 1977, Francire, 2004). The use of land to produce goods and services has been undertaken by humans around the world for the entire 10,000 years of settled agriculture (Houghton 1994, Vitousek et al. 1997). In this regard, the impact of anthropogenic activities on wildlife habitat and species vary depending on the spatial and temporal scales considered and the persistence of the activities. Land use has been defined as a dynamic process that changes in space and time depending on prevailing socio-economic and bio-physical conditions (Esikuri, 1998, Noe, 2003 Otuoma, 2004). Further, (Njago, 2008) explains land use change as identification of environmental problems such as habitat and species loss. The study carried out in Meru Conservation Area examined land use/ land cover changes that have taken place within and around the protected areas between 1985 and 2015 with an emphasis to identifying anthropogenic activities that have altered wildlife habitat and species depending on spatial and temporal scales. The distribution of land use types within and around MCA has produced land use patterns which the study seeks to establish their extent in relation to wildlife conservation.

The choice of Meru conservation Area as the basic unit of analysis was considered appropriate due to several reasons. First is that MCA is one of the important wilderness areas in Kenya with diverse wildlife species. Second, it portrays a classical example of a protected area network systems where there are several PAs merged together to form the MCA ecosystem. Third, the area is surrounded by human communities of diverse cultural backgrounds and with differing land use practices such as agriculture, agro-pastoralist and pastoralist. Hence a potential to experience serious land use conflicts (Smucker 2002, Otuoma, 2004;). Fourth, like many other savannas in Kenya, areas around MCA have been undergoing major land tenure reforms since 1989 following government directive to shift the tenure systems from communal ownership to privately owned individual subdivisions. According to Otuoma (2004), MCA has over the past few decades witnessed a steady immigration of agricultural households for nearby high potential agro-ecological zones into its buffer zones. This situation has subjected natural habitats that formerly served as communal grazing lands and wildlife dispersal areas to sustained fragmentation and alteration, since these migrant households take up land for settlement and crop cultivation. The most affected are the wetter margins of the western and southern buffer zones which are critical for livestock and wildlife especially during the dry season. Therefore, this situation has led to a reduction in the livestock grazing range, decline in the livestock and wildlife resource base and increased competition among wildlife, livestock and agriculturalist. As a result of the above challenges, studies by (Little 1994; KWS, 1994; Said et al. 1997 and Seneels, 2001) have reported the reduction of animal home ranges as a result changing land use/land cover within and around the Protected areas culminating to loss of species and increased human wildlife conflicts.

METHODOLOGY

The objective of the study was to establish changes in land use and land cover that have occurred in Meru National Park and Mwingi National Reserve in Meru Conservation Area over a period of 30 years and its impacts on wildlife conservation and management. This involved acquisition of satellite images of the past 30 years with a span of 10 years difference from 1985 to 2015 for analysis as a post-classification comparison for change detection. The analysis specifically selected classes of land cover for analysis as driven by the study objective. Field visits were made to identify current land uses, land degradation and other notable changes on the ground to validate what was in the maps and images.

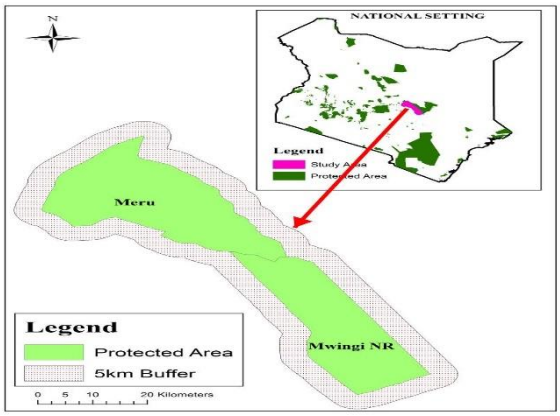


Figure 1: Map of the study area (Source: Auther, 2016)

Data Analysis

The images were first classified independently into land cover categories and then compared them using Arch GIS software. Land use/land cover change data was then analyzed using descriptive statistics to show the variation from 1985 to 2015 which was done by calculating the area under each land use for the entire period under the database query module in Arc Map. The areas were then entered in Microsoft Excel to determine specific land use change for particular class. The area of land in 1985 was subtracted from the areas in 2015 to establish overall change in the study period. Pearson Correlation coefficient statistical analysis was done to establish associations between land use changes in Meru National Park and Mwingi National Reserve. The tests were considered significant if *P*-values were equal to or less than 0.05 and insignificant if *P*-values were greater than 0.05. The data was presented inform of narratives, tables, charts and maps.

RESULTS

To establish the land use land cover changes, satellite image interpretation was used as the basic tool for analysis. The use of remotely sensed information to describe and analyze wildlife-habitat relationships and general ecosystem changes has seen increased application over time by several researchers. For instance (Ondenyo, 1979; Pestena, 1986; Otuoma 2005) have used satellite images for cover type mapping and assessment of wildlife ecosystem conditions in protected areas.

Classification of images into specific land use land cover (LULC) categories in Meru National Park and Mwingi National Reserve produced six land use categories which included forest land, shrubland, grassland, riverline forests, water and bareland. By 1985, the total land cover in Meru National Park and Mwingi National Reserve was 284,728km^2 where forest covered 46,677km^2, shrubland 152, 353km^2, grassland 48,659km^2, riverline vegetation 8,247km^2, water 727km^2 and 28,065km^2 of bareland. By 2015, the area occupied by forests hand changed to 40,255 km^2, shrubland 107, 581km^2, grassland 76,923km^2, riverline vegetation 12,677km^2, water 1,244km^2 and bareland to 46,048km^2. The results are as summarized in the table below showing area each LULC class over the study period and the percentage (%) of each class.

Table 1: Coverage of land use category and percentage cover (Source. Author, 2016)

LULC Class	**1985 (km^2)**	**% cover**	**1995 (km^2)**	**% cover**	**2005 (km^2)**	**% cover**	**2015 (km^2)**	**% cover**	**% LULC change**
Forest	46677	16.4	45792	16.1	75888	26.7	40255	14.1	-2.3
Shrubland	152353	53.5	207470	72.3	138449	48.6	107581	37.8	-15.7
Grassland	48659	17.1	6665	2.3	29773	10.5	76923	27	9.9
Riverline	8247	2.9	750	0.3	14278	5.1	12677	4.5	1.6
Water	727	0.3	538	0.2	7034	2.3	1244	0.4	0.1
Bareland	28065	10.1	23513	8.3	19306	6.8	46048	16.2	6.1
Total	**284728**	**100**	**284728**	**100**	**284728**	**100**	**284728**	**100**	**0**

The analysis of LULC changes in MCA has revealed significant changes in the protected area over the 30 year period in relation to the possible effects of anthropogenic activities on the protected area. For instance, the results revealed that the grassland and bareland have expanded respectively from 48659ha and 28065ha in 1985 to 76923ha and 46048ha in 2015, accounting for approximately 9.9% and 6.1% increase in these land cover change. This could be an indication that agricultural activities are encroaching towards the protected areas that were formerly used as wildlife corridors and dispersal areas. It is also an indication that there is a significant change in the forestland and shrub land which has respectively reduced from 46667ha and 152353ha in 1985 to 40255ha and 107587ha in 2015 accounting to 2.3% and 15.7% decline resulting to bareland and grassland.

There was positive correlation between forests and water (r = .964, Df =2, P = 0.036), riverline and water (r = .651, Df =2, P = 0.349), bareland and grassland (r = .860, Df =2, P = 0.140). on the other hand, a significant negative correlation occurred between forests and bareland (r = .-692, Df =2, P = 0.308), shrubland and bareland (r = -.631, Df =2, P = 0.369), grassland and shrubland (r = -.898, Df =2, P = 0.102) and between bareland and water (r = -.481, Df =2, P = 0.519). See table below.

Table 2: Correlations between various LULC classes in MNP and MNR (Source. Author, 2016)

		Forest	Shrubland	Grassland	Riverline	Water	Bareland
Forest	Pearson Correlation	1	-.073	-.361	.473	.964*	-.692
	Sig. (2-tailed)		.927	.639	.527	.036	.308
Shrubland	Pearson Correlation	-.073	1	-.898	-.913	-.296	-.631
	Sig. (2-tailed)	.927		.102	.087	.704	.369
Grassland	Pearson Correlation	-.361	-.898	1	.648	-.153	.860
	Sig. (2-tailed)	.639	.102		.352	.847	.140
Riverline	Pearson Correlation	.473	-.913	.648	1	.651	.269
	Sig. (2-tailed)	.527	.087	.352		.349	.731
Water	Pearson Correlation	.964*	-.296	-.153	.651	1	-.481
	Sig. (2-tailed)	.036	.704	.847	.349		.519
Bareland	Pearson Correlation	-.692	-.631	.860	.269	-.481	1
	Sig. (2-tailed)	.308	.369	.140	.731	.519	

*. Correlation is significant at the 0.05 level (2-tailed).

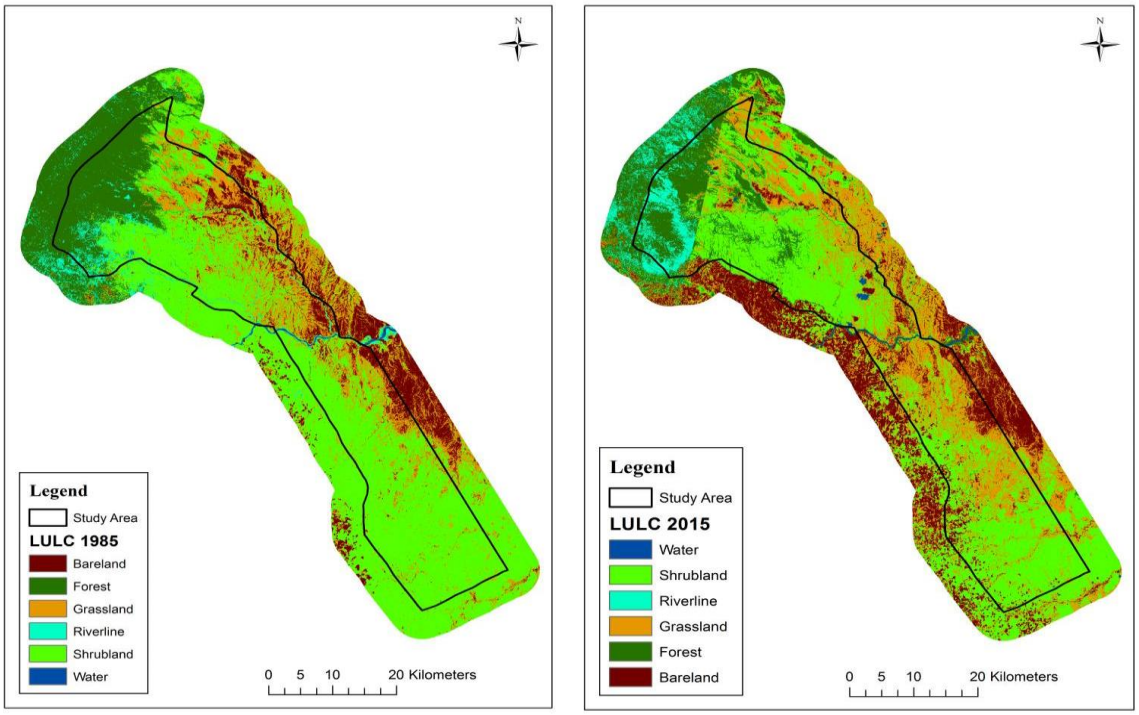
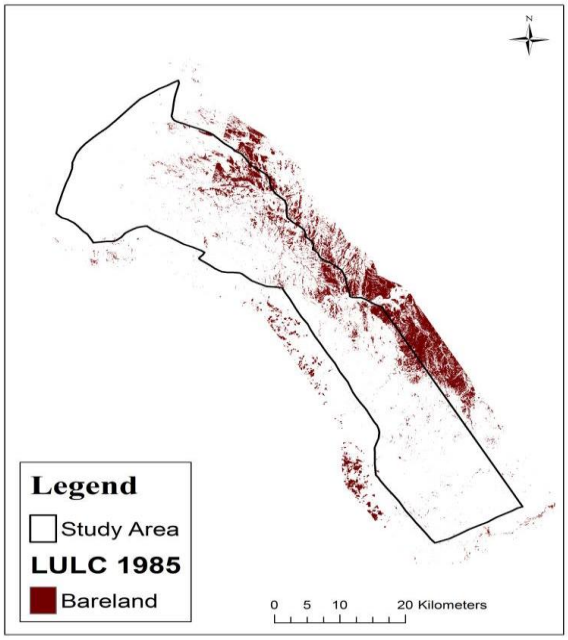


Fig. 3a: Image for 1985 showing land cover characteristics

Fig. 3b: Image for 2015 showing change in land cover in various land use classes



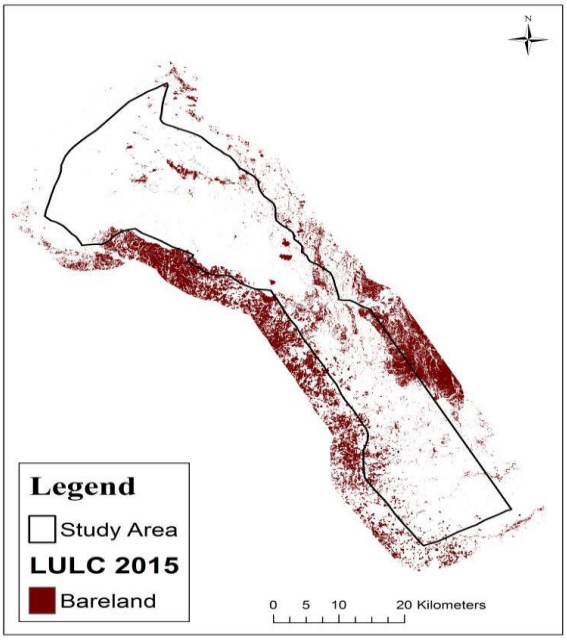
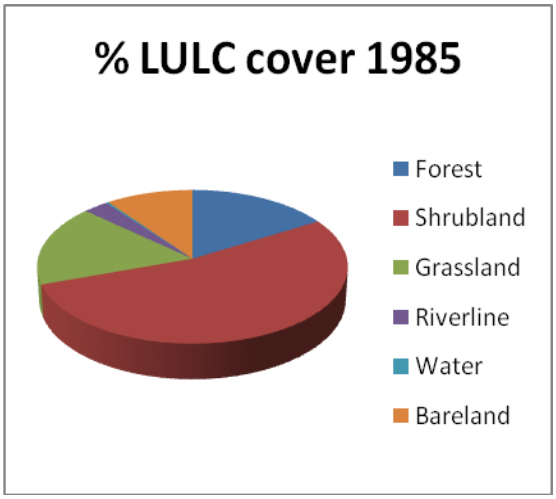
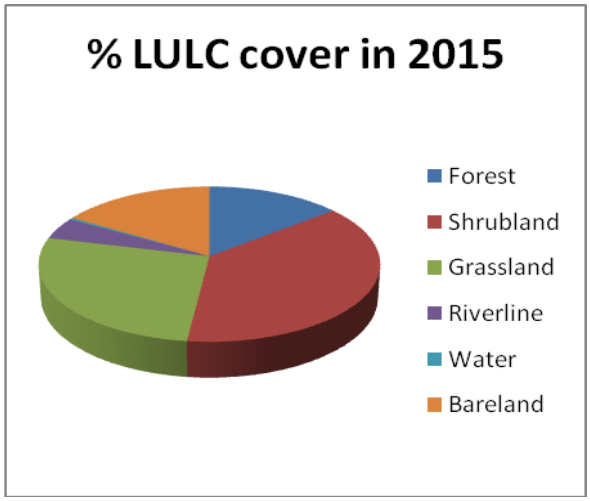


Fig. 6a: Image for 1985 showing only the degraded and cultivated areas

Fig. 6b: Image for 2015 showing changes in degraded and cultivated areas





DISCUSSION

Both MNP and MNR have undergone significant changes in land use land cover over the years which have over time affected the wildlife populations and their ecosystems. As established in the study, MCA is surrounded by communities who have diverse socio-cultural backgrounds depicted by their different land use practices. The Ameru on the western boundary practice mainly agriculture, the Tharaka and Kamba practice mixed livestock keeping and farming while the Borana and Oroma mainly practice livestock keeping. This explains the significant increase in the bareland land use class which represents the degraded areas, farm land and settlements.

Causes of land use land cover changes in MNP and MNR is as a result of climate change, population increase, expansion agricultural land, increased demand and market for horticultural crops and Miraa (Khat), changes in land tenure and drought that lead to encroachment into the protected areas (PAs) for

livestock grazing and charcoal burning. Bareland class around Meru National Park and Mwingi National reserve are becoming important as they replace areas previously occupied by grassland, forests and shrubs that initially served as dispersal areas and movement corridors for wildlife. Majority of the households that occupy the buffer zones were migrants who came to the area in search for more land for agriculture and livestock keeping. Majority of these had moved from agricultural rich areas of Meru, Nyeri, Murang'a and Kiambu (Otuoma, 2004). The main affected areas of MCA were the northern and southern buffer zones which led to permanent settlement due to higher rainfall gradient. The changes further extend to inside the protected area boundaries as a result of continuous encroachment by communities for firewood, building materials, pasture for livestock and charcoal burning. Observations in the field during ground verification revealed that intensive irrigation on the western boundary of Meru National park contributed to reduced river flow into the park with water being diverted to irrigate Miraa (Khat) and horticulture crops through furrow and flooding methods.

These ongoing changes have had effects on existence, distribution and movement of wildlife in MNP and MNR. The changes have led to cases of increased human wildlife conflicts as the wild animals move from the PA boundaries to immediate areas that have been converted to farms hereby destroying crops, causing injuries or even loss of life. The farmers on the other hand invest so much time guarding the crops against wildlife which has resulted to resentment towards wildlife and withdrawn support for conservation initiatives. This study recommends that for future existence of wildlife in MNP, MNR and Kenya at large, integrated planning approaches for changing land use and land cover by incorporating the local communities, their socio-economic needs and those of wildlife to enhance sustainability.

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