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FACTORS AFFECTING SOIL QUALITY MAINTENANCE IN NORTHERN KATSINA STATE, NIGERIA

IBRAHIM, Y. El-Ladan*[1], Nuraddeen A. Maiwada[1] and Abubakar A. Rumah[2]

[1]Deaprtment of Geography, Umaru Musa 'Yar-adua University, Katsina, Nigeria.
[2]Deaprtment of Geography, Nassarawa State University, Keffi, Nigeria.

*Corresponding Author: yusuf.elladan@umyu.edu.ng

ABSTRACT
This study was set-up to determine the key factors affecting soil quality maintenance in Kaita, Mai-adua and Mashi local government areas (LGAs) of Katsina state, Nigeria. Two hundred and forty soil samples were collected and 600 questionnaires administered to obtain information on the various forms of activities affecting soil quality maintenance in the area. The soil samples were analyzed for selected physical and chemical quality indices. Factors affecting soil quality maintenance in the area according to the findings are natural and man-induced, including agricultural practices in general and deforestation, soil degradation and erosion, as well as biodiversity loss in particular. The results also indicated that values of the selected elements affecting soil quality in all the 3 LGAs studied fell below minimum standards. Soils in 2 of the LGAs (Mai-adua and Mashi) were concluded to be sensitive to plant growth. Caution should, however, be exercised for soils of Kaita LGA that are extremely sensitive so as not to continue to increase in salinity. It is recommended that farm management practices in the area should be improved and use of irrigation water encouraged among farmers to check salt accumulation.

Keywords: Soil quality; soil quality maintenance; factors affecting soil quality.

INTRODUCTION
Research on soil quality has advanced to the degree that the potential exists for the creation of a framework that allows growers, regulators, and researchers to monitor and assess positive and negative changes in soil quality (Andrews, *et. al.* 2004). Many researchers focus on the functional approach to measuring soil quality and thus, define soil quality in that light. Gregorich, *et. al*. (1994) define soil quality as "a composite measure of both a soil's ability to function and how well it functions, relative to a specific use." Karlen, *et. al.* (1997) describe soil quality as "the fitness of a specific soil to function within its capacity and within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation." This definition is similar to those of Acton and Gregorich (1995), Doran and Parkin (1994), and Larson and Pierce (1991), and allows for quantification of soil quality as well as for innate differences among soil orders. Harris and Bezdicek (1994) tie soil quality to soil health by stating that together they "reflect the fitness of a soil body, within land use, landscape and climate boundaries, to protect water and air quality, sustain plant and animal productivity and quality, and promote human health". Singer and Ewing (2000) stated that the concept of soil quality includes soil fertility, potential productivity, resource-sustainability, and environmental quality. They also observe that the existence of multiple definitions of soil quality suggests that the concept continues to evolve. Cook and Hendershot (1996) assert that soil quality guidelines are intended to protect the ability of ecosystems to function properly. The whole thrust of soil quality research arose from the recognition that soils are a vital component of and provide necessary services to the ecosystem (Daily, *et. al.* 1997), and that the ability of soils to continue to provide those services is threatened by degradation (Parr, *et. al.* 1992).

The idea for developing soil quality maintenance criteria and using them to facilitate better land use and management was introduced more than 30 years ago (Alexander, 1971; Warkentin and Fletcher, 1977), but has undergone its most rapid evolution and adoption during the past decade (Karlen, *et. al.* 1997, 2001, 2003, 2004). Defined as the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation, soil quality is neither an end-in-itself, nor a replacement for modern soil survey programs or scientifically based soil management strategies. Soil quality assessment is simply a tool focused on dynamic soil properties and processes that are useful for assessing the sustainability of soil management practices. Despite the rapid development of the concept throughout the 1990s, soil quality assessment is still in its infancy in this part of the world. Even though extensive literature has piled up on soil quality assessment across many areas, the geographical spread of the literature has not, because many agricultural ecosystems in dry-lands of Africa in general, and Nigeria, in particular, have not been covered. The aim of this work therefore is, to determine the key factors that affect soil quality maintenance with a view to adding to the existing literature that pertain to soil quality maintenance, especially under small farm holding management practices in the study area.

Fu, *et. al*. (2003) compared a soil quality index to a degradation index (DI) using data gathered from deforested land in the humid, mountainous regions of China. After converting the quality index to a "deduced quality index" the authors note a high correlation between the degradation index and the deduced quality index. They note both methods were efficient in evaluating soil quality levels, but the DI was a simpler method.

An older index that focused primarily on productivity is the Storie Index Rating or SIR (Storie, 1932). Nine soils properties were selected, which include; soil morphology, surface texture, slope, drainage class, sodicity, acidity, erosion, micro-relief, and fertility. The SIR equation multiplied the first three with the product of the last six after the last six have been scored from 1 to 100%. Since the SIR is the product of fractions, it does not readily lend itself to measuring improvements in soil quality. Non-quantitative systems include the USDA Land Capability Class (Klingebiel and Montgomery, 1973) that evaluates arable soils separately from non-arable soils, assigning each into classes, subclasses, and units. The system, besides being qualitative, focuses primarily on productivity and may have limited application when evaluating environmental functions of soils.
Cambardella, *et. al.* (2004) evaluated soil quality assessment on a watershed scale by removing and evaluating soil cores along transects placed along topographic gradients, then, using terrain analysis grouped the data into landform classes. This allowed them to evaluate the effect of topographic position on soil quality. They documented soil quality differences by i) quantification of soil indicator variables, ii) calculation of soil quality indices, and iii) comparison of indicator variable and index results with independent assessment of soil function endpoints such as sediment loss, water partitioning at the soil surface, and crop yield. Other articles have evaluated soil quality indicators from points, to region-wide scales (Brejda, *et. al.* 2000; Karlen *et. al*., 1999; Liebig and Doran, 1999).

Wang and Gong (1998) utilized GIS technology to develop a relative soil quality index (RSQI) and its difference, or changes in time and space (ΔRSQI). Their purpose was to map and assess soil quality changes in small watersheds. The system depends on an extensive database of soil parameters measured over a moderately extensive time period (11 years). Jaenicke and Lengnick (1999) used data envelopment analysis techniques in the reconciliation of two soil quality indices with economic concepts of technical efficiency and productivity growth.

Karlen, *et. al.* (1994) developed a soil quality index based on four soil functions, namely i) infiltration, ii) water holding capacity, i) degradation resistance, and iv) support of plant growth. This index also used the more-is-better, less-is-better, and optimal characterization of soil properties as described by Andrews, *et. al.* (2004). Each soil function is weighted, and each value ascribed is multiplied by the function weight. Then all four products of weight and function score are summed to obtain the soil quality index.

$$SQI = q1\ (wt) + q2\ (wt) + q3\ (wt) + q4\ (wt) \qquad (1)$$

Where: SQI is soil quality index, and **wt** is the weight assigned to $\mathbf{q^n}$, the soil function.

The literature on conceptual indices for soil quality assessment contains a great deal of overlap concerning soil quality indicators. The difficulty in coming to agreement on a "standard" set of indicators is based on the concern that a "one-size-fits-all" approach will lead to inadequate or inaccurate soil quality assessment. Other options besides one single set of indicators include indicators specific to certain soil orders, soil uses, or geographic regions. Alternatively, there is concern among some researchers (Nortcliff, 2002; Dick, *et. al.* 1996) that different investigators using different methods of collection and analysis will produce results that cannot be compared from study to study or within the same study over time. This becomes a critical issue when contemplating the utilization of any system on a national or international basis.
Two alternatives to the repeated collection of samples and data are: a) the use of remote sensing devices that can sample automatically and send data to a central collection point and b) creation of a model such as the Revised Universal Soil Loss Equation (RUSLE) that relies upon research data to predict an outcome based on certain soil conditions and practices. It is noted that researchers, conservationists, regulators, and growers utilize the RUSLE to modify farming systems even though not a single measurement is made prior to the RUSLE's application. This last option holds out the promise of a method that would be readily adaptable at the farm level and would not be constantly subjected to the question of whether samples were being taken objectively, randomly, frequently, and thoroughly enough to accomplish the goal.

Study Area

Katsina is one of the States of the Federal Republic of Nigeria. It was created in 1987 from the defunct Kaduna State and is located between latitude 11⁰ 08' North and 13⁰ 22' North and longitude 6⁰ 52' East and 9⁰ 20' East. It covers a total area of approximately 23,983sq km. The State is bounded to the east by Kano and Jigawa States, to the West by Zamfara State, to the South by Kaduna State and to the North by Niger Republic.
The specific study area covers 2,078.8sq km and falls within the dry-land region of Katsina State, defined roughly as areas lying North of 12⁰ N latitude in the state. Administratively, the following local government areas fall within the study area: Kaita, Mashi and Mai-Adua.
The 2006 census figures put the population of the state at 5,792,578 and that of the 3 LGAs put together at 580, 669 inhabitants..

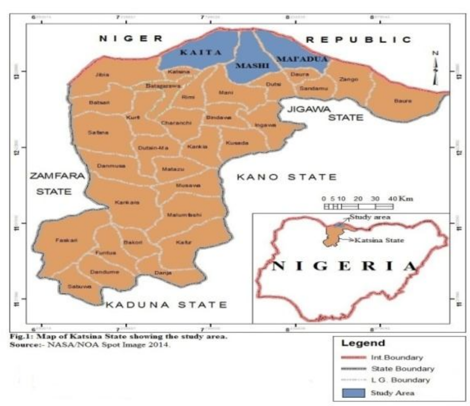

Figure 1: Map of Katsina showing the Study Area.

Katsina State is located on Nigeria's inselberg landscapes. These areas are generally undulating, characterized by numerous domed hills and occasional flat-topped ridges.

General elevation of the area is between 305 – 610 meters above sea level (Ibrahim, 2005). The soil is predominantly ferruginous tropical red and brown soils in the areas underlain by the basement complex rocks. The soil forming parent materials were weathered rocks and sand drifts composed of unconsolidated sands susceptible to erosion on the interfluves and upper slopes. The lateritic drift soil of the area is coarse and tends to be of low to medium fertility. Its fine consistence makes it ideal for growth of such crops as millet and groundnuts. Over large areas, the vegetation does not provide adequate cover for the soils especially at the beginning of rains, hence the soils are generally susceptible to erosion. To the southern part of the State, the soils are of ferruginous type, derived from the basement complex and old sedimentary rocks. These soils are distinguished by a marked differentiation of horizons. The northern part of the State is however covered by brown and reddish brown weakly-developed soils. The sparse vegetation does not provide much litter, but the plant roots that decay in the soil are responsible for much of humus in the soil. These soils have high water and nutrient holding capacities which could make them very productive with adequate water supply. There are few perennial rivers and streams. Two major rivers in the State are Rivers *Gada* and *Karadua*. These rivers flow over the basement complex, thus are characterized by rapids and falls. They flow into the *Rima* and *Sokoto* Rivers which ultimately drain into the Niger River (Yaro and El-Ladan, 2012).

MATERIALS AND METHODS

Soil samples were collected and, structured questionnaire administered to obtain information on the various forms of activities affecting soil quality maintenance in the study area. Composite random sampling technique was used to collect the data and before administering the questionnaire, farms to be used for soil sampling were selected, which included farms of not less than 1 hectare and not more than 2 hectares. Based on this criterion, four farms were selected from each of the three Local government areas. In administering the questionnaire, the settlements close to the selected farm sites where most of the farmers live served as base. Six hundred copies of the questionnaires were served and 442 retrieved. From each of the selected farmlands, comprising 12 plots, 20 soil samples were collected at a distance of 30 meters apart to ensure that the points of collection were not too far apart and enable the researchers determine the rates of changes occurring in the nutrient levels and other soil characteristics analyzed. The soils were collected at a depth of 30cm and 240 samples were collected. The questionnaires were analyzed by encoding responses to the questions on a spread sheet in Excel which were exported to Statistical Package for Social Scientist (SPSS) environment for testing and inference using descriptive statistics. The soil samples were analyzed for particle size using Bouyoucos hydrometer method as described by Black (1975). Textural classes were determined using Marshall's textural triangle. Soil pH was measured in soil water suspension using glass electrode digital pH meter as described by Black (1975). Regular macro-Kjedahl method was used to determine Nitrogen (N). Available phosphorus was determined using the bicarbonate method as described by Olsen, *et. al.* (1964). Exchangeable cations were extracted with IN ammonium acetate solution each. The concentrations of Na^+ and K^+ were determined using flame photometry. The concentration of Ca^{++} and Mg^{++} were determined by titration with 0.02N EDTA solution as described by Page, *et. al.* (1982), and organic carbon content was determined using the dichromate wet oxidation method as described by Walkley and Black (1934).

RESULTS AND DISCUSSION

If a soil is not suitable for a specific use, then it is not appropriate to attempt to assign or describe quality for that specific use or function (Larson and Pierce, 1991; 1994). This section therefore aims at describing the soil quality in the study area as it affects soil productivity with regards to salinity and sodicity effects of the soil. The parameters that formed the evaluation of the soil are based on the Exchangeable Sodium Percentage (ESP), Sodium Adsorption Ratio (SAR), organic matter, pH values, alongside texture of the soil to determine if the soil is saline, saline-sodic or sodic.

Classification of Soils in the Study Area

The major criteria used to classify salt affected soils as put forward by The U.S Salinity Laboratory Staff (1954) and adopted in this study are:

i. The salinity of the saturation extract as measured by the electrical conductivity (EC) at 25^0C of the extract and;
ii. The exchangeable sodium percentage (ESP) as measured by the Sodium Adsorption Ratio (SAR).

These major criteria were complimented by the analyzed percentage base saturation (PBS) of the soil samples in classifying the soils in this study.

The US Salinity Laboratory Staff (1954) and Landon (1991) established a system for classifying saline and sodic soils in three broad categories, which serves as basis of classifying the soils in this study.

Saline Soils

Technically, a saline soil is defined as a soil with an EC greater than or equal to 4 mmhos/cm and exchangeable sodium percent (ESP) of less than 15 or electrical conductivity (EC) greater than 4 decisiemens/meter (dS/m) and sodium adsorption ration (SAR) of less than 13 in their saturation extract. The soil pH is usually less than 8.5 and such soils may have a white crust or white salt crystal accumulation on their surface so they are sometimes called "white alkali soils".

Saline – Sodic Soils

These soils contain soluble salts and exchangeable sodium insufficient to interfere with the growth of most crops. It is technically defined as a soil having an ESP greater than 15 and an EC greater than or equal to 4 mmhos/cm or have an EC greater than 4 dS/m and SAR greater than 13 in their saturation extract.

Sodic Soils

These soils contain sufficient exchangeable sodium that interfere with the growth of most crops but do not contain appreciable quantities of soluble salts. They are soils with an ESP greater than 15 and an EC of less than 4mmhos/cm or have an EC of less than 4 dS/m and SAR greater than 13 in their saturation extract. Drainage and aeration are very poor because soil colloids are much dispersed and pH is generally above 8.5. They are sometimes called "black alkali soils". High pH values generally can be used as an indicator of possible sodium problems, but is not always true.

Based on these classifications established by Jaenicke and Lengnick, (1999) the soils in Mashi, [with ESP of 12.18, which is less than 15, SAR of 2.52 not greater than 13, EC of 0.40 and pH of 6.20 which are less than 4 and 8.5

respectively, and a percentage base saturation (PBS) of 44.4% (see appendix)] can be classified as saline. The level of salinity in this area is, however, negligible when compared to the standards provided by Food Agricultural Organization (FAO, 1997). See appendix Table XI.

The soils in Mai-adua local government area have an ESP of 12.2, which is less than 15, SAR of 3.34 not greater than 13, Ec of 0.85, which is less than 4, pH of 6.6, less than 8.5 and a percentage base saturation (PBS) of 39.98%. This data put the soils in Mai-adua local government area in the class of saline soils. The level of salinity in the area is also negligible because of the conductivity of saturation extract (Ec) of 0.85 as compared to the standards provided by Food Agricultural Organization (1997).

The sampled soils in Kaita local government area have an ESP of 7.49, which is less than 15, SAR of 4.46 not greater than 13, Ec of 2.7, which is less than 4, pH of 5.9, less than 8.5 and a percentage base saturation (PBS) of 40.7%, which therefore, influence the soils in Kaita local government area to also be classified as saline. The level of salinity in this area is slightly saline because of the conductivity of saturation extract (Ec) of 2.7 as compared to the standards provided by Food Agricultural Organization (1997) in Table XI of the appendix.

Bezdicek, *et. al.* (1996) noted in an article concerning the importance of soil quality to health and sustainable land management that there are two approaches to viewing soil quality. The first is to see soil quality as "an inherent attribute of soils that can be inferred from soil characteristics or indirect observations (e.g. erodibility or compactability)." The second is to view soil quality as a dynamic characteristic or in terms of a soil's "capacity to perform certain productivity, environmental, and health functions." In other words, one can measure the quality of a soil based on a comparison to an ideal soil, or measure it in terms of how well it performs and can continue to perform certain functions. In the determination of the factors that affect soil quality maintenance in the study area, the first approach suggested by Bezdicek, *et. al.* (1996) was adopted laying emphasis on the nutrient availability of the soils and comparing with soil quality indicators and their expected ranges based on Harris, *et. al.* (1996) as shown in Table XII of the appendix.

The elements that are considered affecting soil quality with regards to nutrient availability across the three local government areas that make up the study area are phosphorus (P), potassium (K), organic content (OC) and Nitrogen (N), excluding pH, that can sustain optimum integrated plant production and environmental quality. In Mashi local government area, the values of phosphorus (P) is 5.17, potassium (K) is 1.24, organic content (OC) is 2.06 and Nitrogen (N) is 0.15 fell below the range of soil indicators compared with the range of soil quality indicators on Table XII.

The values of the elements affecting soil quality in Mai-adua local government area are phosphorus (3.1), potassium (4.83), organic content (2.9) and Nitrogen (0.18) shown in the appendix also fell below the range of soil indicators compared with the range of soil quality indicators based on Harris, *et. al.* (1996) as shown in (Table XII).

Similarly, the values of the elements affecting soil quality in Kaita local government area are phosphorus (4.33), potassium (4.55), organic content (1.8) and Nitrogen (0.2) all of which are below the range of soil indicators as compared with the range of soil quality indicators based on Harris, *et. al.* (1996).

Despite the nutrient deficiency in phosphorus, potassium, organic content and nitrogen in the soils of the study area, and the low ESP values of 12.18, 12.2 and 7.49 for Mashi, Mai-adua and Kaita local government areas respectively, the physical properties of the soil are still considered to be in good condition, but precaution should be taken to make sure soils in Kaita, that are slightly saline, do not continue to increase in salinity as it would inhibit plant growth, leading to stunted growth, late maturity, plant diseases and subsequent decrease in yield of most crops grown in the area.

Factors Affecting Soil Quality Maintenance in the Study Area

The factors affecting soil quality maintenance in the study area include deforestation, soil degradation and erosion, biodiversity loss and desertification (Table 1). Respondents were allowed to select as many options they think are correct as understood by them. A total of 306 respondents representing those that are into farming as their occupation were collated for analysis.

Table 1: Consequences of agricultural practices

Consequences	Frequency	Percentage
Deforestation	**165**	**53.92**
Soil degradation and erosion	**306**	**100.00**
Biodiversity loss	**49**	**16.01**

From Table 3, all the 306 (100%) respondents agreed that agricultural practices lead to soil degradation and erosion, 53.92% were of the view that agricultural practices lead to deforestation while 16.01% consider biodiversity loss as one of the consequences of agricultural practices. A total of 69.61% of the respondents concluded that desertification in the study area is as a result of agricultural practices. The consequences of agricultural practices have some effects on the environment.

Consequences of Agricultural Practices

The effects of the consequences of agricultural practices are considered as those impacts on the soil that adversely affect or cause disequilibrium in an ecosystem.

Effects of Deforestation

Deforestation is the act of cutting down trees and a total of 165 respondents of the 306 respondents that are into farming are of the view that deforestation has effects on the soil (Table 1). The consequences this act has on the environment {The environment as perceived in this study refers to the sum total of both physical and cultural features comprising the biotic and abiotic factors that create environmental contrast and similarities as observed by Ibrahim, 2010} in general are as shown in Table 4. The presence of vegetation cover shields the soil from the direct rays of the sun thereby reducing the amount of temperature (heat) radiated and circulated in the environment, but with the cutting down of trees the direct ray of the sun is felt on the earth surface generating intense heat. The respondents who agreed that deforestation leads to increase in temperature in the environment which causes discomfort to humans, favor the growth of some germs, leads to witting in plant and in same vein favor the fruiting of some plants are 27 (16.36%).

Table 2: Effects of deforestation on the environment

Effects	Frequency	Percentage
Increase in temperature	**27**	**16.36**
High rate of evaporation	**45**	**27.27**
Increase in noise pollution	**14**	**8.49**
Destruction by wind	**74**	**44.85**
Global warming	**5**	**3.03**
Total	**165**	**100**

As the presence of vegetation helps to shield the soil from the direct ray of the sun so it helps to act as wind-brake. The absence of trees allows the free movement of wind, which, in most cases, destroys soils, properties and plants. Majority of the respondents [74 (44.85%)] were of the opinion that deforestation leads to destructions by wind. Another effect of deforestation on the soil is the high rate of evaporation which when vegetation is present will greatly reduce. The high rate of evaporation could be caused by high temperatures and the presence of wind, factors created by the absence of vegetation. The high rate of evaporation could lead to the wilting of plants when there is not enough of water supply for the plants to compensate for the amount that is given out through evapo-transpiration. Air quality and water use are related to crown density and tree density because the total leaf surface area and leaf surface area per unit of land area controls both air pollutant removal and evapo-transpiration rates (Mashi, *et. al.* 2014). About 27.27% of the respondents are of the opinion that deforestation leads to high rate of evaporation. It is generally asserted in technical literature that vegetation does serve, physiologically, to mitigate noise effects by screening-off virtually the adjacent noise source (Doran and Parkin, 1994). From this assertion, it follows that the absence of vegetation will increase the noise level in such situation, causing human discomfort. The respondents that agreed that deforestation leads to increase in noise are 8.49%. Global warming is the increase in the average temperature of the environment (atmosphere, oceans, and landmasses of earth). The increase in temperature that leads to global warming is as a result of deforestation among other factors that have led to the direct rays of the sun on the soil. The effect of the global warming on the soil or the environment generally can be felt in human health, weather, sea level rise and discomforts to animals and plants. The respondents that are of the view that deforestation has effects on global warming are 3.03%.

Effects of Biodiversity Loss

Biodiversity loss is the disappearance of animals and plants that make a balanced environment. Table 3 shows the various effects of biodiversity loss on the environment.

Table 3: Effects of biodiversity loss on the environment

Effects	Frequency	Percentage
Extinction of plant species	**25**	**51.02**
Extinction of animals species	**11**	**22.45**
Disappearance of medicinal herbs	**13**	**26.53**
Total	**49**	**100**

The effects of biodiversity loss can be felt in the plant and animal kingdoms of which man is the principal beneficiary. A total of 51.02% respondents agreed that biodiversity loss leads to the extinction of plant species, 11 (22.45%) are of 42 ew that biodiversity loss has effects on animals by leading to their extinction, while 13 (26.53%) opine that it leads to disappearance of medicinal herbs. The subsequent impacts of the effects of biodiversity loss is on man who directly and indirectly depends on animals and plants for his survival and the disequilibrium created in the environment as a result of truncation in the web system that sustains the ecosystem.

Effects of Soil Degradation and Erosion

Soil degradation is the reduction in the quality of the chemical composition of the soil while erosion is the gradual removal of the top soil by wind, water or ice depending on the prevailing environment in which it is occurring **(**Cambardella, *et. al.* 2004)**.** The effects of soil degradation and erosion on the soil are shown in Table 4.

Table 4: Effects of soil degradation and erosion on the environment

Effects	Frequency	Percentage
Bad land	**39**	**12.75**
Hard pan	**54**	**17.65**
Poor soils	**213**	**69.60**
Total	**306**	**100**

Bad Lands could be referred to as such lands that have been taken over by gullies, trenches, inselberg and isolated hills that are left behind as a result of resistance to erosion. Such bad-lands make it difficult for agricultural activities to take place. A total of 306 of the respondents that are into farming as their occupation are of the opinion that soil degradation and erosion have effects on soil quality, out of which 39 (12.75%) agreed that it leads to the development of bad lands in the environment. A proportion of 54 of the respondents are of the view that it leads to hard pan, an agricultural concept which relates to the hardening and covering of the pores that are on the surface of the land leading to runoff. While 213 (69.60%) are of the view that soil degradation and erosion leads to poor soils that subsequently affect the growth and survival of plants.

Effects of Desertification

Desertification is the decline in the biological or economic productivity of the soil resulting from the removal of the vegetal cover, human activities and variations in climate. Desertification refers to the formation and expansion of degraded soil. The various effects of desertification on the environment are shown in Table 5.

Table 5: Effects of desertification on the environment

Effects	Frequency	Percentage
Poor soil	**63**	**29.58**
Destruction by wind	**44**	**20.66**
Erosion	**89**	**41.78**
Increase in temperature	**17**	**7.98**
Total	**213**	**100**

Desertification leads to the formation of poor soils as the removal of vegetative cover and other human activities renders the bare and prone to erosion problems. Respondents that agreed it leads to the formation of poor soils and erosion problems were 63 or (29.58%) and 89 or (41.78%) respectively. Those that envisaged destruction by wind as a result of desertification were 44 (20.66%). Those that settled for increase in temperature as a result of desertification were 17 (7.98%).

The effects of agricultural activities on the environment are directly related to the nutrient content of the soil in the study area. Deforestation, soil degradation, soil erosion, biodiversity loss and desertification due to bad agricultural practices also have enormous negative effects on soil quality indices.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Basically, factors affecting soil quality maintenance in the study area are natural and man-induced. They include agricultural practices, deforestation, soil degradation and erosion, biodiversity loss and desertification. The following conclusions were drawn from the study: Soils in Mashi and Mai-adua local government areas may be concluded to be sensitive to plant growth while soils in Kaita local government area were concluded to be extremely sensitive to plant growth. From the results of the SAR tests, soils Mashi Local government area were concluded to have negligible amount of salt accumulation, with soils in Mashi and Kaita local government areas seeming to be increasing in amounts of salt accumulation. Despite the nutrient deficiencies in phosphorus, potassium, organic content and nitrogen in all the soils of the study area, the physical properties of the soil are still considered to be in good condition.

It is recommended that, since soil quality is significantly related to the various farm management practices, such farm management practices as mixed farming (to make animal dung and manure available), intercropping, mulching (to retain soil moisture and check excessive evaporation of soil water), tree planting and the use of check dams (to check erosions), planting of cover crops (to provide green manure) and the use of compost manure (to improve the level of soil nutrients) should be encouraged. Furthermore, due to the deficiency in phosphorus, potassium, organic content and nitrogen in the soils studied, application of fertilizers to boost these elements should be encouraged, just as regular use of irrigation water should be encouraged among farmers to reduce the effects of salt accumulation in the soils. This is taking into cognizance of several earth dams lying idle across the areas.

Similarly, the sodium content of the soils in the study area should be reduced to the barest minimum particularly those of Mashi and Kaita local government areas that are extremely sensitive to plant growth because of the levels of exchangeable sodium percentage (ESP), this may be achieved through extensive and regular irrigation . Soils in Kaita Local government area should be carefully managed especially by use of farm yard, organic and compost manures to reduce cases of impermeability. Regular soil testing is also recommended to assess possible sodium problems in the study area.

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