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Analysis of Spatial and Temporal Changes in Land Uses and its Implications to the Conservation of Eastern Selous-Niassa Transfrontier Conservation Areas (TFCA)

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Abstract
This paper discusses the less known spatial and temporal changes that have occurred over a period of 30 years in land use and land cover and their impacts on terrestrial ecosystem services of Selous – Niassa TFCA. Objectives of the study were to analyze the spatial and temporal changes of land use/cover, estimate amount of trees loss, and analyse wood balance. The study employs field survey, remote sensing and GIS techniques were employed to assess spatio-temporal dynamic of land use/cover. The study has revealed that there has been a significant land use and vegetation cover transformation from one class to another. For the period between 1986 and 1997 the area under closed woodland, open woodland, grassland, built up area, and cultivated land increases by 1.14%, 0.62%, 2.92%, 0.06%, and 2.17% respectively. Likewise, bushland and water decreased by 6.86 and 0.04 respectively. For the period between 1997 and 2005, the closed woodland, open woodland, and bushland declined by 9.65%, 8.41%, and 5.23% respectively. For the same period of time, grassland, water, built up area, and cultivated land increased by 5.3%, 0.01%, 0.29%, and 17.7% respectively. Moreover, for the period between 2005 and 2016, the closed woodland, open woodland, grassland, water, and cultivated area declined by 0.91%, 4.65%, 8.25%, 0.02% and 1.53% respectively. For the same period of time, bushland and built up area increased by 15.27% and 0.08% respectively. Also, the results revealed gain of trees regenerated in the study area during the period 1986 – 1997 with

an average of 3.5 million trees per year. Besides, there was rampant conversion of woodland in the study area during the period 1997 – 2016 with average loss of 27 million trees per year. Wood supply in the study area for the year 2016 is at least 25 times the average demand per year per capita. Conversely, the trend of wood supply from 1986 to 2016 shows dramatic deforestation of the area which implies tragedy of commons and is the public property where there are no control policies or rules. The study recommends an emergence of reviewing management and conservation strategies is unexceptional if we need sustainability of Selous-Niassa TFCA.

Keywords: Land use and land cover change (LULCC); Ecosystem services; Tree loss; Wood balance

1. Introduction

1.1 Background information

Land use and land cover change (LULCC) calls for special attention since humans have been modifying land to obtain food and other essentials for thousands of years, but current rates, extents and intensities of LULC changes are far greater than ever in history [1], driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales. LULCC can occur through the direct and indirect consequences of anthropogenic activities to secure their economic and social needs. Burning of areas to develop the availability of wild game as well as cultivated land, resulting in extensive clearing such as deforestation and earth's terrestrial surface management that takes place today [2]. Many transfrontier conservation areas (TFCAs) are unexceptional from these challenges as they consists of various levels of protected areas (PAs) from strict protection (includes national parks and game reserves) to weak protection (open areas, game controlled areas and wildlife management areas) which shape level of LULCC. For instance, most wildlife protected areas in East Africa are unfenced and wildlife movements are borderless; hence, the dispersal areas connecting two or more PAs depends on the level of protection which can trigger sustainability level of wildlife, habitat and ecosystem services provided by that PA.

LULCC is a complex process which influenced by the jointly interactions between environmental and other social factors at different spatial and temporal scales [3, 4]. More recently, industrial activities and developments, the so-called industrialization, has encouraged the concentration of population within urban areas. This is called urbanization, which includes depopulation of rural regions along with intensive farming in the most productive lands and the abandonment of marginal lands [2]. These conversions and their consequences are obvious around the world and it has been becoming a disaster around the metropolitan areas in developing countries. These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss and the pollution of water, soils and air. Monitoring and mediating the negative consequences of LULCC while sustaining the production of essential resources has therefore become a major priority of researchers and policymakers around the world.

1.2 Problem Statement

Households living in all terrestrial wildlife ecosystems like corridors depend heavily on services provided by those ecosystems for their livelihoods. LULCC can greatly alter the provision of ecosystem services. Land Conversion to human utilization introduces the risk of undermining human wellbeing and long term sustainability [5]. Particularly, it is considered to be one of the drivers of global environmental change [6]. Selous – Niassa ecosystem is not exceptional from this scenario as it connect two terrestrial miombo protected areas (Selous Game Reserve in

Tanzania and Niassa Game Reserve in Mozambique) to form transfrontier conservation area (TFCA) by a corridor which occupies an area of 14, 625.6 km^2 that stretches for about 120–180 km and extending across southern Tanzania and the Mozambique border [7]. The corridor dwellers are the one responsible for conversion of habitat to suit their livelihood.

Transformation of ecosystems into other land use categories, primarily the conversion of various vegetation covers to agricultural land and urban areas, impacts water flows and the biogeochemical cycle, and is closely linked to climate change [8, 9]. The joint effects of land use and climate change are perceived as the most important driver of biodiversity loss. Because biodiversity is known to represent a key prerequisite for the functioning of an ecosystem and delivery of bundles of ecosystem services [10].Land use change may undermine regulatory capacities of the ecosystems for example in terms of the ability to avoid and minimize hazards [5]. A number of risks initiated by land use change or its consequences originate in diminished land productivity, land degradation, disruption of water regime, water contamination, or extra losses of biodiversity [6].

Biodiversity has been diminishing considerably by land change. While lands change from a primary forested land to a farming type, the loss of forest and wildlife species within deforested areas is immediate and huge [2].According to Ellis et al. [2] the habitat suitability of forests and other ecosystems surrounding those under intensive use are also impacted by the fragmenting of existing habitat into smaller pieces, which exposes forest edges to external influences and decreases core habitat area.

The conversion of tropical forest to grassland disrupts the herbivores food chain of different sizes according to their dependent feeding structure and altering of many wildlife species; for example disappearances of “ecotones” (area which separate grassland and wooded grass land) which is the living habitat of some antelopes [11]. LULCC, particularly natural forest alteration makes soils vulnerable to a massive increase in windy and water soil erosion forms, particularly on steep topography. When accompanied by fire, also pollutants to the atmosphere are released. Soil fertility degradation within time is not the only negative impact; it does not only cause damage to the land suitability for future farming, but also releases a huge amount of phosphorus, nitrogen, and sediments to aquatic ecosystems, causing multiple harmful impacts of sedimentation and eutrophication. Thus, this study intended to analyse spatial and temporal LULCC of eastern Selous-Niassa TFCA by estimating habitat conversion area into other activities, amount of trees loss and wood balance.

1.3 Objectives

1.3.1 Main objective: The main objective of this study was to analyse spatial and temporal habitat conversion of eastern Selous-Niassa TFCA.

1.3.2 Specific objectives: Specifically the study intends to:

- analyse LULCC of eastern Selous-Niassa TFCA from 1986 to 2016
- estimate amount of trees loss of eastern Selous-Niassa TFCA from 1986 to 2016
- analyse wood balance of corridor dwellers of eastern Selous-Niassa TFCA

1.4 Justification of the study

1.4.1 Significance of study findings: The Study findings will help stakeholders of Transfrontier Conservation Areas (TFCAs) especially Selous-Niassa TFCA to reveal problems of land uses facing them. These stakeholders include the public, researchers, natural resources extension officers, agriculturalists, policy makers, planners, decision makers, game wardens, park rangers, conservators and all other environmental related experts. Furthermore, the study findings will be useful to stakeholders for knowledge generation and proposing solutions at local, national and international levels on issues related to management of TFCAs. Additionally, the study findings will provide room to researchers for further studies.

1.4.2 Why study transfrontier conservation areas (TFCAs): Political boundaries that demarcate country borders were historically drawn for reasons based on national security and strategic interests, colonial land claims, geological and other riches, and convenience, never with conscious thought of maintaining ecological integrity. And so today a political map of the world shows continents carved into a jig-saw puzzle of countries, each with its own pattern of land use, political priorities, and management styles. Even so, historical coincidence has often left conservation areas in different countries adjoining each other, separated by fences or varying ideologies, resulting in fragmented ecosystems or disrupted ecosystem processes. The fragmented systems lead to a loss of ecological resilience and a steady attrition of species over time. By taking a broader view, a regional view, and jointly managing these natural assets for regional benefit, the cons caused by arbitrary political lines drawn for historical reason can be trounced. Ecological benefits; socio-economic and cultural benefits; collaboration and partnerships; and regional peace, harmony and stability are some of the benefits which can be resulted from collaboration across boundaries and adopting a regional approach in natural resource management.

1.4.3 Why study Selous– Niassa TFCA: The study was done in Selous-Niassa TFCA due to the following reason: (i) scanty information of study area interests which is eastern part of the corridor also known as Selous –Masasi compared to western part; (ii) huge area coverage in Africa as the largest trans-boundary natural dry forest eco-regions covering approximately 154.000 km^2 with a critical gap between these protected areas that stretches for about 120–180 km and extending across southern Tanzania and the Mozambique border. Through a network of protected areas of various categories of protection, an area of 110,000 km^2 of this ecosystem is presently under conservation [5]; (iii) wildlife migration and richness as it constitutes one of the largest elephant ranges in the world and contains half of the world remaining wild dog population, supports a large number of other globally significant, threatened and CITES listed fauna and flora species [1]; (iv) there was no legal protection of wildlife corridors before enaction of wildlife Act of 2009; (v) there was no signed memorandum of understanding between Tanzania and Mozambique concerned protection of the ecosystem before May 2015; and (vi) established wildlife management areas (WMAs) which act as a buffer zone to core protected areas to help conservation of wildlife corridor by involving local communities. WMAs established are bordering Selous, Msanjesi and Lukwika-Lumesule game reserves (MAGINGO WMA, NDONDA and MCHIMALU proposed WMAs respectively) within Liwale, Nachingwea/Masasi and Nanyumbu districts respectively in Tanzania whereas people are living inside Niassa national reserve in Mozambique [12].

2. Materials and Methods

2.1 Materials

2.1.1 Description of the study area: The study was carried out in eastern Selous-Niassa TFCA with an area of 1, 462, 560 hectares called Selous-Niassa wildlife corridor (SNWC) which extends across southern Tanzania into northern Mozambique between 10°S to 11° 40'S with north-south length of 160 to 180 km (Figure 1). SNWC comprises of two parts, western part (administratively passes in Namtumbo and Tunduru Districts of Ruvuma regions in southern Tanzania) and eastern part (administratively passes in Liwale, Nachingwea, Masasi, and Nanyumbu Districts). This study concentrated in eastern part. In eastern SNWC, migration of elephants, buffalos and zebras has been observed [12, 13]. Two migratory routes have been identified as follows:

- From Selous through Nahimba, Nakalonji, Mbondo, Kilimarondo, Matekwe and Kipindimbi proposed game reserve (GR) in Nachingwea District and then via Msanjesi, Mkumbalu, Sengenya, Nangomba and Nanyumbu in Nanyumbu District to Lukwika-Lumesule GR and then crosses Ruvuma River to the Niassa GR.
- From Selous to Kiegei, Namatumu, Kilimarondo in Nachingwea then along Mbangala and Lumesule rivers to Mchenjeuka and Mitanga in the Lukwika-Lumesule GR, from where they cross the Ruvuma River to the Niassa Reserve.

These routes forms SNWC called Selous-Masasi corridor includes the Msanjesi (2,125 ha) and the Lukwika-Lumesule (44,420 ha) GRs in Masasi and Nanyumbu Districts respectively and areas of Liwale, Nachingwea, Masasi and Tunduru Districts.

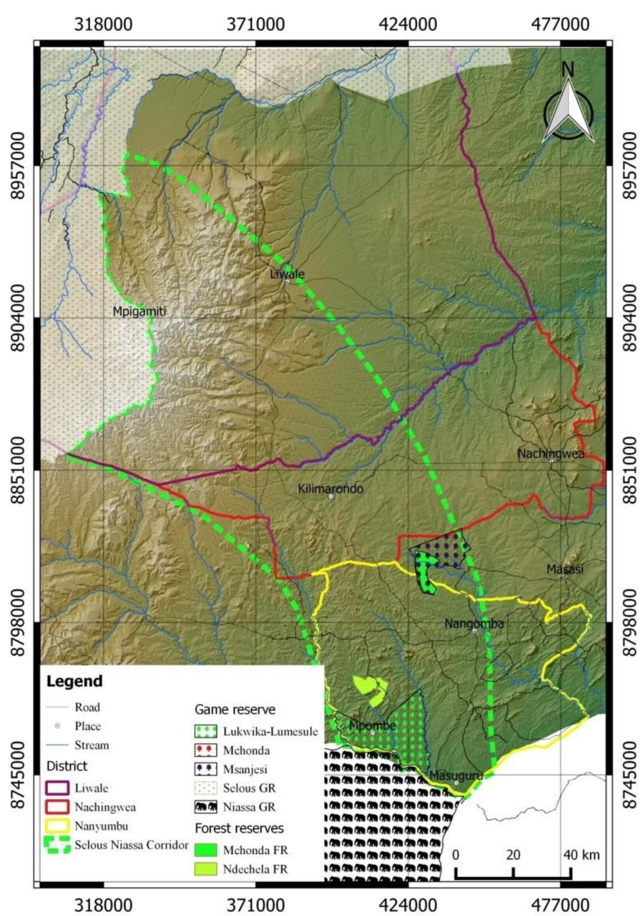

Figure 1: The Map of the study area.

The study area comprise wildlife management areas (WMAs) bordering Selous, Msanjesi and Lukwika-Lumesule game reserves (MAGINGO WMA, NDONDA and MCHIMALU proposed WMAs respectively) which are within Liwale, Nachingwea/Masasi and Nanyumbu Districts respectively. In this study three villages namely Mpigamiti, Kilimarondo, andMpombe within MAGINGO WMA and NDONDA and MCHIMALU proposed WMA were purposely selected for ground Truthing for the study.

2.2 Methods

Spatial data includes satellite images and digital elevation model (DEM) downloaded from USGS – GLOVIS.

2.2.1 Data analysis: To analyse spatial and temporal changes in land use and land cover in easternSelous – Niassa TFCA from 1986–2016.The land cover change detection analysis was conducted based on the following steps:

(i)Satellite image selection and acquisition: Appropriate satellite imagery acquisition was done with highly consideration of cloud cover, the seasonality and phonological effects [14]. Clouds free satellite images with the interval not less than five years from 1986 to 2016 (Table 1) were used in assessing temporal and spatial variation of land use/cover change in the study area.

Year	Satellite	Sensor	Path/Row	Acquisition date	Cloud cover (%)
1986	Landsat 5	TM (SAM)	166/67	19/8/1986	0
	Landsat 5	TM (SAM)	166/68	30/9/1984	0
	Landsat 5	TM (SAM)	167/67	21/8/1990	5
1997	Landsat 5	TM (SAM)	166/67	14/6/1997	7
	Landsat 5	TM (SAM)	166/68	20/8/1998	8
	Landsat 5	TM (SAM)	167/67	27/12/1996	7
2005	Landsat 5	TM (BUMPER)	166/67	10/10/2005	10
	Landsat 5	TM (BUMPER)	166/68	23/6/2006	1
	Landsat 5	TM (BUMPER)	167/67	30/8/20058	8
2016	Landsat 8	OLI-TIRS	166/67	8/10/2006	0.28
	Landsat 8	OLI-TIRS	166/68	8/10/2016	0
	Landsat 8	OLI-TIRS	167/67	13/9/2006	0.8

Table 1: Satellite Imagery Data.

Image Pre-processing: To ensure accurate identification of temporal changes and geometric compatibility with other sources of information, images were pre-processed whereby geo-correction was conducted to rectify precisely matching of images. Band stacking and Images enhancement was performed using different color composite band combination and its contrast was stretched from minimum to maximum to reinforce the visual interpretability of images. Images were registered to the UTM map coordinate system, Zone 36 South, Datum Arc 1960.

(ii)Preliminary image classification and ground trothing:Supervised image classification using Maximum Likelihood Classifier (MLC) was conducted to create base map. Data from ground truth were used to formulate and confirm different cover classes existing in the study area. Training sites were identified by inspecting an enhanced color composite imagery. Areas with similar spectral characteristics were trained and classified.

Supervised classification by using Semi-automatic Classification Plug-in (SCP) available in QGIS 2.12.1 was conducted. The process involved selection of regions of interest (ROI) on the image, which represent specific land classes to be mapped. During Supervised Classification, maximum of seven distinct land cover classes were identified (Table 3) which are; Closed woodland (CWD), Open woodland (OWD), Bushland (BS), Grassland (GL), Water (WTR), Built up area (BLT) and Cultivated land (CL).

(iii)Final image classification and accuracy assessment:Kappa coefficient statistics was used to assess the accuracy of final image classification.

Where N is the total number of sites in the matrix, r is the number of rows in the matrix,

$$K = \frac{N \sum_{i=1}^{r} x_{ii} - \sum_{i=1}^{r}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{r}(x_{i+} \times x_{+i})} \quad \text{.................................. (4)}$$

x_{ii} is the number in row i and column i, $x_{+i}$is the total for row i, and $xi+$ is the total for column.

The classified maps show good agreement with the real world as indicated in Table 2.

Year	**1986**	**1997**	**2005**	**2016**
Overall accuracy (%)	98%	82%	89%	92%
Kappa statistic	0.97	0.79	0.92	0.91

Table 2: Accuracy assessment.

Land cover class	**Description**
Closed woodland	Area of land covered low density trees forming open habitat with plenty of sunlight and limited shade
Open woodland	Area of land covered with low density and scattered trees with crop cultivation activities
Bushland	Area dominated with bushes and shrubs
Grassland	Land area dominated by grasses
Water	Area within body of land, of variable size, filled with water, localized in a basin, which rivers flow into or out of them (Lake/Dam)
Built up area	Man made infrastructure (roads and buildings) and settlement
Cultivated land	Farm with crops and harvested cropland
Unclassified	Area with no input data or insufficient information which has been missed due to several reason including clouds, clouds shadow, darkness, and sensor dysfunctioning

Table 3: Land use/cover classification scheme.

(iv) Landuse and land covers change detection: Post classification comparison was used to quantify the extent of land cover changes over the period 1986 – 2016. Post classification comparison sidesteps the difficulties associated with the analysis of the images that are acquired at different times of the year, or by different sensors and results in high change detection accuracy [15]. The estimation for the rate of change for the different land covers was computed based on the following formulas [11].

$$\text{\% cover change} = \frac{Area_{i\ year\ x} - Area_{i\ year\ x+1}}{\sum_{i=1}^{n} Area_{i\ year\ x}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

$$\text{Annual rate of change} = \frac{Area_{i\ year\ x} - Area_{i\ year\ x+1}}{t_{years}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (3)$$

$$\text{\% Annual rate of change} = \frac{Area_{i\ year\ x} - Area_{i\ year\ x+1}}{Area_{i\ year\ x} \times t_{years}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (4)$$

Area $_{i\ year\ x}$ is the area of cover i at the first date,

Area $_{i\ year\ x+1}$ is the area of cover i at the second date,

$\sum_{i=1}^{n}$ **Area** $_{i\ year\ x}$ is the total cover area at the first

t_{years} is the period in years between the first and second scene acquisition dates

(v) To estimate amount of trees loss of eastern Selous-Niassa TFCA from 1986 to 2016: Amount of land (in hectares) in the study area that has been converted from closed and open woodlands to other socio-economic activities was used to estimate number trees loss. The study area belongs to southern zone as classified by URT[7]. The number of trees and volume per hectare of the distribution of forest and woody vegetation resources have been classified by employing methodology used by NAFORMA [7]of measuring all trees with Dbh of one cm and above as shown in table 4.

Districts	**Average mean volume m^3/ha**	**Average number of trees/ha**
Liwale, Nachingwea & Nanyumbu	49.3	1,654

Table 4: Distribution of forests and woody vegetation resources of the study area.

(vi) To analyse wood balance of corridor dwellers of eastern Selous-Niassa TFCA: Current human population of corridor dwellers was estimated based on NBS(National Bureau of Statistics), 2012 census and computing average demand for wood compared with supply from the corridor ecosystem. The study employed NAFORMA [7]baseline information that estimates Tanzania's average demand for wood is 1.39 m^3/year/capita while the annual allowable cut (the sustainable supply) was estimated at 0.95 m^3/year/capita.

3. Results and Discussion

3.1 Spatial and temporal changes in land use and land cover of eastern Selous-Niassa TFCA for period 1986 – 2016

3.1.1 Land use and land cover assessment: The land use land cover maps for the year 1986, 1997, 2005 and 2016 are presented in Figures 2, 3, 4 and 5. Generally, the maps show variations in cover coverage between the three periods under consideration. Table 5 represents the spatial distribution of land use/cover coverage for the period between 1986 and 2016.

LULC	1986		1997		2005		2016	
	(Ha)	(%)	(Ha)	(%)	(Ha)	(%)	(Ha)	(%)
Closed woodland	227731	15.57	244348	16.71	103198	7.06	89923	6.15
Open woodland	402201	27.50	411211	28.12	288176	19.70	220217	15.06
Bushland	433706	29.65	333399	22.80	256911	17.57	480269	32.84
Grassland	394960	27.00	437621	29.92	515143	35.22	394461	26.97
Water	1431	0.10	790	0.05	906	0.06	646	0.04
Built up area	2532	0.17	3391	0.23	7623	0.52	8851	0.61
Cultivated land	0	0.00	31799	2.17	290602	19.87	268193	18.34
TOTAL	**1462560**	**100**	**1462560**	**100**	**1462560**	**100**	**1462560**	**100**

Table 5: Land use/cover area distribution between 1986 and 2016.

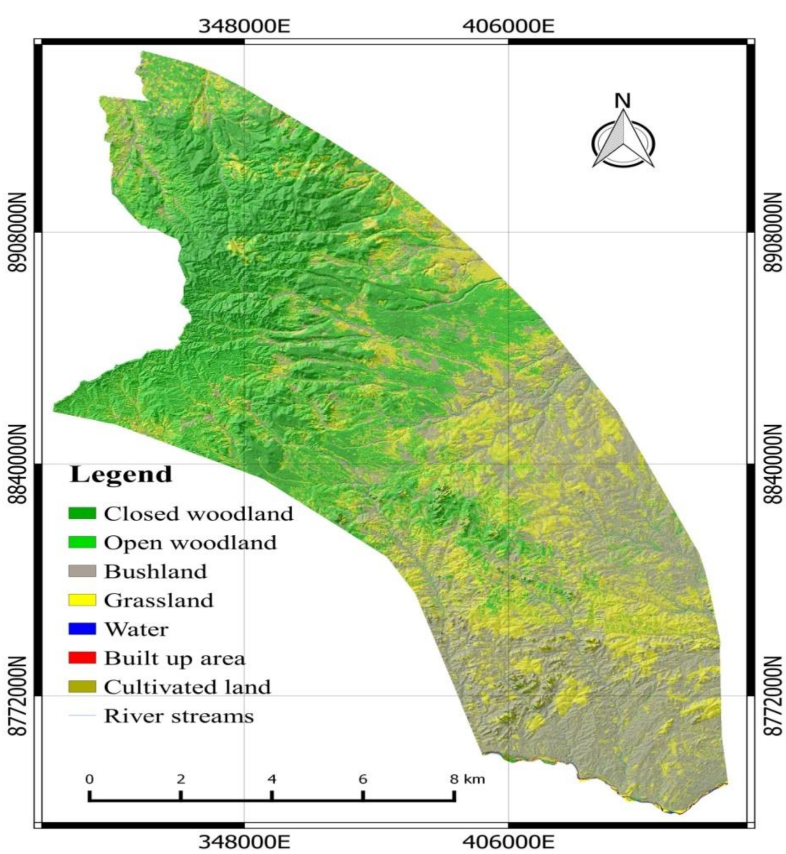

Figure 2: Land use/cover map for eastern Selous – Niassa TFCA 1986.

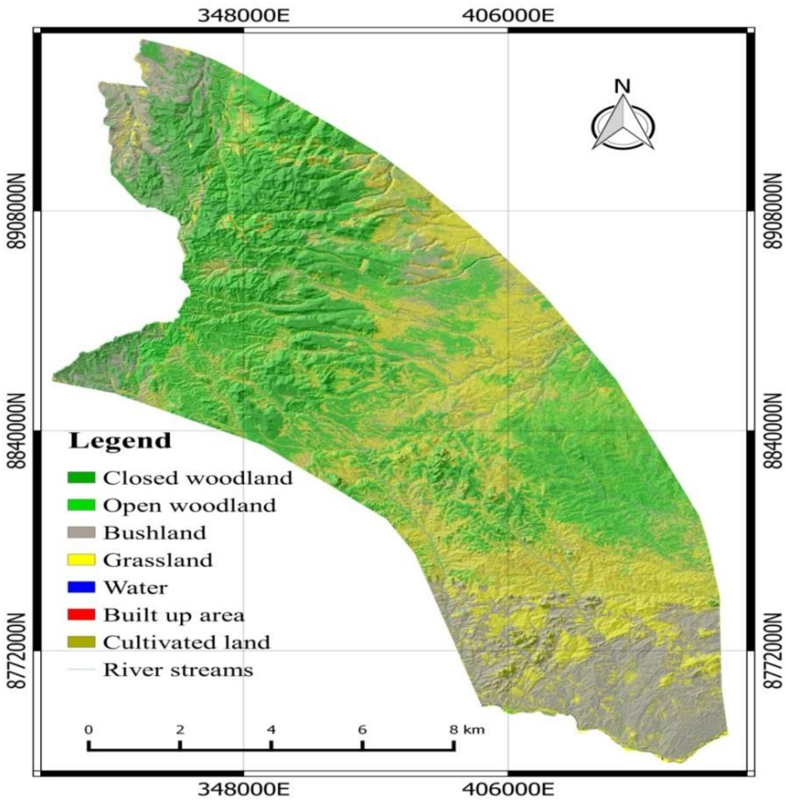

Figure 3: Land use/cover map for eastern Selous – Niassa TFCA 1997.

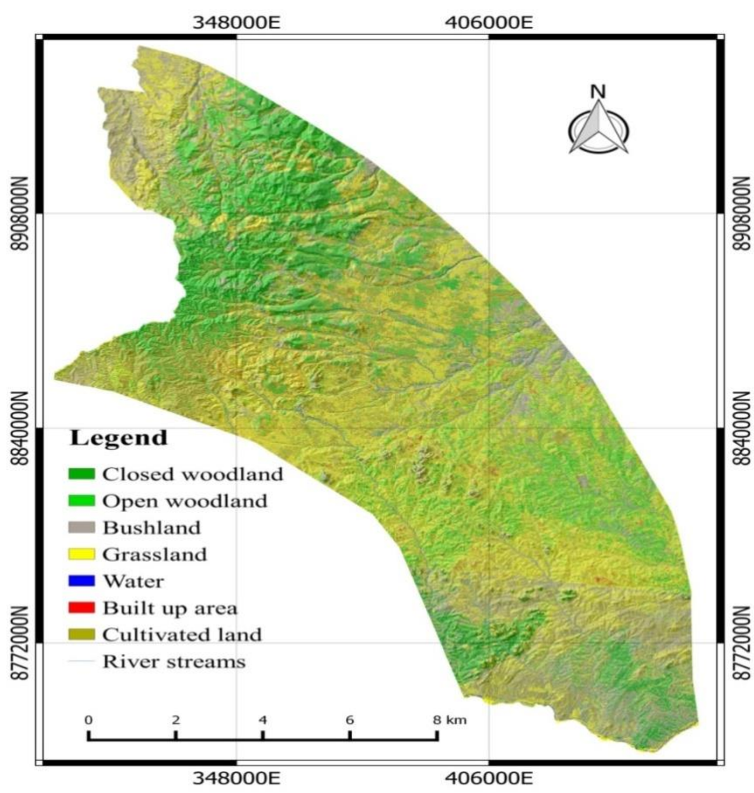

Figure 4: Land use/cover map for eastern Selous – Niassa TFCA 2005.

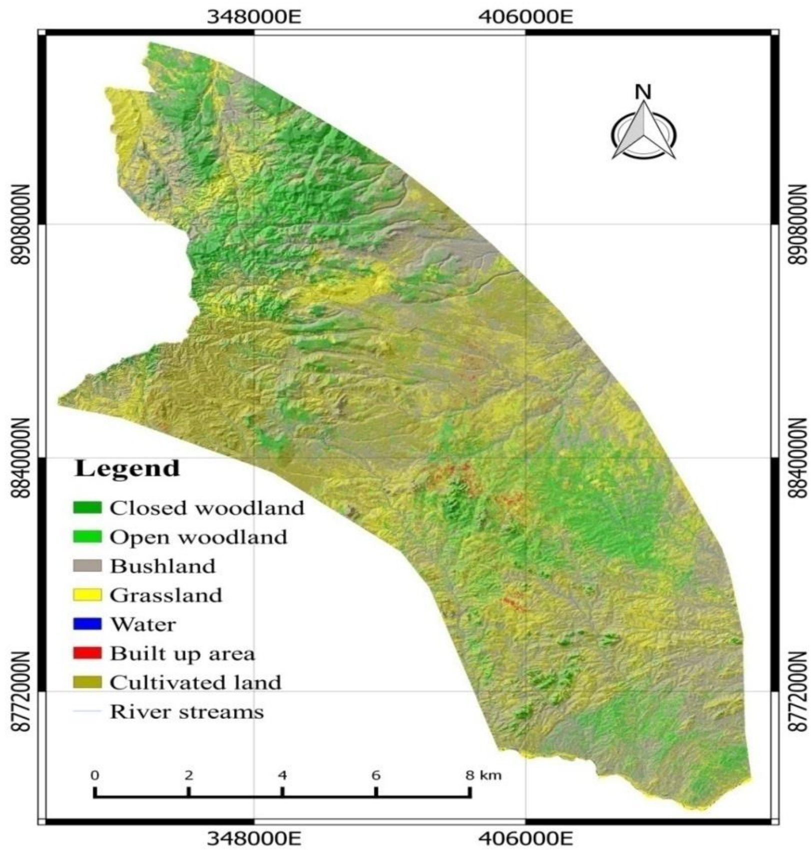

Figure 5: Land use/cover map for eastern Selous – Niassa TFCA 2016.

3.1.2 Land use/cover changes between 1986 and 2016: The extent of land use land cover change including area, percentage area change and percentage annual rate of change are summarised on Table 6. The increased and decreased amount is represented by positive signs (+) and (-) respectively.

LULC	1986 – 1997			1997 – 2005			2005 – 2016		
	Area change (Ha)	Percentage change (%)	Annual Rate of Change (Ha/year)	Area change (Ha)	Percentage change (%)	Annual Rate of Change (Ha/year)	Area change (Ha)	Percentage change (%)	Annual Rate of Change (Ha/year)
CWD	-16617	-1.14	-1511	141150	9.65	11762	13275	0.91	1207
OWD	-9010	-0.62	-819	123035	8.41	10253	67959	4.65	6178
BS	100306	6.86	9119	76488	5.23	6374	-223357	-15.27	-20305
GL	-42661	-2.92	-3878	-77522	-5.30	-6460	120682	8.25	10971
WTR	641	0.04	58	-116	-0.01	-10	260	0.02	24
BLT	-860	-0.06	-78	-4232	-0.29	-353	-1228	-0.08	-112
CL	-31799	-2.17	-2891	-258803	-17.70	-21567	22409	1.53	2037

CWD = Closed woodland, **OWD** = Open woodland, **BS** = Bushland, **GL** = Grassland, **WTR** = Water, **BLT** = Built Up area, and **CL** = Cultivated land.

Table 6: Land use/cover change between 1986 and 2016.

The results (Table 6), indicate that for the period between 1986 and 1997 the area under closed woodland, open woodland, grassland, built up area, and cultivated land increases by 1.14%, 0.62%, 2.92%, 0.06%, and 2.17% respectively. Likewise, bushland and water decreased by 6.86 and 0.04 respectively. For the period between 1997 and 2005, the closed woodland, open woodland, and bushland declined by 9.65%, 8.41%, and 5.23% respectively. For the same period of time, grassland, water, built up area, and cultivated land increased by 5.3%, 0.01%, 0.29%, and 17.7% respectively. Moreover, for the period between 2005 and 2016, the closed woodland, open woodland, grassland, water, and cultivated area declined by 0.91%, 4.65%, 8.25%, 0.02% and 1.53% respectively. For the same period of time, bushland and built up area increased by 15.27% and 0.08% respectively.

As revealed in Table 6, the decrease of closed woodland, open woodland, and bushland from 1997 to 2016 might be due human encroachments for timber, firewood and medicine, noticeable felling of trees for expansion of agricultural farms; whereas during 1986 to 1997 the increase of the closed and open woodlands happened as a result of famous operation “Uhai” done national wide to curb antipoaching and illegal harvesting of forest and wildlife resources. Also, the cashewnuts cultivated land was included in woodlands and thickets because the land cover is uncertain for this.

Also, the results supported by group discussants during focus group discussions emphasized that, wildfire, cutting trees; drying up trees are serious problems in recent years due to expansion of simsim farming, livestock immigrants, and commercial logging and timbering.

3.1.3 Change detection of different land use/cover: The net change of each land use/cover category is presented in Figure 6, and the change detection matrix for the period between 1986 and 2015 is presented in Tables 7 to 9, clearly reflecting on the land use transformation in the study area.

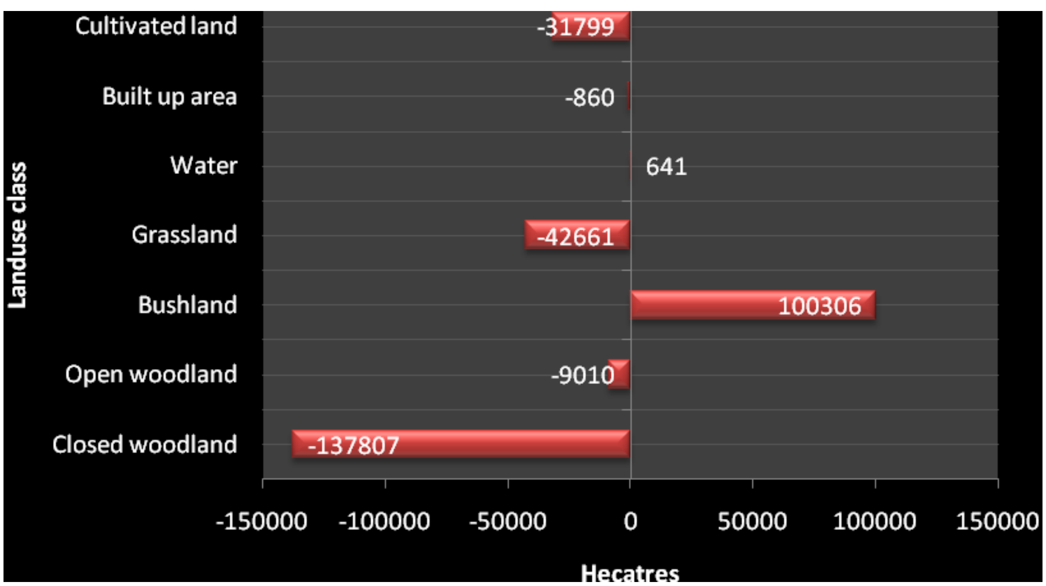

Figure 6: Gain and looses by each land use category between 1986 and 2016.

Cover in 1986	Cover in 1997(Ha)							
	CWD	**OWD**	**BS**	**GL**	**WTR**	**BLT**	**CL**	**TOTAL**
CWD	113076	65719	15637	17197	0	225	1526	**213379**
OWD	81872	165795	68741	84577	31	772	5194	**406982**
BS	20562	91588	169619	146223	9	514	7452	**435967**
GL	28746	87920	78420	187456	131	1826	17493	**401992**
WTR	42	25	255	616	489	3	1	**1431**
BLT	35	141	707	1529	104	153	31	**2701**
CL	1	0	1	6	0	0	100	**107**
TOTAL	**244334**	**411188**	**333381**	**437604**	**763**	**3492**	**31798**	**1462560**

CWD = Closed woodland, **OWD** = Open woodland, **BS** = Bushland, **GL** = Grassland, **WTR** = Water, **BLT** = Built Up area, and **CL** = Cultivated land.

Table 7: Change detection matrix for the period of 1986 to 1997.

Cover in 1997	Cover in 2005 (Ha)							
	CWD	**OWD**	**BS**	**GL**	**WTR**	**BLT**	**CL**	**TOTAL**
CWD	35521	71673	33529	62757	0	479	40457	**244416**
OWD	21869	115440	43831	127066	1	1970	101009	**411188**
BS	32885	39815	102169	104523	6	1063	52920	**333381**
GL	12481	57906	74047	200868	450	3376	88469	**437596**
WTR	0	0	0	343	447	0	0	**790**
BLT	80	229	292	1830	2	167	791	**3391**
CL	356	3178	3029	17727	0	568	6939	**31797**
TOTAL	**103193**	**288242**	**256897**	**515114**	**906**	**7623**	**290586**	**1462560**

CWD = Closed woodland, **OWD** = Open woodland, **BS** = Bushland, **GL** = Grassland, **WTR** = Water, **BLT** = Built Up area, and **CL** = Cultivated land.

Table 8: Change detection matrix for the period of 1997 to 2005.

Cover in 2005	Cover in 2016							
	CWD	**OWD**	**BS**	**GL**	**WTR**	**BLT**	**CL**	**TOTAL**
CWD	30929	20520	24539	16728	9	135	10415	**103275**
OWD	23689	73670	83706	62077	8	835	44175	**288160**
BS	9899	33202	113970	70239	31	538	29019	**256897**
GL	14772	64418	168122	170195	269	3999	93340	**515114**
WTR	0	0	0	587	320	0	0	**906**
BLT	148	452	1740	2809	1	410	2062	**7623**
CL	10482	28025	88165	71805	8	2933	89167	**290586**
TOTAL	**89918**	**220287**	**480242**	**394439**	**646**	**8850**	**268178**	**1462560**

CWD = Closed woodland, **OWD** = Open woodland, **BS** = Bushland, **GL** = Grassland, **WTR** = Water, **BLT** = Built Up area, and **CL** = Cultivated land.

Table 9: Change detection matrix for the period of 2005 to 2016 (Ha).

3.2 Amount of trees loss in eastern Selous-Niassa TFCA from 1986 to 2016

Table 10 shows amount of trees loss in eastern Selous- Niassa TFCA from 1986 to 2016. The results show that, there are intercernal changes of tree loss/gain from 1986 to 2016. The results revealed gain of trees regenerated in the study area during the period 1986 – 1997 with an average of 3.5 million trees per year. The reason behind the results might be due to low population of the area, inaccessible roads, low markets of valuable forests and wildlife resources from the study area, lack of policies for conservation and protection of forest and wildlife resources, and national wide operation "Uhai" which was done in this period. Moreover, there was rampant conversion of woodland the study area during the period 1997–2016 with average loss of 27 million trees per year. This implies that, the loss was due to other socio-economic activities which are environmental harmful but economic rewarding like commercial farming of simsim, cashewnuts, sesame, logging and timbering, artisanal mining, and livestock keeping/gathering. These activities involves clearance of woodlands by using fire and drying of standing trees to remove leaves so as to allow sunlight for crops farming and livestock gathering, and reducing tsetse infections.

Years	Total area converted (ha)	Total volume Million m^3	Number of trees loss/gain (in millions)
1986 – 1997	- 25, 627	- 1.3	- 42
1997 – 2005	+ 264, 184	+ 13.1	+ 437
2005 – 2016	+ 81, 234	+ 4.0	+ 134
Total	**+ 319, 791**	**+ 15.8**	**+ 529**

Table 10: Amount of trees loss from 1986 to 2016.

3.3Wood balance of corridor dwellers of eastern Selous-Niassa TFCA

Existing amount of trees from 1986 to 2016 (Table 11) used to estimate wood balance by using estimated population of the study area in these periods.

Year	Total woodland area (ha)	Total volume Million m^3	Number of trees (in millions)	Estimated human population	Wood balance (trees/capita/year)	Wood balance (m3/year/capita)
1986	629, 932	31.1	1041.9	312, 081	3339	99.7
1997	655, 559	32.3	1084.3	351, 866	3082	91.8
2005	391, 374	19.3	647.3	381, 229	1698	50.6
2016	310, 140	15.3	513	437, 921	1172	34.9

Table 11: Existing amount of trees from 1986 to 2016.

The results reveled in Table 11 above shows that, wood supply in the study area for the year 2016 is at least 25 times the average demand per year per capita. This implies that the area is still virgin interms of wood balance that means wildlife habitat is still intact. However, the trend of wood supply from 1986 to 2016 shows dramatic deforestation of the area which implies tragedy of common and is the public property where there is no control policies or rules. The emergence of reviewing management and conservation strategies is unexceptional if we need sustainability of Selous-Niassa TFCA.

4. Conclusion and Recommendations

4.1 Conclusion

This study analysed land use and land cover changes in eastern Selous – Niassa TFCA**.** The findings have revealed that the study area has undergone notable changes in terms of land use and land cover for the period between 1986 and 2016. Local knowledge revealed various factors associated to land use and cover change that includes fire, cultivation, and deforestation. The main factors mentioned as contributing to fire were beekeeping, hunting activities, and local beliefs, while for deforestation include commercial logging and timbering, charcoals production, population growth, expansion of commercial farming and food crops production.

The results indicate that land use and land cover change has a significant impact to the management of biodiversity and maintaining ecosystem services of the TFCA. The greater increase of land use conversion alters wildlife movements, gene flow and stochastic events like fire and climate change. The study concludes that the modification of the land use and cover has resulted in behavioral changes of some wild animals due to changes of their habitats. The study highlights the effects of land use and land-cover changes on number of trees loss and wood balance of the corridor dwellers which shows unsustainable supply.

4.2 Recommendations

The study provides the following recommendations for sustainable management and conservation of eastern Selous – Niassa TFCA:

- Formulate user friendly guidelines for protection of wildlife corridors as stipulated in Tanzania Wildlife Conservation Act No. 5 of 2009;
- Formulate new and enhancing existing wildlife management areas (WMAs), participatory forests managements (PFMs) and joint forests managements (JFMs) so as accrued benefits should be higher than protection costs of the existing resources;
- Formulate land use plans of the corridors so as to protect wildlife routes within the corridors;
- Usage of alternatives wood resources so as offset the supply deficit and attain sustainability.

5. Disclosures

The authors declare that there is no conflict of interest regarding the publication of this paper

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