Spatial and temporal dynamics of land use and land cover in and around Magamba Nature Forest Reserve, Lushoto, Tanzania

[1]Andrew, S.M. and [1]Sembosi, S.J.

[1]Department of Ecosystems and Conservation, College of Forestry, Wildlife and Tourism, Sokoine University of Agriculture, P.O. Box 3010 Chuo Kikuu, Morogoro, Tanzania.
Corresponding author Tel.: +255-023-2604944, fax: +255-023-2604648.
Email addresses: smacrice@suanet.ac.tz, solomonjeremiah54@yahoo.com

ABSTRACT

Magamba Nature Forest Reserve is the largest forest reserve with endemic, rare and unique species of flora and fauna in Lushoto, Tanzania. It lies within the Eastern Arc Mountains and is important for biodiversity, water catchment, environmental and cultural values. Unfortunately, it is perceived that human activities have had impacts on the forest resources in and around the reserve. However, these perceptions are little proved quantitatively. Thus, a study was carried out to assess the dynamics of land use and land cover in and around Magamba Nature Forest Reserve for the period 1995-2015 to facilitate improved management of the reserve. Remote sensing and GIS methods were used to carry out satellite images classification and ground truthing data were collected during field observations using GPS. Landsat thematic mapper and operational land imagery were used to locate and quantify the land use and land cover changes in the study area. Change detection was done through post classification in SAGA 2.2.0. Results indicated a major expansion of agricultural area from 169.33 ha in 1995 to 902.54 ha in 2015. Likewise, there was an increase of built-up area from 36.50 ha in 1995 to 1792.92 ha in 2015 at the expense of other land covers. Natural forest decreased from 8051.35 ha in 1995 to 3431.30 ha in 2015. Similarly, woodland area decreased from 2333.37 ha in 1995 to 1216.76 ha in 2015. It is evident that there have been considerable changes in land use and land cover in and around the reserve that call for improved management strategies to sustain biodiversity and other values.

Keywords: Remote sensing, GIS, built-up area, landscape, protected area, Eastern Arc Mountains, nature forest reserve

INTRODUCTION

Forest nature reserves are among the largest and very important earth's terrestrial ecosystems (Sunderlin 2006). These ecosystems are vital because they provide food resources to both human and animals. They also serve as critical habitats for biodiversity and they support significant components of terrestrial water and chemical cycles (Pataki *et al*. 2011). As population grows, the reserve lands like any other land use land cover has come under increasing pressure from a wide variety of factors including encroachment and unsustainable harvesting of natural forest products (Bonan 2008). In rural and urban areas, development has resulted into changes in land use and land cover with consequences on environmental change. This will continue to foster environmental changes as most of the people still lives in rural areas where they depend mostly on natural resources especially in developing countries. Consequently, this dependence on natural resources will lead to increase in socio-economic needs which create pressure on land and resulting in unplanned and uncontrolled changes in land use and land cover (Meyer and Turner 1994, Seto *et al*. 2002, Araya 2014). It is widely

known that by using land to produce goods and services human activities alter natural environment, habitats and ecosystems (Vitousek *et al*. 1997, Halpern *et al*. 2008) which altogether affects ecological and social systems.

Tanzania is endowed with twelve nature forest reserves covering about 311,471 ha (TFCG 2017). The nature reserves are offered the highest level of protection under the Forest Act Cap 323[R.E.]. It is not allowed to extract woody or animal species in the reserves and activities are generally restricted to research, education and nature-based tourism. However, there are number of threats facing these reserves which potentially lead to forest fragmentation, land degradation and biodiversity loss at spatial and temporal scales (Rockström *et al*. 2009). Common threats are fire, clearing of natural vegetation, illegal harvesting of forest products, mining, and climate change and climate variability (NEMC 2009).

It is known that among the changes in land use and land cover observed across the globe are caused by uncontrolled harvesting of forest products and utilization of services and agricultural expansion (Andrew *et al*. 2004). This has caused agriculture and forests to turn out to be the most transformative events across the globe (Hansen *et al*. 2001, Foley *et al*. 2007, Pielke *et al*. 2011). Knowledge of land cover and land use changes facilitates understanding of the relationship between human activities and the environment. It also helps to develop the capacity of stakeholders to manage land resources sustainably and facilitate improved biodiversity conservation in protected areas. It is on the basis of this background that this paper is developed.

There are perceptions that Magamba Nature Forest Reserve (hereafter referee to Magamba Nature Forest Reserve-MNFR) in Lushoto, Tanzania and its surrounding environments have been altered by human activities with potential consequences on flora and fauna. However, these perceptions are supported little scientifically and lack of information on land use and land cover changes impedes restoration and development of improved mitigation strategies. Thus, this study was set with the objective of investigating the spatial and temporal changes in land use and land cover that have occurred as a result of human development in and around MNFR for the period 1995 to 2015. Remote sensing techniques and methods were employed in this study because they have demonstrated to be useful tools for monitoring land use and land cover changes and development planning of protected areas.

MATERIALS AND METHODS

Study Area

Magamba Nature Reserve is located between 04°38S and 38°10'E and 04°38'S and 38°19'E within Lushoto District in Tanzania (Figure 1). It was a Forest Reserve until 2016 when it was gazetted as a Nature Reserve (government notice number 103). The reserve covers an area of 9,283 ha and is the largest forest fragment remaining in the West Usambara Mountain block. Usambara Mountains form part of the Eastern Arc Mountains which is a chain of ancient forested mountains stretching across Tanzania and into Kenya. Magamba experiences cool condition all over the year with temperature ranging between 15°C and 30°C. Mean annual rainfall is 1200 mm. Altitude ranges from 1,650 to 2,287 meters above sea level (m.a.s.l). The geology consists of complex series of ancient metamorphic rocks. The soils are mainly loams with varying amounts of sand and colour that varies from red through gray-brown to black with pH ranging between 3.5 and 8.5. Soils are rich in minerals like Iron, Magnesium and Manganese in MNFR (URT 2003).

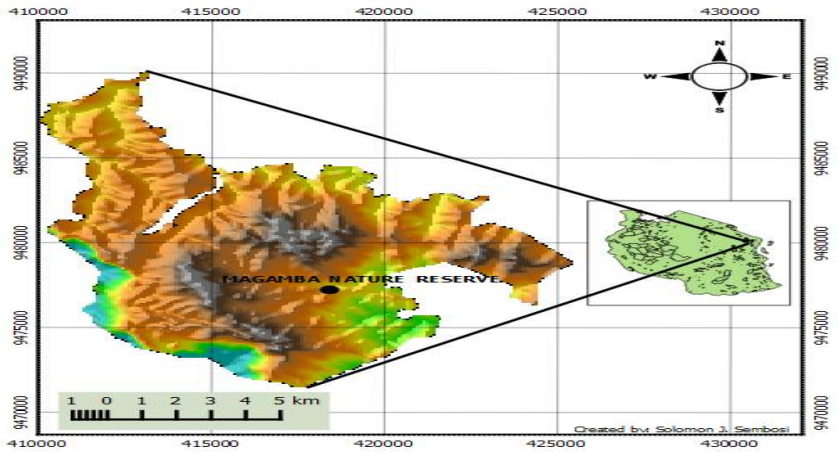

Figure 1. The location of Magamba Nature Reserve in Lushoto Tanzania (Author's own work).

The reserve is a water catchment and a source of many streams. Slopes within the forests have numerous gullies carrying streams of water making almost 28 permanent and seasonal streams in the reserve (URT 2003). Moreover, the reserve is surrounded by 17 villages which comprised of a total population of 58,996 in 2008. Major ethnic groups surrounding the reserve are the Wasambaa, Wapare and Wambugu. Communities adjacent to the reserve depend on agriculture for their livelihood by growing food crops like maize, potatoes, bananas and beans. Cash crops grown include vegetables, fruits, Irish potatoes and beans.

The reserve has a continuous stand of trees which may attain a height of about 45 m or more (URT 2003). In most places of the forest, the majority of trees are evergreen throughout the year. The main indigenous tree species include *Ocotea usambarensis*, *Newtonia buchananii* and *Entendofragma utirii*. Other plant species include a wide range of grasses, herbs and shrubs. The reserve harbours endemic species including Vestergaard's Forest Toad, the Mazumbai Warty Frog and the West Usambara Two-horned Chameleon. Present unique bird species include the Usambara akalat, Usambara weaver, Usambara nightjar, Usambara eagle-owl, Fischer's turaco and the banded green sunbird (Jambiya 1998).

Table 1. Descriptions of LULC categories for the study area

LULC categories	**Description**
Natural forest	Portion of land bigger than half a hectare (5 000 m2) with trees higher than 5 meters and a tree canopy cover of more than 10 %, or with trees that will be able to meet these criteria. It does not include land that is predominantly under agricultural or urban land use.
Plantation forest	Are forested areas either established artificially by planting or seeding. Trees do generally belong to the same specie (whether native or introduced), have the same age and are regularly spaced.
Grassland	Areas where the vegetation is dominated by grasses (Poaceae), however sedge (Cyperaceae) and rush (Juncaceae) families can also be found.
Shrub-land	It includes an open or closed stand of shrubs up to 2 m tall which may either occur naturally or as the result of human activity such as fire.
Woodland	This is a low-density forest forming open habitats with plenty of sunlight and limited shade. It may support an understory of other vegetation types such as shrubs and herbaceous plants including grasses.
Agricultural land	Includes a great deal of land not actively or even presently devoted to agricultural use.
Built-up area	A term used to reflect a developed area on which buildings or non-building structures are present.

Data collection and analysis

Landsat image scenes which were downloaded from the United States Geological Survey (USGS) website were used in the study. All images were obtained during dry season with minimum or without cloud cover to facilitate easy and correct interpretation (Table 2). The period 1995-2015 was chosen because this was the time when there were more development activities in the area with potential consequences to the environment.

Table 2. Landsat images used in the analysis of land use and land cover changes in and around Magamba Nature Reserve in Lushoto Tanzania.

YEAR	Sensor	Path / Row	Acquisition Date	Resolution	Cloud cover (%)	Season	Source
1995	Land sat TM	167/63	02-07-1995	30	4	Dry	USGS
2008	Land sat TM	167/63	07-09-2008	30	14	Dry	USGS
2015	Land sat OLI	167/63	14-01-2015	30	0	Dry	USGS

Topographical maps of 1:50,000 scale were obtained from MNFR and the latest set of Google and aerial photographs covering the study area were obtained from Google Earth. Landsat imageries were rectified to the national coordinate reference system (UTM Zone 37 South, Spheroid Clarke 1880, Datum Arc 1960). Thereafter, rectified images were extracted from the full scenes using reserve boundary after it was clipped using raster operations in QGIS from the Tanzania Nature Reserves shape files and then projected in ArcView GIS 3.2a to Map Projection: Transverse Mercator, Map Coordinate: UTM Zone 37S, Spheroid: Clarke 1880, Central Meridian: 39, Reference latitude: 0, Scale factor: 0.9996, False Easting: 500 000 and False Northing: 1000 000. Image classification followed USGS system as described by Campbell (2007). Post classification method was used to relate data from different dates and sources in order to obtain information on existing land use and land cover dynamics. Supervised classification was used to create Regions of Interest (ROIs) and signature files. Seven classes (Table 1) were then formulated and confirmed through the use of ground truthing field work. During ground truthing random sampling was used to pick the points for the confirmation of the identified classes. The points were picked randomly because the area is mountainous. These classes were natural forest, plantation forest, grassland, shrub-land, woodland, agricultural land and built-up area. In this study classification accuracy was computed using Kappa statistics whereby measures of thematic accuracy including user's accuracy, producer's accuracy and overall accuracy were computed (CCRS 2004; Mideksa 2009). Kappa was computed following Jensen and Cowen (1999). Reference points were collected on the ground using global positioning system (GPS). More than 60 reference points were collected based on the 2015 image because it is the most recent image close to ground observations. Therefore, the confirmed land use land cover map from 2015 was used as an ancillary data for retrieving land use and cover from prior dates with an assumption that there is no addition in land use/cover class in the prior years (i.e. changes are expected for only changes in the area extent and land use/cover class reduction).

The generated land use and land cover thematic maps were analyzed using map overlay method. Change detection was done through post classification in SAGA 2.2.0 software. The method is suitable for detecting land use land cover changes as it is the most common approach for comparing data from

different sources and dates (Kashaigili and Majaliwa 2010). Furthermore, this method it does not only give the size and distribution of changed areas but it also gives the percentages of other land cover classes that share in the change in each land cover class individually (Aldwaik and Pontius 2012, Hussain *et al*. 2013, El-Hattab 2016). The rate of change for different land covers was computed based on Kashaigili (2006).

RESULTS

Accuracy of LULC classification

Natural forest had the highest producer's and user's accuracies and Kappa statistics in classified images of 1995 suggesting that almost all pixels labeled natural forests on the classified images indeed signify natural forest (Table 3). Agricultural land had the lowest producer's and user's accuracies (74.19 % and 81.63 %). The overall classification accuracy was 94.30 % and overall Kappa statistics 0.91 for images of 1995 (Table 3).

Table 3. Accuracy totals and Kappa statistics for classified images of 1995.

Class name	Producer Accuracy (%)	User Accuracy (%)	Kappa Statistic
Natural forest	98.66	99.95	0.99
Plantation forest	97.61	92.66	0.91
Grassland	98.20	86.98	0.87
Shrub-land	88.73	89.13	0.88
Woodland	85.83	89.36	0.87
Agricultural land	74.19	81.63	0.89
Built-up area	80.40	86.43	0.90

Overall classification accuracy (%) = 94.30; Overall Kappa statistics = 0.91

Table 4 shows the total accuracies for producer and user for the classified images of 2008. Grassland had the highest producer's accuracy of 100 and the second highest user's accuracy (99.54%) which altogether suggests that almost all pixels labeled grassland on the classified images indeed represented grassland (Table 4). On the other side, woodland had the lowest user's accuracy of 38.69 % and Kappa statistics of 0.38 (Table 4). The overall classification accuracy was 96.25 % and overall Kappa statistics 0.92 for classified images of 2008 (Table 4).

Table 4. Accuracy totals and Kappa statistics for classified images of 2008.

Class name	Producer Accuracy (%)	User Accuracy (%)	Kappa Statistic
Natural forest	96.90	99.96	0.99
Plantation forest	99.88	97.38	0.97
Grassland	100.0	99.54	0.99
Shrub-land	99.73	97.60	0.98
Woodland	97.94	38.69	0.38
Agricultural land	79.19	91.73	0.91
Built-up area	90.61	76.53	0.76

Overall classification accuracy (%) = 96.25; Overall Kappa statistics = 0.92

Total accuracies for the producer and user in the classified images of 2015 are presented in Table 5. Natural forest and agricultural land had the highest user's accuracies of 99.09 % and 99.20 %. Moreover, the two land covers (i.e. natural forest and agricultural land) had the highest Kappa statistics (Table 5). Altogether, this indicates that the pixels labeled natural forest and agricultural land on the classified image indeed stand for the natural forest and agricultural land. The overall classification accuracy was 93.23 % and overall Kappa statistics was 0.90 for classified images of 2008 (Table 5).

Table 5. Accuracy totals and Kappa statistics for classified images of 2015.

Class name	Producer Accuracy (%)	User Accuracy (%)	Kappa Statistic
Natural forest	94.25	99.09	0.98
Plantation forest	95.29	88.98	0.87
Grassland	94.27	67.55	0.66
Shrub-land	92.61	90.39	0.89
Woodland	84.45	97.51	0.97
Agricultural land	97.81	99.20	0.99
Built-up area	98.78	74.23	0.74

Overall classification accuracy (%) = 93.23; Overall Kappa statistics = 0.90

Land use and land cover area and matrix

This study shows that distribution and coverage of land use land cover varied according to the studied year (i.e. 1995, 2008 and 2015). The land use land cover maps (Figure 2, 3 and 4) were generated based on seven land use land cover units observed in and around MNR. During the year 1995 the dominant land cover was natural forest which accounted for 6448.15 ha in the reserve and 1603.2 ha around the reserve thus making a total of 8051.35 ha (61.06 %). In the same year plantation was the second with 418.54 ha in the reserve and 995.43 ha around the reserve hence making a total of 1413.97 ha (10.72 %) of all the land cover in and around the study area (Table 6; Figure 2). The smallest land cover class was detected to be built-up area which covered 10.8 ha in the reserve and 25.7 ha around the reserve thus making a total of only 36.50 ha in 1995 (Table 5).

The area covered by natural forest and woodland declined in year 2008 (Table 6; Figure 3). On the other hand, plantation forest increased to 1845.91 ha (14 %) whereby 546.41 ha was in the reserve and 1299.5 was around the reserve while grasslands increased to 1379.46 (10.46%) whereby 408.32 ha was found in the reserve and 971.14 ha was found around the reserve. The increase in shrub land was 299.55 ha in the reserve and 712.4 ha around the reserve making a total of 1011.95 ha (7.67%) for the whole study area. Built-up area increased to 641.74 around the reserve and 296.82 ha in the reserve while agricultural land expanded to 83.52 ha in the reserve and 198.64 ha around the reserve making a total of 282.16 ha (2.14 %) among the land covers identified in and around the study area.

Table 6. Areas and extents of respective land use and land cover classes in and around Magamba Nature Reserve for the period 1995 – 2015 in Lushoto Tanzania.

Land use/land cover classes	1995 Area (ha)	(%) coverage	2008 Area (ha)	(%) coverage	2015 Area (ha)	(%) coverage
Natural forest	8051.35	61.06	6017.27	45.63	3431.3	26.02
Plantation forest	1413.97	10.72	1845.91	14.00	2390.59	18.13
Grassland	822.61	6.24	1379.46	10.46	1670.63	12.67
Shrub-land	358.95	2.72	1011.95	7.67	1781.76	13.51
Woodland	2333.37	17.70	1737.77	13.18	1216.34	9.22
Agricultural land	169.33	1.28	282.16	2.14	902.54	6.84
Built-up area	36.5	0.28	911.56	6.91	1792.92	13.60
Total	13186.08	100.00	13186.08	100.00	13186.08	100.00

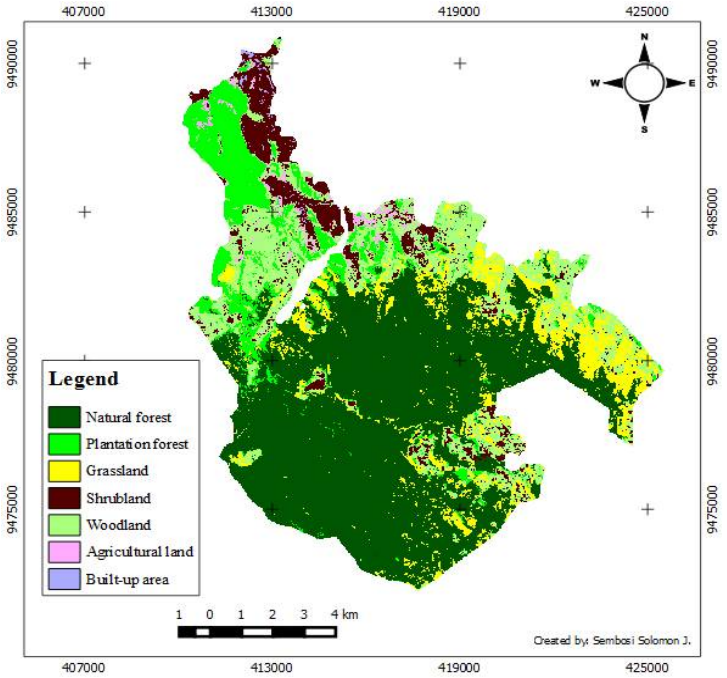

Figure 2. Land use and land cover map in and around Magamba Nature Reserve during 1995 in Lushoto Tanzania (Sembosi, 2017).

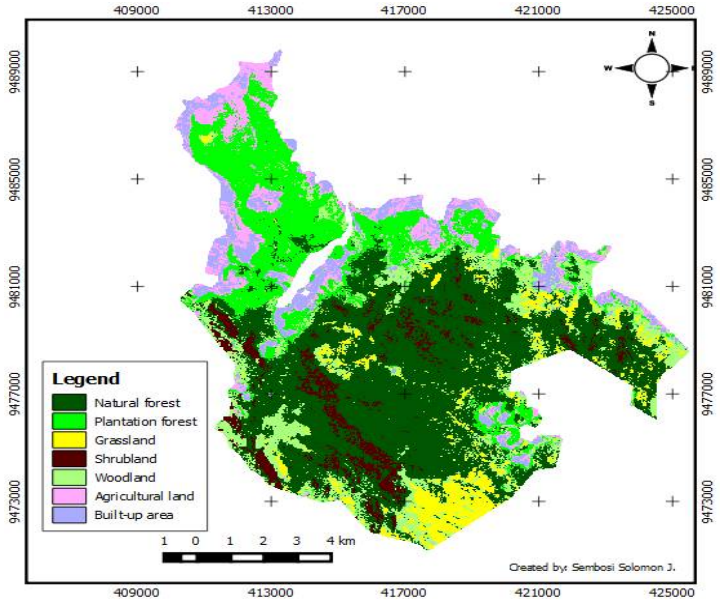

Figure 3. Land use and land cover map in and around MNFR during 2008 in Lushoto Tanzania (Sembosi, 2017).

By 2015, natural forest was still the most dominant land use land cover class although with only remaining 3315.64 ha in the reserve and 115.66 ha around the reserve thus making a total of 3431.3 ha (26.02 %) for the whole study area (Table 6; Figure 4). Other land use land cover such as plantation forest, grassland, shrub-land, agricultural land and built up area increased in areas compared to the year 2008 (Table 6). Distribution of land use land cover in and around the reserve for

the study years (i.e. 1995, 2008 and 2015) is summarized in Figure 5.

Compared to other land use land cover classes built-up areas increased at an annual rate of 47.4 ha around the reserve and 19.91 ha in the reserve making a total of 67.31 ha/year (0.51 %/year) for the years between 1995 and 2008 (Table 7).

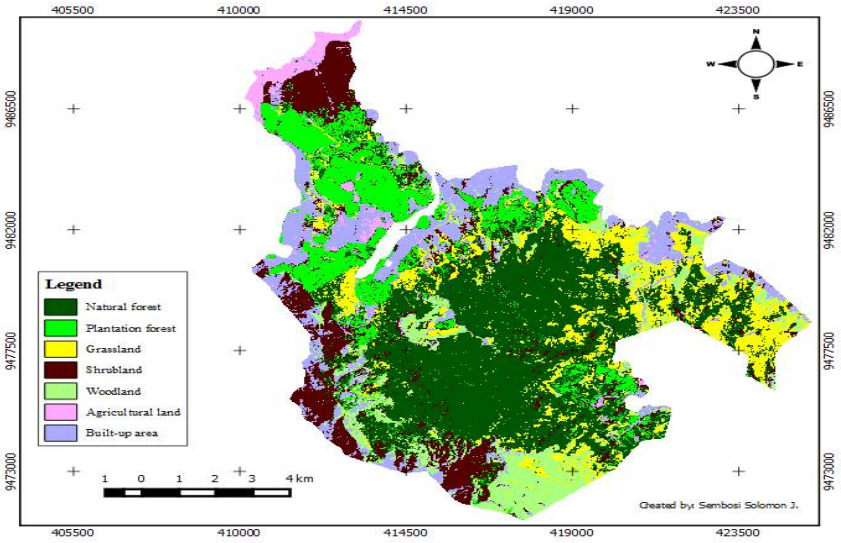

Figure 4. Land use and land cover map in and around MNFR during 1995 in Lushoto, Tanzania (Sembosi, 2017).

Table 7. Cover area, changed area and the rate of change between 1995 and 2008 in and around MNFR in Lushoto, Tanzania.

Land cover in 1995			Land cover in 2008		Land cover change (1995 - 2008)			
Cover class	Area (ha)	% cover	Area (ha)	% cover	Area change (ha)	% cover change	Annual rate of change (ha/yr)	%Annual rate of change (%/yr)
NF	8051.35	61.06	6017.27	45.63	-2034.08	-15.43	-156.46	-1.19
PF	1413.97	10.72	1845.91	14.00	431.94	3.28	33.23	0.25
GL	822.61	6.24	1379.46	10.46	556.85	4.22	42.83	0.32
SL	358.95	2.72	1011.95	7.67	653	4.95	50.23	0.38
WL	2333.37	17.70	1737.77	13.18	-595.60	-4.52	-45.82	-0.35
AL	169.33	1.28	282.16	2.14	112.83	0.86	8.68	0.07
BA	36.50	0.28	911.56	6.91	875.06	6.63	67.31	0.51
Total area	13186.08	100.00	13186.08	100.00				

NF = Natural forest, PF = Plantation forest, GL = Grassland, SL = Shrub-land, WL = Woodland, AL = Agricultural land, BA = Built-up area

Natural forest decreased consistently at an annual rate of -110.15 ha/year around the reserve and -46.31 ha/year in the reserve which is equal to -156.46 ha/year (-1.19 %/year) for the whole study area. On the other side woodlands decreased at the rate of -45.82 ha/year (-0.35 %/year) whereby -32.26 ha/year occurs in the reserve and -13.56 ha/year around the reserve for the period between 1995 and 2008 (Table 7). There was an increase in plantation forest, grassland, shrub-land, agricultural land and built-up areas for the period 2008 to 2015 (Table 8). Moreover, natural forest decreased at an annual rate of -109.35 ha/year in and around the reserve was -260.07 ha/year

which is equal to -369.42 ha/year (-2.80 %/year) in total. Woodlands decreased at an annual rate of 52.44 around the reserve and 22.05 in the reserve making a total of -74.49 ha/year (-0.57 %/year) respectively between 2008 and 2015 (Table 8). Change detection matrix of different land use land cover for the period 1995-2015 in the study area is summarized as appendix 1 and 2.

Table 8. Cover area, changed area and the rate of change between 2008 and 2015 for MFNR

Land cover in 2008			Land cover in 2015		Land cover change (2008 - 2015)			
Cover class	Area (ha)	% cover	Area (ha)	% cover	Area change (ha)	% cover change	Annual rate of change (ha/yr)	%Annual rate of change (%/yr)
NF	6017.27	45.63	3431.3	26.02	-2585.97	-19.61	-369.42	-2.80
PF	1845.91	14.00	2390.59	18.13	544.68	4.13	77.81	0.59
GL	1379.46	10.46	1670.63	12.67	291.17	2.21	41.59	0.32
SL	1011.95	7.67	1781.76	13.51	769.81	5.84	109.97	0.83
WL	1737.77	13.18	1216.34	9.22	-521.43	-3.96	-74.49	-0.57
AL	282.16	2.14	902.54	6.84	620.38	4.70	88.63	0.67
BA	911.56	6.91	1792.92	13.60	881.36	6.69	125.91	0.96
Total	13186.08	100	13186.08	100				

NF = Natural forest, PF = Plantation forest, GL = Grassland, SL = Shrub-land, WL = Woodland, AL = Agricultural land, BA = Built-up area

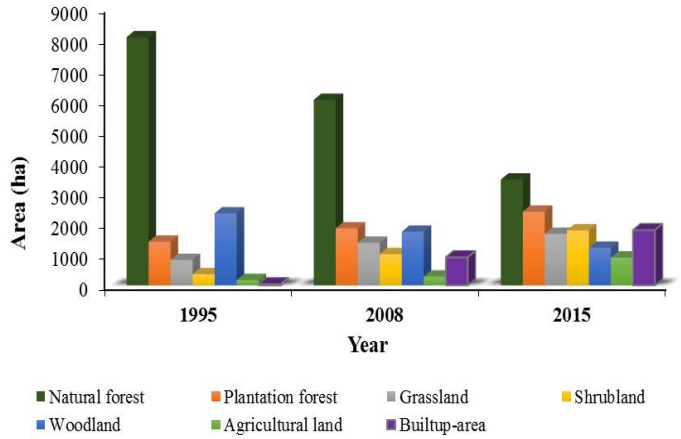

Figure 5. Distribution of land use and land cover in and around MNFR for the period 1995 – 2015 in Lushoto Tanzania.

DISCUSSION

In this study, the assessments of overall accuracies were observed to be over 90% for all the classified images regardless of the year of consideration. It is generally known that if the overall classification accuracy of image is greater than 80% the classification is accepted (Turan and Günlü 2010, Senga *et al.* 2014). Thus, our classification of images in the study area and considered duration appears to be good and reliable. Significant changes in land use land cover were observed over the study period of 1995 to 2015 in Lushoto. Rapid changes associated with urbanization and human activities were revealed in the form of reduction of natural forests and woodlands. At the same time build-up, grassland, plantation forest, shrub land and agricultural land areas increased. Consequently, sharp changes in landscape pattern, use and composition were observed.

Moreover, the original landscape has become fragmented and structure changed as a result of urbanization and developmental needs including settlement and agricultural areas.

From these results, it is obvious that natural forests and woodlands are declining at the expense of other land use land cover classes in and around the study area. Land use shapes the distinguishing patterns of land cover. Consequently, these changes in land use have influenced the loss of natural vegetation mainly driven by the human needs to produce daily basic necessities. The situation of the study area reflects the pattern and pressure of land use land cover changes by communities especially those living around the protected areas. However, in order to understand the land cover changes of an area, it is essential to understand land uses of a particular area. Despite the slow natural processes, the main actors in the dynamics of land use land cover are humans (Foley *et al*. 2005). For decades' land use land cover has undergone tremendous changes in many parts of the world. These changes have occurred as a result of natural and manmade processed. But in our case, the main agent of the changes in land use land cover has been humans. This is supported by Mdemu and Burra (2016) who documented that the increase in human activities has altered the vegetation cover in most areas in Tanzania especially forest vegetation.

Temporal analysis showed that there is a conversion of natural forest and woodland areas to other vegetation types and an increase in built-up and agricultural areas (Table 6). The decline in woodland and natural forest areas and the increase in shrub-land, grassland, plantation forest, agricultural land and built-up areas are associated with the increase in illegal activities and demand for land by the local communities. Mdemu and Burra (2016) support this argument by asserting that the changes in land use land cover are caused by illegal human activities in the forest reserves. At Lushoto there is an increase in demand for firewood, lumber, poles, logs, areas for settlement, grazing and farming activities. It is known that soils of Lushoto are fertile and the area receives good amount of rainfall throughout the year and therefore attracts local communities and migrants in search for better livelihoods and development. The area supports agricultural crops such as potatoes, sugar cane, maize, banana, beans and variety of vegetables plus commercial crops including apples, passion and peaches. Moreover, several other scholars (e.g. Ngalande 2002, Slayback 2003, Nzunda 2011) have documented that settlements and agricultural activities have contributed significantly to the loss of natural vegetation including forests and woodlands. In other parts of Tanzania, it has been reported that the changes in land use and land cover has been caused by intensification of agricultural activities even in the catchment areas (Mati *et al*. 2008). In addition, Allen and Barnes (1985) and Hosonuma et al. (2012) states that the reasons for forest degradation within developing nations have been increase in demand for fuel, timber, areas for agriculture and population increase.

Plantation forest area increased from 1,413.97 ha in 1995 to 2,390.59 ha in 2015 at Lushoto. These plantations are owned by the government and private smallholder farmers and the observed trend is caused by rapidly growing economies and the demand for quality timber in construction and power sectors. In recent years, it has been observed that private forestry and wood processing investments are increasingly prioritized in Tanzania. Similar trend is experienced in rural areas where smallholder plantation forestry is expanding rapidly in the Southern highlands of Tanzania. With the assured incentives and quick returns private forestry it is likely that more land will be converted to plantation forests although this has to be monitored and managed closely to avoid food insecurities and inadequate supply of other forest products and services plantations cannot offer.

CONCLUSIONS AND RECOMMENDATION

This study investigated the land use land cover changes in and around MNR in Lushoto Tanzania. The study used various methodological approaches in discovering the dynamics of forest resources and the results show that the reserve has undergone several changes between 1995 and 2015. Natural forests and woodlands were found to be highly impacted due to the increased human activities in and around the reserve. Agricultural and built-up areas were found to have low cover in 1995 meaning the reserve was much safer from most of the human disturbances. Unfortunately, between 2008 and 2015 agricultural and built-up areas increased at the expense of other land use and land cover, suggesting the intensification of human activities in and around the reserve. Ground observations made in and around the reserve revealed major anthropogenic activities including illegal logging, encroachments to search for firewood, fire and illegal grazing. From these results, it is clear that improved management strategies in and around the reserve is required to monitor the changes. Moreover, it is important to develop land use plan for the villages surrounding the reserve to avoid more degradation of the natural resources the reserve is endowed with. Regular monitoring of land use land cover with information on changes of natural areas, the number and conditions is recommended in protected areas. The present study has set a starting point for regular monitoring and timely comparison of information with the data of previous years to identify the dynamics of land resources and control factors that led to the changes. This study demonstrates that there is a need to integrate current technologies such as remote sensing and GIS to improve management of protected areas and better planning of growing towns. Since Magamba has recently been heightened in protection status from a forest reserve to nature forest reserve it is hoped that the forest condition will improve to sustain biodiversity and other values.

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