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Local Theories on Soil Formation and Classifications by Farming Communities of Semi-Arid Areas of Katsina State, Nigeria

Lawal Abdulrashid and Abdu Yaro
Department of Geography, Faculty of Natural and Applied Sciences
Umar Musa Yaradua University, P. M.B. 2218, Katsina. Nigeria
Corresponding Author E- mail: funtua2009@yahoo.com

Abstract
This paper examines local theories of soil formation and indigenous system of soil classification of farming communities of semi-arid areas. Participatory rural appraisal approach, key informant interview and focus group discussion were used in the data collection. It was found that the local farmer are observing how soil is formed through gradually operating process of weathering and the influence of wind, water and other climatic elements in transportation, deposition and decomposition of the weathered materials. The farmers used soil colour, soil texture and fertility level to classify their soil. Four textural classes and fifteen soil types were identified; twelve have colour and three textural names. It was concluded that local perspectives on soil formation and indigenous system of soil classification will enhance the quality of land use planning if properly collated and standardized for project planning in the area.
Keywords: soil formation, soil classification, soil colour, soil texture, soil fertility, indigenous, local, semi-arid areas.

I.0 INTRODUCTION

Indigenous knowledge (IK) also called traditional, local, folk, ethnoscience or native knowledge has been described as a systematic body of knowledge gained by people who resided in a specific location through accumulation of experience, informal experiment and intimate understanding of the environment spanning several generations (Jonathan, 2013). Many researchers (e.g. Das and Das 2005; Mairura et al,. 2007and Henrik et al., 2010) acknowledged that smallholder farmers accounted for the large percentage of agricultural production, grown on trial and error basis using indigenous knowledge of soils which was defined by Winklerprins (1999) "as the knowledge of soil properties and management possessed by people living in a particular environment for some period of time". The use of local soil knowledge is believed to be an easy way of gathering data on land management practices by the soil scientists and development planners at reduces cost and time for identifying and mapping areas with agricultural potentials (Ingram et al:, 2010; Dawoe et al 2012). Niemeijer and Mazzucato (2003) study in eastern Burkina Faso stressed that for development purposes, local soil knowledge is a better starting point of communication than western scientific soil classification. They maintained that for development planning and intervention to be triumphant it must suit foreign technology and strategies to the indigenous environmental and cultural context .This indicate that ''indigenous knowledge and modern innovation go hand in hand, one cannot solve current global issue without the other'' (Lal, 2009). Osunade (1992) in Dawoe et al., (2012) emphasized that the aspiration for sustainable agriculture depend on amalgamation of all experience rather than reliance on one tradition at the expense of the other. However, the oversight of the soil scientists and development planners to incorporate local soil knowledge into development planning is believed to be responsible for the failure of many development projects in developing countries (Niemejer and Mazzucato, 2003).

Although there are variations in local soil knowledge among different tribes and communities in developing countries including Nigeria, the classification of soil base on experience gained several generations is one of the measures adopted by the smallholder farmers to minimize crops production problems as documented in many African countries (e.g.Osunade, 1992 (a); 1992 (b); Hayashi et al., 2000; Braimoh, 2001; Birmignham, 2003; Oudwater and Martin, 2003; Mairura et al., 2007; Maconachie 2012; Dawoe et al., 2012; Kolawole, 2013); Latin America, (e.g.Barrera-Bassols et al., 2006; Barrera Bassols et al., 2009); Asia, (e.g.Desbiez et al., 2006; Henrik et al., 2010 Kuldi et al., 2011) and Europe (Ingram et al., 2010) However, it has been observed that there is the needs for local soil knowledge research to go beyond soil taxonomies as large part of the studies on ethonopedology are concentrated on soil classification and related processes. Niemejer and Mazzucato (2003) stressed the importance of studying also the local perspectives on soil physical process (local theories on soil formation and degradation process) However, it is not a conclusion that local soil classification is not relevant in ethonopedological study, "they are good starting point but not an end point" (Niemjer and Mazzucato, 1999). Local soil classification do not always give a clear and sufficient information on the rationale behind local ways of categorization and use of soil in the studied communities; local classification of soil is mistakenly deal with as a constant representation of knowledge; comparison of local and scientific classification is often unfeasible and many researchers and development planners focus on soil knowledge has been devoted to indigenous soil

classifications (Winklerprins, 1999; Niemejer and Mazzucato 2003)
This paper explore and document local theories on soil formation and classification system used by Hausa farmers living in semi-arid environment of Katsina state , along Nigeria- Niger republic border to complement the geographic knowledge system of different ethnic groups.

2.0 Materials and Methods

2.1 Geographical setting of the Study Area

The study area is located between latitude 12o 52'N and13o 19'N and longitude 7o 16'E and 8o 43'E. The area falls within six local government areas (LGA) of Katsina state, northern Nigeria. The landscape is underlain by sedimentary rock, flat with an average of 300 meters above sea level, broken in some parts by hills. Trees and grasses adapt to climate rhythm of long dry season and short wet season. Most trees developed long tap roots, thick bark which enable them to withstand the long dry season and bush fires. The vegetation is subjected to various form of abuse which includes fire, wood cutting, cultivation, overgrazing and bush fire. The area is characterized by unimodal rainfall pattern with most of the rain received between May to September, annual average below 700mm.Temperatures are high in most parts of the year with the mean daily maximum ranging between 27oC to 40oC occurring between March and May. The mean minimum ranging between 18oC to 25oC experienced in the month of November to early February The area has four different seasons; a cool dry season (December to February), a hot dry season (March to May), a warm wet season (May to September) and a season of falling temperature (September to November), (Tomlinson, 2010). The soils are sandy ferruginous type of the latosols group which is highly weathered and markedly laterised and slightly acidic in reaction to low organic matter content and phosphorous, its total nitrogen rarely exceed 0.2%.(Abubakar, 2006) The subsistence rainfed farming is the common economic activity in the area and fragmented farm land form the dominant feature of the land use pattern,

2.2 Exploratory survey and selection of sampled village

The research was conducted between January – November 2011, in two phases, first, an exploratory survey of three weeks was conducted to be acquainted with the study area. Prior to formal contact with the local farmers, the study and its purpose were explained to the local traditional rulers with a view of facilitating maximum cooperation from their subjects. A total of 12 villages were systematically selected and the number of respondents chosen in each village takes into consideration its population size. All the villages were located few meters away from Nigeria – Niger republic border. A pilot survey was conducted to test the reliability and viability of the research tools and techniques. All the research assistants that helped in questionnaire administration have tertiary education, and are well acquainted with the terrain of the area and fluent in Hausa, the local language spoken by nearly all the people residing in the study area.

2.3 Household survey

A baseline questionnaire with open-ended and closed-ended questions which allowed for statistical analyses (the result of which are not included here) were used to get information on soil related processes, man-environment relations such as size, land holding, livelihood, farming practices, histories of families, and communities etc. This pave the way for asking questions on fluctuation of weather condition, local weather forecast practices and their influence in decision making in crop production process. Only the household head were interviewed. The household were stratified into three (small, medium and large scale farmers), the numbers of samples taken from each category of farmers/herders take into consideration their total percentage in each village. Their answer served as a guide for further discussion in the second phase of data collection.
The second phase took place during the cropping season, May – November, 2011. It was planned, to follow farmer's activities during a 6 months period from planting to harvesting. Information was gathered through Participatory Rural Appraisal (PRA) methods such as participant observation, timeline and local history, transect walk, daily activity profile, seasonal resources calendars, historical resource matrix, key probe, shared presentation and analysis, etc

2.4 Focus Group Discussion

Series of Focus Group Discussion (FGD) with 8-12 people were held in each village. The FGD is aimed at weighing and balancing the information generated through interview with a view of getting a consensus and develop generalization about traditional knowledge on soil formation and classification of communities living along Nigeria-Niger republic border. Selections of key informants take into consideration, the age, gender, literacy (western or Arabic/Islamic knowledge) and social status of the participants. As Mogotisi et al., (2011) pointed out that these factors affects variation in traditional knowledge in communities.
Three groups of people were chosen to participate in three different tasks, following Oudwater and Martin (2003):

i. First, transect walk with groups of respondents in each of the villages for free listing and description of all the terms used to describe and classify soils.

The transect walk across representative farmlands and rangelands in every village was held, respondents were asked to illustrate their understanding, with real examples on local belief (theories), on soil formation, to show and mark the point of transition between different soil types and describe each one of them and the criteria used in classifying the soils. After the transect walk, the respondents were requested to list all the soil types within their landholdings and their villages individually. Later, a group discussion was held to discuss the complete list of soil types listed.

ii. The second group was chosen in each of the study villages to undertake the task of sorting out the terms used in soil description and classification.

The essence of sorting is to understand farmers' soil classification and how they relate different soil types to each other and how they describe them. The respondents were requested to arrange each soil type according to any criteria they thought relevant and the criteria used to group them together or separate them (e.g. colour, texture, water holding capacity, vegetation, soil depth, management problem, et cetera.)

iii. The third group was also chosen in every village for conducting focus group discussion.

At this stage all information obtained during the transect walk and sorting was presented for discussion. The discussion was with the members that participated in the transect walk and sorting task .Basically, focus group discussion is rapid appraisal technique that involves a semi-structured discussion by a group of eight to twelve people i e following Dlakwa 2006 and Banda 2008, it aimed to generate new information, clarify further points in detail, validate information and build consensus between group members. Besides taking the minute of the discussion, tape recorder was also used to record the discussion for reference

3.0 Results and Discussion

3.1 Local Theories on Soil Formation

Most of the respondents during the FGD described soil as a natural body created by God, which contains disintegrated materials formed as a result of the interaction of some climatic elements (rainfall and wind) and the activities of man. While other respondents believed that due to insufficient vegetation cover in the area, wind and run-off always carry away the top soil and left sand, gravel and stones. They indicated that as time goes on, rainwater soak and loose the gravels and stones to break and disintegrate, after sometime they become fully mature soil. Others saw soil as loose materials where plants get nourishment and other conditions of growth.

However, it has been observed that the elderly respondents have better understanding and detail descriptive account of soil formation than those between 50 years and below. For example, a 97 years old farmer in Faru village relates the disintegration of a huge granite rock close to his village to the influence of climatic elements. He recalled that when he was about 7 to 10 years old, the granite rock was solid without any sign of cracks, but now had disintegrated into huge fragments. He attributed the changes in the rock structure to the influence of the sun, the wind and rainwater. The old man compared the granite rock surface with a cemented floor of a house without a protective cover from the direct heat of the sun. He suggested that once the floor of the house was allowed to have direct contact with the sun, it absorbed heat and eventually became loose and crack. When rain water penetrates and surges into the cracks, the crack size increases. As time goes on, the cemented floor become loose and disintegrated. He maintained that the long period of rock surface exposure to the sun, rain and wind, would eventually result in complete disintegration of the rock near their village and become part of the soil they cultivate. He explained that it is through erosion that hilly areas became smaller and rocks below the surface became exposed. He further explained that ''l have been observing the transportation of the eroded materials from the hilly sides to the lower lying parts of our farms down to the valley from there to far away rivers and dams.'' He also mentioned how the fine particles are always washed away first and gravely and stony particles are left behind. And posited that as one followed the course where the eroded soil particles are transported, the soil become less gravely, and more sandy or becoming loamy or even clayey down to the valley. In other words, soil thickness increases from hill to valley. The old man, showed the sign of these processes during the transect walk.

Another respondent from Yardaje village, a 91 year old farmer narrated his experience on soil formation. He said: "I have a site in my farm where gravely soil became exposed as a result of wind and water erosion. After planting shrubs along the border of my farm, to minimize the effects of runoff, mulched the exposed site with stalk and trees and shrubs branches during the dry season to minimize wind erosion; in the rainy season cultivated millet and legume crops to protect the soil from the direct contact with rain and reduce erosive power of run-off. This allows the water to infiltrate and soak the gravel to disintegrate. After 19 years of continuing using this technique, the site has been reclaimed; all the gravels have now disappeared and became fully matured soil".

Another 87 years old respondent in Yakubawa village suggested that where erosion is severe, it exposed not only the gravely materials, but also the root of the crops and trees. He explained that in the course of planting or weeding in their farms one can come across gravel at certain depth, some very close to the surface, others deeper. The respondent believed that some gravels may disintegrate quickly and becomes part of the soil. And maintain that this is the reason where soil became fully matured, such hard gravels are found deeper in the soil and

gradually disappear with time and where the soil is shallow, and the gravels are found very close to the surface.
In Gishirawa village, 79 years old respondent observed in his farms how erosion washed away the top soil and exposed gravely and stony materials and in other places gravely and stony materials are buried deeper by the sediments, and where sand was deposited on the soil. He pointed out that after sometime, if one digs deeper where gravely materials were buried, the gravel might have all disintegrated and become part of the soil.
For the farmers of Gishirawa, the impact of erosion is not restricted only in soil formation. It also affects soil productivity. Some farmers gave examples of how fertile soil is washed away to lower lying parts of their farm or to other neighbouring farms. As one of the respondent said "after spreading manure in all parts of my farm heavy rain washed it away to the neighbouring farms.''
In Bududu village, the impact of wind erosion is visible all over the village and the surrounding farms. Hence, the villagers stressed the importance of wind erosion in soil formation. They explained that windblown particles are transported from one location to another, depending on the wind speed and the size of the particles. They observed that soil materials are normally eroded from unprotected fields and deposited in protected fields where wind speed is reduced by obstacles, such as, trees, shrubs, herbs, and the roughness of the soil surface or redistributed within the same field. All the respondents in this village unanimously agreed that where windblown materials are deposited, soil fertility and the productive potential of the entire field are improved and decrease the fertility of the eroded fields. The farmers' account supported the earlier findings of Sterk (1996) and Sterk and Hagis (1998).
Similar experience of role of wind erosion in soil formation was narrated in Bumbum village by an elderly man, a 96 year old farmer. He explained that when wind blows in a high speed, some of the particles lifted can only move above the soil surface, less than the height of a man. But the smallest particles are held aloft by the wind as suspended dust to faraway places. He said most of the deposited sand in his farm is from far places and pointed out that the color of the deposited sand cannot be found anywhere around the Bumbum village. The elderly farmers' account is similar to the scientific account of the wind transportation process (creeping, saltation and suspension) discussed by Sterk (2003).

3.2 Indigenous Soil Classification

Soil classification involves grouping of the soil of an area into classes based on certain factors or criteria (Braimoh, 2002). Farmers used different criteria of classifying soil and have an array of terminologies of describing different soil types but their classification and description are based on what they can see, touch or smell in few instances i.e. their criteria of classifications are more user-oriented and based on the fertility and physical properties that affect workability. These are colour, fertility and texture. These criteria are similar to the ones used by the people of South-western Nigeria (Osunade, 1992) and Swaziland (Osunade, 1993); Farmers classify the soil into four broad classes of texture; the classification is on the basis of sand and clay content. However, it is important to note that the name of the textural classes differ from one village to another even though they mean the same thing. The differences in name of the textural classes could be attributed to differences in the local Hausa dialect, due to the closer proximity of the study area to Niger republic in the north.

3.2.1 Soil Texture

Farmers define soil texture by the water holding capacity of the soil, which is influenced by soil organic matter content. Majority of the respondents during the FGD believed that soil rich in organic matter has higher water holding capacity and thus a better textural characteristic. In other words, the dominant particle sizes determine the different soil types. Farmers identified four textural classes soil. (see table 1)

Table I: Soil Texture Classification

Soil Class	Description
Yashi/Meso/Jigawa (sandy soil**)**	This refers to sandy soil characterized by very loose materials and rapid loss of moisture
Dabora/Laka (clay soil)	Is a fine texture soil (clay), when wets, it is sticky and can be moulded into various shapes. when dried, it hardens and cracks
HancinKare/Turbaya (loamy soil)	The soil contain both clay and sand (loamy), can be water logged during severe rainstorm. Most farmers prefer growing crops on Turbaya/Hancin kare soil than Laka/ Dabaro or Yashi/Meso/Jigawa
Fako/Geza/Koya (hard stony soil)	The soil is compact, impermeable, and hard when dry and difficult to work on. It consists of small rocks, pebbles, rounded or irregular in shape, it can also contain a hard mass of materials unsuitable for cultivation, may contain stones of various sizes.

Source: Fieldwork (2011)

3.2.2 Soil Colour

Soil colour provides qualitative information about its content, Most of the farmers believed that the darker the soil the more organic matter they contain and the more fertile they are. Light colour soils are believed to contain less organic matter hence less fertile. Majority of the farmers prefer Hancin kare/Turbaya (loam soil) which is believed to be the most fertile. The farmers are aware that soil colour is derived from the presence or absence of organic matter and from the nature of parent materials. It is observed that it is the colours that are added to the four textural classes to arrive at those soil types defined by colours. In other words, pre-fixes of colour are combined from specific soil name based on the four textural classes.These pre-fixes are fara mai haske (white), baka (black), Ja (red) and ruwan makuba (dark-brown). These prefixes are attached to such name as yashi/meso/jigawa, Dabaro/laka, Hancin kare/turbaya and Fako/Koya/Geza. In colour and textural classification, 15 soil types were identified, named and described by the farmers (table 2). Out of the 15 soil types, 12 have colour names added to them while three have textural names. However, it is observed that even soil type with textural names must be of either one of the identified colour.

Table 2: Colour and Textural soil Classifcation

Soil Class	Soil Types
Meso /Jigawa/Yashi (sandy soil)	Farin yashi (light sandy soil) Bakin yashi (dark sandy soil) Jan yashi (reddish–brown sandy soil)sandy Yashi Mairuwan Makuba (dark-brown sandy soil)
Dabaro/ Lakka (clay soil)	Farar laka (light clay soil) Bakar laka (dark clay soil) Jar laka (reddish-brown clay soil) Laka mairuwan makuba (dark-brown clay soil)
Hancin are/Turbaya (loamy soil)	Farar turbaya (light loamy soil) Bakar turbaya (dark loamy Soil) Jan turbaya (reddish-brown loamy Soil) Turbaya Mai Ruwan Makuba (dark-rown loamy soil)
Fako/geza/koya (hard-stony soil) can be light, dark, reddish-brown or dark-brown	Birji (laterite soil) Fako mai tsakuwa (gravely Soil) Fako mai duwatsu (stony soil)

Source: fieldwork (2011)

3.2.3 The Relevance of Colour in Farmers Understanding of Soil

During the FGD in the villages, farmers were asked to identify and explain the importance of colour in understanding the soils of their immediate environment. The farmers believed that most of the soil types derived their names from the colour of the soil. In other words, soil colours are attached to main textural classes to give a particular name to the soil type.

The farmers also indicated that the colour reflects the parent materials the soil originates, but a few farmers have observed that in some cases the colour is independent of what lies beneath, as eroded materials can be transported from somewhere and deposited in a different environment. Some farmers have suggested that the colour in most instances indicate soil fertility and help to differentiate soil types. They also pointed out that the colour facilitates a quick identification and description of soil. As Osunade (1992) rightly observed, "Once a soil name is mentioned with colour, a mental image of the physical appearance of the soil is formed; its feature and viable uses can be guessed with a high degree of accuracy." Apart from aiding in classifying soil composition, the colour also according to many farmers, helps to determine the location of each soil type in an environment.

3.2.4 Soil Fertility

During the FGD, farmers were asked to mention the tools or indicators they used in assessing soils fertility in their farms. The most frequent indicators mentioned included soil colour in which all the farmers believed the darker the soil, the more organic matter they contained and the more fertile they are. Light colour soil contained less organic matter and is therefore less fertile.

In all the soil types identified by the farmers, bakin turbaya/hancin kare is considered the most fertile, followed by turbaya mai ruwan makuba (dark-brown loamy) then bakar laka (dark-clay-soil) and laka mairuwan makuba (dark-brown soil). Other soil types are being utilized particularly those which respond well to manure or fertilizers.

Other indicators used by farmers to identify soil fertility levels are crop yield, the colour of the crop, soil response to manure and fertilizer, water holding capacity, crop height and growth rate, and the presence and behaviour of certain animals (worms and insects).

The farmers believed that earthworms are always found on rich workable fertile soil, they are never found on acidic infertile land. Earth worms or gwazarma, tana, and Kurkudu as they called in the local language (Hausa) are always associated with fertile land. The abundance of earthworm is used as a soil fertility indicator in all the villages, earthworm positively affect soil fertility by maintaining soil structure, enhancing soil nitrogen mineralization and by taking back to the surface, through their cast, nutrient that would have been leached (Mando, 1997).

The farmers also believe that burrowing animals such as gyare (cricket), are always found on a rich fertile land because such animals hardly burrow on sandy, gravely or stony soil. Termites and ants such as Gara (mitemes laurensis), are always considered fertility insect. Some termites can build huge mounds of several meters high. The mounds are often removed by farmers and spread on the field as manure. Many farmers believed that crops grow well where mounds or termites hills are available. Some farmers deliberately seek out land with many and large termite mounds for reasons of fertility and the availability of soil moisture. Also termite mounds or termite foraging areas are considered to influence vegetation succession and patterns (Mando, 1997).

Farmers also used the presence and growth of several weed species as land quality indicators to differentiate the soil fertility status on their fields. The weeds are seen as plants that are unwanted where they grow because of their direct competition with crops and causing indirect damage by harboring insects' pests. Long time relationships with the environment have enabled the local farmers to understand the dynamic nature of weeds and other plants by observing and identifying different types of weed plants, how and where they grow better. Hence, when choosing new land for crop production some farmers make selections base on the type of vegetation or weeds found on the land. In other words, some plants provide information about mineral nutrients availability or deficiency; others indicate which crops are best adapted to the soil. Plant species are used to identify soil fertility status of an area. For example, Tafasa (cassia tora). Gyada-gyada (chrozophora bracchiana), Nonon kurciya (Euphorbia poisony) and many other species, their grow in an area is an indication of high soil fertility of the farm while presence of Wuta-wuta (striga spp) and Alkamar tururuwa (Spermacoce stachydea) in a farm signify low level of fertility of the farm.

The use of weeds growth as indicators of soil fertility in other parts of the world is widespread. For example, they are used to identify areas of good agricultural potentials or to detect soil impoverishment after cropping (e.g. Osunade (1992), and Desbiez et al., (2004). However, the ability of weeds to act or used as unambiguous indicators for land evaluation is limited because their presence may reflect cropping practice, rather than soil condition. Some weeds in the study area are planted along farm boarders e.g. Yayida (lepta Lancia folia Dania).

4.0 Conclusion

The foregoing account demonstrates that local perspectives on soil formation are to some extend similar to that of western science. It also indicates that local people have been observing and transmitting meaningful knowledge of soil and environment in general, which they acquired through experiences that have been gained for many generations that lived and depended on the land. The local perspectives also signified that local farmers have been monitoring the impact of slowly operating process around their environment, such as weathering, erosion and sedimentation as noted also in Burkina Faso by Niemejer and Mazzucato (2003). Therefore, familiarity with the local perspectives (indigenous knowledge) of soil formation by the scientist means appreciating local realities, which is crucial for the successful planning and implementation of any type of agriculture and other land related development projects. The farmers' perspectives on soil classification indicated that soil names in the study area are derived from the four main textural classes and the four main soil colours. The local soil classification has tremendous planning implications, as it will enhance land use planning, if the local soil classification is collated and standardized for projects planning in the area. Scientific perspectives can provide platform of enhancing the knowledge of soil bio-physical process, on the other hand farmers can provide micro-specific account needed to adapt this knowledge to the local biophysical and socio-economic conditions.

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