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EFFECT OF FOREST DEGRADATION ON THE SOIL QUALITY IN THE KWARI-KWASA FOREST RESERVE OF KEBBI STATE, NIGERIA

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Abstract

The Kwari-Kwasa forest reserve is reportedly degraded as a result of anthropogenic influences. How much of changes it has undergone and the effect on the soil quality remain unknown. This study therefore used Lansat ETM of 1986 and ETM+ of 2013 to assess the changes in the forest reserve and the effect of such changes on the soil quality. With standard algorithms within the Idrisi Taiga Environment, the data were rectified radiometrically and geometrically and eventually classified into Land Use-Land Cover (LUC) types using Maximum Likelihood Classifier. To determine the effect of forest degradation on the soil, eight plots were randomly sampled from each LUC, each plot measuring 30m×30m. Within each plot, four sub-plots were also randomly sampled, and soil samples were taken at 10 cm, 10 -30 cm and 30 - 60 cm soil depths. Replicates within a plot and same depth were bulked and homogenised, part of which was taken to the laboratory for analysis following standard procedures. Results showed increase in farmland, reduction in scrubland, dense shrubland and grassland which were the Land Use/Land Cover (LUC) classes obtained. Based on Chi-Square value derived from the Cross Map Tabulation (CMT), the forest reserve experienced significant change ($P<0.05$) between both dates. Soil texture is predominantly sandy (84.18%), while pH values are acidic. The CEC and organic matter content of the soils were low and ranged from 4.98 to 5.43 cmol kg-1 and 1.78 to 2.02% respectively. Total nitrogen and available phosphorus values ranged from 0.78 to 0.89% and 0.78 to 0.88 mg kg-1 respectively. It was concluded that the forest reserve got seriously degraded with serious effect on the soil quality.

Keywords: Kwari-Kwasa; Forest Reserve; Land use/Land cover; Cross Map Tabulation; Kebbi

Introduction

Vegetation cover and composition, particularly forests, are important aspects of the dry-land environments because they provide livelihood to humans and also protect soil resources against erosion (Omuto, 2011). However, man has degraded the forest ecosystems in attempts to facilitate economic prosperity through farming, grazing, and establishment of settlements and industries (Hellden, 1988; Coppin et al., 1996; Glenn et al., 1998; Barbier, 2000; Fuhlendorf and Engle, 2004; An et al., 2008; Karen et al., 2010; Li et al. 2011).

Encroachment into forests and their subsequent destruction mainly through rapid expansion of agricultural frontiers affect ecosystems functions and services, land-atmosphere interactions and climate and have caused land degradation, social tension and rapid, precarious urbanization (Dregne and Chou, 1992; Alves, 2002; Yelwa and Eniolorunda, 2012). Available evidence shows that while forest degradation has slowed down in the industrialised world, it has accelerated in the developing world (Allen and Barnes, 1985; Boahene, 1998). Thus, by the year 2020, land degradation may pose a serious threat to food production and rural livelihoods, particularly in poor and densely populated areas of the developing world (Scherr and Yadav, 1996).

The African Sahel-Sudan zone is a dynamic ecosystem that responds to fluctuations in climate and anthropogenic land use patterns (Herrmann et al., 2005; Tewari and Ariya, 2005). Environmental history shows that the area undergoes land degradation in form of deforestation, disappearance of useful species, soil erosion, soil nutrient depletion, among others generally referred to as desertification (Rasmussen et al., 2001). During the past three decades, about 50% - 75% of Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Kebbi, Sokoto, Yobe, and Zamfara States of Nigeria have been plagued by desertification (Abdu and Kio, 1998; Onyewotu et al., 2003).

Constituent elements to combat desertification and mitigate the effects of drought, within the framework of the National Policy on Environment, include encouraging individual and community participation in viable afforestation and reforestation programmes, among others. It was in line with this policy framework that the Kwari-Kwasa Forest Reserve and others were established in the early 1950s with the following rights granted to the inhabitants of the surrounding communities: rights to hunt and fish within the reserve; rights to collect Non-Timber Forest Products (NTFPs) such as edible fruit/nuts, mushrooms, thatching/roofing materials, medicinal herbs (back of trees, leaves and roots, etc.); rights of way to the general public along certain paths within the forest reserve; rights to controlled grazing of such livestock as cattle, sheep, etc. Today, the reserve has reportedly been degraded due to land use land and cover change, aggravated by continuous population increase (CERAD, 2009).

Human population has put pressures upon forested areas, and the conversion of forestland to cropland, grazing land, and settlements has often resulted in soil degradation and nutrient losses which have increased the need to assess impacts of land use change on soil (Islam and Weil, 1999; Ann et al., 2008). Ecologically sustainable forest resources management calls for reliable spatial database with a provision to update and retrieve for management decisions at various levels (Dutt et al., 2009). Thus, a remote sensing approach is used to determining the extent of forest degradation through assessment of land use/land cover changes between 1986 and 2013, and an assessment of the effect of the changes on soil is carried out.

Materials and Methods

Study area

The Kwari Kwasa Forest Reserve is situated along Kontagora–Jega Road. It lies between Latitudes 11o 48'- 11o 55'N and Longitudes 40 24'- 40 32'E (Figure 1) and occupies 10,723ha. It is one of the gazetted forest reserves, owned by the Kebbi State Government under the management of the Department of Forestry. The forest reserve was created for forest production and environmental protection (e.g. Protection of the watershed areas). The study area is characterized by rainy and dry seasons. The dry season usually lasts between 6 and 8 months and has two distinct periods: the cold- dry period and the hot-dry period. Contrary to this, rainy season is usually short (3-6months). Annual rainfall varies between 500 – 750 mm, with over 60% of the rain falling during July and August (Mamman et al., 2000). Potential evapotranspiration exceeds 1400 mm per annum, and mean annual temperature is about 350C and 400C during the rainy and dry seasons respectively, while mean relative humidity ranges from 51 to79% during the rainy season and from 10 to 25% during the dry season (SERC, 2010). The vegetation is Sudan Savanna, and due to low annual rainfall and prolonged dry season, the study site supports few tree and shrub species. It is characterized by abundant short grasses of 1.5-2m and few stunted shrubs/trees that are hardly above 15m tall. Dominant grasses include Pennisetum pedicellatum, Mitracarpus scaber, Borreria radiate, Striga gesneriodes, Eragrotis tremula, etc.

Dominant trees/shrubs species include Combretum spp, Guiera senegalensis, Detarium ,microcarpum, Cassia spp, Parkia biglobosa and Rogera adenophylla etc. The soil of the study area is classified as aridisol, and is poorly developed, with little chemical weathering, infrequent leaching, and low organic content. The texture of the topsoil is sandy clay loam; salinization is widespread, resulting in the concentration of mineral salts at or near the surface (Kowal and Kassam, 1978; CERAD, 2009).

Methods

The data used in this study include the topographical map (1:100,000), Landsat Thematic Mapper (TM) of 15th June, 1986 and Landsat Enhanced Thematic Mapper Plus (ETM +) of 7th June, 2013, the Ground Control Points (GCPs) of the forest reserve and soil samples. The first three data were used for image processing leading to Land Use /Land Cover (LUC) classification and Land Use /Land Cover Change (LUCC) detection, while soil samples were used to test the effect of forest degradation on the soil properties.

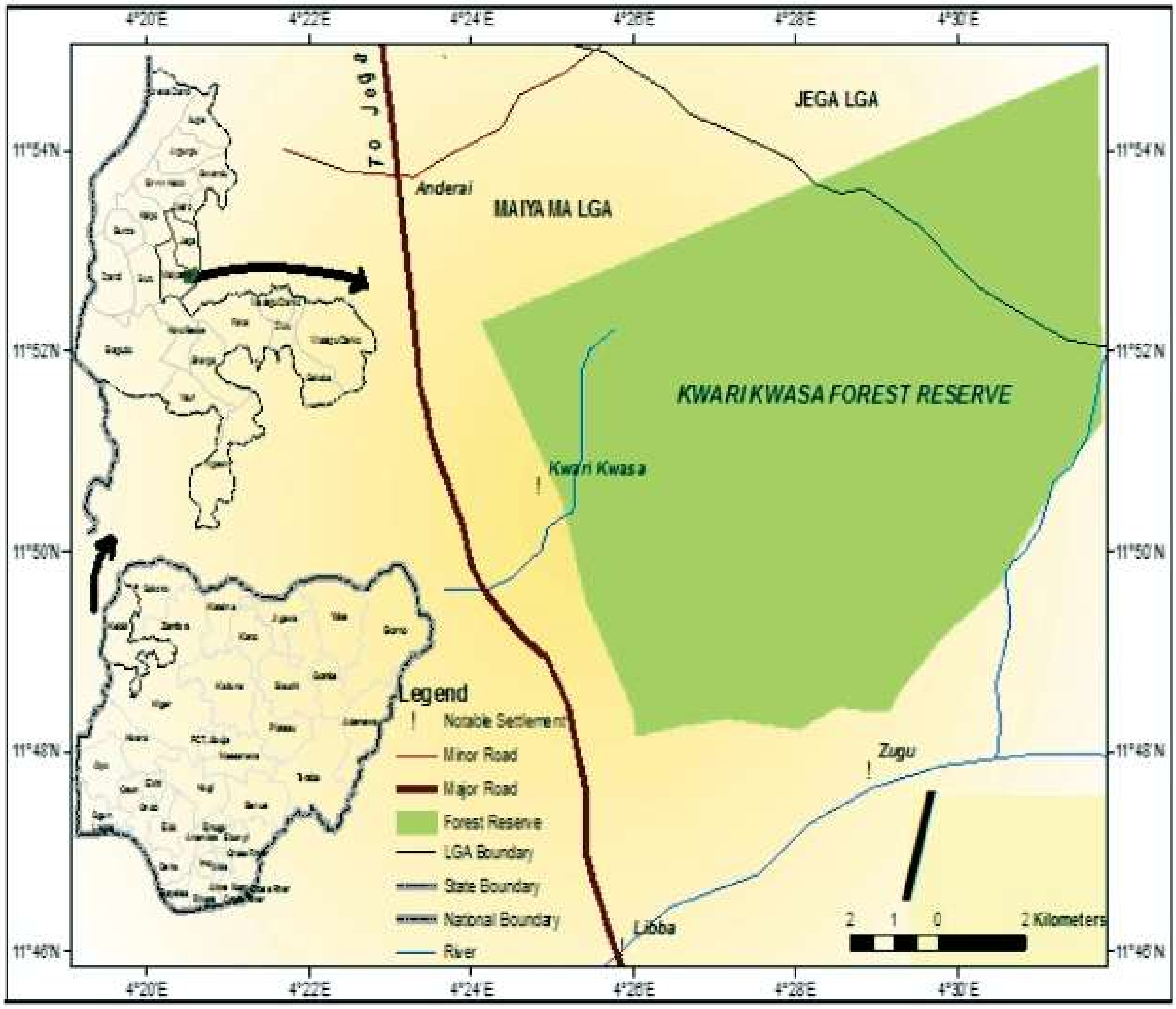

Figure 1: Map of Nigeria showing the location of KwariKwasa Forest Reserve.

The Landsat data (path/row: 191/052), provided in GeoTIFF and pre-processed to Level IT (i.e. terrain corrected), were obtained from the United States Geological Survey Department (USGS). Metadata shows that these selected near-anniversary images referenced in Universal Transverse Mercator (UTM 31N) system were cloud free. Bands 1 through 7, excluding 6 of the TM and ETM+ images were used for the study. These are adequate to capture common Earth's surface materials such as soil, water and vegetation (Eastman, 2009). With 10,732ha coverage of the forest reserve, the 30m resolution data were considered appropriate for the study.

The images of both dates were assessed for radiometric quality through true-colour composite formation and spatial query of deep water areas which were supposed to have zero values in the near infrared band (Eastman, 2009). These tests confirmed the presence of haze and Scan Line Corrector-Off (SLC-Off) error.

The images, although were already georeferenced from source, investigation into positional accuracy of the Landsat 2013 using some GCPs from the topographical map of 1979 showed an overall root mean square error (RMSE) of 0.097. The 1986 Landsat data was subsequently registered to the 2013 image with an RMSE of 0.0061. An RMSE of less than 0.5 is acceptable (Janssen et al., 2004; Eastman, 2009).

Haze correction was carried out using PANCROMA software by simply subtracting from each band the amount by which the values of the water areas were above zero, on the assumption that haze effect is uniform over the image (Eastman, 2009). To correct the SLC-Off error, the bands of 2013 were submitted for gap filling using the bands of

1986 within the PANCROMA environment. The conditions in gap filling that the Adjust image (the one to be used for correction) should be cloud-free and near-anniversary to the Target image (image to be corrected) were complied with. Figures 2 and 3 show the original band 4 with SLC-Off error and its gap-filled version.

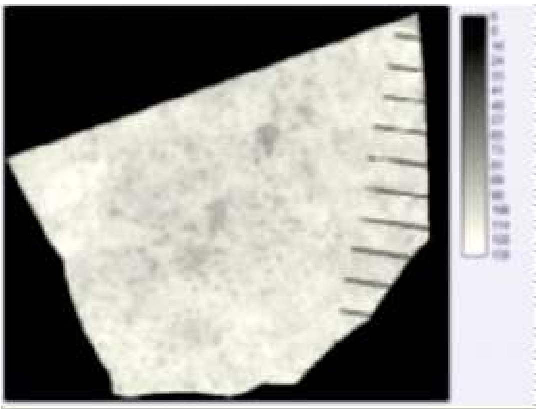

Figure 2: Gap Image (Bands 4) of 2013

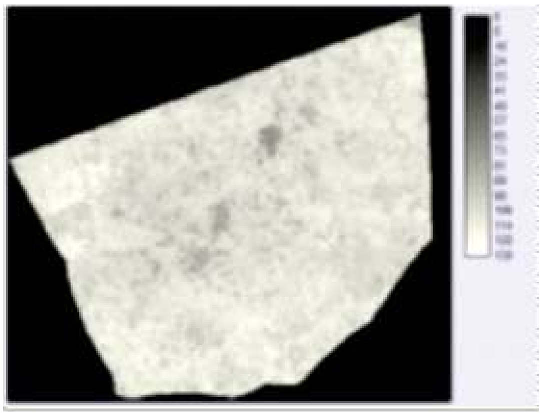

Figure 3: Gap-filled Image of 2013

The selected bands of each Landsat data were subjected to unsupervised classification with cluster algorithm, and 7 classes were established. For the ground truth, 180 points were sampled using stratified random sampling (Janssen and Gorte, 2004). The centre of each ground control point (GCP) was subsequently located with the guide of a Global Positioning System (GPS) hand-held receiver. A 30m * 30m plot was established for each GCP, and LUC were described and captured. Signatures of the classes observed were extracted and maximum likelihood classifier was used to classify each date. Additional 81 GCPs were visited in the field to generate the error matrix.

Post classification comparison was used to detect changes between classes of 1986 and 2013 land cover maps. To use this method, the area coverages (in hectares) of classes for both years were estimated and graphed. Also, Cross Map Tabulation (CMT) was used to assess the trade-offs between both dates and among the classes. CMT can be described as a multiple overlay showing all combinations of LUC types (each represented by pixels) (Eastman, 2009). Chi-Square, Cramer's V and Kappa Index Agreement (KIA), which are products of cross image tabulation, were used to test for significance of difference and relationship between LUCs of both dates at 95% confidence level.

Soil Data

To determine the effect of forest degradation on the soil, eight plots were randomly sampled from each LUC, each plot measuring 30m×30m. Within each plot, four sub-plots were also randomly sampled, and soil samples were taken at 0-10 cm, 10 -30 cm and 30 - 60 cm soil depths. Replicates within a plot and same depth were bulked and homogenised, part of which was taken to the laboratory for analysis.

Kjeldahl method was used to determine total nitrogen as proposed by Black (1965) while available phosphorous was determined using Bray P1 method (Olsen and Watanabe, 1982). Exchangeable cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+) were determined as proposed by Jacson (1962). The K^+ and Na^+ concentration in soil extract were read on Gallenkamp flame Photometer while Ca^+ and Mg^{2+} concentration in soil extracts were read using Perkin-Elmer model 403 Atomic Absorption Spectrophotometer. Percentage organic carbon (C) in soil was determined first based on the Walkley-Black (1934) Chromic acid wet oxidation method where; 1 gram of 5mm sieved soil was put in a 250ml conical flask. 5ml each of 1N $K_2Cr_2O_7$ was added to the soil samples followed by a rapid addition of 10ml of concentrated H_2SO_4. Organic carbon was calculated as follows:-

$$\% \text{ organic carbon} = \frac{\text{Blank tire - Actual tire x 100 x MF}}{\text{Weight of air dried soil}}$$

Where M = One of $(Fe\,(NH4)\,SO_4)_2$

F = Correction factor (1.33).

Then percentage (%) organic matter in soil was calculated by multiplying % org. C with conversion factor 1.729. Therefore, % Organic matter in soil = % Org. C × 1.729. Soil samples from each identified land use/land cover were collected using core sampler/ ring to determine BD. The soil was removed from core sampler, dried and weighed. The volume of the core is determined and density was calculated as mass of the dry soil divided by volume of the core. Soil pH was determined in water suspension at 1: 2 soil water ratios using pH meter to verify the pH of soils in each identified land cover type in the study area.

Descriptive statistics of soil properties were obtained from each of the classes, while Analysis of Variance (ANOVA) was used to examine the effect of forest LUCC on the soil quality.

Results and Discussion

Land Use/Land Cover classification

The results of the LUC classification performed on both dates are presented in Figures 4 and 5. Four broad categories of land use/land cover were identified: Farmland, Scrubland, Dense Shrubland and Grassland. Based on the error matrix (Table 1), the classification of 2013 image was performed with an overall accuracy of 88.8%.

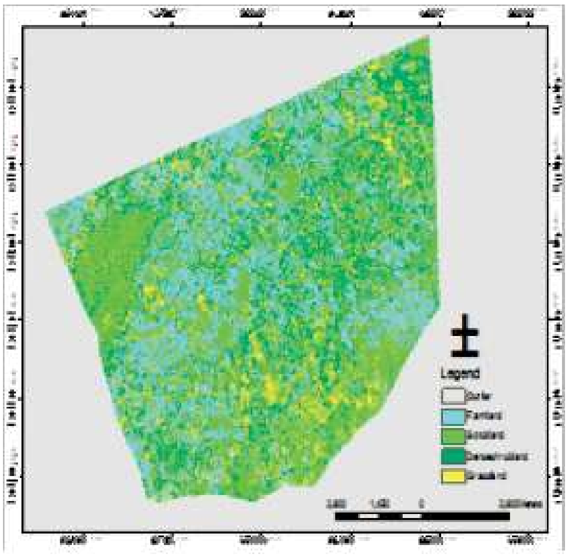

Figure 4: Land use over of 1986

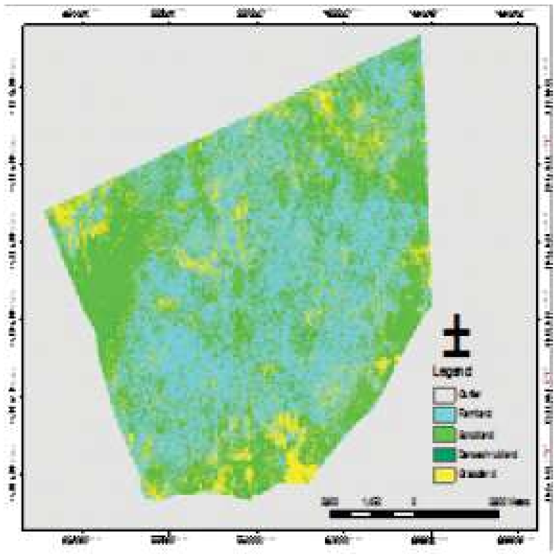

Figure 5: Land use cover of 2013

Table 1: Error Matrix

	A	B	C	D	TOTAL	EC	UA
A	**18**	2	1	1	22	18	82
B	1	**17**	0	1	19	11	89
C	0	1	**19**	1	21	10	90
D	2	0	0	**17**	19	11	89
TOTAL	21	20	20	20	**80**		
EO	14	15	5	15			
PA	86	85	95	85			

Columns: Ground truth; Rows: 2013 maps; EC = Error of Commission; UA = User's Accuracy; EO = Error of Omission; PA = Producer's Accuracy; Overall Accuracy = 18+17+19+17/80 = 88.8%.
Source: Generated from the GCPs and 2013 LUC map

Land Use/Land Cover Description

A major class was farmland. This is mainly composed of cultivated land with few standing trees. The dominant crop cultivated is millet followed by groundnut and bambara nut. Scrubland is another class scattered throughout the forest reserve covering 22% of the area. It is dominated by sparse shrubs with very low growing grasses. The shrubs are mainly of *Combretum nigricans (Tsiriri)* and *Guiera senegalensis* (Saabaraa). The dominant grasses here are *Acroceras amplectena* (Geron tsuntsaye) and *Eragrostia tremula* (bubburwa). Dense shrubland is also a prominent LUC, consisting of dense shrubs. The shrub species consist mainly of *Combretum nigricans* (Tsiriri), Guiera senegalensis (Saabaraa), *Combretum collinum* and *Poliostigma reculatum* (Kalgo) and *Acacia macrostachysa* (gardaye). It covers about 12% of the total land area of the reserve. The dominant grass here is gadagi. Generally, these areas are subjected to continuous farming, bush burning and tree felling. Grass land covers about 14% of the total land area of the study area. The dominant grasses are P*ennisetum pedicellatum, Mitracarpus scaber, Borreria radiate, Striga gesneriodes* and *Eragrotis tremula*. Various agricultural activities such as continuous cultivation, grazing and bush burning are apparent.

Land use/Land Cover Change (LUC) Detection

In order to assess LUCs in the study area between 1986 and 2013, post classification comparison and cross image tabulation were applied. From Figure 6, it can be seen that farmland is the only class that increased in area coverage between both dates. The increase was more than twice its size in 1986 as at 2013, while other classes reduced in size. The scenario suggests that farmland expansion is a factor of land degradation in the forest reserve. To further illustrate change scenarios not visible in Figure 6, gains and losses of each class between both dates and the net change in each category were charted (Figures 7 and 8). From these figures, the farmland lost 1,005ha but gained 3,974ha having a net gain of 2,968ha; scrubland lost 2,192ha and gained 1,332ha, having a loss of 860ha. Dense shrubland lost 2,837ha and gained 777ha, having a loss of 2,060ha. The grassland lost 1,294ha and gained 1246ha with a loss of 48ha.

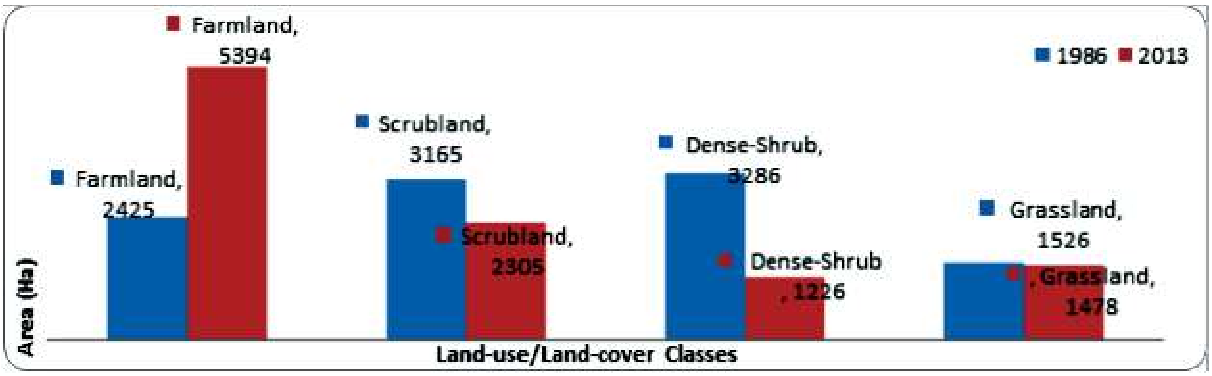

Figure 6: Landuse/Landcover Post Classification Comparison

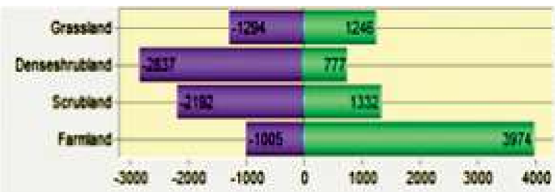

Figure 7: Gain and losses between 1986 and 2013

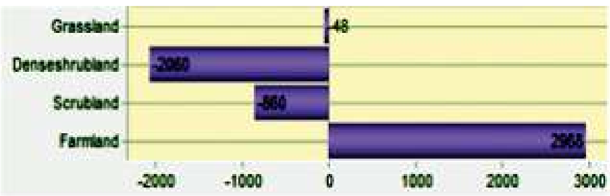

Figure 8: Net change between 1986 and 2013

Cross Map Tabulation (CMT)

Table 2 was generated from the CMT performed between 1986 and 2013 LUC maps. The diagonals represent no change in the classes of both dates, while off-diagonals represent changes. Thus, 43% change was recorded. The result of the Chi-Square test showed that the changes were significant (p<0.05).

Table 2: Cross-tabulation of 1986 LUC (columns) against 2013 LUC (rows)

	0	1	2	3	4	Total
0	77337					77337
1		15778	15065	19949	9139	59931
2		4588	10815	7029	3178	25610
3		2835	3741	4990	2059	13625
4		3748	5550	4548	2575	16421
Total	77337	26949	35171	36516	16951	192924

Chi Square = 197788.51563; df = 16; P-Level = 0.0000

Where 0 = outliers; 1 = Farmland; 2 = Scrubland; 3 = Dense Shrubland; 4 = Grassland

Soil Property Assessment

The results (Table 3) showed that the sand content ranged from 69.14 % to 84.18%, clay 5.67% to 19.84% and silt content was found to range from 8.16% to 10.13%. Percentage values of sand differed significantly (P<0.05) across the land use types. Grassland recorded the highest mean value of 84.18 % and dense shrubland had the lowest (69.14 %). Percentage silt in dense shrubland differed significantly (P<0.05) compared with that of scrubland, farmland and grassland whose values appeared similar (P>0.05). Similarly there was also a significant difference (P<0.05) in percentage clay between all the land use types (Table 3). The texture of the landuse types is predominantly sandy (69.14 to 84.18%).

BD values varied significantly (P<0.05) between scrubland, dense shrubland and grassland and appeared similar between scrubland and farmland. BD values were 1.80, 1.83, 1.80 and 0.77 mg/m3 for scrubland; dense shrubland; farmland and grassland respectively (Table 3). pH varied significantly (P<0.05) between scrubland and grassland and appeared similar (P>0.05) between dense shrubland and farmland. pH values were 5.44, 5.43, 4.91 and 4.83 for farmland, dense shrubland, grassland and scrubland respectively (Table 3).

For exchangeable bases, calcium and magnesium differed significantly (P<0.05) between land use types but sodium appeared similar (P>0.05). Dense shrubland, farmland and scrubland had statistically similar (P>0.05) Mg content. Scrubland and grassland in terms of Ca appeared similar (P>0.05). Exchangeable Ca in the soil ranged from 0.39 to 0.54 cmol kg-1, magnesium and sodium values ranged from 0.06 - 0.13 cmol kg-1 and 0.95 – 0.99 cmol kg-1 respectively (Table 3). The values of potassium in all the land use types ranged from 0.36 to 0.71 cmol kg-1. The cation exchange capacity (CEC) values were similar (P>0.05) between Dense shrubland, farmland and scrubland land use types but differed significantly (P<0.05) with that of grassland. The CEC of soil was low and range from 4. 98 – 5.43 cmol kg-1 (Table 3).

Organic carbon differed significantly (P<0.05) between dense shrubland and farmland but appeared similar (P>0.05) between scrubland and grassland (Table 3). Its content was very low and ranged from 1.0 to 1.2%. The same trend was obtained in organic matter content of the land use types. Dense shrubland had the highest mean value of 2.02% and farmland recorded the lowest mean value of 1.78%. Total nitrogen showed significant difference (P<0.05) across the land use types. Dense shrubland recorded a highest mean value of 0.89% while farmland recorded the lowest mean value of 0.78% (Table 3). Available phosphorus differed significantly (P<0.05) between all the land use types. Available Phosphorus content of the soil is generally low and values range from 0.78 to 0.88 mg/kg (Table 3).

Table 3: Chemical and Physical Properties of soils from study area

PROPERTIES	LAND USE/ LAND COVER (LUC) CLASSES					SOIL DEPTH			
	Scrubland	Dense shrub	Farmland	Grassland	SE+_	0-10 (cm)	10-30 (cm)	30-60 (cm)	SE+_
pH	4.85^{c}	5.04^{a}	5.04^{a}	4.91^{b}	0.01	4.87^{c}	4.96^{b}	5.05^{a}	0
Organic Carbon (%)	1.13^{b}	1.03^{c}	$1.20^{a'}$	1.11^{b}	0.02	1.34^{a}	1.16^{b}	0.84^{c}	0.02
Organic Matter (%)	1.95^{b}	2.06^{a}	1.78^{c}	1.92^{b}	0.03	2.31^{a}	2.00^{b}	1.46^{c}	0.03
Nitrogen (%)	0.84^{b}	0.89^{a}	0.78^{d}	0.82^{c}	0.00	0.07^{a}	0.06^{b}	0.05^{c}	0
Phosphorus (mg/kg)	0.84^{b}	0.89^{a}	0.78^{d}	0.82^{c}	0.00	0.86^{a}	0.82^{b}	0.80^{c}	0
Calcium (Cmol/kg)	0.51^{a}	0.39^{b}	0.41^{b}	0.53^{a}	0.01	0.55^{a}	0.45^{b}	0.38^{c}	0.01
Magnesium (Cmol/kg)	0.09^{ab}	0.13^{a}	0.12^{a}	0.07^{b}	0.04	0.08^{b}	0.10^{ab}	0.12^{a}	0.01
Potasium (Cmol/kg)	0.70^{a}	0.61^{b}	0.43^{c}	0.36^{d}	0.01	0.72^{a}	0.48^{b}	0.37^{c}	0.01
Sodium (Cmol/kg)	0.95^{a}	0.97^{a}	0.98^{a}	0.99^{a}	0.02	1.16^{a}	1.04^{b}	0.71^{c}	0.01
CEC (Cmol/kg)	5.44^{a}	$5.\ 40^{a}$	5.34^{a}	4.98^{b}	0.01	5.79^{a}	5.35^{b}	4.71^{c}	0.06
Sand (%)	78.74^{c}	69.14^{d}	82.88^{b}	84.18^{a}	0.43	74.70^{c}	79.28^{b}	82.24^{a}	0.38
Silt (%)	9.08^{bc}	11.01^{a}	8.16^{c}	10.13^{bc}	0.38	10.43^{a}	8.61^{b}	9.75^{a}	0.33
Clay (%)	12.16^{b}	19.84^{a}	8.94^{c}	5.67^{d}	0.29	14.86^{a}	12.10^{b}	8.00^{c}	0.25
Bulk Density (BD)	1.80^{b}	1.83^{a}	1.80^{b}	1.77^{c}	0.01	1.81^{a}	1.80^{ab}	1.79^{b}	0.01
Particle Density (PD)	2.47^{a}	2.48^{a}	2.49^{a}	2.47^{a}	0.01	2.51^{a}	2.47^{b}	2.45^{b}	0.01
Porosity	32.65^{a}	33.16^{a}	32.53^{a}	31.05^{b}	0.34	32.13^{a}	32.57^{a}	32.35^{a}	0.29

Means with the same superscript along the same row are not significantly different (P > 0.05)

Discussion

Although there is no universally approved accuracy value (Foody, 2008), in their studies, Munyati (2000), Chen and Rao (2008), Biro et al. (2011) and Hubert et al. (2012) accepted classification accuracy values of 85% and above. There was no reference information for 1986 for retrospective accuracy check as such data are rarely available in African countries (Biro et al., 2011). However, the algorithms used for radiometric corrections and the fact that the same signatures were used to classify both dates make the Land Use Land Cover (LUC) classification of 1986 reliable.

In all the classes, the farmland had the highest gain while dense shrubland suffered the most loss. Although changes were dynamic in all the classes, the resilience of farmland class and non-recovery of other classes clearly indicates that anthropogenic influence (farming) is responsible for forest degradation in the study area. This indicated a negative trend in forest reserve conversion. This finding agrees with the works of Akingbogun (2012) and Bello and Eniolorunda (2012) who reported a similar scenario in some Nigerian forest reserves. Boahene (1998) also attributes expansion of subsistence farming and extraction of fuel wood to forest loss in tropical Africa. FAO (2000) and Ayoola (2012) found out that farm land expansion and cutting down of forest trees were the principal causes of degradation in forest reserves. According to the United Nations Framework Convention on Climate Change (UNFCCC, 2007), the overwhelming direct cause of deforestation is agriculture. Subsistence farming is responsible for 48% of deforestation; commercial agriculture is responsible for 32% of deforestation; logging is responsible for 14% of deforestation and fuel wood removals caused 5% deforestation (UNFCCC, 2007).

Population increase could have necessitated the expansion of farmland in the study area (CERAD, 2009) between both dates. An et al. (2008) believe that continued increase in human population results in expansion of cultivation into forested zones with consequent effect on soil degradation. In the view of Fuhlendorf and Engle (2004), the major factors in the shaping of the arid, semi-arid and dry sub-humid landscapes are population pressure on the vegetation, bush burning, cultivation, grazing pressure by different species of domestic herbivores, among others. Also, the closeness of the reserve along the main road is another factor for human encroachment.

The texture of the land use types in forest reserve is predominantly sandy (69.14 to 84.18%) and this could be as a result of higher rate of erosion in the reserve triggered by deforestation, over grazing, bush burning and other causes of desertification. The result of this finding indicated that the soil fertility status in the forest reserve is poor. The findings agreed with Young's (1981) results which stated that classes such as sand, heavy clay and loamy sand are considered as undesirable to fertility status, because the texture is either too heavy or too light. This result indicated that degradation has taken place which altered the rich soil of the reserve and is a good manifestation of desertification process. A similar investigation by CERAD (2009) revealed that the soils of Kwari-Kwasa forest is aridisols, which are characterized by poor development, little chemical weathering, infrequent leaching and low organic content.

The Bulk Density (BD) values shown in the Table 3 (1.80, 1.83, 1.80 and 0.77 mg/m3 for scrubland, dense shrubland, farmland and grassland respectively) are approximately in agreement with the values suggested by Brady and Weil (1996) for cultivated sandy-loams and sand textured soils (1.25 to 1.85 mg/m3). These higher values of the soil BD could lead to lower water content. USDA/NRCS (1998) reported that BD has a strong bearing on available water due to its influence on pore spaces.

The pH result (4.83 to 5.44) indicates that the soils were highly acidic. The results were in conformity with Jackson (1981) who characterized value ranging from 4.83 to 5.44 as acidic, implying that some essential elements were not available in the soil due to the binding nature of organic colloids under acidic condition and therefore only selected agricultural and tree crops could be supported. Brady and Weil (1996) have emphasized that pH of soil influences solubility, which in turn influences availability of several essential nutrients elements including phosphorus, nitrogen and potassium. The soils analysed were acidic and at high pH values, the organic colloids bond micro-nutrients such as Zn, Cu and Mn thus leading to their deficiency.

The result in Table 3 shows that exchangeable Ca in the soils ranged from 0.39 to 0.54 cmol kg-1 which falls within average described as low to medium (Landon, 1991), similarly magnesium and sodium with values of 0.06 - 0.13 cmol kg-1 and 0.95 – 0.99 cmol kg-1 respectively, were also within low to medium category (Landon, 1991). Landon (1991) reported that magnesium values of 0.05 cmol kg-1 are considered as low, especially in tropical cultivated lands. This finding conformed to the low values recorded by Folorunsho (1998) and Faruk (1999) in the Jakara valley cultivated lands. But Landon (1991) stated that low values of sodium are required for maintenance of soil structure. Average value of potassium in all the land use types were low and ranged from 0.36 to 0.71 cmol kg-1 and these correspond to low potassium level described by Landon (1991) of the tropical soils. According to Young (1981) the tropical rainforest and sandy textured Savannas are areas prone to excessive leaching and this conformed to CERAD's (2009) findings that the soils of Kwari-Kwasa forest is aridosols, which are characterized by poor development, little chemical weathering and infrequent leaching.

The result in Table 3 reveals that the CEC of the soils was low and ranged from 4. 98 – 5.43 cmol kg-1. According to CERAD (2009) the soils of the study area are characterized by poor development, little chemical weathering, infrequent leaching and low organic matter content which according to Brady and Weil (1996) is responsible for low CEC values in the soils. The results of this work also agreed with that of Patrick (1980) which showed that most tropical soils are characterized by low to very low CEC.

The result obtained in Table 3 shows that organic carbon content was very low and ranged from 1.0 – 1.2%. The same trend was obtained in organic matter content of the land use types. Dense shrubland had the highest mean value of 2.02% and farmland recorded the lowest mean value of 1.78%. This variability is principally caused by the higher rates of decomposition associated with the tropical environment and the desertification process that already set- in the forest reserve. Soil organic matter varies with so many factors; some of which include profile depth with the higher concentration mostly found in the upper horizon. This finding agrees with the claims that organic matter content of mineral soils of the tropics are always ranging from a mere trace to only as high as 20 to 50% (Young, 1981; Brady and Weil, 1996; Reich et al., 2001). Other factors influencing organic matter content include the texture of the soil with sand holding less organic matter than clays (Young, 1981; Brady and Weil, 1996).

The result in Table 3 reveals that dense shrubland recorded the highest mean value of 0.89% while farmland recorded the lowest mean value of 0.78% as nitrogen concentrations. Analytical values of nitrogen that ranged from less than 0.05% to 0.3% are described as very low to very high, especially in the tropics (Landon, 1991). The values recorded in this work are by far higher than that of CERAD (2009) and Dawaki (2004) but was found to agree with the works of Landon (1991).

Brady and Weil (1996; 2013) explain two problems associated with phosphorus management in the soils. These are (i) the low level concentration of the element in soils (as low as 0.001mg/1 in soil solution of very infertile soils (characteristic of Kwari- Kwasa forest reserve) and only as high as 1mg/1 in fertile soils) and (ii) the insolubility of most commonly found phosphorous compounds in the soil. These cumulatively make the natural phosphorus supply in the soil to be small and availability of that which is present to be low. Phosphorus is an element whose available form is highly influenced by organic matter mineralization (Tisdate at al., 2003). The low organic matter content of the forest reserve soils was reflected in the Phosphorus content of the soil as all the values in four land use types are within the low range. This finding agreed with the work of CERAD (2009).

Conclusion and Recommendations

Based on the findings in this study, the Kwari-Kwasa forest reserve has changed significantly, and that the changes are a characteristic response to anthropogenic interference by continuous farming activities, which in turn has significantly affected the soil quality of the study area. Increased and concerted efforts in forest reserve 'rebirth' and rejuvenation can preserve the forest reserve. Thus, government by way of policy should be strict in conserving forest reserves from illegal deforestation. Better farming practices that will improve crop yield and conserve the reserve should be encouraged through government's participation. Also government should promote the use of alternative energy source other than fuel wood in order to reduce pressure on the forest.

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