Effect of Different Land Uses on Soil Characteristics and Production in Aiyetoro Enclave of Ogun State

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Abstract
One of the major problems confronting modern day agriculture is the inappropriate allocation of good agricultural lands for other purposes especially of quicker economic returns. Hence, there is a need to assess the effect of different land uses on the soil characteristics and determines its implication on soil productivity especially in the Nigeria where food production is still a major challenge. Five different land uses; Building Site (BS), Secondary Forest (SF), Fallow land (FL), Arable Farm (AF) and Tree cropped Farm (TF) were selected and soil samples at surface (0-15 cm), sub-surface and (15-30 cm), and profile depths were collected for laboratory analysis. Most of the soil properties correlated positively at the surface and sub-surface depths ($p<0.05$). The bulk density, structure, Organic carbon, Organic matter, soil pH, CEC, Nitrogen, Available Phosphorus, exchangeable bases, and available micronutrients were affected by land use. %Nitrogen, %Carbon and %Organic matter were highest significantly at the surface and sub-surface depths in SF. Secondary forest also had the highest CEC (7.47) at the surface depth although AF had the highest (6.55) at the sub-surface. Exchangeable Ca, Na and Mg were also highest in SF although not significantly different from the other land uses. pH values of all the land uses were close to neutral at the surface and sub-surface depths. The study indicated that secondary forest land use option was the best followed by tree cropped farm for promoting sustainable agricultural development and in order to also meet up with the food demand of the ever increasing world population.

Keywords: *Land Use, Soil characteristics, Production, Ogun State.*

Introduction
The inadequacy of good agricultural lands due to too much pressure on it other than agricultural purposes in tropical region call for appropriate use of land especially in enhancing sustained production and alleviating hunger of ever-increasing human population (Omoniyi, 2011).

According to Lal (1996a) and Shepherd *et al.* (2000), land use in tropical ecosystems could cause significant modifications in soil properties hence there is urgent need for continuous assessment of land resources so as to address consistent changes and ensure that limitations imposed on productivity by improper allocation of land is minimized.

In all regions of the world, human activities are degrading some soils faster than nature can rebuild them (Senjobi, 2007). The system of land use however goes a long way in determining the availability of land for prolonged agricultural use in perpetuity i.e. sustainability. Sustainableagriculturerefers to theability of a farm to produce perpetuallybased on long-term effects of various practices on soil properties and processes essential for crop productivity, and the long-term availability of inputs (Medugu, 2006).

Agricultural sustainability and judicious use of soil and water resources in the humid tropics are major global issues of modern times because of the interplay among human population, socio-economic and political factors, and natural resources of the fragile ecoregion (Omoniyi, 2011). Mismanagement of soil resources and inefficient, resource-based agricultural systems are causing serious degradation of the ecoregion and perpetuating food deficit, malnutrition and poor standard of living. Therefore, maintenance of soil quality is critical to the success and sustainability of land-use and farming systems (Lal, 1995) especially in tropical areas which are endowed with fragile top soils.

To address the global problem of hunger which has been more persistent in the third world countries including Nigeria and to stop it from further aggravating, there is a need to study the effect of different land use patterns on the characteristics of soil and their output potential. This will go a long way to alleviate hunger and encourage food security especially at this period of economic meltdown.

Several researches have been carried out in this regard on different study areas (Lal, 1995; Medugu, 2006; Lal, 1991; Brady and Weil, 1999; Hamblin, 1985, Senjobi, 2007, 2010 & 2011; Igwe, 2001, Ogunkunle and Eghaghera, 1992), however there is dearth information on the effect of different land uses on the characteristics of Yewa soils, in Ogun State and how it affects its production potentials. This is the essence of this study. Specifically, the study aims at assessing the effect of different land uses on soil characteristics and production potential with the view of providing proper guidance on optimum production and sustainable agriculture.

Materials and Method

Description of the Study Area

This study was carried out at the Teaching and Research Farm of the College of Agricultural Sciences of the Olabisi Onabanjo University, Ayetoro Campus. Ayetoro is 35 kilometres northwest of Abeokuta on Latitude 7°12^{l}N and Longitude 3°0^{l}E, with a mean annual rainfall of 1, 250 mm and average temperature of 26^{0}C.

Ayetoro lies between 90 and 120 metres above the sea level. The entire area is made up of undulating surface, which is drained majorly by River Rori and River Ayinbo (Ayinde, 1983). These two rivers meet at a point to the West side of the town and finally empty into River Yewa after Saala Orile.

Choice of the site

The experimental sites were chosen for the research using purposive sampling, which involves choice of areas with specific land use that are of interest to this research. Five land use types were considered and on this basis five sites were selected and investigated.

These sites are briefly described as follows:

1. A Building site (BS): This site was chosen based on the presence of building, a lawn, parking space and a walk area. It covers extensive part of the total area i.e. about 5 hectares. It has been on this use for more than four decades.
2. A Secondary forest (SF): A land that has not undergone any form of intense cultivation by human intervention before was chosen. This was evident by the presence of trees, shrubs and grasses and a fairly dense canopy formation. This was about 2 hectares.
3. A Fallow land (FL): A pineapple farm that has been left to fallow for a period of 5 years was chosen to establish how such a land use can affect the characteristics of the soil and production. This covers an area of about 2 hectares.
4. An Arable farm (AF): An arable farm in which mixed cropping of maize with cassava were practiced for a period of 7 years and had probably undergone some level of disturbance was used. This was about 5 acres (2 hectares).
5. A Tree cropped farm (TF): The choice of this site cultivated with teak, a tree plant which is also a cash crop was selected to study the soil properties under uniform storey plants compared with secondary forest of different plants of storey patterns. The land area was about 2 hectares.

Soil Sampling

Soil samples were collected by augering into the soil using stratified random sampling procedures at the surface (0 – 15cm) and sub-surface (15 – 30cm) depths respectively from all the sites that were chosen for the research work. As a result of the homogeneity of the areas in consideration i.e. of typical mapping units, about 10 sampling points were taken. These were then bulked together, before representative samples were taken to laboratory for analysis. Soil profile pits were dug to about a depth of 1.5m where there is no interference with ground water, rocks or concretions and this was done in each mapping unit i.e. one modal profile per land use type. Profile pits were described following the standard reference. Soil samples were collected at each horizon using a metallic core sampler after the horizons were demarcated, measured and also differentiated based on colour, texture, structure, consistency etc. The soil samples collected were air dried, crushed using a pestle and mortar, sieved and taken to the laboratory for analysis.

Laboratory Analysis

Laboratory analyses were carried out on the soil samples to examine the physical, chemical and biological characteristics of the soil samples that were collected. Soil samples were analyzed for the following parameters: soil pH in water using glass electrodes pH meter (Mclean, 1965). Total nitrogen was determined by the macrokjeldahl digestion method of Jackson (1962), available P was after (Bray and Kurtz, 1945) extraction using Bray-l extract followed by molybdenum blue colorimetry. Exchangeable cations were extracted with 1M NH4OAC (pH 7.0), K, Ca and Na were determined using flame photometer and exchangeable Mg by atomic absorption spectrophotometer (Sparks, 1996). Exchangeable acidity (H^+) was determined by the KCl extraction method (Mclean, 1965) and organic carbon was after dichromate wet oxidation method (Walkley and Black, 1934). The organic matter content was got by multiplying a factor of percent organic carbon by 1.72. Cation exchange capacity (CEC) was calculated from the sum of all exchangeable cations. Available micronutrients were extracted with 1N NH4Cl solutions and determined by Atomic Absorption Spectrophotometer (AAS) (Water and Sammer, 1948 cited from Senjobi, 2007). Particle size analysis was done by the Bouyoucos (1951) method. Saturated hydraulic conductivity was determined using a constant head method and bulk density by core method. Soil porosity was estimated from the bulk density data at an assumed particle density of 2650 kgm^{-3}. Water retention at 15 bars was determined in order to calculate available water holding capacities of the soil profile horizons (Mbagwu, 1985).

Statistical Analyses

The results obtained from the laboratory test carried out on the soil samples were subjected to Analysis of Variance (ANOVA) to test the difference in soil properties across land uses, Duncan Multiple Range Test (DMRT) for ranges and Least Significant Difference (LSD) for the differences in soil characteristics between the different land uses were employed. Correlation analyses were carried out to detect functional relationship among key soil variables.

Results and Discussion

Soil physical and morphological properties

Table 1: Physical properties of soils of the different land uses at surface and sub-surface depth

Land uses	Soil depth (cm)	Particle size distribution Sand	Silt(g/Kg)	Clay
Building Site (BS)	0 – 15	652.6	182.8	164.6
	15 – 30	566.6	233.4	200.0
Secondary Forest (SF)	0 – 15	636.1	196.1	167.8
	15 – 30	599.8	199.3	200.9
Fallow land (FL)	0 – 15	624.5	203.3	172.2
	15 – 30	584.0	208.8	207.2
Arable Farm (AF)	0 – 15	615.5	215.5	169.0
	15 – 30	599.1	209.2	191.7
Tree cropped farm (TF)	0 – 15	634.5	171.5	194.0
	15 – 30	599.0	197.5	203.50

Table 1 showed the particle size distribution of soils from the different land uses at the surface (a) and sub-surface (b) depths respectively. Sand content decreased with soil depth in all the different land uses. Silt content increased with depth in all the land uses except in Arable Farm where there is a slight decrease, Clay content increased with depth in all the different land uses.

The physical properties of the soils of the different land uses across the vertical section of the soil (soil profile) are shown in Table 2, which showed that all the soils had high sand content at the surface level. Clay was highest in Arable farm (AF) at soil depth 28-88cm, Tree cropped farm showed highest sand content (741.40g/Kg) and lowest clay content (100.20g/Kg) values when compared to other land uses.

Table 2: Physical properties of profile soils of the different land uses

Land use	Depth	Particle size distribution			Bulk density (mg/m^3)	Available water (AWC)	Total Porosity (m^3/m)	Macroporosity
		Sand	Silt	Clay				
		(g/Kg)						
Building Site (BS)	0–13cm	661.40	158.40	180.20	1.30	0.0232	0.4724	0.0884
	13–27cm	581.40	98.40	320.20	1.21	0.0292	0.5176	0.1631
	27 – 63cm	481.40	128.40	390.20	1.51	0.0316	0.4104	0.1449
	63–150cm	511.40	158.40	330.20	1.08	0.0281	0.5465	0.2093
Secondary Forest (SF)	0 – 15cm	661.40	158.40	180.20	1.55	0.0269	0.4481	0.2351
	15 – 30cm	581.40	98.40	320.20	1.38	0.0701	0.4707	0.1380
	30 – 55cm	481.40	128.40	390.20	1.36	0.0411	0.5301	0.1324
	55-150cm	511.40	158.40	330.20	1.18	0.0207	0.5135	0.1670
Fallow land (FL)	0 – 30cm	601.40	178.40	220.20	1.55	0.0219	0.3642	0.1759
	30 – 63cm	691.40	128.40	128.40	1.56	.0203	0.3625	0.1335
	63- 140cm	581.40	128.40	290.20	1.42	0.0335	0.4177	0.1128
Arable farm (AF)	0 – 15cm	691.40	128.40	180.20	1.50	0.0149	0.3625	0.1335
	15 – 28cm	631.40	228.40	140.20	1.34	0.0231	0.4927	0.2279
	28 – 88cm	461.40	138.40	400.20	1.20	0.0259	0.5625	0.2745
	88–120cm	531.40	148.40	320.20	1.44	0.0327	0.5071	0.2116
Tree cropped farm (TF)	0 – 12cm	741.40	158.40	100.20	1.12	0.0314	0.6360	0.3157
	12 – 20cm	681.40	128.40	190.20	1.53	0.0416	0.4819	0.2229
	20 – 34cm	651.40	148.40	200.20	1.43	0.0348	0.4837	0.1956
	34 – 90cm	681.40	158.40	160.20	-	-	-	-

Table 3: Morphological properties of profile soils from the different land uses

Land use	Depth	Colour	Structure	Consistence	Concretion	Roots	Drainage	Boundary
Building Site (BS)	0-13cm	5YR5/4	SAB	Sl – st	Many	Few	wD	S-A
	13– 27cm	2.5YR4/6	SAB	Sl – st	Many	v-few	wD	S-A
	27– 63cm	5YR3/3	SAB	Non – st	Few	v-few	wD	S-G
	63-150cm	2.5YR4/8	SAB	Sl – st	None	v-few	wD	-
Secondary Forest (SF)	0–15cm	10YR3/4	Crumby	Non – st	None	Many	fwD	W – C
	15– 30cm	5YR5/6	SAB	Sl – st	None	Few	fwD	I – C
	30– 55cm	4YR4/6	SAB	Sl – st	None	v-few	fwD	I – C
	55-150cm	5YR5/8	SAB	Sl – st	None	v-few	fwD	I – C
Fallow land (FL)	0–30cm	2.5YR4/3	SAB	Sl – st	None	Few	fwD	S – C
	30– 63cm	5YR5/4	SAB	Sl – st	None	v-few	fwD	I – G
	63-140cm	2.5YR4/8	SAB	Sl – st	None	v-few	fwD	S – C
Arable farm (AF)	0–15cm	5YR3/3	Crumby	Non – st	None	Many	fwD	S – C
	15–28cm	5YR5/8	SAB	Sl – st	None	Common	fwD	S – C
	28–88cm	5YR6/8	SAB	Sl – st	None	Few	I-D	S – G
	88-120cm	2.5YR4/5	SAB	St	None	v-few	I-D	S – G
Tree cropped farm	0–12cm	5YR4/3	Massive	w-st	None		P-D	
	12–20cm	5YR5/3	Massive	w-st	None		P-D	
	20–34cm	7.5YR5/6	Massive	w-st	None		P-D	
	34–90cm						P-D	

Key: Sl-st- Slightly sticky; non-st- non sticky; st- sticky; w-st-wet sticky; v-few-very few; fwD-fairly well drained; I-D- Imperfectly drained; P-D- poorly drained; S-A- smooth and abrupt; S-G- smooth and gradual; W-C- wavy and clear; I-C- Irregular and clear; S-C- smooth and clear; I-G- Irregular and gradual.

Table 3 showed morphological properties of the soils which include the soil colour, soil structure, consistency, presence or absence of concretion among others. Tree cropped farm had massive soil structures and was wet and sticky at all the soil depths. The other land uses had sub-angular blocky structures through out all the soil depths except at the surface depths of secondary forest and arable farm which had crumby structures. Building site showed the presence of concretions at all soil depths, while there were no concretions in the soils of the other land uses.

Chemical properties of soils from different land uses

The sodium content at building site decreased from 2.04cmol/kg at the surface to 1.96cmol/kg at the sub-surface depth (Table 4.). The same trend was noticed in all of the different land uses. The potassium content also decreased with depth in all the different land uses with the tree cropped farm having the highest (1.11cmol/kg) at the surface depth followedby Secondary forest which also had the highest content (0.99cmol/kg) at the sub-surface depth. %N, %C and %O M was highest at the surface and sub-surface depth in Secondary Forest (Table 4.). Percentage organic matter at the surface depth was highest in Secondary forest (6.79%) followed by tree cropped farm (5.66%), Fallow land (4.46%), Building Site (2.44%) and Arable farm (2.19%) at the surface of the different land uses. However, the value decreased with depth as reflected at the sub-surface of all the different land uses. Secondary forest for example had 6.79% organic matter at the surface depth, but decreased to 3.51% at the sub-surface depth. The order with which organic matter decreased at the sub-surface depth is as follows; Secondary Forest (3.51%)>Fallow land (2.03%)>Tree cropped farm (1.97%)>Building Site (1.65%)>Arable farm (1.60%). ECEC ranged from 6.13 to 7.47 at the surface depth and 6.01 to 6.55 at the sub-surface depth, it was highest in secondary forest (7.47) at the surface and Arable farm (6.55) at the sub-surface depths respectively. Table 6 showed the chemical properties of the soils from each horizon in the profile of the different land uses. The percentage organic matter (% OM) decreased as soil depth increased in all the different land uses. Most of the other soil properties in table 6 did not show any definite pattern.

Table 4: Differences in Soil properties among land uses at Soil depth 0 – 15 cm

Soil Properties	Building Site (BS)	Secondary forest (SF)	Fallow land (FL)	Arable Farm (AF)	Tree cropped Farm (TF)
Sand (g/Kg)	652.60	636.10	624.50	615.50	634.50
Silt (g/Kg)	182.80	196.10	203.30	215.50	171.50
Clay (g/Kg)	164.60	167.80	172.20	169.00	194.00
Texture	SL	SL	SL	SL	SL
pH in H_2O	6.44^{a}	6.54^{a}	6.60^{a}	6.48^{a}	6.18^{a}
Ca (cmol/kg)	2.12^{ab}	2.42^{b}	2.18^{ab}	2.34^{ab}	1.93^{a}
K (cmol/kg)	0.69^{ab}	1.04^{ab}	0.58^{a}	0.67^{ab}	1.11^{b}
Mg (cmol/kg)	1.89^{ab}	2.23^{b}	2.04^{ab}	2.11^{ab}	1.63^{a}
Na (cmol/kg)	2.04^{ab}	2.19^{b}	1.99^{ab}	2.16^{b}	1.60^{a}
H^+ (cmol/kg)	0.11^{a}	0.08^{a}	0.08^{a}	0.16^{a}	0.11^{a}
% N	0.16^{a}	0.39^{c}	0.26^{b}	013^{a}	0.33^{c}
% C	1.60^{a}	3.93^{c}	2.58^{b}	1.27^{a}	3.28^{bc}
Av.P (ppm)	6.81^{a}	6.50^{a}	7.07^{a}	3.44^{a}	6.68^{a}
CEC	6.13^{a}	7.47^{a}	6.92^{a}	7.45^{a}	6.24^{a}
%B.Sat	97.49^{a}	98.80^{a}	98.74^{a}	97.56^{a}	98.22^{a}
%O.M	2.44^{a}	6.79^{c}	4.46^{b}	2.19^{a}	5.66^{bc}

Key: Ca-Exchangeable calcium; K-Exchangeable potassium; Mg-exchangeable Magnesium; Na- exchangeable sodium; H^+-exchangeable hydrogen; N-Total Nitrogen; C-Organic carbon; Av. P-Available phosphorus; CEC-Cation exchange capacity; B. Sat- Base saturation; O.M.-Organic matter; Cu-Copper; Zn-Zinc; Mn-Manganese; cmol/kg-centimole per kilogramme; ppm- parts per million.; SL-Sandy loam.

Means with the same letters are not significantly different from each other.

Table 5: Differences in Soil properties among land uses at soil depth 15-30cm

Soil Properties	Building Site (BS)	Secondary forest (SF)	Fallow land (FL)	Arable Farm (AF)	Tree cropped Farm (TF)
Sand (g/Kg)	566.60[a]	599.80[a]	584.00[a]	599.10[a]	599.00[a]
Silt (g/Kg)	233.40[a]	199.30[a]	208.80[a]	209.20[a]	197.50[a]
Clay (g/Kg)	200.00[a]	200.90[a]	207.20[a]	191.70[a]	203.50[a]
pH in H_2O	6.61[a]	6.49[a]	6.57[a]	6.29[a]	6.93[a]
Ca (cmol/kg)	2.33[a]	2.03[a]	2.03[a]	1.84[a]	1.77[a]
K (cmol/kg)	0.36[a]	0.99[b]	0.45[a]	0.69[ab]	0.91[b]
Mg (cmol/kg)	2.04[a]	1.79[a]	1.75[a]	1.67[a]	1.70[a]
Na (cmol/kg)	1.96[a]	1.73[a]	1.71[a]	1.68[a]	1.60[a]
H^+ (cmol/kg)	0.09[a]	0.08[a]	0.08[a]	0.10[a]	.07[a]
% Total N	0.10[a]	0.20[b]	0.12[a]	0.09[a]	0.16[ab]
% Org. C	0.96[a]	2.04[b]	1.18[a]	0.93[a]	1.18[a]
Av. P (ppm)	5.19[a]	5.41[a]	4.48[a]	5.68[a]	7.11[a]
CEC	6.48[a]	6.53[a]	6.01[a]	6.55[a]	5.64[a]
% B. Sat	94.73[a]	97.53[a]	98.44[a]	97.34[a]	87.62[a]
% O.M	1.65[a]	3.51[b]	2.03[a]	1.60[a]	1.97[a]

Key: Ca-Exchangeable calcium; K-Exchangeable potassium; Mg-exchangeable Magnesium; Na- exchangeable sodium; H^+-exchangeable hydrogen; N-Total Nitrogen; C-Organic carbon; Av. P-Available phosphorus; CEC-Cation exchange capacity; B. Sat- Base saturation; O.M.- Organic matter; Cu-Copper; Zn-Zinc; Mn-Manganese; cmol/kg-centimole per kilogramme; ppm- parts per million.

Means with the same letters are not significantly different from each other.

Table 6: Chemical properties of profile soils from the different land uses

Land use	Depth	Na	K	Ca	Mg	pH in H_2O	Av. P (ppm)	%N	%C	%O M	%B. Sat
Building Site (BS)	0-13cm	1.32	0.17	1.62	1.62	6.03	0 .55	0.03	0.32	2.4480	99.06
	13-27cm	2.00	0.11	2.28	2.02	7.60	8.90	0.04	0.44	0.9500	99.50
	27-63cm	1.84	0.09	2.12	1.86	5.64	8.10	0.04	0.36	0.7590	98.00
	63-150cm	2.67	0.15	2.88	2.69	6.80	6.85	0.26	2.60	0.6210	99.20
Secondary Forest (SF)	0–15cm	2.44	0.33	2.89	2.46	5.87	7.20	0.14	2.48	4.4820	98.60
	15–30cm	2.29	0.22	2.60	2.30	5.97	6.05	0.08	0.75	1.4310	98.60
	30–55cm	3.62	0.26	3.89	3.69	6.07	9.20	0.08	0.83	1.2930	99.00
	55-150cm	2.95	0.12	3.20	2.97	5.85	8.35	0.06	0.56	0.9650	97.90
Fallow land (FL)	0–30cm	3.40	0.37	3.84	3.46	6.74	16.10	0.07	0.66	1.4140	98.10
	30-63cm	2.00	0.65	2.44	2.08	6.69	8.95	0.08	0.82	1.1380	98.90
	63-140cm	3.33	0.27	3.62	3.37	6.17	9.00	0.05	0.49	0.8450	99.00
Arable farm (AF)	0–15cm	1.88	0.15	3.22	2.00	7.16	9.65	0.22	1.42	3.7930	99.30
	15–28cm	2.00	1.00	2.34	2.04	6.32	8.70	0.06	0.63	1.0860	98.90
	28–88cm	2.22	0.17	2.42	2.24	5.71	8.20	0.03	0.34	.5860	98.30
	88-120cm	1.49	0.18	2.00	1.52	5.35	5.40	0.03	0.28	.4830	97.30
Tree croppedfarm (TF)	0–12cm	3.10	0.41	3.55	3.14	6.25	10.90	0.25	2.20	4.2760	99.00
	12–20cm	2.00	0.22	2.45	2.13	6.61	9.25	0.14	1.42	2.4480	98.80
	20–34cm	2.42	0.42	2.67	2.48	7.57	16.10	0.06	0.55	.9480	99.60
	34–90cm	4.00	0.70	5.20	4.20	7.78	11.90	0.06	0.58	.9100	99.90

Differences among land uses at the different soil depths

At the surface depth, secondary forest and fallow land differed in four soil properties (K, %N %C, %O.M), arable farm and tree cropped farm also differed in four properties (Na, %N, %C, %O.M) while fallow land and tree cropped farm differed in 2 properties (K, %N). The rest land use pairs differed in 3 properties. The land use pairs also differed in certain soil properties at the sub-surface depths. For instance, building site and secondary forest, as well as secondary forest and fallow land land-use pairs differed in four properties while fallow land and tree cropped farm land use pairs, arable farm and tree cropped farm land use pairs differed in only one property. Also Building Site and Arable Farm differed in one property (Table 7).

At the surface, Building site had the highest %Sand though there was no significant difference among the land uses. Arable farm had the highest percent silt content, though not significantly different from the other land uses. Tree cropped farm had the highest percent clay content but is not significantly different from other land uses (Table 4). There was no significant difference among the pH of the different land uses at the surface and sub-surface depths. Exchangeable calcium, sodium and Magnesium content were highest in secondary forest but were not significantly different from the other land uses (Table 4).

Arable farm had the highest sand content (599.10g/Kg) and Building site had the lowest (576.60g/Kg) at the sub-surface depth though there was no significant difference among the land uses. The silt content at this soil depth was highest in the building site (232.30g/Kg) but was not significantly different from the other land uses (Table 4). %Nitrogen, %Carbon and %Organic matter were highest significantly in secondary forest at the surface and sub-surface depths.

There was a significant inverse relationship between 9 pairs at the surface which include clay and Na, pH in H_2O and H^+ pairs. There was also significant direct relationship between 22pairs at the surface depth. These include K and %N, %N and %O M., %C and %O M. pairs(Table 8).

At the sub-surface depth (Table 9), 7 pairs of properties had significantly negative relationships which include Clay and Av. P, pH in H_2O , H^+ and %O M pairs respectively. 19 pairs of soil properties pairs were significantly positively related which include pH in H_2O and %O M; %C and % ECEC; Av. P and %O M pairs. At the surface depth, 8 pairs of soil properties had significant negative relationships and 15 pairs had significant positive relationship.

Table 7: Significantly different soil properties between land use pairs

Key: AF-Arable Farm, BS- Building Site, FL- Fallow land, TF- Tree cropped farm, SF-

Land use pairs	Number of properties	Soil properties
	Surface (0 – 15cm)	
SF – TF	3	Ca (cmol/kg), Mg (cmol/kg), Na (cmol/kg)
SF – FL	4	K (cmol/kg), %N, %C, %O.M.
FL – TF	2	K (cmol/kg), %N
AF – TF	4	Na (cmol/kg), %N, %C, %O.M.
BS – SF	3	%N, %C, %O.M.
BS – FL	3	%N, %C, %O.M.
BS – TF	3	%N, %C, %O.M.
SF – AF	3	%N, %C, %O.M.
FL – AF	3	%N, %C, %O.M.
	Sub-surface (15 – 30cm)	
AF – TF	1	%N
BS – TF	2	Ca (cmol/kg), K (cmol/kg)
BS – SF	4	K (cmol/kg), %N, %C, %O.M.
SF – FL	4	K (cmol/kg), %N, %C, %O.M.
FL – TF	1	K (cmol/kg)
SF – AF	3	%N, %C, %O.M.
SF – TF	2	%C, %O.M.

Secondary forest

Significant at $p > 0.05$

Table 8: Relationship between soil properties at the surface depth (0 – 15cm)

	Silt (g/Kg)	Clay (g/Kg)	pH in H_2O	Ca	K	Mg	Na	H^+	%N	%C	Av. P	CEC (me/100g)	%B.Sat	%O.M
Sand (g/Kg)	-.318*	-.585**	.130	-.268	-.064	-.274	-.329*	-.074	-.043	-.051	.111	-.263	.002	-.053
Silt (g/Kg)		-.339*	.145	-.172	.183	-.187	-.037	.064	.002	.015	.060	-.063	.000	.032
Clay (g/Kg)			-.236	.229	-.088	.266	.318*	.050	.023	.010	-.169	.280	.014	.012
pH in H_2O				-.204	.157	-.317*	-.148	-.401**	.069	.076	.149	-.313*	.245	.074
Ca(cmol/kg)					-.124	.934**	.863**	-.102	-.183	-.176	-.125	.669**	.046	-.217
K(cmol/kg)						-.147	-.051	-.145	.476**	.463**	.144	.157	.169	.462**
Mg(cmol/kg)							.885**	-.039	-.147	-.143	-.199	.647**	-.038	-.201
Na(cmol/kg)								-.070	-.167	-.164	-.156	.690**	.021	-.211
H^+(cmol/kg)									-.207	-.218	-.129	.006	-.795**	-.206
%N										.998**	.279	-.076	.181	.982**
%C											.281	-.084	.183	.983**
Av.P(ppm)												-.110	.172	.295*
CEC(me/100g)													.333*	-.016
%B.Sat														.281
%O.M														

Key: Ca-Exchangeable calcium in cmol/kg; K-Exchangeable potassium in cmol/kg; Mg-exchangeable Magnesium in cmol/kg; Na- exchangeable sodium in cmol/kg; H^+-exchangeable hydrogen in cmol/kg; N-Nitrogen; C-Carbon; Av. P-Available phosphorus in ppm; CEC-Cation exchange capacity; B. Sat- Base saturation; O.M.-Organic matter; Cu-Copper in ppm; Zn-Zinc in ppm; Mn-Manganese in ppm; cmol/kg-centimole per kilogramme; ppm- parts per million.

*Significant at p>0.05

**Significant at p>0.01

Table 9: Relationship between soil properties at the sub-surface depth (15 – 30cm)

	Silt (g/Kg)	Clay (g/Kg)	pH in H_2O	Ca (cmol/kg)	K (cmol/kg)	Mg (cmol/kg)	Na (cmol/kg)	H^+ (cmol/kg)	%N	%C	Av.P (ppm)	CEC (me/100g)	%B. Sat	%O.M
Sand (g/Kg)	-.694**	-.578**	.046	.008	-.079	-.020	-.024	.045	-.022	.168	.296*	.017	-.208	.152
Silt (g/Kg)		-.006	.071	.135	-.033	.142	.129	-.125	.018	-.084	.045	.022	.189	-.071
Clay (g/Kg)			-.248	.048	.079	.025	.045	.151	-.046	-.276	-.421**	.030	.112	-.265
pH in H_2O				-.185	.190	-.104	-.133	-.728**	.255	.309*	.007	-.057	-.098	.304*
Ca(cmol/kg)					-.292	.915**	.914**	.237	-.047	.080	.208	.574**	.141	.092
K(cmol/kg)						-.213	-.185	-.229	.382**	.317*	.083	.105	.010	.316*
Mg(cmol/kg)							.988**	.158	.019	.115	.117	.603**	.042	.119
Na(cmol/kg)								.199	.008	.096	.134	.611**	.057	.102
H^+(cmol/kg)									-.308*	-.365*	.019	.091	.050	-.359*
%N										.669**	.208	.257	.018	.667**
%C											.343*	.365*	.021	.998**
Av.P(ppm)												.229	.173	.346*
CEC(me/100g)													.273	.381**
%B.Sat														.080
%O.M														

Key: Ca-Exchangeable calcium; K-Exchangeable potassium; Mg-exchangeable Magnesium; Na- exchangeable sodium; H^+-exchangeable hydrogen; N-Total Nitrogen; C-Organic carbon; Av. P-Available phosphorus; CEC-Cation exchange capacity; B. Sat- Base saturation; O.M.- Organic matter; Cu-Copper; Zn-Zinc; Mn-Manganese; cmol/kg-centimole per kilogramme; ppm- parts per million.

*Significant at $p>0.05$

**Significant at $p>0.01$

Discussion

At the surface depth, there was no significant difference in the sand content among the land uses. Building site had the highest percent sand content which makes it highly vulnerable to one form of erosion or the other upon exposure and consequently increase the degradation processes (Senjobi and Ogunkunle, 2010). The use of mulching materials which will drastically reduce the effect of erosion at the same time enrich the soil is valuable (Senjobi and Ogunkunle, 2011). Arable farm had the highest percent silt content, though not significantly different from the other land uses. Tree cropped farm had the highest percent clay content; this might reduce the infiltration rate of the soil (Senjobi, 2007) and thereby enhances runoff or flooding on the landform or slope. Consequentially flooding may occur due to poor drainage condition of the soil. The pH range from 6.18 in tree cropped farm to 6.60 (slightly acidic) in fallow land even though there was no significant difference among the different land uses.

Exchangeable calcium, sodium and magnesium content were highest in secondary forest but were not significantly different from the other land uses. Exchangeable potassium was highest in tree cropped farm but was not significantly different from other land uses. The percentage total nitrogen was significantly highest in secondary forest when compared to the other land uses. Parton (1994) suggested that higher N levels occurred in undisturbed forests, due to a higher number of N-fixing trees. One possible explanation was a higher plant litter production in the natural forest than the other land uses. Organic carbon was highest in secondary forest and was significantly different from the other land uses; this is similar to what was obtained by Yao *et al* (2010). Percentage organic matter was also highest in secondary forest than all the other land uses, this result is expected because of the intense litter recycling taking place in forest soils. In the case of arable land use there is a high decomposition of organic matter and mineralization of nutrients contained in the organic matter rather than utilization by crop. The high mineralization rate was due to exposure to high temperature. This result is similar to what was reported by Igwe (2001). Organic matter improves soil aggregation or structure formation (Caravaca *et al.*, 2004; Pinheiro *et al.*, 2004) and it mediates many chemical and physical soil properties (Dexter, 1988). Soil organic matter compounds bind the primary particles in the aggregate, physically and chemically, and this, in turn, increases the stability of the aggregates and limits their breakdown during the wetting process (Emerson, 1977) thereby increasing root penetration and water holding capacity of the soil.

Buol *et. al.*, (1975) noted that soils with ECEC of 4 me/100 g or less had limited ability to retain nutrient cations. All the soils had ECEC above 4 with Secondary forest soil having the highest ECEC (7.47) at the surface depth and Arable farm has the highest ECEC at the sub-surface depth (6.55). Although ECEC decreased with depth in all of the soils, they all had high ECEC which means they had high ability to retain nutrient cations, and that more nutrients can be retained by the surface than the sub-surface. The consequence of this is that productivity in all of the soil will increase appreciably with fertilizer application.

Clay content increased with depth in all of the land uses at the sub-surface depth, having greater values at this depth compared to the surface depth, this was similar to what was observed by Agoumé and Birang, (2009). They further stated that this was a sign of clay translocation and that clay accumulation in the sub-soil could result in reduced porosity, increased water retention and reduced drainage. Also at the sub-surface, tree cropped farm had the highest pH value (6.93) which was very close to neutral pH but is not significantly different from other land uses. Secondary forest differed significantly from the other land uses in the %N and %C, even thoughthere is no significant difference among theother land uses. That was also the view of Schroth *et al.* (2002) who showed that carbon concentrations below 10 cm were very similar under all vegetation types, indicating that the effect, on soil C and N contents, of forest conversion to crop land, as a result of agricultural activities, was largely restricted to the topsoil. %Organic matter are highest in Secondary Forest and is significantly different from that of other land uses, this is similar to what was observed at the surface depth. CEC decreased with depth in all the land uses except in building site, this implies the surface soil had higher ability to exchange and retain cation than the sub-surface soils. Therefore, application of fertilizer will be more effective at the surface than at the sub-surface in all the land uses except building site in order to increase the fertility of the soil hence its productivity.

Building site had sub-angular blocky structure through out the profile. Although secondary forest had a sub-angular blocky structure down the profile, it had a crumby structure at the surface, which might be due to the presence of high quantity of organic matter. This structure might also have been due to the activities of mesofaunas like earthworms, termites etc that has processed and mixed the soil properly to give it a good or fine tilt which is best productive land for cultivation purpose.

Building site was well drained throughout the profile, Secondary forest was fairly well drained through out the profile, and fallow land was also fairly well drained through out the profile. In the arable farm, the surface depths were fairly well drained, but the sub-surface were imperfectly drained. The tree cropped farm had a poorly drained profile in all the horizons; this might be as a result of its very high clay content which promotes high water retention and reduce drainage (Senjobi, 2007). Most arable crops cannot survive under this water logged condition, because such soils have low oxygen content, which the roots of the plant need to respire in order to survive. Although this land use might be very good for dry season or fadama farming of vegetables. % Organic matter decreases down the profile in all the land uses. The organic matter layer was absent in fallow land.

Most of the important soil quality indicators were significantly influenced by different land use systems, particularly at the surface horizon. The bulk density, structure, Carbon, Organic matter, soil pH, CEC, Nitrogen, Available Phosphorus, exchangeable bases, and available micronutrients were affected due to the use to which the land has been put over a long period of time.In general, the continuous intensive cultivation and use of arable farm for crop production without appropriate soil management has degraded most of the important soil quality indicators. The study indicated that secondary forest land use option was the best land use option followed by the tree cropped farm for promoting sustainable agricultural development and in order to also meet up with the food demand of the ever increasing world population. Well established agro-forestry is both sustainable in terms of agricultural production and provides some basic needs for the environment.

To achieve this condition in modern agriculture, it is recommended that reduced intensive cultivation as well as established agro-forestry systems such as alley cropping (i.e. planting of arable and tree crops on the piece of farmland) should be established in the area to increase the fertility status of the soil by increasing the organic matter content, percent nitrogen, percent carbon by increased litter production and consequently increasing biomass production. It is therefore important that further studies be conducted to further ascertain these results to urgently address the challenge of making food available due to the rapid increase in human population which has hitherto led to a scarcity of prime land for agriculture thereby making it difficult to keep land fallow for a long period.

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