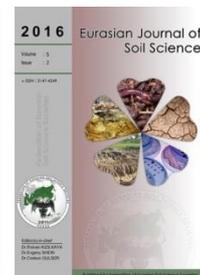




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Dynamic surface soil components of land and vegetation types in Kebbi State Nigeria

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Abstract

Land and vegetation are important components of soil and provides many benefits to surface soil including protection against erosion, climate change impact and unacceptable degradation of soil particles. Visual Soil Assessment was used as a mechanism to assess and classify the land and vegetation types of some agricultural sites in Kebbi State, Nigeria. The aim was to get better understanding of the environmental soil function for sustainable crop production in dryland and fadama areas of the State. The assessment was able to put together combinations of different vegetation types and land age classes. It is valued that the land age classes possessed the characteristics of Holocene-natural, Holocene-anthropogeomorphic, Holocene-young-natural, young-anthropogeomorphic, very-young anthropogeomorphic and very-young natural. However, the vegetation types could be related to evergreen forest, short medium forest (scattered clustered), dwarf vegetation (scattered isolated), grass vegetation, thick vegetation, stony-grass vegetation (scattered sparse) and short-length vegetation. The assessment provides an improve understanding of the current status of land and vegetation conditions of the study area and suggested regular soil management for sustainable crop production in the State.

Keywords: Visual soil assessment, classification, land, vegetation

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Introduction

Soils vary on how long they can be used in agriculture without decline in quality and functional status before management may be needed. Assessments and classification of surface soil components, including land and vegetation are helpful in understanding the current status and condition of soil for proper and sustainable soil management in crop production (Usman, 2007). Unfortunately, scientific knowledge of surface soil components and in particular the aspect of assessment and classification of land and vegetation is very limited in Kebbi State, Nigeria (KARDA, 1997). Consistently, the need for background information outlining the major components of surface soil environment in poor research areas is also essential (McFadden and Kneupfer, 1990; Levine, 2001; Lemke et al., 2003; Furian et al., 2011). In the present study, the major components of the surface soil (land and vegetation types) according to the geo-physical context of the current status of the soil environment in Kebbi State are taken into consideration based on visual assessment. This assessment was regarded as a key element for obtaining soil data information, and especially when the methodology and procedure are developed under the general principles on which the

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assessment and classification of soils should be made in the field (IUSS Working Group WRB, 2006). This assessment is highly cost and time consuming, and needs to be carried out according to the purpose intended (FAO, 2006). Soil Survey Staff (1999) noted that visual assessment requires many assessments and classifications that can be related to the surface soil and that facilitate comparisons of both similarities and differences among the soil characteristics for a great variety of uses. In this study, visual assessment was intended to assess and classify the land and vegetation types from 2010 to 2011 in Kebbi State. Therefore, the objective of this study was assessment and classification of land and vegetation types in dryland and fadamasites of Kebbi State Nigeria. This is hoping to ensure better understanding of environmental soil function for sustainable crop production in the State.

Material and Methods

Study area

The study was carried out in Kebbi State Nigeria around Arewa, Argungu, Augie, Birnin-Kebbi and Dandi. These areas were dominated by the tribes of Hausa and nomadic Fulani ethnic groups, whose sources of income depend greatly on farming systems (Usman, 2007). The zone has tropical weather conditions with three seasons: rainy, dry and hot. The annual rainfall is variable and declining, being 600 mm to 875 mm and on average 650 mm during the period 1997 to 2014 (Local Meteorological Record). The monthly temperature in the region ranges from 25°C to 45°C. The State possessed two important agricultural lands namely: dryland (arid – prolong dryness) and fadama (floodplains – significant alluvial clay particles). These two lands remained the key source of income to millions of people in the State. Figure 1 shows the study area and its geographical position in sub-Saharan Africa.

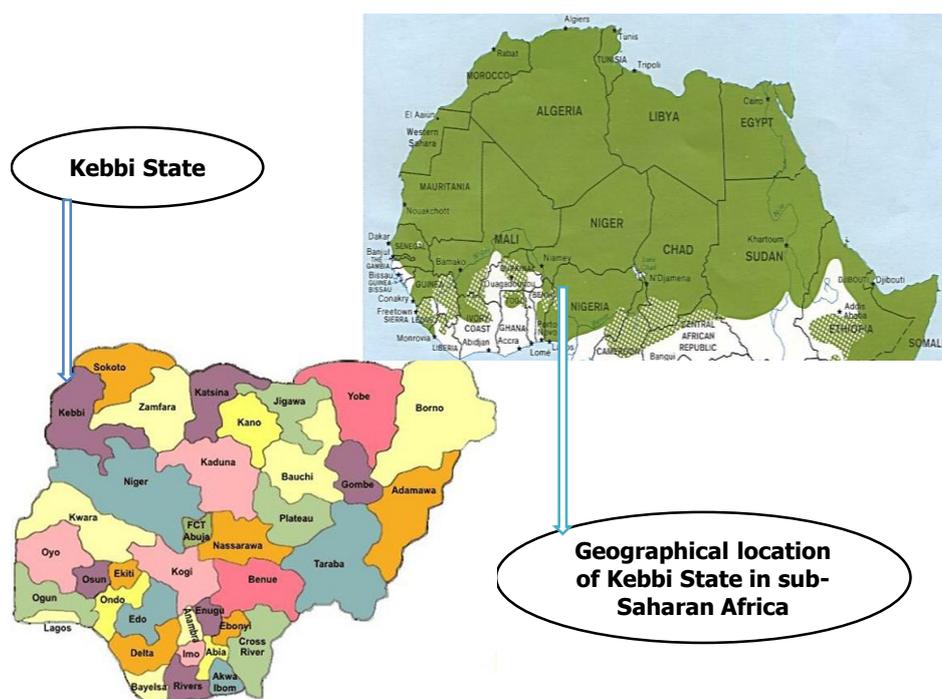


Figure 1. Map of Kebbi State located in Nigeria from sub-Saharan Africa: Adapted and modified after Perry-Castañeda Library Map Collection (2011)

Visual soil assessment

The assessment and classification were basically carried out according to the general background of Visual Soil Assessment (VSA) in the field from 2010 to 2011. The European Commission (EU, 2010) defined VSA as a direct evaluation of those soil properties, which are visible by the naked eye and which can be evaluated directly in the field. The method was found profitable in assessing the key soil 'states', which are dynamic indicators capable of changing under different management regimes and land-use pressure (FAO, 2008). The VSA has included the description of surface soil characteristics, classification of surface soil components according to a standard system of classification (Soil Survey Staff, 2010). Notably, the field exercise in the study area was divided into two namely – assessment and classification of land age classes and vegetation types.

Classification of land age

Surface land ages were classified according to soil maturity classes. The guidelines provided by [FAO \(2006\)](#) are used to classify all land age in the field. This assessment of land age classes was carefully made at different location of dryland and fadama areas of Kebbi State by adapting the procedure of soil pedon – a smallest volume of soil that can represent a given soil site ([Soil Survey Staff, 1999](#)). However, on each site a small surface area 2 m² was secured after a preliminary measurement with a tape (Figure 2). The importance of this measurement is only related to pedon as the targets position of the assessment around each study site.

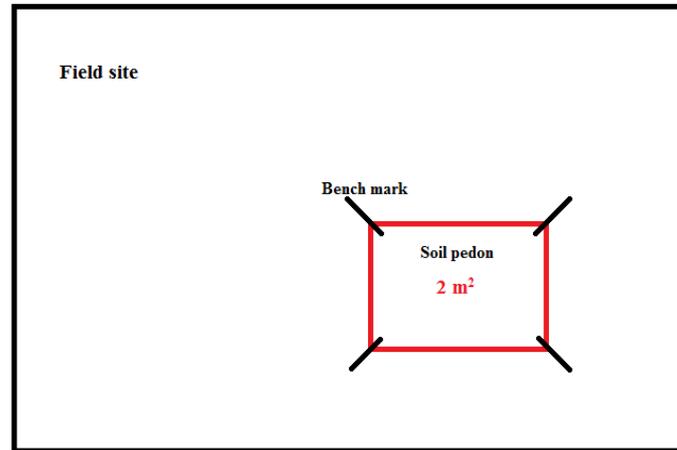


Figure 2. Typical example of schematic diagram of pedon area on the field site

Overall, the VSA and classification of land age classes were made according to the following notation of use extracted from [FAO \(2006\)](#):

- a. *Very young natural*: is attributed to surface soil area loss/affected by erosion or deposition of materials such as on tidal flats, of coastal dunes, in river valleys, landslides or desert areas (field observation).
- b. *Very young anthropogeomorphic*: this refers to areas with complete disturbance of natural surfaces (and soils) such as in urban, industrial and mining areas with very early soil development from fresh natural or mixed materials (field observation).
- c. *Young natural*: this refers to areas affected by erosion or deposition of materials such as sand dunes in desert areas or poor vegetation areas in dryland (field observation).
- d. *Young anthropogeomorphic*: this is refers to areas with complete disturbance of any natural surfaces soils such as areas affected by deforestation with early soil development from fresh natural or a mixture of materials (field observation).
- e. *Holocene natural*: this refers to areas affected by erosion or deposition of materials in very poor vegetation sites of desert areas leading to gullies or landslides (field observation).
- f. *Holocene anthropogeomorphic*: refers to areas affected by human-made relief modifications, such as terracing of forming hills or restriction of flooding by dykes, or surface intensifying or surface contours (field observation).

Classification of vegetation type

Direct observation according to VSA method was used to identify the vegetation cover of the study area. An observation refers only to sites visited in the field and was used to record the major types of vegetation features in the study area. Following this observation, the vegetations of the study areas were assessed and classified according to notation of use outlined in [FAO-SWALIM \(2007\)](#). The summary of the definitions of the key term is given below:

- a. *Evergreen vegetation*: Woody perennial plants with a single, well-defined stem carrying a more or less defined crown and at least greater than 5 m tall (measured in the field).
- b. *Short medium shrubs*: Woody perennial plants with persistent woody stems without any defined main stem, less than 5 m high (measured in the field).
- c. *Dwarf shrubs*: Woody perennial plants with persistent woody stems but are dwarf in nature less than 3 m (measured in the field).

- d. *Grasses vegetation*: Short plants characterised by long thin/fine leaves growing wild in bush areas, vary in sizes and shapes (field observation).
- e. *Thick vegetation cover*: Woody perennial plants or grasses or shrubs covered most of surface area under survey (based on physical observation).
- f. *Short-length plants*: Shrubs or grasses with varying sizes (short and long) less than 3 m and greater than 3 m (measured in the field).

Photographs and images

Photographs and images of some assessment sites were taken. These images were used to show the examples of the land age classes and vegetation types of the study area in Kebbi State.

Results and Discussion

Surface land age classes

The results of land age classes in the study sites are presented in Table 1. The sites are characterised by six different land age classes in dryland and fadama areas. These land age classes are: Holocene natural, Holocene anthropogeomorphic, Holocene young natural, young anthropogeomorphic, very-young anthropogeomorphic and very-young natural (Table 1).

Table 1. Major land age classes around Arewa, Argungu, Augie, BirninKebbi and Dandi

Location	Land age class: FAO (2006)	Agricultural site
Arewa	Young anthropogeomorphic	Dryland
	Holocene natural	Dryland
	Holocene young natural	Dryland
	Very young natural	Dryland
Argungu	Very young anthropogeomorphic	Fadama
	Holocene anthropogeomorphic	Fadama
	Young anthropogeomorphic	Dryland
	Holocene young natural	Dryland
Augie	Very young natural	Dryland
	Very young anthropogeomorphic	Fadama
	Young anthropogeomorphic	Dryland
	Holocene young natural	Dryland
BirninKebbi	Very young natural	Dryland
	Very young anthropogeomorphic	Fadama
	Holocene anthropogeomorphic	Fadama
	Young anthropogeomorphic	Dryland
Dandi	Very young natural	Dryland
	Young anthropogeomorphic	Dryland
	Holocene young natural	Dryland
	Very young natural	Dryland

Field Survey: S. Usman: 2010 – 2011

An observation made, noted that the holocene-natural and holocene-anthropogeomorphic are physically referred to surface soils affected by erosion and human made relief modification, respectively. Also, the young natural, young anthropogeomorphic, very-young anthropogeomorphic and holocene very-young natural are characterised by deposition of new soil particles plus organic materials of plant and animal kinds. Both the holocene-natural and holocene-anthropogeomorphic have similar surface soil nature that is physically undisturbed compared to the surfaces of young and very young anthropogeomorphic soils, which are physical disturbed. Bodily, the parent materials developed in the surfaces of young and very young anthropogeomorphic soils are fine, mixed-up and combined with different organic materials. These different materials are examined according to the physical condition of the surface soil appearances of the study sites. The development and formation of surface land cover as well as natural and synthetic changes are considered important factors, which might have contributed to the formation of young and very young anthropogeomorphic classes (e.g. Colhoun and van de Geer, 1986). Ideally, addition of organic materials changes surface soil appearances by exchanging contact with natural surface soil particles under addition of soil formation process (Harris and Yusuf, 2001; Ghosh et al., 2010). This might have taken part in the transformation and genesis of some surface soil sites characterised as young anthropogeomorphic condition in the study area (e.g. Figure 3).



Figure 3: Examples of land age classes in the study sites: (a) very young anthropogeomorphic, (b) young anthropogeomorphic, (c) Holocene anthropogeomorphic, (d) very young natural, (e) Holocene natural and (f) Holocene young natural. Photos by Suleiman Usman

Generally, the six land age classes are characterised by the presence of consolidated and unconsolidated sedimentary parent materials, which might have formed from the weathering of rocks 100 to 10,000 years old (FAO, 2006; Morrocco et al., 2007). The results of agricultural activities and other human impact on surface soil, land and natural vegetation cover in most part of the study sites, have also caused tremendous changes in holocene-natural and holocene-anthropogeomorphic classes (Figure 3). Results of such changes have been the formation of new surface lands from young to very-young anthropogeomorphic 10 to 100 years old (Figure 3). Lal (1997) described the conditions of these surface soils as soils with inability to: (a) sustain biomass production and biodiversity; (b) regulate water and air quality by filtering: retain water after passing through, buffering: protect from damaging impact and geochemical cycle); (c) preserve archaeological, geological records; and (d) support socio-economic structure, cultural and aesthetic values (study of art, building) and provide engineering foundation.

Reasonably, if there really is erosion combined with humans' inappropriate activities to which holocene-natural and very-young-natural surface soils were formed in the study sites, they would have undoubtedly caused deterioration of natural surface soil quality of the study sites, as similarly noted by Zhang et al. (2006) in China and Usman (2007) in northern Nigeria. On the contrary, factors such as poor vegetation cover, poor soil management, lack of awareness and poor environmental government policy might have also taken a major part in the occurrence of holocene-natural and very-young natural in the study sites (e.g. Usman, 2007). The formation of many young soil particles would have increased due to combined effect of the stated factors, and this has been a case report in most of Saharan and arid regions of Africa (Colhoun and van de Geer, 1986; McIntosh et al., 2004; Furian et al., 2011).

Vegetation types

The results of vegetation types in the study sites are also presented in Table 2.

Table 2. Different types of vegetation around Arewa, Argungu, Augie, B/Kebbi and Dandi

Type of vegetation ¹	Study area	Physical importance to surface soil
a Evergreen vegetation	Argungu	Good for soil and environmental protection.
b Short medium shrubs (Scattered clustered)	B/Kebbi	Protect soil against devastating wind.
c Dwarf vegetation (Scattered isolated)	Arewa	Reserve soil moisture, improve soil fertility.
d Grass vegetation	Argungu	Serve as soil carpeting, reserve soil moisture.
e Dense (thick) vegetation	Augie	Good for soil and environmental protection.
f Thorny-grass vegetation (Scattered sparse)	Arewa	Support soil particles by reducing the direct and indirect impact of terrible rains.
g Short-length vegetation	Dandi	Protect soil against wind and mass movement.

Field Survey: Suleiman Usman: 2010 – 2011, [FAO-SWALIM guide \(2007\)](#)

The result shows that the study sites consist of different vegetation types from BirninKebbi to Argungu through Augie and Arewa to Dandi areas (Table 2). In the Hausa language, most of these vegetation areas are called Kuya (mixed-forest), Kurmin-daji (clustered-forest) and Kali (orchard-forest). Physically, these areas are characterised by fewer annual grasses, thorny tree species and trees of different shapes, length and sizes. Areas dominated by taller trees/shrubs around Argungu, are named as evergreen vegetation and areas covered by shorter and very-shorter flora are classified as dwarf and short-medium vegetation types in Arewa and BirninKebbi, respectively. However, areas covered by thicker or chunky areas (bushy) are classified as dense and short-length shrubs in Augie and Dandi, respectively. Surfaces characterised by present of flora grasses with thorny or prickly plants are classified as 'thorny-grass vegetation' in Arewa. Short medium shrubs and dwarf vegetations are classified according to the condition of plants grown in their respective sites. The physical importance of these vegetation types to surface soil was also assessed based on VSA in the field at that time of assessment. Physically, most of the vegetation plays an important role in binding soil particles, improving soil fertility and protecting surface soil condition against erosion, hence improving the potential of crop productions, sustainability.

The survey also noted that, physically during the rainy season these vegetation types grow productively, and they dried out in dry period. The major plant species observed during the survey are listed in Table 3. The typical examples of the plant species and vegetation types are also shown in Figures 4 and 5, respectively.



Figure 4. Example of some flora in the study sites: (a) *Ziziphusspp* (Magarya), (b) *Adansoniadigitata* (Kuka), (c) *Acacia nilotica* (Bagaruwa) (d) *Hyphaenethebaica* (Goriba) (e) *Piliostigmareticulatum* (Kalgo) and (f) *Azadirachtaindica* (Darbejiya). Photos by Suleiman Usman

Table 3. Major plant species identified in dryland and fadama areas of the study sites

Scientific name ¹	Local name ²	Land site
<i>Acacia nilotica</i>	Bagaruwar- bushe	Fadama
<i>Acacia nilotica</i>	Bagaruwa	Dryland and Fadama
<i>Acacia senegalensis</i>	Dishe	Fadama
<i>Adansoniadigitata</i>	Kuka	Dryland and Fadama
<i>Anogessusleiocarpus</i>	Marke	Fadama
<i>Annona senegalensis</i>	Gwanda-daji	Dryland
<i>Balanitesaegyptiaca</i>	Darbejiya	Dryland and Fadama
<i>Balanitesaegyptiaca</i>	Aduwa	Dryland and Fadama
<i>Detariummicrocarpum</i>	Taura	Dryland and Fadama
<i>Eucalyptus spp</i>	Turare	Dryland and Fadama
<i>Faidherbiaalbida</i>	Gawo	Dryland and Fadama
<i>Ficus ovata</i>	Gamji	Fadama
<i>Ficuspolita</i>	Durumi	Fadama
<i>Ficusthonningii</i>	Chediya	Dryland and Fadama
<i>Gmelinaarborea</i>	Sabara	Dryland and Fadama
<i>Hyphaenethebaica</i>	Goriba	Dryland and Fadama
<i>Khayasenegalensis</i>	Madachi	Fadama
<i>Moringaoleifera</i>	Zogala	Dryland and Fadama
<i>Parkiabigbosa</i>	Dorawa	Dryland
<i>Piliostigmareticulatum</i>	Kalgo	Dryland and Fadama
<i>Psidiumguajava</i>	Gwaba	Dryland
<i>Rogeriaadenopylla</i>	Loda	Dryland and Fadama
<i>Tamarindusindica</i>	Tsamiya	Fadama
<i>Vernonaamygdalina</i>	Shiwaka	Fadama
<i>Vitellariaparadoxa</i>	Kadayi	Dryland and Fadama
<i>Vitexdoniana</i>	Dinya	Fadama
<i>Ziziphusspp</i>	Magarya	Fadama

¹Field Survey: Suleiman Usman: 2010 – 2011, ¹PROTA Precursor (2002); ²Hausa language



Figure 5. Examples of major vegetation types in the study sites: (a) evergreen, (b) short medium, (c) dwarf, (d) grazing, (e) dense (thick) tree shrubs, (f) stony-grass-shrubs, (g) short-length, (h) medium thorny-tree shrubs.

Photos by Suleiman Usman

Conclusion

In a framework of précised VSA carried out between 2009 and 2010 in Kebbi State, the evaluation was able to put together combinations of different environmental soil components mainly vegetation types and land age classes. The information obtained can be considered as pre-requisites for the attainment of the basic requirement and objective of environmental aspect of surface soil management for achievable sustainable crop production in the study sites. The study provides an improve understanding of the current status of surface soil environment in term of land age and vegetation types of the study sites. It is therefore, suggest that a regular observation of the environmental components of soil would provides more detail information on land and vegetation conditions for proper and permanent sustainable crop production in the entire Kebbi State agricultural systems.

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