ASSESSMENT OF AGRICULTURAL LANDUSE AND SOIL CHEMICAL PROPERTIES IN THE OBUDU MOUNTAIN SLOPE, SOUTHEAST-NIGERIA

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ABSTRACT: The severity of anthropogenic activities such as deforestation, conversion of rangeland to cropland and cultivation without good management practices are known to result in changes in soil chemical and biological properties which altered the characteristics of the earth surface, leading to loses in soil fertility and subsequently it's capacity to support sustainable crops development. This research was carried out to provide important information about agricultural land use types and soil chemical properties in order to proffer recommendations for optimal and sustainable utilizations of land resources especially in fragile micro agricultural tropical ecozones of Nigeria like the Obudu plateau. Soil samples were collected with a soil auger at different predetermined slope positions. This was done subjectively to capture the full range of soil variability within landforms. The samples were taken to the laboratory where standard procedures were employed to analyze selected soil parameters. Placement of transects were established to identify take inventory of the different crops per slope. Descriptive statistics of mean, averages and coefficient of variation was used to analyze the data. The results revealed that, the peasant farmers carry out their farming activities without any formal survey of the fertility status of the soil. However, they intuitively plant certain crops at areas that are perceived to support the growth and development of certain crops. Prolong cultivation of soils in the area without any addictive to improve its quality was identified to be a leading factor of soil fertility decline in the study. Soils fertility of the area was observed to be low across the sampled slopes. Temperate crops were cultivated at the summit while other staple food and cash crops such as cassava, yams, upland rice, vegetables among others dominated the middle and lower toe slope but at different concentration and diversity. In view of this, it is recommended that farmers in the region should add manure on a regular basis to enhance the soil quality. Cover crops should be cultivated across the slope segments to reduce the rate soil wash.

Key Words: Agricultural Land use, soil chemical properties, Obudu Mountain & southeast.

Introduction

According to Gol (2009), land use change is determined by spatial and temporal interactions between biophysical factors (e.g. soil, climate, vegetation and topography) and anthropogenic factors (e.g. population size and density, technology levels, economic conditions, the applied land use strategy, and social attitudes and values). Uzoho, Oti & Ngwati (2007) developed an analytical framework that illustrates these interactions and summarized the models of human-environmental dynamics based on three critical dimensions: time, space and decision-making.

Time and space comprises all the biophysical and human processes operated within them, and the decision-making dimension is relevant to where human processes are involved.

Land use defined as the aggregate uses to which a particular land is put to at a given time, it could be under natural, cultural or agricultural use (Ruthenberg, 1980). Generally, the quality of agricultural land use is very important in developing economies. This may not be unconnected to the fact that most developing nations of the world rely on the soil for their daily subsistence (FOA, 2002). Besides, the food security condition of a country has something to do with its soil quality, prevailing government policies of agricultural development among others (Amuyou, & Kelly, 2015). This is a truism in areas where rain-fed agriculture is a dominant feature of the agricultural enterprise. Large parts of sub-Saharan Africa depend on climatic parameter like rain and temperature for the growth and development of both cash and staple food crops. It is estimated that about 80 % of the world total land area is under physical agricultural practice which accounts for over 60% of world's staple food (FAOSTAT, 2005). But in sub-Saharan Africa, the organization further submits that 92 percent of her cultivated land is rain fed.

In Nigeria, NEXT (1992) reported that agriculture still occupies a prominent position in the daily survival of the rural population. More so, out of Nigeria's total population of about 170 million, 60 to 65% of this figure is in the rural areas (Ebong, 1999). It has also been reported that a large proportion of Nigerians are farmers which clearly points to the fact that soil is very key to the livelihood sustenance of a large majority of her citizens. This explains why most farmers in the country jealously guard their land irrespective of the use to which it is put to, (Amuyou, Okon & Oko, 2013). However, poor agricultural practices like land use intensification and other unsustainable practices due largely to increase peopling of most developing economics often leads to a reduction in yield and diversity of crops. In Nigeria like other parts of developing nations, one fundamental problem that farmers and policy makers continue to grapple with is poor land use practices (Miles, 1990). In view of this, it is feared that the recent gains made in the agricultural sector in the country could be threatened by increasing human population and poor land use practices (Amuyou & Kelly, 2015).

The trend in the country has been hitherto a steady decline in the fertility status of soil due to poor land use practices (Ndor, Agbede & Duada, 2010). It is imperative to note that extreme rainfall couple with poor land use practices accentuate the rate of soil nutrient loss in tropical regions particularly in rugged terrains (Nkor & Iorkua, 2013). More so, the cultivation of a given land changes the nutrient status of the soil. Java, Hassan and Esmaiel (2014) confirmed this, when they observed that land use changed from natural ecosystem to agriculture ecosystem alters the soil structure and quality. As a particular land is put into cultivation especially continuous cropping, the properties of the soil reduce in potency to support further plants development thereby increasing the vulnerability of farmers to food insecurity.

The severity of anthropogenic activities of land use have altered the characteristics of the Earth's surface, leading to changes in soil chemical properties/crops equilibrium, particularly soil fertility, soil erosion sensitivity, content of soil moisture and the overall capacity of the soil to support sustainable crops development (Miles, 1990). Land use changes such as deforestation, conversion of rangeland to cropland and cultivation without good management practices are known to result in changes in soil chemical and biological properties (Essoka, 2010). Land use changes and agricultural practices, especially cultivation of critical ecosystems may rapidly diminish soil quality. Severe deterioration in soil quality may lead to a permanent degradation of land productivity (Wang, 2001). Surface soils in critical eco-zones of Nigeria like the Obudu Mountains can easily be washed away due to extreme and prolong rainfall couple with the unstable geomorphic nature of the terrain (Amuyou & Kelly, 2015).

When the top soil is washed away, all the nutrients that are supposed to provide the base for healthy crop growth is lost hence poor crop yield. It is important to note that the information about the effect of agricultural land use types on soil chemical properties is essential in order to proffer recommendations for optimal and sustainable utilizations of land resources especially in fragile micro agro-ecological zones of Nigeria like the Obudu plateau. It is in view of this that the focus of this study is to identify the diversity of crops cultivated in the study area and examines the soil chemical properties therein.

MATERIAL AND METHODS

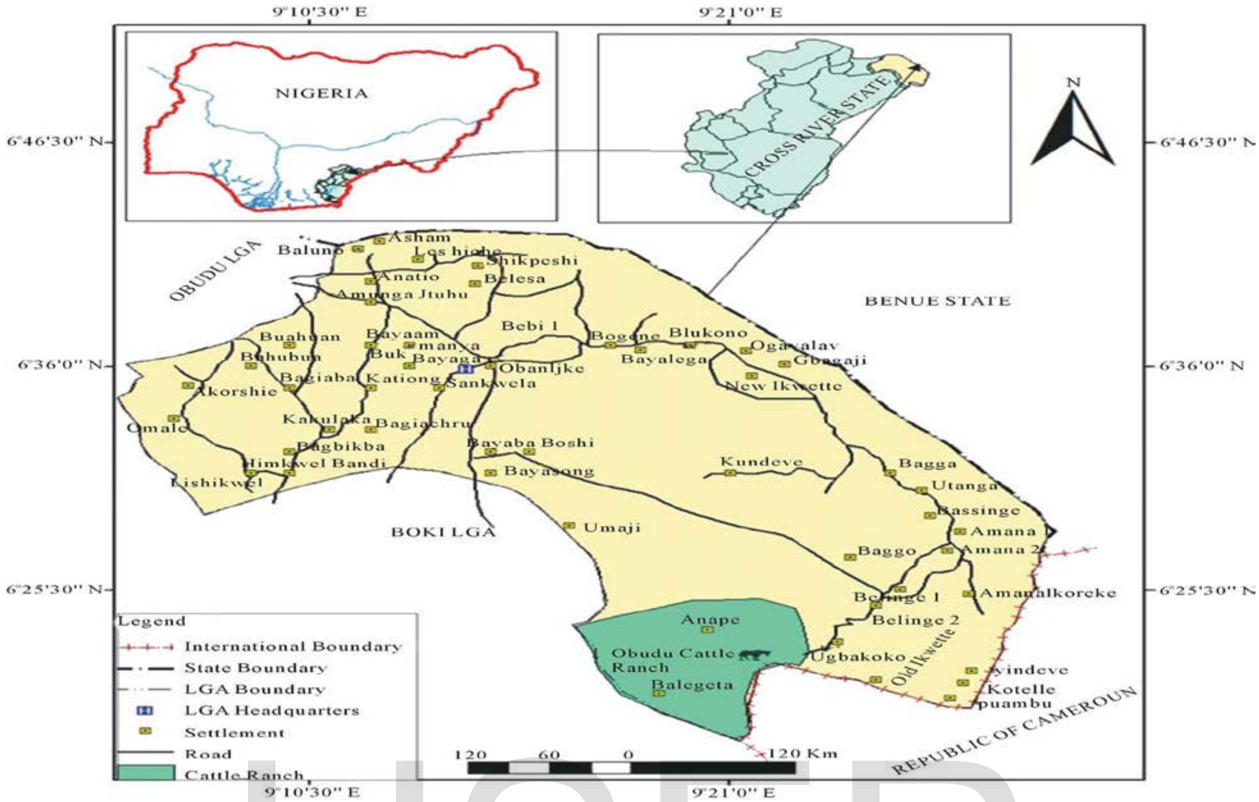
Study area

The study area is the Obudu Plateau located in the Obanliku Local Government Area of Cross River State, Southeastern Nigeria. It lies between longitude 9^0 22' 00" and 9o 22' 45" E, and latitude 6^0 21' 30" and 6o 22' 30" N (Figure 1), with an approximate area of 104sqm2, and a height of about 1576m above sea level (Ekwueme, 2003). Obudu Plateau is bounded in the north by Benue State, northeast by the Republic of Cameroon, to the southeast by Boki Local Government Area in Cross River State of Nigeria.

The area is situated within the tropics but it has a climate that is likened to temperate region with mean daily temperatures range between 150C and 220C. It has a mean annual rainfall of about 4300mm with highest rainfall of about 76.2cm usually recorded in August while the lowest of 0.76cm is usually recorded in December (Mabugunje, 1983). The Obudu Plateau is part of the Precambrian Basement Complex of Nigeria (Ekwueme, 2003). It is a giant spur forming the western prolongation of the Cameroon Mountains into the Cross River plains of southeastern Nigeria.

The natives of the study area are farmers and they cultivate mostly arable crops. On the mountain summit, temperate vegetables are cultivated particularly as home gardens while staple food crops are predominantly cultivated on the mountains slopes. More so, cattle’s rearing is practice by the Fulani herdsmen and the government of Cross River State.

The population density coupled with the weather conditions of the area poses a constraint on the length of fallow period being allowed. The fallow period in the area is between 1 and 3 years for most farmers in the area while for some, it is over 3 years. There are improvised irrigation facilities in the area used by very few farmers between December and March when the weather condition is relatively harsh. However, a greater number of them practices rain fed agriculture.



Fig;ure 1: Cross River State showing the Study area.

Source: Akpan-idiok & Ofem (2014)

Soil samples collection and crops inventory

Soil samples were collected from the median points of six predetermined and mapped out landform positions (summit, shoulder, base, toe, middle & lower toe slopes). Transect placement and sampling intervals along transects were determined subjectively to capture the full range of soil variability within landforms as described by Young *et al*, (1992). Soil samples were taken with a soil auger at 0-15 and 15-30 cm depths of the soil. These layers are considered the most productive soil layers that exert the greatest effect on crop yield and geomorphologic processes are enacted within such layers (Aweto & Enaruvbe, 2010). All samples were assumed to be independent of one another. In each of the slope, several transects were also established for the identification of the different types of crops cultivated in the area. This was also done subjective to ensure adequate coverage of each farm plots across the study region.

Laboratory Methods

The soil samples were air-dried, crushed and passed through a 2mm-sized sieved. Particle size analysis was carried out by Bouyoucos (1962) hydrometer method. Soil pH was determined in 1:2 soil/water ratios by use of glass electrode pH meter. The Walkley and Black method as outlined by Juo (1979) was used to determine organic carbon, available phosphorus by Bray No I method (Bray & Kutz 1945). Exchangeable cations were extracted with NH_4OAC (pH 7); potassium and sodium were determined by the flame photometry while calcium and magnesium contents were measured by EDTA titration method.

RESULTS AND DISCUSSION

Table 1 shows the different types of crops cultivated at different segment of the slopes and prevailing geomorphic features in the Obudu Mountain slope. From the table, it can be observed that at the submit segment, most of the crops cultivated are vegetables that suit temperate climate. Crops like parsley, carrot, leak onion, and Irish potatoes are cultivated in the government owned farms while banana and plantain are commonly found in the native's farmyards or backyards. On the geomorphic characteristics of the summit mountain, it was observed that the segment was relatively undisturbed by severe soil erosion as only slight signs of it was recorded.

However, it is imperative to note that the few crops cultivated at the summit of the Obudu Mountain may be connected to government restriction on farming activities. More so, the nature of soil may not support the cultivation of any type of crop given the hard nature of the soil as most of it is covered with laterite brought in by construction activities over the years. In addition, previous studies in the area indicate that the soil is characterized by high preponderance of sand fractions (Essoka, 2010; Amuyou & Kelly, 20015) which limit the cultivation of variety of crops.

Furthermore, the weather could be another determinant for the paucity of crop diversity and for the dominance of certain temperate related species of crops in the area. In a similar study carried out by Olowolafe (2004) in the Jos Plateau area, it was also confirmed that most of the crops cultivated in the area are limited to temperate crops.

Table 1: Common Crops cultivated in the Obudu Mountain region

Slope segments	Dominant crops per slope segment	Prevailing geomorphic features/processes
Submit	Leak onion, Irish potatoes, carrot, banana, and parsley	Relatively smooth surface with slight presence of erosion features
Shoulder	Cover with pasture	Active slope with intense run-off, soil creep & rick fall, movement of materials are visible during rainstorms.
Base	Yam, cassava, and sweet potatoes	Soil creep very dominant
Toe	Upland rice, millet and maize	Acute channel beds
Middle toe	Yam, cassava, melon, maize & groundnut	Undulating surfaces with stream channels beds &relative downward movement of materials by run-off.
Lower toe	Water yam, cocoyam, cassava, banana, plantain, vegetables & maize.	Colluvial deposits from the upper unit of the slope mostly of fine materials

Source: Authors field survey (2016)

At the shoulder slope, it was observed that the segment is under pasture land use. The shoulder slope is quite steep, which is a major impediment to the cultivation of any type of crop by the natives. The unit is characterized by steep slope, intense runoff, rock fall and soil creeps among others. In the base slope, staple food crops like yams, cassava, and sweet potatoes are commonly cultivated. It is important to note that soil creep is a common visible geomorphic feature in the base slope.

At the toe slope, the study observed the cultivation of shallow rooted crops like upland rice, millet and rice at areas that are yet to be covered by acute and sharp channels edges. At the middle toe slope, crops such as yam, cassava, melon, maize and groundnut are cultivated. While at the lower toe slope segment, crops like water yam, cocoa yam, cassava, banana, plantain, vegetables, and maize ere dominant.

The general observation on the area is that the peasant farmers carry out their farm level agricultural activities without any formal survey of the fertility status of the soil. However, they intuitively plant certain crops at areas that are perceived to support the growth and development of certain crops. The findings of this study corroborate an earlier study by Ruthenberg (1980) who observed that the cultivation of crops in Ukara Island of Lake Victoria followed a peculiar pattern in line with the soil type and fertility status using local soil fertility rating scale.

Chemical properties of soils at different soil depths

Table 2 shows the summary result of soil chemical properties at two soil depths. It was observed that organic matter ranged from 0.57-1.69 with mean values of 1.30 at 0-15cm of soil depth while at 15-30 cm depth, range values of 0.12-1.71 with mean of 1.20 was recorded. In terms of total nitrogen, the study revealed that it varied from 0.050 to 0.1110 percent with mean values of 0.083 for surface soils and ranged from 0.050 to 0.119 percent with mean values of 0.084 percent. These values according to Defeor *et.al* (2000) are rated low as there are below recommended threshold of 0.1 percent for good soils.

Similarly, available phosphorus was also low as there were generally less than 8ppm which is the minimum threshold for good soils (Odu & Ogunwale, 1986) as it ranged from 3.4-5.4 with mean of 4.40 for surface soils while at subsurface soils range and mean values of 2.24-4.46 and 3.50 respectively were recorded.

It was also observed that the result of the exchangeable cation (Ca, Mg, K & Na) were characterized by different values. For example, exchangeable calcium varied from 3.38 to 10.6cmol/kg to 2.10 to 14.0cmol/kg with mean values of 4.49 and 5.60 for surface and subsurface samples. Exchangeable magnesium (Mg) varied from 1.12 to 2.90cmol/kg with mean values of 1.80 and 0.99 for soil depth of 0-15 and 15-30 cm depth respectively. In the same vain, exchangeable potassium ranged from 0.18 to 0.49cmol/kg with average values of 0.30 at soil 0-15 soil depth and 0.21 to 0.61cmol/kg at 15-30 depth of soil. Exchangeable sodium also revealed uneven distribution across soil depth. This observation is attributed to both lateral and vertical flow of water within the area (Essoka and Namaku, 2007).

The cation exchange capacity did not show any discernable pattern across soil depth. At the surface layer (0-15cm), the following values were recorded; range 6.8-15.0cmol/kg, (surface)5.0-20.5 (subsurface) with mean values of 9.30 and 9.90 for the two layers respectively. Table 2 also revealed that base saturation ranged from 83.0-94.0 and 82.0-90.0 with mean values of 89.0 and 86.0 for surface and subsurface samples respectively.

Table 2: Summary of result showing chemical properties of soils at 0-15 and 15-30 soil depth

Soil parameters	Surface Soils (0-15cm depth)		Subsurface soils (15-30cm depth)	
	Range	mean	Range	mean
Organic matter	0.57-1.69	1.30	0.12-1.71	1.20
Total Nitrogen	0.050-0.110	1.30	0.050-119	0.10
Avail. P	3.4-5.4	4.40	2.24-4.46	3.50
Exch. Ca	3.38-10.6	4.49	2.10-14.0	5.60
Exch. Mg	1.12-2.90	1.80	0.99-1.15	1.70
Exch. K	0.18-0.49	0.30	0.21-0.61	0.40
Exch. Na	0.38-0.72	0.60	0.31-2.45	0.90
CEC	6.8-15.0	9.30	5.0-20.5	9.90
Base saturation	83.0-94.0	89.0	82.0-90.0	86.0

Source: Authors field survey (2016)

Influence of agricultural land uses on soil chemical properties

Data on the influence of soil properties on soil chemical properties at different slope segments are presented in Table 3. From the table, it can be observed that different values of soil properties were recorded at different slopes and with varying crops cultivated. For instance, at the summit slope, where most of the crops were vegetables are favored by temperate climate, values of soil organic matter were low and did not show any consistent pattern in distribution from top soils to subsurface soils as values of 1.69 and 0.69 were recorded at the two soil sample depth. The table also revealed at the shoulder slope which is under pasture land use, had values of organic matter of1.40 and0.098 at 0-15cm and 15-30cm of soil depth respectively.

Similarly, the distribution of total nitrogen was not consistent across the sampled soil depth and slope positions irrespective of the fact that this slope segment is under one form of land use. This

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according Offiong, Atu, Njah & Iwara (2009) is due to the fact that such slope position are often characterized by intense geomorphic processes particularly soil erosion. In the case of available phosphorus, table 3 also indicates that higher values were recorded at the upper soil layers even when different food crops are cultivated in each of the slope positions. This study outcome is consistent with an earlier study by Essoka & Namaku (2007) where it was reported that soils of a given terrain under a particular agricultural land use did not differ significantly across the different slope segments. More so, the exchangeable cation also exhibited the same pattern across the two sample depth but not in slope positions from the summit to the lower toe slope. This again could be due to the fact that most of the crops cultivated in the area are stable food crops whose nutrient requirement may not significantly be different.

Table 3: Influence of agricultural land use on soil properties along a toposequence

Dominant land use type	Org. Matter (%)	Total N (%)	Avail. (PPM)	Exchangeable Cation (cmol/kg)				CEC (cmol/kg)8.4	Base saturation (%)	Slope position
				Ca	Mg	K	Na			
Leak onion, Irish potatoes, carrot, banana, vegetables & parsley	1.69 0.69	0.102 0.056	5.4 2.7	3.94 2.10	1.62 0.99	0.60 0.32	0.49 0.21	8.33 5.0	86 88	Summit
Pasture	1.40 1.56	0.077 0.098	4.6 5.0	3.80 5.60	1.71 2.24	0.72 0.85	0.40 0.61	9.5 10.5	90 88	Shoulder
Yam, cassava, and sweet potatoes	1.71 1.30	0.069 0.058	3.4 2.50	3.38 2.95	1.15 1.15	0.69 0.31	0.35 0.19	6.8 5.5	91 82	Base
Upland rice, millet and maize	1.52 1.71	0.110 0.119	5.1 4.56	3.70 4.55	1.88 1.86	0.38 0.70	0.29 0.30	7.1 8.4	89 84	Toe
Yam, cassava, melon, maize & groundnut	1.37 1.71	0.090 0.119	4.80 4.56	4.20 4.55	1.75 1.86	0.55 0.70	0.32 0.30	9.2 8.4	83 84	Middle toe
Water yam, cocoyam, cassava, banana, plantain, vegetables & maize.	0.57 0.21	0.50 0.051	3.36 2.24	10.6 14.0	2.90 1.9	0.37 2.450.60	0.18	15.0 20.5	94 84	Lower toe

Source: Authors field survey (2016)

Unlike other chemical parameters, sodium showed a discernable pattern in its distribution across the sample depth but not in slope gradient. It is imperative to note that sodium distribution is not affected by the type of land use in the Obudu Mountain. Possible explanation

Conclusion and recommendation

The study revealed the dominance of certain temperate related species of crops at the submit segment of the slope while other slopes hard different types of crops cultivated. However, at the shoulder slope characterized by steep slope intense run, rock fall and soil creeps among others were common geomorphic processes observed as no crop is cultivated in this slope segment.

Values of soil chemical properties needed for the development of food crops are low. This is accentuated with prolong cultivation of the farm plots without any measure for its recuperation. It is therefore recommended that farmers should use cover crops, terrace the landscape, add manure to the soil, and practice rotational cultivation to boost agricultural production in the zone.

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