ASSESSMENT OF RELATIONSHIP BETWEEN PHYSICOCHEMICAL CONDITIONS OF ARABLE LAND AND PREVALENCE OF RICKETS DISEASE IN CHIKUN LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA

BY

JOHN KEHINDE BALOGUN

DEPARTMENT OF GEOGRAPHY,

AHMADU BELLO UNIVERSITY, ZARIA

NIGERIA

JULY 2016

ASSESSMENT OF RELATIONSHIP BETWEEN PHYSICOCHEMICAL CONDITIONS OF ARABLE LAND AND PREVALENCE OF RICKETS DISEASE IN CHIKUN LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA

BY

John Kehinde BALOGUN, B.Sc, GEOG (ABU) 2010
MSc/SCI/4925/2011-2012

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA

IN PARTIAL FULFILMENT OF THEREQUIREMENTS FOR THE AWARD OF MASTERS OF SCIENCE DEGREE IN GEOGRAPHY

DEPARTMENT OF GEOGRAPHY,
FACULTY OF SCIENCE
AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA

JULY, 2016

DECLARATION

I declare that the work in this thesis entitled Assessment of Relationship between Physicochemical Conditions of Arable Land and Prevalence of Rickets Diseases in Chikun LGA of Kaduna State, Nigeria, has been performed by me in the Department of Geography under the supervision of Prof. I. A. Jaiyeoba and Dr. R. O. Yusuf. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other Institution.

BALOGUN, JOHN KEHINDE

....
Name of Student Signature Date

CERTIFICATION

This thesis titled 'ASSESSMENT OF RELATIONSHIP BETWEEN PHYSICOCHEMICAL CONDITIONS OF ARABLE LAND AND PREVALENCE OF RICKETS DISEASES IN CHIKUN LGA OF KADUNA STATE, NIGERIA' by BALOGUN JOHN KEHINDE meets the regulations governing the award of the degree of Master of Science (Physical Geography) of the Ahmadu Bello University, and is approved for its' contribution to knowledge and literary presentation.

Prof. I. A. Jaiyeoba ....
Chairman, Supervisory Committee Signature Date

Dr. R. O. Yusuf ....
Member, Supervisory Committee Signature Date

Dr. A. K Usman ....
Head of Department Signature Date

Prof. K. Bala ....
Dean, School of Postgraduate Studies Signature Date

DEDICATION

This dissertation is dedicated to Almighty God who gave me the grace, wisdom and strength to achieve this success and my mother, Mrs. L.B. Balogun for her support and encouragement.

ACKNOWLEDGEMENT

I am most grateful to God for seeing me through this work. My profound gratitude goes to my supervisors, Prof. I. A. Jaiyeoba and Dr. R. O. Yusuf for their intellectual guidance, encouragement and the valuable amount of time they spent supervising this work. My sincere thanks go to brethren in the Chapel of Redemption, Good Foundation School of FCS, you made my stay worthwhile.

I am also thankful to my colleagues in the Department of Geography, namely; Ibrahim Wahab Jimoh, Grace Olubunmi Johnson, Grace Shiayet Ibrahim, Florence, Kehinde Adegbeye, Emmanuel Aruya, Maina Mamman and Daniel Okere, for your robust academic support as well as your kindheartedness.

I will not fail to mention friends like Adebayo Asorose, Freedom Joseph, Mama Dawa, Sim Haruna, Adati Anselm, Binta Galadima, Amayindi Aboki, Emmanuel Oguche, Ohaba J. Ohaba, Oluwatosin Adeyemi, Ocholi Edogbanya, Francois, Jesse T. Mamman, Stephen Akinwamide, Paul Abass, Ibrahim Musa, Becky, Moses I. Auza, Stephen Lazarus, John Galadima, Julius Oneoyekan, Jessica Kefas, Grace Davou, Ijabani James, Sedoo Shimaka'a and Matthew Habila my brother and roommate, your financial support, words, concerns, attention and prayers really helped to make this possible. You all made a huge difference.

ABSTRACT

This work is an assessment of the physicochemical conditions of arable land and prevalence of rickets disease. The aim of the study was to assess the relationship between the physicochemical conditions of arable land and prevalence of rickets in Chikun Local Government Area of Kaduna State, Nigeria. The set objectives were: to determine and compare some key physicochemical properties of arable land upland and Fadama (lowland) soils between rickets infected areas and non-rickets infected area; determine the level of calcium in the selected plant residues of the study area; and to establish the extent of dependency of calcium in the measured soil physicochemical properties.

30 soil samples were collected across the three communities of the study area during the dry season. Plant residues of maize, sorghum and rice were collected from the study areas of Kafari, Kaso Sarki and Tsohon Kaso. The samples were analysed in the laboratories of Institute of Agricultural Research (IAR) Samaru, Zaria and Multiuser Student Research Laboratory (MUSRL), Department of Chemistry, ABU, Zaria.

The soils of the study area range from moderately acidic to neutral as such leaching is prevalent in the study area. The calcium, Ca content varied between 1.52 to 4.56cmol/kg^{-1}as shown by the analysis of variance .The Magnesium, Mg content ranges from 0.77cmol/kg^{-1} to 2.3cmol/kg^{-1} and are prone to leaching though they seem moderate at the time of this research. The Potassium, K contents of the communities ranges from 0.10 to 0.24cmol/kg^{-1}. The soils are low in K, Ca and Mg but it does not seem that they are responsible for calcium deficient rickets. Due to inadequate comparable reference values, it was not possible to link the physicochemical properties of soils in the study area to calcium deficient rickets.

TABLE OF CONTENTS

DECLARATION i

CERTIFICATION iv

DEDICATION v

ACKNOWLEDGEMENT vi

ABSTRACT vii

TABLE OF CONTENTS viii

LIST OF FIGURES xii

CHAPTER ONE: INTRODUCTION 1

1.1 Background to The Study 1

1.2 Statement of Research Problem 4

1.3 Aim and Objectives of Study 8

1.4 Hypothesis 8

1.5 Scope of the Study 8

1.6 Justification of Study 9

CHAPTER TWO: CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW 10

2.1 Conceptual Framework 10

2.2 Literature Review 12

2.3 Prevalence of Rickets Around The World 15

2.4.1 Roles Of minerals, Vitamins To human health 17

2.4.1 Classification Of rickets diseases 19

2.4.2 Nutritional and hereditary rickets 20

2.4.2.1 Nutrition rickets 21

2.5 Clinical Characteristics of Rickets 23

2.6 Sustainable Land Management and The Tropical Smallholders 24

2.7 Soil Fertility and Sustainable Agriculture 26

2.8 Soil Calcium and Organic Matter as an Indicator of Sustainable Agriculture 28

2.9 Implication of Tropical Land Use Intensification for Land Degradation and Food Security and Health 33

CHAPTER THREE: STUDY AREA AND METHODOLOGY 35

3.1 Study Area 35

3.1.1 Location 35

3.1.2 Climate 36

3.1.3 Relief and drainage 37

3.1.4 Soils and vegetation 38

3.1.5 Population and socioeconomic activities 38

3.2 Materials and Methodology 39

3.2.1 Reconnaissance survey 39

3.2.2 Types of data 39

3.2.3 Sources of data 40

3.2.4 Detailed fieldwork 40

3.2.5 Soil and crop sampling 40

3.2.6 Laboratory analysis of soil and plant samples 41

3.2.7 Techniques of data analysis 41

CHAPTER FOUR: RESULTS AND DISCUSSION 43

4.1 Introduction 43

4.2 Status and Variability of Soil Properties 45

4.2.1 Texture 47

4.2.2 Organic carbon, nitrogen and available phosphorus 49

4.2.3 Exchangeable cations 51

4.2.4 pH and CEC 53

4.2.5 Exchangeable acidity 54

4.3 Relationship Between Ca and other Soil Properties 55

4.3.1 Organic carbon, nitrogen and available phosphorus 55

4.3.2 Exchangeable cations of K and Mg 55

4.3.3 pH and CEC 55

4.3.4 Exchangeable acidity 56

4.4 Summary of Variation of Ca and Relation to Incidence of Rickets 64

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS 66

5.1 Summary of The Study 66

5.2. Conclusion..... 68

5.3. Recommendation..... 69

LIST OF FIGURES

Figure 3.1 Map of the Study Area ----------

LISTS OF ABBREVIATIONS

FAO- Food and Agriculture Organization

ISM- Integrated Soil Management

MAWP- Mid Atlantic Water Program

SLM- Sustainable Land Management

SOM- Soil Organic Matter

W.H.O- World Health Organization

Avail. N- Available Nitrogen

Avail. P- Available Phosphorus

Exch. Ca- Exchangeable Calcium

Exch. Mg- Exchangeable Magnesium

Exch. K- Exchangeable Potassium

Exch. Na- Exchangeable Sodium

Exch. H+Al- Exchangeable Acidity

CEC- Cation Exchange Capacity

pH- value of soil acidity or alkanity

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Environmental challenges such as climate change, land degradation, deforestation, desertification, erosion, etc, are consequences of human exploration of the environmental resources (Rekacevicz, 2005, 2008). Historically, human activities have continually altered the landscape with attendant negative effects on land, soil and human health. Plato was credited to have written that the hills of Attica in Greece were "skeleton" of their selves because of deforestation at the height of the ancient Greek civilization (Botkin, Caswell, Estes and Orio, 1989). Deforestation was also recorded near East and the Roman Empire before the modern era (Perklin, 1989). However, the rate and consequences of such anthropogenic activities differ from place to place. Of the environmental resources, soil is perhaps the most susceptible to abuse. This is mainly because of its multi-functionality.

Soil is not only the basis for practically all of human food and livestock feed, and substantial basis for fibre and fuel, but also forms the spatial dimension for the development of human settlements. It provides raw materials, including water, minerals and construction materials. It forms an essential part of the landscape; it conserves the remains of our past and is itself a relevant part of our cultural heritage. Within apparently uniform geographic area, several major soil types may be identifiable; each with potential to supports a different range of functions and has a different vulnerability to the various pressures. Soil is however a limited resource, and unlike air and water, damage to it is not easily recoverable. While limited remediation of some functions can be made,

it is not renewable within the time span needed for its regeneration. Yet, its relevance to a wide range of human activities makes it more vulnerable to damage and depletion from many sides (Eswaran, Lal and Reich, 2001).

Physicochemical properties of soils are those characteristics of soils that concern the physical and chemical features of the soils (Dictionary.com, 2014). The physical properties of a soil are the result of soil parent materials being acted upon by climatic factors (such as rainfall and temperature), and being affected by relief (slope and direction or aspect), and by vegetation, with time (MAWP, 2006). The physical properties of soils are those related to the size and arrangement of solid particles, and movement of liquids and gases through soils. They include: texture, structure, density, porosity, consistency, temperature, colour, permeability and aeration. (Jaiyeoba, 2011). Soil chemical properties reflect the influence of the soil minerals and organic materials on the soil solution. The plant root obtains essential nutrients almost entirely by uptake from the soil solution; therefore the importance of soil chemical properties is vital and influences the growth and yield of crops. Chemical properties include: soil pH, cation exchange capacity (CEC), base saturation, anion exchange capacity (AEC). The chemical properties of soil determine its ability to supply available plant nutrients and affect its physical properties and the health of its microbial population. It also determines corrosivity, stability, and ability to absorb pollutants and to filter water (Buol, Hole, McCracken, 1973; MAWP, 2006).

Rickets is a disease that affects bones. It causes bone deformity and has been associated with inadequate mineralization in growing bones (Thacher, 2003; Pettifor, 2006). The Roman physician

Saramus reported deformation of the bones in children as far back as the first and second centuries A.D. He recognized those deformities as a consequence of improper nurturing and cleaning of the infants by the Roman mothers but did not directly implicate poor dieting (Claerr, 2008).Much of recent literature on the prevalence of nutritional rickets has come from those industrialized countries experiencing a resurgence of clinic presentations with rickets.

However, the greatest burden of the disease world-wide appears to be in Africa, the Middle East and Asia. Thereby inferring that the prevalence rates of these countries are greater than in Western countries and are of a magnitude that represents a global public health concern (Schoemakers, Laskey, de Bono, Ginty, and Goldberg, 2006; Prentice, 2008; Petttifor, 2012). In North Africa, the Middle East and India rickets have been linked with the cultural practices of clothing that prevents adequate exposure to sunlight. In sub-Saharan Africa, rickets is common in countries, such as Gambia, Ghana, Benin, Senegal, Tanzania, Kenya, Ethiopia, the Central African Republic, South Africa and Nigeria. Studies which distinguish between vitamin D and calcium deficiency have only been known to be conducted in South Africa and Nigeria with inferences that rickets had the nature of calcium deficiency (Thacher, Fischer, Strand, Pettifor, 2006).In the 1970s rickets was for the first time linked to low dietary calcium intakes (Pettifor, 2004).

There exists a strong link between soil health and human health (Sing and Sing, 2008). Pimentel, *et al.*, (2007) for example has attributed prevalence of several human diseases to pollution of water, air and soil. With rapid industrialization in China and other emerging economies, for example, soil pollution (e.g., Pb and As poisoning) has become a severe health concern (Chen, 2007; Qi, Yang, and Wang, 2007). Also in India, food crops grown on scalped soils are deficient in micronutrients.

Wind erosion can cause serious health problems by blowing soil particles and microbes into the air, aggravating allergies and asthma. Following large-scale deforestation, hookworm infection in Haiti increased from 0% to 12% of the population in 1990, and to 15% in 1996 (Lilley, Lammie, Dickerson, and Eberhard, 1997).

Occurrence of rickets in Nigeria among infants and children seems to be a consequence of calcium malnutrition (Laditan, 1975; Okonofua*et al*., 1991; Ekanem, Bassey, Eyong, 1995; Thacher, Ighogboja, Fischer, 1997), though, some evidences suggested that genetic factors may be partly responsible for rickets in some areas in Nigeria (Fischer, Thacher, Pettifor, Jorde, Eccleshall and Feldman, 2007). The issues surrounding rickets and soil nutrients deficiency are the focus of this study using Chikun Local Government area of Kaduna State.

1.2 Statement of the Research Problem

The Chikun local area is located in the southern part of Kaduna State, northern Nigeria and inhabited predominantly by the Gbagyi people. Because of proximity to the rapidly expanding city of Kaduna, where overwhelming majority of household still depend on subsistence agriculture and fuelwood for energy supply, the area is predisposed to various physical and biological forms of land degradation. In the past, as in most parts of Nigeria, the practice of slash and burn agriculture, in combination with shifting cultivation, was commonplace in the region. After a few years of cropping, the soil is left fallow for 10 – 20 years to restore its fertility. This makes more sense ecologically than mechanized clearing and subsequent large-scale agricultural production resulting in soil degradation.

In recent times however, the practice is coming under strain due to increasing population pressure and move from subsistence to market economy. The increased population pressure is as a result both of increase natural growth of the local population and the expansion of Kaduna. As a result, there has being and increasing shift to continuous cultivation in the region. Such land use changes and intensification, unfortunately, however, are not usually supported by increased farm input. The obvious results are: accelerated soil erosion and deterioration of soil nutrient status, altered hydrological regimes and sedimentation of wetlands and loss of forests and their biodiversity.

Thus, given the low adoption of soil and water conservation measures, smallholder farmers have continued to rely on depleting natural land resources for their living in the Chikun area of Kaduna. Although most farmers are aware that their soils are degrading and that soil degradation is the primary cause of declining productivity being experienced, not much interest has been shown in implementation of soil water conservation measures to sustain soil productivity. Across the study area, there are visible evidences of land degradation processes. The area is arguably one of the most infested by rickets in Nigeria, and possibly in the world. In some villages, as much as 40% of the children are clinically affected, and the figure is still increasing (Hartmaan and Sponholz, 2011).To date, however, only fragmentary information is available on the pattern of land use changes, and on the nature of rickets disease in the area.

The extent to which a given soil degrades depends on its relative sensitivity to degradation (Stocking and Murnaghan, 2001), which are in turn related to a combination of soil inherent properties and management history. This therefore implies that the quality status of a given soil

may differ spatially and temporally due to the history of management regimes. It has long been known for example that soil organic matter and other soil properties decline rapidly following forest clearance, burning and subsequent cultivation (e.g. Nye and Greenland, 1960; Lal, 1976). However, the rates and magnitudes of the declines are highly variable, depending on factors such as soil type, climatic condition and land use intensity (e.g. Tiessen, Cueva and Chacon, 1994; Tinker, Durall and Jones, 1994; Parfitt, Theng,Whitton and Shepherd, 1997). Nevertheless, in most part of Nigeria, few scientific studies have been made on soil quality and biodiversity changes following deforestation and land use intensification (Kuru, 1990), most especially in places like the Chikun area. Most of the available literatures are on rickets were with respect to Vitamin D.

Thus, while some information on the impact of deforestation and conversion to permanent cultivation on soil is available for some areas, and the rate of generation of such scientific information rapidly increasing, there is generally lack of quantitative information in many areas. The same is true for the nutritional and health impacts of such land use changes. Studies show that the occurrence of rickets in Nigeria among infants and children seems to be a repercussion of Calcium (Ca) malnutrition (Laditan, 1975; Okonofua *et al*., 1991; Ekanem, Bassey, Eyong, 1995; Thacher, Ighogboja, Fischer, 1997). Though, some evidences suggested that genetic factors may be partly responsible for rickets in some areas in Nigeria (Fischer, *et al*., 2007). Generally, it is agreed that Calcium intakes as well as high phosphorus intakes are the major factors. In Nigeria there is dearth of information on the mineral content of diets that form the staple foods which are mainly high in phosphorus. Therefore, it is imperative to evaluate the mineral contents of the soil in which the crops eaten as food are cultivated in so as to ascertain the best approach to curtailing the occurrence of the disease.

To date, there are possibly only two major reports on the link between physical characteristics and occurrence of rickets in the area. One was by Hartmaan and Sponholz (2011) and the other by Marvin (2012). The two separate studies centered on possible linkage of rickets disease in the region to the physical environment. The Hartmaan and Sponholz (2011) study compare calcium contents in rocks, soils, and drinking water, and maize cobs between rickets infested communities and non-rickets infested community, and concluded that values in the non-rickets area were moderately higher than those for rickets areas. In the study by Marvin (2012), the focus was on assessment of quality of arable and fallow soils and the conclusion reached then was that the fertility of such soils are low. In both studies, however, it was recommended that more studies are needed for a clear picture of the rickets-environment relationship in the region. It is such challenge of the need for expanded information on the landuse changes and attendant soil degradation, as well as the ecological relation of the rickets disease, in the region that provided the basis for this study.

The study attempt to answer the following questions in the cause of the study:

i. Is there a link between rickets disease and the physicochemical properties of the soil in the area?
ii. What is the level of significance of rickets to the physicochemical properties of soils of the area?
iii. How significant is the Calcium level of the soil in relation to the plant residue?

1.3 Aim and Objectives of the Study

The aim of the study is to assess the relationship between physicochemical conditions of arable land and prevalence of rickets disease in Chikun LGA of Kaduna State, Nigeria. The specific objectives of the study are to:

i. determine and compare some key physicochemical properties of arable upland and Fadama soils between rickets disease infected and non-infected areas;
ii. determine and correlate level of Ca in selected plants growing on the studied soils with those of the pedon.
iii. establish the extent of dependency of Ca on the measured soil physicochemical properties.

1.4 Hypothesis

The hypothesis derived from the aim and objective of the study are:

H_o (i) there is no significant difference in the level of Ca and other soil properties between the arable upland and Fadama land in the study area.

H_o (ii) there is no significant difference in the level of Ca and other soil properties between rickets infested and non-rickets infested communities in the study area.

1.5 Scope of the Study

Rickets have been known to be prevalent in most communities of the Chikun area. However, the spatial scope of this study is limited to the Gbagyi tribe which is the main dwellers of the settlement. Though, few Fulanis (herdmen) inhabit the area but there is no reported case of rickets among the Fulanis. Though, there is no findings to support the non-infestation of rickets among the Fulanis in the area but it could be as a result of calcium in their diary meals of milk, cheese,

etc. which are known to be rich in vitamin D and calcium (Raubenheimer and Noffke, 2011). The German-American based charitable organization, Hope for the Village Child, has since 2005 studied rickets in the area and therefore have established contacts with communities within the Chikun area. The breadth of the subject matter on the other hand is limited to the assessment of the physical and chemical properties of the surface and subsurface soils of both the arable upland and Fadama land, in rickets disease communities and non-rickets disease infested communities.

1.6 Justification of the Study

The challenges posed by rickets on human health in Nigeria and the study area calls for robust studies on the subject matter. Compared to treatment of affected children, prevention of rickets is clearly better for children, desirable for communities, and possibly less expensive for society. However, it is essential to identify the nature of the disease as well as the appropriate target population and their nutritional need before preventive interventions against rickets can be effective.

Globally, there has been renewed interest and attention on the roles of Vitamin D status and Calcium intakes in the prevention of rickets and osteoporosis. Nigeria as part of the global community has little research in this regard. Studies that focus on pattern of diseases and pests, in particular, rickets in the area in question, only began in 2011 by the German –American bases NGO, Hope for the Village Child, in collaboration with the University of Wurzburg in Germany. Ahmadu Bello University, Nigeria, joined the research team in 2012. The two most recent works on the subject matter in the area, cited earlier, represent essentially preliminary investigations in the area. This study represents yet another move towards establishing the ecological relation of

rickets in the area. Knowledge of the ecological relation of rickets disease is expected to provide sound basis for the management of the disease, including soil management, toward curtaining the disease in the area.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 Conceptual Framework

Dochukaev a foremost Russian scientist suggested a classification of soils based on scientific principles and was the first to examine their geographical distribution. He defined soil as an independent natural body developed over time under the influence of five soil-forming factors: parent rock, living organisms, climate, relief, and time. This has become a classic definition of

soil.Dokuchaev (1898) was probably the first to suggest a soil forming factor equation (Gerrard, 1992). The equation is taken basically as a symbolic expression or conceptual model and does not imply that it can be solved mathematically, thus: $S=f(cl,o,p)t^o$

where s = soil

cl= climate

o= organism

p= parent material

t^o= relative age (youthfulness, maturity, senility).

The equation was merely conceptual and cannot be solved in a mathematical sense. Relief was not included in Dokuchaev's equation but he acknowledged it as important in the formation of azonal soils. Relief was later added to the soil forming factors equation by Jenny (1941) and the equation became: S= f (cl, o, r, p, t……)

where s = any soil property

cl= climate

o= organisms

r= relief

p= parent material

t= time.

According to the canons of the Russian pedological school, the diagnostics, taxonomy, and nomenclature of soils are based on the following principles:

i. profile method: soil profile is an integral unity of interrelated and interdependent genetic horizons;

ii. integrated approach: soil diagnostics include analysis and description of a number of properties and indicators (morphological, physical, chemical, physicochemical, biological, and mineralogical);

iii. comparative geographical analysis based upon soil-forming factors (vegetation cover, climate, weathering crusts, and geochemical landscapes.

iv. genetic aspect: primary use of properties and indications connected with the origin and history of soils related to the general geological history and paleogeography of a given area. This approach uses a degree of expression and differentiation of soil profile accumulation or loss of separate compounds, and transformation of the soil-forming material (Complete Dictionary of Scientific Biography, 2008).

These are the underlying principles guiding soil survey generally. Hartmaan and Sponholz (2012) and Marvin (2012) employed the use of this concept in their works. This study therefore adopts it too. Thus, this study is based on the major assumption that soil degradation promoted by continuous cultivation under low input agriculture is the major predisposing factor of rickets disease in the study area. The method of investigation adopted in this study thus involve comparing soils and plants of two rickets affected villages with the third village where rickets disease does not manifest.

2.2 Literature Review: The Rickets Disease in Transition – Historical Perspective

Rickets is a disease that affects bones. It causes bone deformity and has been associated with inadequate mineralization in growing bones (Thacher, 2003; Pettifor, 2006). The Roman physician Saramus reported deformation of the bones in children as far back as the first and second centuries A.D. He recognized those deformities as a consequence of improper nurturing and cleaning of the

infants by the Roman mothers but did not directly implicate poor dieting (Claerr, 2008). Daniel Whistler (1619-1684) wrote a thesis in 1645 on rickets for the degree of MD in Leyden. The work gave the earliest known chemical description of the disease such as enlargement of the head, the epiphyses and the abdomen, the rickety rosary and "the whole bony system… flexible like wax that is rather liquid, so that the flabby and toneless legs scarcely sustain the weight of the super imposed body, so that the tibiae yield to the weight of the fabric pressing down on them from above and bent; and for the same reason that the thighs above are curved and the back, through the bending of the spine, projects hump fashion in the lumbar region so they are too feeble to sit up, much less to stand when the disease is increasing…" The teeth are cut late; other accompaniments are narrowness of the chest prominence of the sternum and asymmetry. Whistler thought the disease had an antenatal origin and he basically put forward that too much alcohol by a mother could cause rickets in infants (Dunn, 1998).

According to Dunn, (1998) Francis Glisson (1597-1677) published a treatise in 1650 titled "De Rachitide" acknowledging the help of seven other physicians which together with him belonged to a small group of doctors and distinguished scientists who met weekly to discuss natural and experimental philosophy. The English edition of the treatise was edited by Nicholas Culpeper (1616-1654) in 1651. Glisson stress the fact that rickets affect the anatomy of it victims. He was first to delineate infantile scurvy from rickets. Glisson also put forward that rickets were neither congenital nor inherited, were not contagious nor caused by syphilis. His work was based mainly on observations. He was unable to determine the cause of rickets. The closest he got to a nutritional

cause was to blame excessive feeding with its resulting indigestions adding (Dunn, 1998; Claerr, 2008).

By the 19th century rickets was present in urban Britain as well as northern European countries. Descriptions of its physical signs were alluded to by findings of early Chinese, Greek, and Roman texts. It seems it became common in England around 1600 when atmospheric pollution by coal smoke first became severe. At that time, the appearance of rickets as a new disease was noted by Daniel Whistler and Francis Glisson. They described its uneven geographical distribution: it was prevalent among commoners in the south and west of the country than in Scotland and the north (Brimblecomble, 1987; Kiple, 1993). This was attributed to urbanization which followed the industrial revolution. Cities were overcrowded, unplanned, smoke reduced the amount of vitamins that people absorbed from the sun. The smoky environment resulted in women and children spending more time indoors. The deprivation of sunlight was compounded by poor diets and poor children practices (Mosley, 2001). Efforts were made forward finding a cure for rickets. In 1889 at the London zoo, lion cubs were fed with boneless lean meat. Some of the cubs developed florid rickets and were treated by the addition of cod liver oil and crushed bones to their meal. This made the cubs to fully recover (Claerr, 2008). Combs (1998), also gives credence to the fact that by 1800s sunlight and cod liver were used for the treatment of rickets. By early 1900s vitamin D was extracted from cod-liver oil and used for the treatment of rickets. Preventive measure such as fortification of milk with vitamin D was also taken in 1918 (Rajakumar, 2003; Thacher, 2010).

2.3 Prevalence of Rickets around the World

Rickets was at a point common in Europe until the mid-20th century. It was prevalent in England to the extent that it was referred to as 'The English Disease'. The seminal work of pioneers such as Harriette Chick and Elsie Dalyell demonstrated that this was due to vitamin D deficiency (Carpenter, 2008). Rickets cases have been reduced to the barest minimum in the UK since the 1950s due to the clean air legislation, food fortification and public awareness (The Stationery Office, 2007). Though, recently a resurgence of rickets cases has been reported from the major cities in the UK and some Northern European countries especially among children who are of South Asian, African, Afro-Caribbean or Middle-Eastern origin (Ashraf, Mughal, 2002; Odeka, 2005;Ahmed, Franey, McDevitt, Somerville, Butler, Galloway, Reynolds, Shaikh, Wallace, 2011).As at 2006, there are no national statistics on the prevalence of nutritional rickets in the UK but there was considerable concern that there was a widespread problem despite public health recommendations for pregnant women, children and those with restricted sunshine exposure to consume a daily vitamin D supplement (The Stationery Office, 2007).

Much of recent literature on the prevalence of nutritional rickets has come from those industrialized countries experiencing a resurgence of clinical presentations with rickets.

However, the greatest burden of disease world-wide appears to be in Africa, the Middle East and Asia. Thereby inferring that the prevalence rates of these countries are greater than in Western countries and are of a magnitude that represents a global public health concern (Schoemakers, Laskey, de Bono, Ginty, and Goldberg, 2006; Prentice, 2008; Petttifor, 2012). In North Africa, the Middle East and India rickets have been linked with the cultural practices of clothing that prevents adequate exposure to sunlight. In sub-Saharan Africa, rickets is common in countries such as

Gambia, Ghana, Benin, Senegal, Tanzania, Kenya, Ethiopia, the Central African Republic, South Africa and Nigeria. Studies which distinguish between vitamin D and calcium deficiency have only been known to be conducted in South Africa and Nigeria with inferences that rickets had the nature of calcium deficiency (Thacher, Fischer, Strand, Pettifor, 2006).

In the 1970s rickets was for the first time linked to low dietary calcium intakes (Pettifor, 2004). It has become increasingly clear that poor calcium diet plays a crucial role in causing rickets in the low latitudes. In Nigeria rickets does not occur mainly due to deficiency in vitamin D but also attributed to little or diminished intake of calcium (Okonofua, Gill, Alabi, Thomas, Bell and Dandona, 1991). Till the 1990s calcium insufficiency was not generally accepted as the reasonable cause of rickets (Barness, 1996). Though, Pettifor, Ross, Wang, Moodley and Couper-Smith, (1978).Okonofua, *et al.*(1991) had reported that calcium deficiency was possibly linked to rickets in South Africa and Nigeria, yet most scholars still attributed rickets to vitamin D deficiency. Accumulation of evidence by the late 1990s confirmed that low intake of calcium was connected to the development of rickets (Ogini, 1996; Bishop, 1999; Thacher, Fischer, Pettifor, Lawson, Isichei, Reading, 1999).

Occurrence of rickets in Nigeria among infants and children seems to be a repercussion of calcium malnutrition (Laditan, 1975; Okonofua et al., 1991; Ekanem, Bassey, Eyong, 1995; Thacher, Ighogboja, Fischer, 1997). Though, some evidences suggested that genetic factors may be partly responsible for rickets in some areas in Nigeria (Fischer, Thacher, Pettifor, Jorde, Eccleshall and Feldman, 2007). Generally, it is agreed that calcium intakes as well as high phosphorus intakes are the major factors. In Nigeria there is dearth of information on the mineral content of diets that form

the staple foods which are mainly high in phosphorus. Therefore, it is imperative to evaluate the mineral contents of the soil in which the crops eaten as food are cultivated in so as to ascertain the best approach to curtailing the occurrence of the disease.

2.4.1 Roles of minerals, vitamins to human health

The nutritional health and well-being of humans are entirely dependent on plant foods. Plants are critical components of the dietary food chain in that they provide almost all essential mineral and organic nutrients to humans either directly, or indirectly when plants are consumed by animals, which are then consumed by humans. Because plants are autotrophic, they can acquire elemental compounds and convert these into the building blocks (e.g. amino acids, fatty acids, nucleic acids, secondary metabolites) needed to make all complex macromolecules necessary to support plant growth and reproduction. Humans, on the other hand, require many of the same mineral nutrients as plants, but have additional requirements for various complex organic molecules. With the exception of vitamins B12 and D, a plant-based food supply can ensure the adequate nutrition of humans at all stages of life.

Not all plant foods, however, contain all the essential nutrients needed for human health, nor do they usually contain given nutrients in sufficiently concentrated amounts to meet daily dietary requirements in a single serving. For instance, seed foods are good sources of carbohydrates, proteins, lipids, and lipid-soluble vitamins, but tend to have low concentrations of Fe and Ca. Leafy vegetables are good sources of most minerals and vitamins, but are less nutrient dense with respect to protein and carbohydrates. Fruits provide carbohydrates, water-soluble vitamins, and various carotenoids, but generally are minor (Grusak and Dean, 1999).

Many people do not consume sufficiently diverse diet. In the developing world, many low-income families exist on a simple diet composed primarily of staple foods (e.g. rice, wheat, maize) that are poor sources of some macronutrients and many micronutrients (Calloway, 1995). As a result, recent estimates are that 250 million children are at risk for vitamin A deficiency (of which 250,000–500,000 will suffer irreversible blindness every year), 2 billion people (33% of the world's population) are at risk for iron deficiency (infants, children, and women of reproductive age are particularly vulnerable), and 1.5 billion people are at risk for iodine deficiency (FAO, 1997).Vitamin D deficiency continues to be common in children and adults. It has been estimated that 1 billion people worldwide have vitamin D deficiency (Hollick, 2007). A recent survey in the UK showed that more than 50% of the adult population has insufficient levels of vitamin D and that 16% have severe deficiency during winter and spring. The highest rates were found in Scotland, Northern England and Northern Ireland (Pearce and Cheetham, 2010). One study found the prevalence of rickets in non-Caucasian children to be 1.6% (Ashraf and Mughal, 2002).

In addition to water and oxygen, humans require an energy supply that can be obtained from a mixture of carbohydrates, lipids, and protein (amino acids), as well as 17 mineral nutrients and 13 vitamins. Among the lipids, linoleic acid and linolenic acid cannot be synthesized by humans (Innis, 1996), and must be gotten from dietary sources. Nine essential amino acids must be obtained in various amounts from ingested protein (Linder, 1991), which also provides dietary sulfur and nitrogen. The 15 remaining essential mineral nutrients and 13 vitamins are required in varying amounts.

Dietary standards have been around for over 100 years, and were initially developed as recommendations to alleviate starvation and associated nutrient deficiency diseases during economic and wartime crises (Harper, 1985; Harper, 1987). Vitamins, minerals, and other dietary constituents at varying levels are now known to be significant contributors to the reduction of risk of chronic diseases such as cancers, cardiovascular diseases, and degenerative diseases associated with aging (Kehrer and Smith, 1994; Steinmetz and Potter, 1996; Buring, and Henneken, 1997; Tangney, 1997; World Cancer Research Fund, American Institute for Cancer Research, 1997;Bingham, Atkinson, Liggins, Bluck and Coward, 1998), in addition to alleviating the classical nutritional deficiency diseases.

Plant foods can contribute significantly to human nutrition and health, because they contain almost all essential human nutrients. Many vitamins and minerals are lost or greatly reduced in concentration during cooking, storage, or processing (Salunkhe and Desai, 1987). Therefore, enhancing the nutrient concentration of many plant food products would contribute significantly to human nutrition and health.

2.4.2 Classification of rickets diseases

Rickets can be classified into three main types depending on the biochemical profile: calciopenic, phosphopenic and inhibited mineralization (Mughal, 2011; Pettifor, 2012). Typically, calciopenic rickets is associated with an elevated plasma parathyroid hormone concentration (PTH) in response to low plasma calcium, which results in internalization of phosphate transporters in the kidneys and decreased renal phosphate reabsorption. Phosphopenic rickets is associated with a

chronically low plasma phosphate with normal PTH and results from increased production or gain-of-function of FGF23, a Phosphaturichormone, or from renal disorders that compromise Phosphate reabsorption. In both cases the result is urinary phosphate loss and hypophosphatemia, leading to reduced apoptosis of hypertrophic chondrocytes in the growth plate and rickets.

The third category, inhibition of mineralization, refers to rickets where the mineralization process in the growth plate is directly affected and typically the plasma concentrations of calcium and phosphate are normal. There are a variety of underlying causes responsible for the various forms of rickets, including genetic disorders, such as autosomal dominant hypophosphatemic rickets(ADHR) and X-linked hypophosphatemic rickets (XLH), tumors, organ malfunction, drugs and exposure to toxic agents such as aluminum and fluoride (MRC Human Nutrition Research, 2013).

2.4.3 Nutritional and hereditary rickets

Various reasons have been put forward to cause rickets these include: vitamin D deficiency gastrointestinal tract disorders, disorders of vitamin D metabolism, calcium deficiency, acidosis, chronic renal failure, phosphate depletion, generalized renal tube disorders, primary numeralization defects, states of rapid bone formulation with or without a relative defect in tone reabsorption, defective matrix synthesis - fitrogenesisimperfectaossium, etc (Kitz, Ebert, Jacob, Raab, 2012)

The reasons are broadly due to: hereditary syndromes renal diseases, use of medication and nutritional deficiency (Craviari, Pettifor, Thacher, Meisner, Arnand and Fischer, 2006). These reasons are further examined.

2.4.3.1 Nutrition rickets

Nutrition rickets is prevalent throughout much of the developing world and have increased in the developed countries of the world (Thacher, Fischer and Strand, 2006). There is increasing evidence that dietary calcium intakes play a role in the pathogenesis of nutritional rickets (Pettifor, 2005). There is also an awakened interest and attention on the roles of vitamin D status and calcium intakes in the prevention of rickets and osteporosis, reduction of cancer risk, immune related disorder and infectious diseases (Holick, 2004).

Calcium and Phosphate are known to enter the body through nutrition and are partly absorbed in the intestines. The unabsorbed parts leave through the gastrointestinal tract; the whole process of metabolism also includes excretion via the kidneys. Gains and losses of such nutrients in adults are optimally in balance, whereas children intake needs to exceed excretion (World Health Organization, 2004).

Nutritional rickets is frequently seen in many parts of the world. Vitamin D deficiency decreased exposure to sunlight or cultural habits block exposure to sunlight, calcium deficiency has emerged as an important cause of rickets in parts of Africa and Asia. (Craviari et.al, 2006).

Nutritional rickets is reported in at least 59 countries in all latitudes since 1987. Diverse reasons are responsible for this. In North Africa, Middle East and Asia (India) rickets have been associated with the cultural implications of clothing that prevents sunlight exposure.Studies in some sub-Saharan African countries revealed that rickets is associated with Calcium-deficiency. Dietary intake in those countries were found to be low-which inferred that calcium-deficiency is most

likely responsible for rickets (Thacher, *et.al.*,2006).

2.4.3.2 Genetic form of rickets (hereditary rickets)

Rare forms of rickets can be inherited and passed from a parent to a child. X-linked hypophosphatemic rickets is a hereditary disorder in which the kidneys and bones deal abnormally with phosphate. This leaves little phosphate in the blood and bones causing weak and soft bones. "Hypophosphatemic" means there is a deficiency of phosphates in the blood due to excessive excretion of phosphates in the urine. The physical signs of rickets such as bowed or knocked-kneed legs are present. Unlike most other forms of rickets, the calcium levels of patients with X-linked hypophosphatemic rickets are usually normal (Kloesel, 2002, Thacher*et.al*, 2006).

Patients have a problem assimilating and using calcium and phosphorus due to inadequate activation of vitamin D, which results in soft and deformed bones. If inadequately treated in childhood, a middle-aged patient often experiences painful cracks in bones, osteoarthritis brought on by premature wear in the knees and hips, and calcification in the membranes around the joints and between bones. Dental problems, particularly unexplained abscesses in primary teeth, also are a common sign of the disease. X-linked hypophosphatemic rickets is genetically transmitted due to a defect carried on the X, or female, chromosome. The condition is passed from affected fathers, to all of their daughters, but none of their sons, or from affected mothers with a 50 percent risk to their children of either gender.

The treatment for X-linked hypophosphatemic rickets consists of phosphorus and activated vitamin D (calcitrol) by mouth. Due to the quick loss of phosphorus in the urine, there is need for

the frequent replacement about four or five times a day. Initially, the daily doses of phosphorus and activated vitamin D are based on body weight – about 70 milligrams per kilogram of body weight for phosphorus and 20 nanograms per kilogram of body weight for calcitrol Early detection is vital to treatment children treated before walking age have the best chance of recovery, (Kloesel, 2002).

2.5 Clinical characteristics of rickets

Clinical characteristics of rickets disease may result in occurrence of craniotabes, in which the bones of the skull soften and flattening of the posterior skull can be seen. These effects may be transient or permanent. Another feature is the prominence of the frontal bones and the major foramen, resulting in frontal bossing or a prominent, sometimes square, forehead (caput quadratum). Teeth may erupt later than normal because of under mineralization. Enamel can be of poor quality, resulting in caries. Rickettic rosary-The enlarged ends of the ribs, resembling beads, can be palpable and visible at costochondral junction. As a result, the sternum can become more prominent, leading to pigeon breast or pectuscarinatum appearance (Kloesel, 2002; Kitz, C., Ebert, R., Jacob, F., Raab, P, 2012).

Harrison groove- The groove is a semicoronal impression over the abdomen at the level of the insertion of the diaphragm which can be seen in rickets.

Spine- A mild to more pronounced scoliosis may be seen as a result of rickets.

Pelvis- A prominent promontory can be found, and the anteroposterior (AP) diameter of the pelvis can shrink as a result of scoliosis. If this persists in girls, it can cause complications later in life during childbirth (Kitz, et.al, 2012).

Extremities

Arms- Bowing of the long bones, as a reaction to greenstick fractures, results from concurrent osteomalcia.

Thickening of the wrist at the level of the epiphysis is not visible radiographically, since the lesion consists of cartilage, although fraying and cupping of the metaphysic is evident.

Legs – Bowing of the long bones (genu varum) as a result of weight bearing is typical. Anterior bowing of the tibia (saber shin deformity) may occur. Development of knock-knees (genu valgum) may occur because of displacement of the growth plates during active disease. Thickening at the level of the ankle may occur, identical to the process in the wrist.

Ligaments and muscles- Laxity in the ligaments is increased, and muscle tone is decreased. This combination leads to a delay in motor development (Kloesel, 2002; Kitz, et.al, 2012).

2.6 Sustainable Land Management and the Tropical Smallholder

Sustainable Land Management, SLM can be defined as "the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions" (Food Agriculture Organization, 1992).

Sustainable Land Management is vital to meet the requirements growing population. Improper land management can result in land degradation and a significant reduction in the productive and service (biodiversity niches, hydrology, carbon sequestration) functions of watersheds and

landscapes. Sustainable land management is important for enhancing and sustaining productivity food and fibre systems globally. The world's highly productive grain, livestock, and forestry products systems need to be sustained and made more efficient in terms of reduced environmental impact (FAO, 1992).

Smallholding farm landscapes in the tropics contrast strongly with industrial monocropped agribusiness, fenced-off protected areas, and state-owned forests. These diverse landscapes—think of the terraced rice fields and farm forests of southeast Asia, the multi-storied gardens of Caribbean or Pacific islanders, or African rain-fed maize, cassava, or millet farms—are celebrated for their contributions to food security, for their preservation of a diverse array of crop varieties, for their role in local culture, or for their aesthetic appeal (Netting, 1993; Clarke and Thaman, 1997).The typical smallholder farming landscape of the tropics includes a variety of favorite widely dispersed introductions (like banana, mango, cassava, and eucalyptus) with regional cultivars and native species. Alien plants are often the chief source of food, fiber, and construction wood for subsistence and cash income. Yet these plants—like the agroforestry trees *Prosopis*, *Leucaena*, and *Acacia*—sometimes become problematic weeds, or escape into nearby natural or secondary vegetation, and negatively affect agriculture, aesthetics, or native biodiversity (Robbins, 2001, Tassin, Rangan and Kull, 2012).

Smallholder farming landscapes in the tropics are recognized for maintaining and improving soils and biodiversity—particularly when compared to large-scale agribusiness. Farmers have long sought out alien plants to help restore or improve soil fertility—this inspired the diffusion of clover across Europe in the past, and today's agronomic research into leguminous plants (Kaergaard, 2003).

Rural smallholder farming communities are active creators and stewards of landscapes. They try out new plants; they exchange seeds and cultivars with friends and family (Coomes, 2010). They react to new plant arrivals, seeking to make best of opportunities, develop practical knowledge about the plants, surmount obstacles, and guide the landscape into an acceptable future. They are neither passive victims of invasive aliens, nor indiscriminate spreaders of weeds, and as such may regard as unjust certain well-meaning but disempowering interventions such as blanket invasive alien eradication programs (Shackleton, Mc Garry, Fourie, Gambizia, Shackleton, Fabricius, 2007).

2.7 Soil Fertility and Sustainable Agriculture

Soil is the natural medium for the growth of plants and it is doubtful that soilless agriculture will ever be a cost effective alternative for the production of the bulk of the food and fiber needed. For at least the foreseeable future the world will continue to rely on soil for agriculture. Soil fertility is an important factor, which determines the growth of plant. Soil fertility is determined by the presence or absence of nutrients i.e. macro and micronutrients. Mineral nutrients increase plant productivity, leaf and grain yield. Deficiencies of it could drastically affect the growth, metabolism and reproductive phase in plants, animal and human beings (Nazif, Perveen and Saleen, 2006).

Modern science helps to have a fairly sophisticated understanding of the nutrient requirements of plants. Science has identified some twenty (20) nutrient elements that are essential for the growth and reproduction of plants. Plants obtain three (3) of these elements - carbon, hydrogen, and oxygen - from the air and water. Although these elements are extremely important, (for most plants, 94 percent or more of their dry tissue is composed of these three elements) there is really not much that can be done to improve or manage their availability. The other elements combined

represent less than 6 percent of the plant dry matter but crop production is frequently reduced and growth limited by a deficiency of one or more of these (Aglearn.net, 2004).

These essential elements are generally divided into two groups. The macronutrients are nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), and magnesium (Mg). The second group of essential elements is called micronutrients (or sometimes ‘minor’ or ‘trace’ elements) because those elements are required in small (micro) amounts by plants. They include manganese (Mn), iron (Fe), boron (B), zinc (Zn), copper (Cu), molybdenum (Mo), chlorine (Cl), cobalt (Co), nickel (Ni), sodium (Na) and silicon (Si) (Aglearn.net, 2004; MAVP, 2006).

Fertile soil is characterized by ongoing complex interactions involving decomposition of rocks, organic matter, animals, and microbes to form inorganic nutrient ions in soil water. Roots absorb these mineral ions if they are readily available and not 'tied up' by other elements or by alkaline or acidic soils. Soil microbes play a critical role in ion uptake and in the cycles that permit nutrients to flow from the soil to the plant. The microbiological community of the soil system around the roots breaks down the available organic material in the soil into a usable form that the plant root system can readily absorb (Aglearn.net, 2004).

Low soil fertility, which is a major constraint to increased food production in Africa, is a factor of natural and socio-economic aspects and is itself a large contributor to poverty and food insecurity. Approximately 65% (121 million hectares) of Africa’s total land (187 million hectares) is degraded. Rates of nutrient depletion are particularly high in areas with favourable climates for crop production and high population densities. There is also high macronutrient loss as compared to application with many cropping systems reporting negative nutrient balances. For example,

whereas 4.4 million tonnes per year are removed, only 0.8 million tonnes per year are applied, hence production takes place at the expense of the soil natural capital. Similarly, annual losses of K of up to 7% at farm level have been noted in semi-arid tropics of Africa (Bationo, Vanlauwe, Kihara and Kimetu, 2003).

Low productivity of agriculture is related to the low quality of the soil resource base which on one hand has been due to inherent or induced deficiencies of major nutrients N, P, and K or low nutrient holding capacities, high acidity and low organic matter. Other constraints include low capacity for water retention, high P fixation and high erodability and flooding (Van Pueler and Prins, 1993). On the other hand low soil fertility is driven by socio-economic factors, which include macro-economic policies, unfavorable exchange rates, poor producer prices, high inflation, poor infrastructure and lack of markets. These multiple causes of low soil fertility are strongly inter-related including the interaction between biophysical and socio economic factors and hence need for a holistic approach in ameliorating the soil fertility constraints in sub-Saharan Africa (Bot and Benites, 2005).

2.8 Soil Calcium and Organic Matter as an Indicator of Sustainable Agriculture

2.8.1 Soil Calcium

Calcium is a macronutrient and liming element associated with minerals such as feldspars, calcite, apatite, dolomite, gypsum and amphibole. Most economic crops yield best in soils where calcium ion dominates the exchange complex (Isirimah, Dickson and Igwe, 2003) as abundance in soils indicates near-neutral soil pH desirable by both crops and microorganisms. Exchangeable calcium

is considered high if it is greater than 10cmol kg^{-1} while low if it is less than 4.0cmol kg^{-1} (Landon, 1991).

Calcium is an essential part of plant cell wall structure and provides for normal transport and retention of other elements as well as strength in the plant. It influences water movement; cell growth and division and is required for uptake of nitrogen and other minerals. Calcium is not translocated within the plant so an adequate supply through the season is very important for sustained terminal and root growth. Calcium is essential for cell elongation and division. It is required for root and leaf development, function and cell membranes, formation of cell wall compounds and it is involved in the activation of several plant enzymes. Symptoms associated with Ca deficiency include stunting of new growth in stems, flowers and roots; black spots on leaves and fruit and yellow leaf margins. Calcium is a divalent cation whose movement is relatively low when compared with anions and other cations such as potassium or sodium.

Calcium plays a role of regulating of various cell functions one of such function is in the regulation of the protein pump that regulates the uptake and movement of nutrients into the root and throughout cells within the plant. At the root level calcium activates stimulation of protein channels that take up nutrients. Calcium is able to mitigate heat stress effects by improving stomatal function and other cell processes; calcium is also believed to have an influence on the development of heat shock proteins that help the plant tolerate the stress of prolonged heat.

Most organisms that infect plants do so by penetrating the cell tissue with enzymes known as *pectinase*, which dissolves *pectins*. The higher the concentration of pectins holding cells together the greater the ability to withstand these enzymes. In some cases, the pectinase that the pathogen

secretes is oxalic acid which sequesters calcium from the leaf to form calcium oxalate. Calcium plays a major role in certain crops thereby impacting on the quality and shelf life. For instance, deficiency of calcium in carrot results in cavity spot; in cabbage its deficiency causes internal tip burn and club root; calcium deficit in pepper, tomatoes and watermelon is shows blossom end rot, etc. (MAWP 2006; Hodges, 2010).

2.8.2 Soil organic matter

To secure food supply for the increasing population there is an urgent need to intensify the agricultural production especially in less developed countries of the tropics. There, soils are frequently poor and not suitable for intensive sustainable agriculture because low organic matter contents and minerals with low cation exchange capacity favor nutrient leaching.

Soil organic matter consists of living parts of plants (mainly roots), dead forms of organic materials (mainly dead plant parts), and soil organisms (microorganisms & soil fauna) in various stages of decomposition. Soil organic matter is one of the best indicators of soil quality because it impacts the biological, physical and chemical properties of the soil. Soil organic matter is defined as the soil fraction derived from materials of plant and animal origin. It includes these residues in various stages of decomposition, soil organisms, and their synthesized by-products. Since soil organic matter is derived mainly from plant residues, it contains all of the essential plant nutrients. Accumulated organic matter, therefore, is a storehouse of plant nutrients. Upon decomposition, the nutrients are released in a plant-available form. The stable organic fraction (humus) adsorbs and holds nutrients in a plant available form (Aglearn.net, 2004). Most soil organic matter originates from plant tissue. Plant tissues contain 60-90% moisture. The remaining dry matter

consist of Carbon (C), Oxygen(O), Hydrogen (H) and small amount of Phosphate (P), Potassium (K), Calcium (Ca) and Magnesium (Mg). Though, these nutrients are present in small amounts they are vital from the viewpoint of Soil fertility management (Bot and Benites, 2005)

While there is not yet a consensus on exactly how to measure soil quality, there is little disagreement that organic matter content gives soils many of their desirable properties. Organic matter is important to soil structure and soil cultivation. It provides energy for soil microorganisms, improves water infiltration and water holding capacity, reduces erosion potential and is an important element in the nutrient and carbon cycles. Organic matter is the adhesive of the soil, binding together the soil components into stable aggregates. It is widely considered to be the single most important indicator of soil quality and productivity. Soil organic matter plays a critical role in soil processes and is a key element of integrated soil management (ISM). Almost all integrated soil management technologies are dependent on Soil organic matter for their full success. Also soil organic matter content can be used to set critical values that can help to make decisions when implementing ISM programs. The SOM and ISM relation is tricky, SOM build up is ISM dependent and ISM efficacy is SOM dependent (Aglearn.net, 2004).

Soil organic matter consist of a continuum of components ranging from labile compounds that mineralizes rapidly during the first stage of decomposition to more recalcitrant residues (difficult to degrade) that accumulate as they are deposited during advance stages of decomposition as microbial by-products(Duxbury, Smith & Doran, 1989). Some of the important functions of soil organic matter are:

i. It increases soil fertility as it retains cations and conserves nutrients in organic forms and slowly releases required nutrients for plants uptake and growth.
ii. It binds soil particles together; cementing and aggregation functions improving soil structure and aeration.
iii. It acts as a sponge in the soil, therefore retaining soil moisture. Soil with high organic matter content can more water than those low in organic matter.
iv. It provides food for living organism living in the soil (Aglearn.net, 2004; Bot and Benites, 2005).

Organic matter affects the overall health of soils. Properties such as soil structure, moisture holding capacity, diversity and activity of soil organisms, both those harmful and beneficial to crop productions, and availability of nutrient are all influenced by the organic matter of soil. It also influences the effects of chemical amendments, fertilizers, pesticides and herbicides (Brown, Anderson, Woomer, Swift and Barrios 1994; Aglearn.net, 2004; Bot and Benites, 2005).

Organic inputs are also major sources of energy and nutrients for soil microbial communities which promote soil aggregation and nutrient buffering capacity. However, the use of organic materials to increase the carbon reserves of soil under tropical conditions requires large amounts of annual additions. Approximately 7 t ha-^{1} year^{-1} dry matter of low quality residues (roots, stems) or10 t ha^{-1} year^{-1} of high quality residues (green manure leaves) are required to maintain a 1.0% organic C level in a sandy loam soil in the sub-humid tropics (assuming 0.05 fraction decomposed per year, Janssen, 1993). Typical biomass production in on farm trials comparing agroforestry species is around2±4 t ha-

^{1}year^{-1}. Often biomass production is less than 1 t ha^{-1} year^{-1}in the first year of establishment and in drought years of hedgerow intercrop systems (Saka, Phoemebya, Itimu, Jones, Minae and Snapp, 1995). Thus it is difficult to produce adequate organic materials under smallholder farm conditions to build or maintain soil organic matter (SOM). The level of soil organic matter that is sufficient to support crop production is an area of intense debate. Long-term experiments conducted in the semi-arid zones of West Africa (Pieri, 1995) suggest that a "sufficient soil organic matter", below which severe physical degradation will occur, is related to soil texture.

2.9 Implication of Tropical Land Use Intensification for Land Degradation and Food Security and Health

Food production is almost impossible without healthy soil. Having a healthy soil requires good management practices due the fact that farming itself disturbs the natural soil processes of nutrient cycling. Agriculture is important for food security in two ways: it produces the food people eat; and (perhaps even more important) it provides the primary source of livelihood for 36 percent of the world's total workforce. In the heavily populated countries of Asia and the Pacific, this share ranges from 40 to 50 percent, and in sub-Saharan Africa, two-thirds of the working population still make their living from agriculture (ILO, 2007). If agricultural production in the low-income developing countries of Asia and Africa is adversely affected by land degradation, the livelihoods of large numbers of the rural poor will be put at risk and their vulnerability to food insecurity increased.

Common agricultural practices such as ploughing, disc-tillage and vegetation burning as practiced in the tropical areas make the soil susceptible to wind and water erosion thereby degrading the land. Until alternative management practices that enhance soil health and allow for sustainable agricultural production are employed. The decline in nutrients as well as soil organic matter continues except management practices are improved. The present farming systems is responsible for loss of soil nutrients through leaching, runoff and erosion.

Crop production worldwide has generally resulted in a decline due to deficiency in soil fertility. In low-input agricultural systems yields generally decline rapidly as nutrient and organic matter level decline. Restoration is possible through the use of fallow lands, mixed crop-livestock, crop rotation and agroforestry system. The challenge is to identify soil management practices that promote sustainable food production as well as profitable to farmers in the short term. A better understanding of the linkages between soil life and ecosystem function and the impact of anthropogenic activities will enable the reduction of negative impacts and more effective capture of the benefits of soil biological activity for sustainable and productive agriculture (Bot and Benites, 2005).

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 Study Area

3.1.1 Location

Kaso, Tsohon Kaso and Kafari are villages in the Chikun Local Government Area of Kaduna State. The Local Government Area covers an area of about 446,659km^2. The region in which the study will be conducted is situated in the central Kaduna state. It lies at a distance of about 500-600 km from the Atlantic coast and about 300 km south of the Nigerien border. Chikun LGA is on latitudes 10.27^{o}N and longitudes 7.11^{o}E. The mean altitude is about 600 m above sea level.

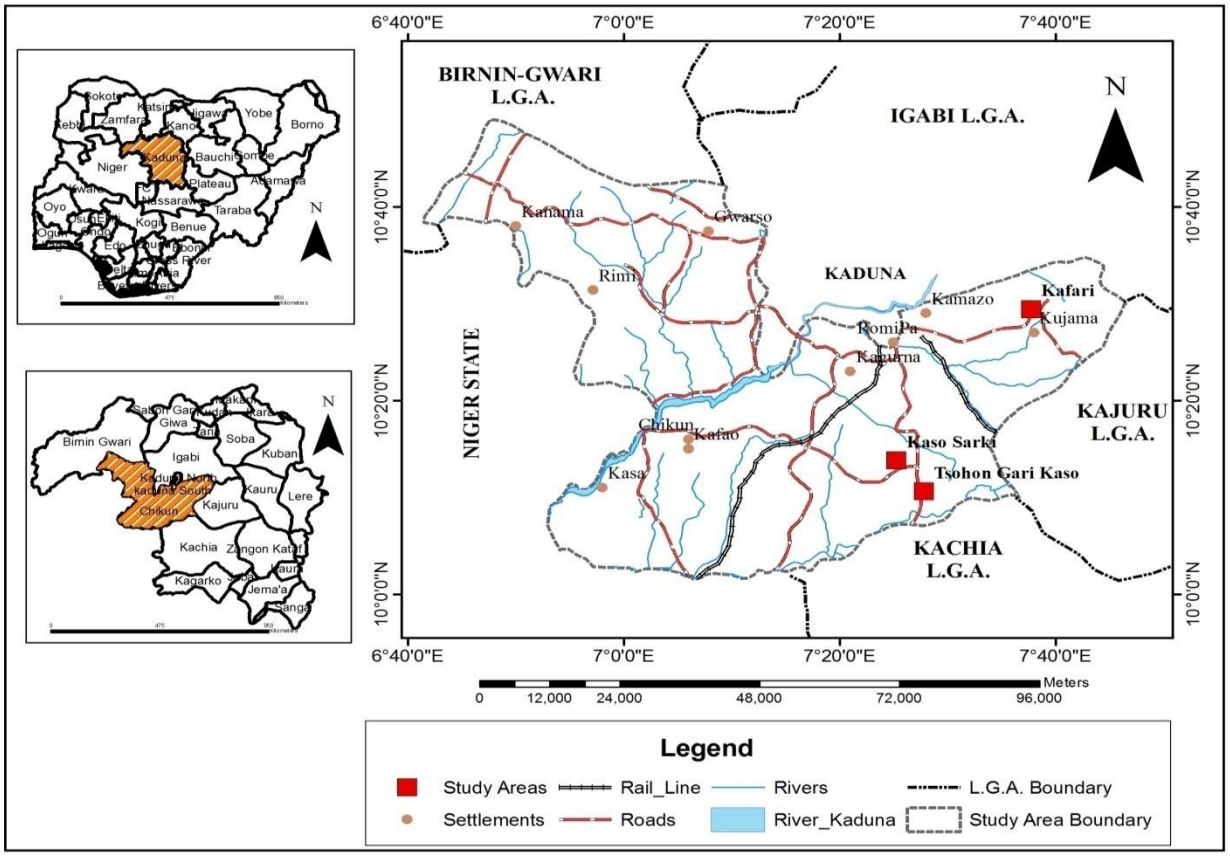


Fig 3.1: Map of the Study Area. Source: Modified from Administrative Map of Kaduna State

3.1.2 Climate

The climate in the Kaduna region is characterized by a strong seasonal contrast, primarily influenced by the movement of the Inter-Tropical Convergence Zone (ITCZ). Between April and October it crosses twice over Kaduna, following the sun's zenith point between the Tropic of Cancer and the Tropic of Capricorn. In this interval southwesterly winds with moisture-laden air from the Gulf of Guinea, pour inland; a phenomenon also known as the West African Monsoon. Leading to an unstable atmospheric stratification, heavy convective rainfalls are the consequence. The entire season is characterised by high air humidity and heavy rainfalls, and is therefore referred to as the rainy season (Ojo, 1977; Sultan and Janicot, 2000).

According to a discussion by Kowal and Knabe (1972) it starts between 11th –20th of April and ends in between the 11th –20th of October (Bennett *et.al*, 1979). Therefore it has a length of about 180 days (Blair- Rains, 1977). The average precipitation increases from the beginning in April until it is peaks around August and September with up to 300mm per month. Afterwards it swiftly declines until the end of October.

3.1.3 Relief and drainage

The study sites are located in a landscape which is known as the *Kaduna Plain* referring to Bennett et al. A complex of old igneous and metamorphic rocks underlies the entire area, originating from Jurassic to Precambrian age. Therefore, the basement complex consists mostly of granite and granitic gneiss (Bennett *et al*., 1979).In general the landscape has a simple structure. It is composed of some few features, namely inselbergs, pediments, gently undulating plains and floodplains with (seasonal) streams. Gently undulating plains dominate the landscape, partly broken by shallow valleys and scattered inselbergs. Except for the inselbergs, slopes in the landscape are inclined at average angles of about 2° and rarely exceed 5-8° of inclination (Bennett, Hutcheon, Kerr, Mansfield, and Rackham, 1977; Bennett *et al*., 1979).

The driving forces behind the shaping of the landscape are weathering and erosion. Semmel (1991) suggests that the relief of the pediplain landscapes in West Africa have mainly been formed in former ages. The process of pediplanation occurs mostly on crystalline basements and requires conditions of tectonic stability. Also it requires somewhat different climate conditions, more arid and accentuated by stronger precipitation than nowadays. Periods of drought alternating with

periods of soddenness are the basis for intense chemical weathering. As the products of this process are small, far less than pebble size, fluvial erosion in the rainy period is culminating in sheet denudation instead of incision, due to a lack of carving tools. Therefore, erosion does not cut deep gorges in the basement, although it widens stream channels to broad plains by eroding the flanking slopes eventually inselbergs may occur as remnants in between watersheds (Semmel, 1991).

3.1.4 Soils and vegetation

The soils in the Kaduna plains are affected by merely a few main pedogenetic processes, which are basically determined by the climate. The weathered material is subsequently altered by clay translocation, secondary accumulation of sesquioxides, leaching loss of soil elements, bioturbation and rapid decomposition of organic matter (Bennett *et.al*, 1977a, Bennett *et al*, 1979). Common are desilicification and the illuvial accumulation of sesquioxides. As the texture of the soils generally benefits a good drainage, a descendent water direction is predominant during the rainy season. Moreover, the soils on slopes and on gently undulating plains are generally well drained. Consequently, dispersion and translocation of clay from the topsoil, leads underneath to the formation of argic horizons with clay illuviation (Bennett *et al*., 1977b, Bennett *et al*., 1979).

3.1.5 Population and socioeconomic activities

The 2006 census estimated the population of Chikun Local Government Area to be about 368,250 people of which 186,874 are males and 181,376 females and projected an annual growth rate of about 3.2% within 15years(FGN, 2007). Majority of the inhabitants of Chikun local government area are farmers. This is because the land is very fertile, which attracted higher population of the area to engaged in farming. Chikun LGA is one of the agricultural producing areas in Kaduna,

some of the agricultural products produce are rice, beans, yam, guinea corn, maize, soya beans etc. Besides farming, the people also engage in hunting during the drying season, rearing of livestock such as goats, pigs, chickens and cattle, they also engaged in the making of handcraft (Oyeniyi, 2013).

3.2 Methodology

3.2.1 Reconnaissance survey

The reconnaissance survey of the study area was carried out in November 2012. The basis of the preliminary survey were three. First, for the researcher to get acquainted with the environment, in particular the environmental setting and incidence of rickets disease in the study area. Second, to conduct preliminary interview the management and staff of the Hope for the Village Child an NGO that has been working in the area and also with community leaders and farmers, whose farms offer promising site for this study, on the management history of their farms. Third, to select the plots to be used for the detail field investigations. The outcome of the reconnaissance survey was the selection of two rickets infested communities, and a third community that so far has not recorded rickets infection. The two rickets affected communities are Kaso Tsohon Gari and Kaso Sarki.

3.2.2 Types of data

Qualitative information on soil management practices and incidence of rickets diseases in study area as well as analytical properties of soils drawn over continuously cultivated upland and Fadama across the study area will serve as the types of data. Ca and nutrients content of crop residues drawn over cropland across the study area will also be analysed.

3.2.3 Sources of data

Interviews were conducted for the farmers in the study area. Field observations of the study area and relevant publications were consulted.

3.2.4 Detailed fieldwork

The method of investigation involves comparison of soil properties of upland arable land and Fadama land under continuous cultivation, and nutrient elements of the crops grown thereof, amongst two rickets affected communities and a third community that so far has not recorded rickets infection. In each selected community, two farmlands, one an upland farm and a Fadama were selected for soil and crop residue sampling. The size of the farmland vary between 0.8 ha and 1.2 ha and have been under arable cropping of mostly sorghum and maize. Their selection are constraint by two major factors: availability of reliable information on the management history of farm plots in the study area and the need to keep as much as possible all other influencing variables, other than the topographical and soil management practice factors, under control. All plots are underlain by granitic materials and experience similar climatological conditions.

3.2.5 Soil and crop sampling

For purpose of soil sampling and description, a 10 to 15 square meter plot was marked out at the center of each farmland selected for study. At the four corners and center of each square, a 4 square meter was subsequently demarcated and surface samples (0-10cm) taken at each corner and bulked to give a single sample. In essence, 5 bulked surface samples per farmland were involve, making a total of 10 per community and 30 overall.

With respect to plant sampling, respective samples of sorghum and maize were drawn over all upland farmland and then bulked; giving 1 bulked sample of sorghum and 1 bulked sample of maize per community. Along with the above drawn upland crop residues is one bulk sample of rice each over all the Fadama farmland selected for study.

3.2.6 Laboratory analysis of soil and plant samples

The analyses were conducted at the Institute for Agricultural Research (IAR) Samaru, Zaria and Multiuser Student Research Laboratory (MUSRL), Department of Chemistry, ABU, Zaria.

The bulked soil samples taken from the field were air dried, crushed lightly, and then passed through a 2mm sieve, less than 2mm fraction was used subsequently. The bulked plant samples from the field were air dried, crushed lightly and sieved with a 2mm sieve. The sieved fractions was analysed through standard procedures.

The digested plant samples were analysed at IAR and Multiuser Student Research Laboratory (MUSRL), Department of Chemistry, ABU, Zaria. Potassium, K% and Sodium, Na% were analysed at IAR while Calcium, Ca and Magnesium, Mg were analysed at Chemistry Department.

3.2.7 Techniques of data analysis

Two major statistical techniques were employed in the analysis of the data of the study. These are one-way analysis of variance (i.e. F-ratio) and Student t-test. The analysis of variance was used to test for any significant differences in soil and plant parameters amongst the three villages used for the study. The Student t-test on the other hand was used to test significant differences exist in the properties of soils between pairs of villages, as well as between the upland and Fadama land. All tests were performed at the 0.05 probability level.

Table 3.1: Summary of Plant Nutrient Elements and Soil Properties to Be Determined

Soil/Plant	Parameter	Determination Method
Plant	Total Ca, Mg, Na and K	Wet digestion methods using Triple acid, Nitric acid, Perchloric acid and Sulphuric acid.
Soil	Particle size distribution	Hydrometer method by G.W Gee and T.W Bauder, 1986
	Organic matter content	Walkley-Black Method by Nelson and Sommer, 1982
	Total nitrogen	Micro-kjeldahl Method described by Bremner and Mulvaney, 1982
	Exchangeable Ca, Mg, Na, K	Ammonium Acetate extraction methods by Thomas 1982
	Available P	Bray No1 Method by Bray and Kurtz 1945
	Exchange acidity	Using KCl solution leaching method by Thomas 1982
	CEC	Using the Ammonium acetate saturation method by Rhoades 1982

Note: The methods employed are standard procedures in soil analysis. Though, they are subject to the available reagents as well as their precision. To the best of knowledge of the researcher, they are the most appropriate.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussion of the findings. It examines the level and variation of the properties over the study area, the levels of the nutrient elements in plant and soils, as well as the discussion of the results of the study.

Table 4.1: Variation of Soil Properties across the Studied Sites

Soil properties	Sites								
	Kaso Sarki			Kaso Tsoho			Kafari		
	Upland	Fadama	t-Test	Upland	Fadama	t-Test	Upland	Fadama	t-Test
Sand %									
[redacted]	62.60	39.80	0.00	66.20	46.20	0.00	59.80	61.00	1.40
SD	6.54	3.90		6.57	5.76		4.60	1.41	
CV%	10.45	9.80		9.93	12.47		7.70	7.70	
Silt%									
[redacted]	25.60	36.80	-9.14**	21.60	31.20	-3.07*	23.20	21.20	0.00
SD	4.56	3.03		10.14	9.65		5.40	2.28	
CV%	17.82	8.24		46.94	30.94		23.29	10.76	
Clay%									
[redacted]	11.80	23.40	-11.06**	12.20	22.60	-5.64**	17.00	17.80	0.00
SD	3.03	3.58		4.83	5.57		4.00	1.10	
CV%	25.70	15.29		39.62	24.65		23.53	14.04	
pH H_2O									
[redacted]	6.48	5.98	0.00	6.70	6.50	0.00	5.94	6.38	-6.75**
SD	0.13	0.13		0.47	0.19		0.09	0.28	

CV%	0.02	0.02		7.08	2.88		1.51	4.35	
pH 0.01M ($CaCl_2$)									
	5.16	5.20	-0.30	5.94	5.60	0.00	5.20	5.38	-1.21
SD	0.09	0.58		0.62	0.34		0.64	0.16	
CV%	1.73	11.21		10.42	6.19		12.39	3.05	
	7.50	9.64	-2.88*	14.08	6.19	0.00	6.57	9.01	-1.74
SD	3.08	1.26		3.90	2.95		0.86	6.22	
CV%	41.02	13.09		27.72	47.76		13.10	69.03	
Avail. N (g/kg^{-1})									
	0.67	0.84	-3.02*	0.98	0.64	-0.03	0.56	1.40	-11.21**
SD	0.21	0.14		0.22	0.23		0.10	0.31	
CV%	31.52	16.67		22.59	36.38		17.68	22.60	
Avail. P (mg/kg^{-1})									
	7.39	3.36	0.00	4.13	2.87	0.02	5.22	4.52	0.00
SD	6.38	1.25		0.93	0.64		1.44	0.75	
CV%	86.40	37.21		22.57	22.31		27.59	16.70	
Exch. Ca ($cmol/kg^{-1}$)									
	1.52	2.24	-4.55***	2.84	2.04	0.00	1.88	4.56	-7.84**
SD	0.63	0.33		1.34	0.22		0.54	1.43	
CV%	41.19	14.67		47.08	10.73		28.74	31.38	
Exch.Mg ($cmol/kg^{-1}$)									
	0.88	1.10	-2.52*	1.44	0.77	0.00	0.94	2.30	-6.64**
SD	0.36	0.16		0.78	0.12		0.22	0.89	
CV%	40.50	14.37		53.93	15.64		23.31	38.64	
Exch. K ($cmol/kg^{-1}$)									
	0.10	0.13	-1.63	0.24	0.06	0.04	0.20	0.11	0.10
SD	0.05	0.07		0.12	0.01		0.09	0.03	
CV%	47.22	50.65		50.02	20.36		42.57	27.18	
Exch. Na ($cmol/kg^{-1}$)									
	0.02	0.07	-3.92**	0.10	0.06	-0.06	0.17	0.11	0.09
SD	0.02	0.05		0.15	0.05		0.14	0.06	
CV	111.80	75.27		151.25	80.16		82.98	54.44	
Exch.H+Al ($cmol/kg^{-1}$)									
	0.06	0.09	-4.24**	0.05	0.05	0.14	0.10	0.07	0.00
SD	0.02	0.02		0.03	0.00		0.00	0.03	
CV	37.27	24.85		61.42	0.00		0.00	39.12	

CEC ($cmol/kg^{-1}$)									
$\bar{x}$	5.42	6.00	-2.49	7.96	6.76	0.00	5.78	10.94	-6.60**
SD	1.03	0.16		2.85	0.73		0.93	3.37	
CV	18.97	2.64		35.84	10.80		16.16	30.79	

Level of significance: * = 0.001; ** = 0.01; * = 0.05**

$\bar{x}$ **= mean, SD= Standard Deviation, CV%= Coefficient of Variation.** Field work, 2014

4.2 Status and Variability of Soil Properties

Table 4.1 shows the status and variation of the soil properties considered over the different sites. It also incorporates the results of the t-Test employed to test for significant differences in the properties between the Upland arable land and the Fadama land in the respective location. Table 4.2 shows the comparison of the soil properties amongst the three study locations and the associated analysis of variance test, while Table 4.3 shows the result of t-Test employed to test for significant differences between pairs of locations.

Table 4.2: Comparison of Soil Properties Among the three Study Locations

Soil properties	**Upland**				**Fadama**			
	Sarki	Tsoho	Kafari	ANOVA	Sarki	Tsoho	Kafari	ANOVA
Sand %								
$\bar{x}$	62.60	66.20	59.80	1.44	39.80	46.20	71.00	80.83**
SD	6.54	6.57	4.60		3.90	5.76	1.41	
CV%	10.45	9.93	7.70		9.80	12.47	7.70	
Silt%								
$\bar{x}$	25.60	21.60	23.20	0.40	36.80	31.20	21.20	8.71**
SD	4.56	10.14	5.40		3.03	9.65	2.28	
CV%	17.82	46.94	23.29		8.24	30.94	10.76	
Clay%								
$\bar{x}$	11.80	12.20	17.00	2.31	23.40	22.60	7.80	21.92**
SD	3.03	4.83	4.00		3.58	5.57	1.10	
CV%	25.70	39.62	23.53		15.29	24.65	14.04	
pH H_2O								
$\bar{x}$	6.48	6.70	5.94	9.18**	5.98	6.50	6.38	8.62**
SD	0.13	0.47	0.09		0.13	0.19	0.28	
CV%	0.02	7.08	1.51		0.02	2.88	4.35	
pH 0.01M($CaCl_2$)								

$\bar{x}$	5.16	5.94	5.20	3.59*	5.20	5.60	5.38	1.24
SD	0.09	0.62	0.64		0.58	0.34	0.16	
CV%	1.73	10.42	12.39		11.21	6.19	3.05	
Organic Carbon (g/kg^{-1})								
$\bar{x}$	7.50	14.08	6.57	9.90**	9.64	6.19	9.01	24.89**
SD	3.08	3.90	0.86		1.26	2.95	6.22	
CV%	41.02	27.72	13.10		13.09	47.76	69.03	
Avail. N (g/kg^{-1})								
$\bar{x}$	0.67	0.98	0.56	6.92**	0.84	0.64	1.40	12.58**
SD	0.21	0.22	0.10		0.14	0.23	0.31	
CV%	31.52	22.59	17.68		16.67	36.38	22.60	
Avail. P (mg/kg^{-1})								
$\bar{x}$	7.39	4.13	5.22	0.94	3.36	2.87	4.52	4.21*
SD	6.38	0.93	1.44		1.25	0.64	0.75	
CV%	86.40	22.57	27.59		37.21	22.31	16.70	
Exch.Ca ($cmol/kg^{-1}$)								
$\bar{x}$	1.52	2.84	1.88	2.83*	2.24	2.04	4.56	13.35**
SD	0.63	1.34	0.54		0.33	0.22	1.43	
CV%	41.19	47.08	28.74		14.67	10.73	31.38	
Exch. Mg($cmol/kg^{-1}$)								
$\bar{x}$	0.88	1.44	0.94	1.82	1.10	0.77	2.30	11.72**
SD	0.36	0.78	0.22		0.16	0.12	0.89	
CV	40.50	53.93	23.31		14.37	15.64	38.64	
Exch.K($cmol/kg^{-1}$)								
$\bar{x}$	0.10	0.24	0.20	3.11*	0.13	0.06	0.11	4.12*
SD	0.05	0.12	0.09		0.07	0.01	0.03	
CV	47.22	50.02	42.57		50.65	20.36	27.18	
Exch. Na ($cmol/kg^{-1}$)								
$\bar{x}$	0.02	0.10	0.17	2.02	0.07	0.06	0.11	1.01
SD	0.02	0.15	0.14		0.05	0.05	0.06	
CV%	111.80	151.25	82.98		75.27	80.16	54.44	
Exch. H+Al ($cmol/kg^{-1}$)								
$\bar{x}$	0.06	0.05	1.00	6.53*	0.09	0.05	0.00	4.80*
SD	0.02	0.03	0.00		0.02	0.00	0.00	
CV%	37.27	61.42	0.00		24.85	0.00	39.10	
CEC ($cmol/kg^{-1}$)								
$\bar{x}$	5.42	7.96	5.78	2.81*	6.00	6.76	10.94	8.91**
SD	1.03	2.85	0.93		0.16	0.73	3.37	
CV	18.97	35.84	16.16		2.64	10.80	30.79	

Level of significance: * = 0.001; ** = 0.01; * = 0.05**

$\bar{x}$ =mean, SD= Standard Deviation, CV%= Coefficient of Variation. Field Work, 2014

4.2.1 Soil texture

The sand content shows consistently greater mean value over the Upland arable land than the Fadama land across the different sites. The value for Tsoho Upland and Fadama land are 66.20% and 46.20% respectively. The corresponding values for Sarki are 62.6% and 39.80% and for Kafari, they are 59.80% and 61.00%. However, none of the pair of values show statistically significant differences between the two arable land use categories, by t- test (table 4.1). On the whole, the two arable land conditions, at all sites, show comparatively homogenous values, as depicted by relatively low Coefficient of Variation(CV%); less than 15%.

When the values of the sand content for the three locations, for the respective arable land conditions, were subjected to analysis of variance test, the results obtained show that the differences amongst the three locations is statistically significant at 0.05 level for only the Fadama land (Table 4.2). Similarly, when the differences between pairs of locations, for the respective Upland and Fadama condition, were tested by t-Test, the result shows that only the Fadama of Tsoho and Sarki, and Upland of Tsoho and Kafari, shows statistically significant differences (Table 4.3).

The silt content reveals significantly different amount between the Upland and the Fadama over the Tsoho and Sarki sites. The respective mean value for the Upland condition and the Fadama condition are 21.60% and 31.2% for Tsoho, and 25.60% and 36.80% for Sarki. By contrast, the differences between the two arable conditions at the Kafariis not significant, statistically, being 23.2% for the Upland condition and 21.2% for the Fadama, respectively. The CV% is generally higher at Tsoho, being about 46.94% over the Upland condition and 30.94% over the Fadama. By

contrast, the values for the Sarki and Kafari locations are generally below 25%. This implies that the fraction is more uneven within each farmland condition at Tsoho and relatively homogeneous at the Sarki and Kafari locations. Similar to the sand content, analysis of variance reveals statistically significant different values amongst the three study locations only in respect of the Fadama land. When the differences between pairs of locations, for the respective UplandandFadama condition, were tested by t-Test, only Fadama of Sarki and Kafari shows significant differences (Table 4.3).

Table 4.3: Summary of t-Test Results for Soil Properties between Pair of Study Locations

Soil Properties		**Upland**			**Fadama**	
	Sarki/ Tsoho	Sarki/Kafari	Tsoho/ Kafari	Sarki/ Tsoho	Sarki/ Kafari	Tsoho/ Kafari
Sand%	-1.74	-1.57	-3.57	-4.11	0.00	0.00
Silt%	0.00	-1.52	0.00	0.00	-18.38	-4.51
Clay%	-0.29	0.00	0.00	0.00	-18.65	-10.47
pH H_2O	-2.00	-15.27	-7.04	-10.20	0.00	-1.60
Organic Carbon (g/kg)	-5.92	-1.30	-8.41	0.00	0.00	0.00
Avail. N (g/kg^{-1})	-4.55	-2.10	-7.75	-0.03	-0.02	0.01
Avail. P(mg/kg^{-1})	-0.01	-1.48	-0.01	0.00	0.01	-0.01
Exch.Ca($cmol/kg^{-1}$)	-4.00	0.00	-2.98*	0.00	0.00	0.00
Exch. Mg($cmol/kg^{-1}$)	-2.93*	0.00	-2.77*	0.00	0.00	0.00
Exch. K ($cmol/kg^{-1}$)	-4.81	-0.05	-1.19	-0.13	-1.72	0.00
Exch. Na ($cmol/kg^{-1}$)	-2.36	0.03	0.04	-0.13	-0.06	0.12
Exch. H+Al($cmol/kg^{-1}$)	-0.11	-4.09	-0.14	0.00	0.01	0.00
CEC ($cmol/kg^{-1}$)	-3.75	0.00	-3.25*	-4.55	0.00	0.00

***t-value significant at 0.05 level.FieldWork, 2014**

Similar to the silt content, the clay content showed significant different mean values between the two arable conditions at Tsoho and Sarki. For the two locations, the value is higher over the Fadama than the Upland farm. The respective mean values for the Upland condition and the Fadama conditions are 12.20% and 22.60% for Tsoho, 11.80% and 23.40% for Sarki. The differences between the two arable conditions at the Kafari site, on the other hand arenot,statisticallysignificant, being approximately the same values of 17.00% and 17.80%. The CV% is generally below 30% over the two arable conditions, and at all locations. The only exception is at the Upland condition at Tsoho, where the value is about 39.62%. Similar to the pattern of the sand and silt contents, only the values for the Fadama showed significant differences amongst the three different study locations by analysis of variance. When the t-Test was applied to differences between pairs of locations, for the respective Upland and Fadama conditions, only the Upland of Sarki and Kafari shows statistically significant differences.

Overall, all groups of soils are sandy, which may be due mainly to the coarse textured nature of the parent rock over which the soil was formed (Brady and Weill, 1999; Jaiyeoba, 1986). Other factors that could account for the sandy nature of the soils could be the illuviation of finer particles from the top horizon and illuviation in the lower horizon and also, the selective removal of finer particles in wash processes (Young, 1976; Jaiyeoba, 1986).

4.2.2 Organic Carbon, Nitrogen and available Phosphorus

The mean soil organic carbon content is consistently greater over the Fadama land than the Upland farm. For Tsoho, the respective values at Upland and Fadama are 14.08g/kg^{-1} and 6.19g/kg^{-1}. At Sarki, the corresponding values are 7.50g/kg^{-1} and 9.64g/kg^{-1}. Similarly at Kafari, the

corresponding values are 6.57g/kg^{-1} and 9.01g/kg^{-1}. However, the differences between the two arable conditions are significant for only the Sarki site.

When the values for the three different locations were subjected to analysis of variance test, the result obtained, for the respective farm land category, shows significantly different amount for only the Upland condition. Similarly, when the differences between pairs of locations were tested by t-Test, the result shows that only Sarki /Tsoho and Sarki/Kafari shows statistically significant differences (table 4.3). Similarly, as revealed by the CV%, the values within each farm category show considerable variability. The only exceptions are the Fadama conditions at Sarki, and the Upland condition at Kafari, where the CV% is about 13%. The lack of significant differences in the mean organic carbon content and the generally low values of CV% is a reflection presumably, of intensive anthropogenic influence and therefore, low organic matter (Young, 1976; Jaiyeoba, 1988).

The pattern of the total nitrogen and that of the soil organic carbon content as shown by the mean values reveals that it is consistently greater for the Fadama than the Upland farm. Unlike the organic carbon, however, only the Tsoho site did not reveal significantly different values between the two farm conditions. The mean value for Tsoho are 0.98cmol/kg^{-1} and 0.64cmol/kg^{-1}, for the Upland and Fadama, respectively. The corresponding values for Sarki are 0.67cmol/kg and 0.84cmol/kg^{-1}, and for Kafari, they are 0.56cmol/kg^{-1}and 1.4cmol/kg^{-1}. Only arable Sarki and Fadama of Tsoho show CV% above 30%, suggesting that the element is relatively homogenous within most of the farm plots. When analysis of variance was applied to the data, the result obtained reveal significant differences amongst the three different sites for the respective farm land

condition. When the t-Test was applied to the differences between pairs of locations, the result showed significant differences for only the Upland farms.

The available Phosphorus showed fairly similar values across the different locations and over the different farm land conditions. The values are 4.13mg/kg and 2.87mg/kg, for Upland and Fadama, respectively at Tsoho, 7.39mg/kg and 3.36mg/kg at Sarki; and 5.22mg/kg and 4.52mg/kg at Kafari. Consequently, the differences between the Upland and Fadama, at the respective study site, and among the three study sites are, not statistically significant. The comparatively low available Phosphorus over the different sites is a reflection of the low organic carbon content. This is because available Phosphorus and Organic Carbon occur in organic combination and therefore, a reduction in one would lead to a reduction in the other and vice versa (Brady and Weil, 1999).

4.2.3 Exchangeable Cations

The mean values of the exchangeable Ca shows relatively similar values over the Upland farm (2.84cmol/kg^{-1}) and Fadama farm (2.04cmol/kg^{-1}) at Tsoho location. Consequently, the differences between the two farm land conditions are not statistically significant. By contrast, the element shows comparatively higher amount over the Fadama than the Upland farm at both the Sarki and Kafari locations. The values are 1.52cmol/kg^{-1} and 2.24cmol/kg^{-1} over Upland and Fadama, respectively, at Sarki. The corresponding values at Kafari are 1.88cmol/kg^{-1} and 4.56cmol/kg^{-1}. The differences between the two farm conditions are therefore statistically significant. The CV% shows considerably greater value over Tsoho Upland (47.08%), Kaso Upland (41.19%) and Kafari/ Fadama (31.38%), compared to the remaining farm conditions.

The results of analysis of variance shows that the values for the respective Upland conditions and the Fadama, of the three study locations, are significantly different. However, when the differences between pairs of locations, for the respective Upland and Fadama condition, were subjected to t-Test, the results shows that only the values for the Fadama at Kafari is significantly greater than those of the other two locations. At the Upland, the values for the three sites are not statistically significant at the 0.05 probability level.

The exchangeable Mg shows greater amount over the Fadama than the Upland farm, except for Tsoho where the reverse is true. It average 1.44cmol/kg over Upland farm and 0.77cmol/kg over the Fadama at Tsoho. The corresponding values for Sarki are 0.88cmol/kg^{-1} and 1.10cmol/kg^{-1}, and for Kafari, they are 0.94cmol/kg^{-1} and 2.30cmol/kg^{-1}.The t-Test result shows statistical significant differences between the two farm condition at Sarki and Kafari. The result of analysis of variance only shows significant different values, amongst the three study sites, for the Fadama land. By contrast, most of the values for the pair of sites, show significant differences.

Exchangeable K did not reveal significant difference between the Upland farm and the Fadama across all sites. The values for Tsoho are 0.24cmol/kg^{-1} over Upland farm and 0.06cmol/kg^{-1} over the Fadama. The corresponding values for Sarki are 0.10cmol/kg^{-1} and 0.13cmol/kg^{-1}, and for Kafari, they are 0.2cmol/kg^{-1} and 0.11cmol/kg^{-1}.The result obtained by analysis of variance is similar, and so also that obtained by t-Test between pairs of sites.

The t-Test shows significant differences in the exchangeable Na between the Upland and Fadama land only at Sarki. The values are 0.10cmol/kg^{-1} and 0.06cmol/kg^{-1}, for Upland and Fadama, respectively at Tsoho, 0.02cmol/kg^{-1} and 0.07cmol/kg^{-1}at Sarki, and 0.17cmol/kg^{-1} and 0.11cmol/kg^{-1} at Kafari. Given the rather similar values, ANOVA did not reveal significant differences amongst the various sites, so also the t-Test between pairs of locations. It is significant to point out that all groups of soils across the study area are relatively low in exchangeable cations, with values for the Fadama only slightly greater in most cases. Similarly, values for the Kafari site is only often slightly greater than the rest locations at the Upland farm. The relatively low values of exchangeable cations may be a reflection of losses through either cultivation, harvesting or leaching (Jones and Wild). This phenomenon could also be as a result of greater mobilization by plants or greater weathering and release of the elements within the soil (Fitzpatrick, 1980).

4.2.4 pH and CEC

The soil pH show fairly similar values between the Upland and Fadama of respective study locations. The values for the pH in water, for example, averaged 6.70 and 6.50 over Upland condition and Fadama, at Tsoho respectively. The corresponding values for Sarki are 6.48 and 5.98, and for Kafari, they are 5.94 and 6.38. This shows that they are slightly acidic. Consequently, only Kafari shows significantly different value between the two farm land conditions. Similarly, as suggested by the relatively low CV%, the values within the different plots are fairly similar. The highest value occurs over Tsoho Upland (7.08%) and the lowest over both the Upland and Fadama of Sarki (0.02%).The result obtained by analysis of variance amongst the three study locations, and by t-Test between pairs of sites, however, show considerable significant differences. Similar to the soil pH, the soil CEC varies a little between the Upland farm and the Fadama in the respective study site. The values for the Fadama is generally greater than that for the Upland farm,

except at Tsoho. It average 7.96cmol/kg^{-1}over Upland farm and 6.76cmol/kg^{-1} over the Fadama at Tsoho, 5.42cmol/kg^{-1} and 6.00cmol/kg^{1} for Sarki, and 5.78cmol/kg^{-1} and 10.94cmol/kg^{-1} for Kafari. This implies that the Fadama soils are richer in nutrients that those of the upland soils. This is expected and normal because Fadama are usually rich in clay minerals that upland. The differences between the two farm land conditions, by t-Test are significant only for the Kafari site. On the other hand, analysis of variance reveals statistically significant different values amongst the three study locations for both the Upland farm and the Fadama. Similarly, when the differences between the pairs of locations, for the respective Upland and Fadama condition, were tested by t-Test, most shows statistically significant different values. As suggested by the relatively low CV% values, there is considerable homogeneity in the CEC of plots in the respective sites. .

Overall, all groups of soils are low in CEC. The comparatively smaller CEC values of the various plots reflects lower organic carbon content of the different sites, or it may be that the clay mineralogy of the soil is predominantly the chemically less active Kaolinite type (Fitzpatrick, 1980).

4.2.5 Exchangeable Acidity

The exchangeable H + Al show fairly similar values between the two farm conditions of respective study locations, with significant differences between the two only at Kafari. The value averaged 0.05 and 0.05 over Upland condition and Fadama respectively at Tsoho. The corresponding values for Sarki are 0.06 and 0.09, and for Kafari, they are 0.10 and 0.07 conditions. The result obtained by analysis of variance amongst the three study locations, and by t-Test between pairs of sites, are also generally not significant, statistically. The only exceptions are for Sarki/Kafari.

4.3 Relationship between Ca and other Soil Properties

4.3.1 Organic Carbon, Nitrogen and Available Phosphorus

Soil organic carbon is more available in soils whose pH is near-neutral soil. Acidic soils slow down microbial activities such as nitrogen fixation, nitrification, and organic matter decay. Rhizobia bacteria are known to thrive at near-neutral pH. Phosphorus is known to be greatest in the pH range of 5.5 to 6.8 but at high pH values, P reacts with Ca to form Ca Phosphates that are relatively soluble and less available to plants (MAVP, 2006). The Calcium content of the soils of the study area is fairly low as such it may not be readily available for plant uptake. As such the soils are not rich in Organic matter and Nitrogen, though P seems to be moderately available which may be one of the reasons why Ca may not be available for plant use.

4.3.2 Exchangeable Cations of K and Mg

These soil nutrients as well as Ca are more available in the soils of the study area except that K seems to be less available compared to Ca and Mg in the soils. The CEC seems to be low in the soils of the area (MAWP, 2006). This may be due to leaching thereby making the nutrients not readily available for plant uptake.

4.3.3 pH and CEC

The leaching of Ca, Mg and K, basic cations and their replacement with Al^{3+} and H^{+} results in the acidic characteristics of the soils. Though, Ca may be in the soils but it is not readily available for plant uptake because Ca may be in a form that plants cannot use them. In relation to Calcium, pH tending towards neutral will infer that it is not deficient in calcium. This is not so, the acidic

characteristics of the soils may be an indicator of low available calcium as well as low CEC of the soils.

4.3.4 Exchangeable Acidity

The leaching of basic cations (Ca, Mg, K, Na) results in the replacement by Al^{3+} and H^{+} thereby making the soil acidic. The development of soil acidity is due to the removal of carbonates by leaching. Though, the soils of the study area tends towards acidic it is not strongly acidic and it supports cultivation. A high exchangeable acidity infers that the soils are low in CEC and a low exchangeable acidity shows that the CEC is entirely saturated with basic cations.

Table 4.4 Comparison of Nutrient Elements of Plant and of Soil

Nutrient Elements ($cmol/kg^{-1}$)	**Plant**			**Soil**	**t-Test**
	Maize	Rice	Mean Total		
No of samples	2	2			
		Tos			
Ca	2.24	0.68	1.46	2.04	-1.4
Mg	9.03	12.91	10.97	0.77	0
K	0.67	2.60	1.64	0.06	1.64
Na	0.02	0.08	0.05	0.06	-0.32
		Sarki			
Ca	0.01	0.01	0.01	2.24	-30.35
Mg	5.61	7.66	6.64	1.10	0.00
K	1.55	0.77	1.16	0.13	-0.01
Na	0.33	0.44	0.39	0.07	-0.05
		Kafari			
Ca	0.49	1.92	1.21	4.56	-6.99**
Mg	7.66	6.38	7.02	2.30	0.00
K	0.77	1.83	0.87	0.11	-0.82
Na	0.04	0.15	0.10	0.11	-0.35

***t-value significant at 0.05 level. Field Work, 2014**

The soil CEC vary little between the Maize residue and the Rice residue in the respective study site. The values for Mg is generally greater than that of the other CEC. It average between 6.64cmol/kg to 10.97cmol/kg while Na has the lowest records of CEC with average between 0.05 to 0.10cmol/kg. The differences between the two farm land conditions, by t-test is significant only for the Kaso Sarki site. Generally, the plant residues are low in CEC. The comparatively smaller CEC values of the residues indicates that there is low organic carbon content of them, or it may be that the CEC may have been acted upon by the elements of weather.

Table 4.5: Correlation Coefficient Values of Ca and other Soil Properties

Soil Properties	Kaso Sarki			Kaso Tsoho			Kafari		
	Upland	Fadama	Combine	Upland	Fadama	Combine	Upland	Fadama	Combine
Sand%	0.67	-0.58	-0.46	-0.53	-0.60	0.51	-0.27	0.44	0.72
Silt%	-0.64	-0.04	0.33	-0.88	0.40	-0.26	-0.38	-0.41	-0.37
Clay%	-0.48	0.66	0.54	0.96	-0.06	-0.43	0.83*	0.28	-0.60*
H_2O	0.83	0.37	0.36	-0.83	0.73	-0.22	0.43	0.93*	0.95
Organic C (g/kg^{-1})	0.28	-0.14	0.43	0.50	-0.77	0.62*	-0.27	0.59	0.87*
N $cmol/kg^{-1}$	0.43	-0.61	0.41	0.34	-0.76	0.59*	-0.52	0.11	0.73*
Avail. P (mg/kg)	0.96*	0.63	0.35	0.65*	0.85*	0.86*	0.04	-0.66	-0.41*
Exch. Mg $cmol/kg^{-1}$	0.93*	0.87*	0.91*	0.41*	0.63	0.97*	0.90*	0.95*	0.97*
Exch. K $cmol/kg^{-1}$	0.42	-0.28	0.26	0.08	0.08	0.64*	0.32	0.16	-0.45
Exch. Na $cmol/kg^{-1}$	0.46	0.87	0.21	0.43	-0.14	-0.18	0.19	-0.55	-0.07
Exch.H+Al$cmol/kg^{-1}$	-0.46	0.41	0.64*	0.74	-0.10	-0.64*	0.08	-0.87*	-0.89*
CEC $cmol/kg^{-1}$	0.80	0.77	0.79*	0.51*	0.08	0.89*	0.36	0.92*	0.94*

Level of significance: * = 0.05, Field Work, 2014

4.5.1. Relationship between Ca and Other Soil Properties

Table 4.5: summarize the result of the correlation analysis between exchangeable calcium and other soil properties

4.5.2 Soil Texture

At Kaso Sarki, the relationship between Ca and sand percent was negative while at both Kaso Tsoho and Kafari the relationship was positive. When examined against the background of the two arable conditions, the result obtained showed considerable variability. At Kaso Sarki the correlation coefficient value over the Upland soil was positive while it was negative over the Fadama, over both land use categories at Kaso Tsoho, the relationship was negative while at Kafari was negative while of Kafari it was negative over the Upland and negative over the Fadama. Overall, however, none of the correlation coefficient value obtained between Ca and sand percent was statistically significantly.

Over the three communities, the relationship between Ca and silt percent was negative like with the sand fraction, however, there was considerable variation between the Upland Fadama lands. Furthermore, none of the correlation coefficient values was statistically significant.

At Kaso Sarki, the relationship between Ca and clay content was positive At Kaso Tsoho and Kafari on the other hand, the relationship was negative. Again, the result obtained when the samples were broken down into the two arable land conditions were often different.

Organic Carbon, Nitrogen, and available Phosphorus, over the three communities, the exchange Ca showed positive correlation with the organic carbon and total nitrogen the result obtained when the samples was broken down into Fadama and Upland were similar except over Fadama at both Kaso Sarki and Kaso Tsoho and over the Upland at Kafari. The relationship were however, significant statistically only for the combined data for Kaso Tsoho and Kafari.

At Kaso Sarki and Kaso Tsoho, the relationship between Ca and available P was positive while at Kafari, it was negative the result obtained when the data was split into the two land use categories was slightly different in that only the Upland soils at Kafari showed contrary relationship. The correlation coefficient values for most of the locations were statistically significant.

4.5.3. Exchangeable Cations

The correlation coefficient values between Ca and exchangeable Mg was positive at all communities and over the respective up land and Fadama condition. Furthermore nearly all the values were statistically significant.

At both Kaso Sarki and Kaso Tsoho, the relationships with exchangeable K were positive but at K it was negative. By contrast, while the correlation coefficient values with Na was positive over Kaso Sarki, it was negative over Kaso Tsoho and Kafari. For both cations, however, the relationships were nearly all insignificant.

4.5.4 pH and CEC

Over Kaso Sarki and Kaso Tsoho, the correlation coefficient for Ca and pH were negative but over Kafari it was positive then the result was broken down into the two arable conditions, however, the result obtained showed that the correlation coefficient over the Fadama at Kaso Tsoho was

positive. Across the three communities and over the respective arable condition, the correlation with the CEC was positive, combined with some significant relationship. By contrast, the correlation with the exchangeable acidity was negative over Kaso Tsoho and Kafari and positive over Kaso Sarki.

Thus over all, while Ca showed significant correlation with very few other soil properties at Kaso Sarki community, it showed significant relationship with in any of the remaining two communities. At Kaso Sarki, only Mg, exchange acidity and CEC revealed significant correlation with Ca. While the relationship with Mg and CEC were positive that for exchange acidity was negative. While, the general impression of this result is that the Ca is correlated with the other soil properties determined the relationships is not statistically significant. The positive relationship between the soil Ca and such other soil properties as organic cations, clay, cations and CEC revolve around the cations exchange complexity of the soil (Brady and Weill, 1999).

At Kaso Sarki, organic carbon, N, available P, exchangeable Mg, K and H + Al and CEC show significant correlation with Ca all of which were positive, except exchangeable acidity.'

At Kafari, the clay percent, organic carbon N, available P, mg, H + Al and CEC showed significant correlation with Ca and all the relationship were positive, except for clay, P and H + Al.

4.6 Result of Regression Analysis in Kaso Sarki.

The result of regression analysis for samples taken from Kaso Sarki arable land is presented in Table 4.6.1

Table 4.6.1: Ordinary Least Square Estimates of the Multiple Regression of Calcium In Kaso Sarki Arable

Variable	Coefficient	Standard Error	T-value	P-value
Constant	0.08	0.34	0.23	0.83
Exchange Mg	1.64	0.37	4.46	
R^2	0.87			0002***
F-value	19.91			

***<0.05; **<0.01 ***<0.1, Field Work, 2014.**

Table 4.6.1 shows that there is significant relationship between the Calcium (Ca), the dependent variable and Magnesium (Mg) the independent variable at 5% level. The prediction accuracy was estimated at 87%. If Mg is increase by 1cmol/kg, Ca will increase by 1.64cmol/kg.

The result of regression analysis for samples taken from KasoSarkiFadama is presented in Table 4.6.2.

Table 4.6.2: Ordinary Least Square Estimates of the Multiple Regression of Calcium In KasoSarki Fadama

Variable	Coefficient	Standard Error	T-value	P-value
Constant	1.12	0.33	3.42	0.008***
pH1:2:5, 0.01M	1.10	0.13	8.80	0.001***
Organiccarbon	-0.48	0.06	-8.26	0.001***
R^2	0.98			
F-value	39.51			0.002***

<0.05; **<0.01<0.1, Field Work, 2014**

Table 4.6.2 is statistically significant at the 5% level considering relationship between the Ca the dependent variable and pH and organic carbon being the independent variables. The result shows

that the prediction accuracy is 98% of the variation in Ca as shown by the relationships of the independent variables. This implies that if an independent variable increase by 1unit the Ca will increase or decrease by the coefficient on the independent variable. Therefore, increase in the pH by 0.01M will result in 1.10cmol/kg but increase in Ca by 1cmol/kg will result in decrease in organic carbon by 0.48g/kg^{-1}.

The result of regression analysis for samples taken from Tsoho Kaso arable land is presented in Table 4.6.3

Table 4.6.3.: Ordinary Least Square Estimates of the Multiple Regression of Calcium In Tsoho Arable

Variable	Coefficient	Standard Error	T-value	P-value
Constant	-0.26	0.03	-9.81	0.001***
Exch. Mg	1.82	0.01	191.08	0.00***
Clay%	0.04	0.001	28.30	0.00***
R^2	0.99			
F-value	20236.28			

***<0.05; **<0.01 ***<0.1, Field Work, 2014**

Table 4.6.3 shows that there is a statistically significant relationship between Ca and exch Mg and the % of clay of the Tsoho Kaso Arable land. The relationship prediction accuracy is 99% indicating that exch Mg and clay% will be helpful in underscoring the availability of Ca in the soil.

The result of regression analysis for samples taken from Tsoho Kaso Fadama land is presented in Table 4.6.4

Table 4.6.4.: Ordinary least square estimates of the multiple regression of calcium in tsohokasoFadama

Variable	Coefficient	Standard Error	T-value	P-value
Constant	4.15	0.45	9.26	0.008***
Exch. Na	7.84	0.87	9.02	0.007***
Clay%	-0.06	0.01	-5.49	0.005***

Silt%	-0.04	0.01	-4.85	0.009 ***
R^2	0.75			
F-value	43.79			0.07***

***<0.05, **, 0.01, ***<0.1, Field Work, 2014**

Table 4.6.4 shows that the result is a statistically significant relationship at 5% between the dependent variable Ca and the independent variables of exchangeable Na, % of Clay and % of Silt. The prediction accuracy of the result also shows that 77% of variation in calcium is explained by the independent variables. If the independent variables are all set to zero the average level of Ca is estimated to be 4.15cmol/kg. If an independent variable increases by 1 unit the Ca will increase or decrease by the coefficient on the independent variable. For instance, if exchangeable Na increase by 1cmol/kg then Ca will increase by 7.84cmol/kg but if Ca increase by 1cmol/kg clay will decrease by 0.06% and silt by 0.04%.

The result of regression analysis for samples taken from Kafari arable land is presented in Table 4.6.5

Table 4.6.5: Ordinary least square estimates of the multiple regression of calcium in Kafari Upland

Variable	Coefficient	Standard Error	T-value	P-value
Constant	1.46	0.10	15.41	0.004***
Exch.Mg	0.96	0.07	14.32	0.004***
Organiccarbon	-9.23	0.63	-14.68	0.004***
Avail. N	-0.65	0.17	-3.72	0.007***
R^2	0.99			
F-value	365.3			0.001***

***< 0.1; ** < 0.05 *** < 0.01,Field work, 2014**

Table 4.6.5 shows that there is significant relationship between the Ca, the dependent variable and exchan. Mg the independent variable at 5% level. The prediction accuracy was estimated at 99%. If Mg is increase by 1cmol/kg, Ca will increase by 0.96cmol/kg.

The result of regression analysis for samples taken from Kafari Fadama is presented in Table 4.6.6

Table 4.6.6: Ordinary least square estimates of the multiple regression of calcium in kafari lowland

Variable	Coefficient	Standard Error	T-value	P-value
Constant	3.65	0.34	10.64	0.001***
Exch. Mg	1.07	0.08	13.14	0.001***
H+Al	-22.16	2.64	-8.39	0.001***
R^2	0.99			
F-value	351.86			0.00***

***< 0.05; ** < 0.01 *** < 0.1, Field Work, 2014**

Table 4.6.6 shows that the prediction accuracy of the model used is high with 99% R^2value the relationship between Ca and the independent variables of exchangeable Mg and H+Al is statistically significant.

4.4 Summary of Variation of Ca and Relation to Incidence of Rickets

The result shows that most of the soils of the study area are sandy. The textural classes include: Kafari, sandy-loam; KasoSarki ranges from sandy-clay-loam to clay-loam and loam; TsohoKaso, from sandy-clay-loamy to clay loam and loam. Bennett *et.al*., (1977a), Jones and Wild (1975), stress the fact that such textures are typical for soils in West Africa as well as in regions north of the study area. As such it may not be a unique characteristic of calcium deficient rickets. The pH values ranges from slightly acidic to neutral. Schulin, Johnson and Frossard (2010) asserted that high pH values inhibit micronutrients availability and low pH values stimulates element availability. Inhibition of micronutrients have been thought to cause calcium deficient rickets (Comb Jr. and Hassan, 2005; Lamberg-Allaardt, Karp and Kemi, 2010). The pH values of the study area though acidic but supports cultivation and plant growth and may not infer the deficiency of calcium.

The organic carbon is generally low, though it could support cultivation. High organic carbon concentrations usually results in the retention of macronutrients and micronutrients in the soils culminating in healthy plant growth and high yield of crops (Kabata-Pendias and Mukherjee, 2007; Alloway, 2013). The soil mineral-N is dependent on the decomposition of soil organic matter; the general expectation is that availability of nitrogen will be proportional to organic matter status (Scarsbrook, 1965). Therefore, under normal condition high nitrogen content available for plant growth will also influence macro and micro nutrients retention in the soil. Therefore, the low nitrogen content may not be responsible for calcium deficient rickets.

P deficiency is common throughout many savannah regions and not restricted to calcium deficiency rickets areas only (Jones and Wild, 1975).Plant availability of P is generally greatest in the pH range of 6.5 to 7.6 (MAWP, 2006). Therefore, the soils of the study are not deficient in P. As such P deficiency in the Kaduna study area may not be assumed to be an indicator for the deficiency of calcium in the area. K, Ca, and Mg are most present in soils with pH values ranging from neutral to alkaline. They are generally not as available for plant uptake in acid soils since they may have been partially leached out of the soil profile (MAWP, 2006). The soils of the study area range from moderately acidic to neutral as such leaching is prevalent in the study area. This infer that the soils are low in K, Ca and Mg but it does not seem as though calcium alone is deficient in the soils of the area. Other factors such as low micronutrients may be responsible for deficiency of calcium in the soils of the area.

The CEC contents of the soils are low which is the same as the soils of the savannah (Jones and Wild, 1975) and agrees with the FAO map of Nigeria showing different organic carbon fertility

(FAO, 2005). Despite its low content it supports cultivation of crops in the study area and it cannot be concluded that calcium deficient rickets prevalence in the area is due to low CEC.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of the Study

This study is aimed at determining and comparing some key physicochemical properties of arable Upland and Fadama soils between rickets disease infested and non-infested areas; determine and correlate level of Ca in selected plants growing on the studied soils with those of the pedon and

establish the extent of dependency of Ca on the measured soil physicochemical properties. Thirty (30) samples were collected over the three communities.

The result shows that most of the soils of the study area are sandy. The textural classes include: Kafari, sandy-loam; Kaso Sarki ranges from sandy-clay-loam to clay-loam and loam; Tsoho Kaso, from sandy-clay-loamy to clay loam and loam. It is a fact that such textures are typical for soils in West Africa as well as in regions north of the study area. As such it may not be a unique characteristic of calcium deficient rickets. It might be socio-cultural behavior of mothers and caregivers, etc.

The pH value ranges from slightly acidic to neutral. High pH values, that is, high acidity in the soils inhibit micronutrients availability and low pH values, that is, soils which range in slightly acidic to basic stimulate element availabilities. Inhibition of micronutrients has been thought to cause calcium deficient rickets. The pH values of the study area though acidic but supports cultivation and plant growth and may not infer the deficiency of calcium.

The organic carbon is generally low, though it could support cultivation. High organic carbon concentrations usually results in the retention of macronutrients and micronutrients in the soils culminating in healthy plant growth and high yield of crops.

The soil mineral-N is dependent on the decomposition of soil organic matter; the general expectation is that availability of nitrogen will be proportional to organic matter status. Therefore, under normal condition high nitrogen content available for plant growth will also influence macro

and micro nutrients retention in the soil. Therefore, the low nitrogen content may not be responsible for calcium deficient rickets.

P deficiency is common throughout many savannah regions and not restricted to calcium deficiency rickets areas only.Plant availability of P is generally greatest in the pH range of 5.5 to 6.8. Therefore, the soils of the study are not deficient in P. As such P deficiency Kaduna study area may not be assumed to be an indicator for the calcium in the area.

K, Ca, and Mg: These nutrients are most present in soils with pH values ranging from neutral to alkaline. They are generally not as available for plant uptake in acid soils since they may have been partially leached out of the soil profile. The soils of the study area range from moderately acidic to neutral as such leaching is prevalent in the study area. This infers that the soils are low in K, Ca and Mg but it does not seem that they are responsible for calcium deficient rickets.

The CEC contents of the soils are low which is the same as the soils of the savannah and agrees with the FAO map of Nigeria showing different organic carbon fertility. Despite its low content it supports cultivation of crops in the study area and it cannot be concluded that calcium deficient rickets prevalence in the area is due to low CEC.

5.2 Conclusion

The soils of the study area ranged from moderate acid to neutral in pH values; had low organic matter contents, low CEC, and it can also be inferred that the base saturation will be low. The

macronutrients analysed seems not to categorically underscore their deficiencies as being responsible for calcium deficient rickets. Due to inadequate comparable reference values, it was not possible to link the physicochemical properties of soils in the study area to calcium deficient rickets. Though, possible causes may be due to other metabolic errors which have been given little or no attention. For instance, it could be the socio-cultural behavior of mother and caregivers. Further analyses could be done to assess and determine the micronutrients properties of the soils of the areas as well as the micronutrients of the plants in the study area so as to establish whether their availability or their otherwise is responsible for the prevalence of rickets disease.

5.3. Recommendations

i. Further research should be carried out to determine factors that are responsible for calcium deficient rickets in the study area and in developing countries such work might investigate the effects and impacts of micronutrients on the soils and of plants of the study area. This should go beyond the physical element to include other influencing anthropogenic and medical factors.

ii. Sampling locations and samples should be increased such that will cover a wider area extending to the entire Southern part of Kaduna State and possibly the entire Kaduna State. That will help in investigating the linkage between the population growth and land-use with respect to loss of Ca in the soils.

iii. Laboratory analyses that are better comparable to reference values from other nutritional and environmental studies in semi-arid tropics should be chosen.

iv. Other areas that have bearing on rickets itself different from the factors that have to do with soils and its micro/macro nutrients should be investigated.

REFERENCES

Aglearn.net. (2004) Principles and Concepts of Soil Fertility, Module 2. *Integrated Soil Fertility Management*, 25F, Rasa Torrer, 555 Phaholyothin Rd., Chatuchak, Bangkok, 10900, Thailand.

Ahmed, S.F., Franey, C., McDevitt, H., Somerville, L., Butler, S., Galloway, P., Reynolds, L.,Shaikh, M.G., Wallace, A.M. (2011). Recent Trends and Clinical Features of Childhood Vitamin D Deficiency Presenting to a Childhood's Hospital in Glasgow, *Archives of Disease in Childhood* 96, 263-264

Alloway, B.J. (2013): Bioavailability of Elements in Soils.- In: Selinus, O.; Alloway, B.; Centeno, J.A.; Finkelman, R.B.; Fuge, R.; Lindh, U. &Smedley, P. [Eds.]: Essentials of MedicalGeology. Impacts of the Natural Environment on Public Health, Amsterdam, 352-373.

Ashraf, S., Mughal, M.Z. (2002) The Prevalence of Rickets among Non-Caucasian Children, *Archives of Disease in Childhood* 87, 263-264

Barness, L.A. (1996) Rickets: The Chicken or the Eggs! *Journal of Pediatrics* 129: 941-942

Bationo, A., Vanlauwe, B., Kihara, J., Kimetu, J. (2003) Use of Mineral and Organic Fertilizers to Increase Land Sustainability and Productivity (Unpublished) CTA. International Seminar on Information Support for Sustainable Soil Fertility Management.

Bennett, J.G., Hutcheon, A.A., Kerr, W.B., Mansfield, J.E. and Rackham, L. J. (1977a) Land Resources of Central Nigeria-Environmental aspects of the Kaduna Plain . Volume 1. *Landforms and Soils*. Land Resource Division, Ministry of Overseas Development Surbiton, 290.

Bennett, J.G., Hutcheon, A.A., Kerr, W.B., Mansfield, J.E., and Rackham, L.J. (1977b) Land Resources of Central Nigeria- Environment aspects of Kaduna Plains. Volume 3. *Land Systems.*Land Resource Division, Ministry of Overseas Development, Surbiton, 284.

Bennett, J.G., Blair-Rains, A., Gosden, P.N., Howard, W.J., Hutcheon, A.A., …and Rose Innes, R (1979) Land resources of Central Nigeria- Agricultural Development Possibilities. Volume 5B Kaduna Plains. *Land Resource Study* 29. Land Resource Development Centre, Ministry of Overseas Development. Surbiton, 190.

Berry, J.L., Davies, M., Mee, A.P. (2002) Vitamin D Metabolism, Rickets and Osteomalacia. *Seminars in Muscoskeletal Radiology* 6, 173-182.

Bingham, S.A., Atkinson, C., Liggins, J., Bluck, L., Coward, A. (1998) Phytoestrogens: Where Are We Now? *British Journal of Nutrition* 79: 393-406

Bishop, N. (1999) Rickets Today- Children Still Need Milk and Sunshine. *N. England Journal Med 341:* 602-604

Blair Rains, A., Lawton, R.M., Mansfield, J.E. and Rose Innes, R (1977) Land Resources of Central Nigeria- Environment aspects of Kaduna Plains. Volume 2. Climate and Vegetation. *Land Resource Report* 19. Land Resource Division, Ministry of Overseas Development. Surbiton, 8.

Bot, A., Benites, J. (2005) The Importance of Soil Organic Matter Key to Drought-Resistant Soil and Sustained Food Production. *FAO Soils Bulletin* 80, 1p. Publishing Management Service Information Division Food and Agriculture Organization of the United Nations Vialedelle Terme di Caracalla 00100, Rome, Italy

Botkin, D.B., Caswell, M., Estes J.E., and Orio A., eds (1989) Changing the Global *Environment: Perspectives on Human Involvement*. New York: Academic Press.

Brady, N.C. and Weil, R.R. (1999) Practical Nutrient Management: The Nature and Properties of Soils 12th Edition Prentice Hall New Jersey, 612-666

Bray, R.H., and Kurtz, L.T., (1945) Determination of Total, Organic and Available forms Phosphorus in Soils. *Soil Science,* 59: 39-45

Bremner, J.M., and Mulvaney, C.S. (1982) Total Nitrogen,In: Page, A.L., Miller, R.H., and Keeney, D.R (ed) Method of Soils Analysis Part 2. *Agro* 9. Madison W. pp I 149-157.

Brimblecombe, J. (1987) The Big Smoke A History of Air Pollution in London Since Medieval Times. London: Routledge, 30, 63

Brown, S., Anderson, J.W., Woomer, P.L., Swift, M.L., Barrios, E. (1994) Soil Biological Processes in Tropical Ecosystems. In: Woomer, PL; Swift, MJ (Eds) The Biological Management of Tropical Soil Fertility. Tropical Soil Biology and Fertility Programme Nairobi, Kenya and Wiley-Sayce Publication, UK, 15-46

Buol, S.W., Hole, F.D. and McCracken, R.J. (1973). Soil Genesis and Classification (1st ed.). *Ames,* Iowa: Iowa State University Press

Buol,S.W. (1990) Soil Genesis and Classification, Ames, IOWA: Iowa State University Press, pp 36, doi 10. 1081/E-ESS

Buring, J.E. and Hennekens, C.H. (1997) Antioxidant Vitamins and Cardiovascular Disease. *Nutr. Rev* 55: 53-60

Calloway, D.H. (1995) Human Nutrition: Food and Micronutrient Relationships. Washington, DC: *Int. Food Policy Res Inst.* 230

Carpenter, K.J. (2008) Harriette Chick and the Problem of Rickets. *Journal of Nutrition* 138, 827-832

Chen, J. (2007) Rapid Urbanization in China: A Real Challenge to Soil Protection and Food Security. *Catena Journal* 69:1–5

Claerr, J. (2008) The History of Rickets, Scurvy and other Nutritional Deficiencies. An Interesting Treatise on Human Stupidity. *Yahoo! Contributor Network*

Clarke, W.C. and Thaman, R.R. (1997) Incremental Agroforestry: Enriching Pacific Landscapes, *The Contemporary Pacific* 9, 1: 121–147.

Combs, Jr G.F. (1998) The Vitamins: Fundamental aspects in Nutrition and Health 2nded. New York, NY: *Academic Press*, 618

Combs Jr., G.F. and Hassan, N (2005) The Chakaria Food SystemStudy: Household-Level, Case-Control Study to Identify Risk Factorfor Rickets in Bangladesh, *European Journal of Clinical Nutrition*, 59, (11) 1291–1301.

Complete Dictionary of Scientific Biography. (2008):"Dokuchaev, VasilyVasilievich." *Encyclopedia.com.* (July 20, 2012). http://www.encyclopedia.com/doc/1G2-2830901198.html

Coomes, O.T. (2010) Of Stakes, Stems, and Cuttings: The Importance of Local Seed Systems in Traditional Amazonian Societies, *Professional Geographer* 62: 323–334

Craviari, T. Pettifor, J.M., Thacher, T.D., Meisner, C., Arnand, J., Fisher, P.R. (2006) Rickets: An Overview and Future Directions with Specific Reference to Bangladesh. *Journal of Health, Population and Nutrition.*

Dictionary.com Unabridged (2014). Retrieved August 25, 2014, from Dictionary.com website: http://dictionary.reference.com/browse/physicochemical

D'Hoore, J.L. (1964) *Soil Map of Africa*, 1:5000, 000. Joint Project no. 11, Commission for Technical Cooperation in Africa, Lagos

Dunn, P.M. (1998) Perinatal Lessons from The Past. *Arch Dis Child Fetal Neonatal Ed*, University of Bristol Department of Child Health South mead Hospital South mead Bristol BS10 5NB. 78: 154-155.

Duxbury, J.M., Smith, M.S., Doran, J.W. (1989) Soil Organic Matter As A Source and Sink of Plant Nutrient. In D.C Coleman, J.M Oades and G Uehara eds. Dynamics of Soil Organic Matter in Tropical Ecosystem, University of Hawaii Press, USA, 33-57

Ekanem, E. E., Bassey, D.E and Eyong, M (1995) Nutritional rickets in Calabar, *Nigerian Annual Tropical Paediatrics* 15: 303-306.

Esu, I.E. and Ojanuga, A.G. (1985) .Morphological, Physical and Chemical Characteristics of Alfisol in the Kaduna Area of Nigeria, *Samaru Journal of Agricultural Research*, 3, 39–49

Eswaran, H., Lal, R and Reich, P.F. (2001) Land Degradation: An Overview. In: Bridges, E.M.,Hannam, I.D., Olderman, L.R., Pening de Vries., Scherr, S.J and Sompatpanit (eds). *Responses to Land Degradation.* Proc. 2nd International Conference on Land Degradation and Desertification, Khon Kaen, Thailand, Oxford Press, New Delhi, India.

Ezenwa, M.I.S. and Esu, I.E. (1999): A Pedological Study of Soils Derived from Basement Complex Rocks in the Guinea Savanna Area of Nigeria, Samaru *Journal of Agricultural Research* 15: 35-50.

Fischer, P.R., Thacher, T.D., Pettifor, J.M., Jorde, L.B., Eccleshall, T.R. and Feldman, D. (2007) Vitamin D Receptor Polymorphisms and Nutritional Rickets in Nigerian children. *Journal Bone Miner,* 15(11): 2206-2210.

Fitzpatrick, E.A. (1980) Soils: Their Formation, Classification and Distribution, Longman, London, 353.

Food and Agriculture Organization (1992) UN Earth Summit. In: Sustainable Land Management www.fao.org/nr/land/sustainable-land-management/ Accessed on 4th April, 2013.

Food and Agriculture Organization (1997). Preventing Micronutrient Malfunction: A Guide to Food- Based Approaches. Washington DC: *Int Life Sci Inst.* 105 Author

Foth, H.D. (1990) Fundamentals of Soil Science. 8th edition. John Wiley and Sons Inc, New York, USA. 164-185

Gbadegesin, A and Akinbola, G.E. (1995) Nigeria: Reference Soil of the Southern Guinea Savanna of South Western Nigeria. Soil Brief Nigeria 7. University of Ibadan, and International Soil Reference and Information Centre, Wageningen 13.

Gee, G.W., and Bauder, J.W (1986) Particles-Size Analysis. pp 383-411 In: Page, AL(ed) Method of Soil Analysis Part 1, Physical and Mineralogical Methods 2nd Edition, *Agronomy Monograph* 9, American Society of Agronomy, Madison, W.I. 320-376

Gerrard, A.J. (1992) Soil Geomorphology. Chapman and Hall, 2-6 Boundary Row, London SE1 8HN, UK, 3

Grusak, M.A., Dean, D. (1999) Improving the Nutrient Composition of Plants to Enhance Human Nutrition and Health. *Ann. Rev Plant Physiol. Plant Mol. Biol*50: 133-61

Guerinot, M.L., Yi, Y. (1994) Iron Nutritious, Noxious, and not readily available. *Plant physiol.* 104: 815-20

Harper, A.E. (1985) Origin of Recommended Dietary Allowances- An Historic Overview. *American Journal of Clinical Nutrition.* 41: 140-48

Harper, A.E. (1987) Evolution of Recommended Dietary Allowances- New Directions? *Annu Rev. Nutr.* 7: 509-37

Hartmann, L. and Sponholz, B. (2011) Spatial Distribution of Calcium in Food, Water and Soil and Its Possible Influence on Rickets Disease in Northern Nigeria, *Environmental Geochemistry and Health*, 34, (3) 503–512.

Hassan, A.M and Raji, B.A (2007): Phosphorus Distribution and Forms in Nigerian Basement Complex Rock, Bauchi. In Uyovbisere, E.O., Raji, B.A., Yusuf, A.A., Ogunwale, J.O., Aliyu, L. And Ojeniyi, S.O. (ed). Soil and Water Management for Poverty Alleviation and Sustainable Environment. Proceedings of the31th Annual Conference of the Soil Science Society of Nigeria held at Ahmadu Bello University Zaria, Nigeria. 506-511.

Hodges, S.C. (2010) Soil Fertility Basics. N C Certified Crop Advisor Training. *Soil Science Extension* North Carolina State University 1-75

Hollick, M.F. (2004) Vitamin D: Importance in the Prevention of Cancers, Type 1 Diabetes, Heart Disease and Osteoporosis. *Am, Journal of Clin Nutri*: 79: 362-371.

Hollick, M.F. (2007) Vitamin D deficiency. *North Engl Journal of Med*. Jul 19; 357(3):266-81.

IITA. (1979): Selected Methods for Soil and Plant Analysis. International Institute of Tropical Agriculture. Manual Series No. 1: 70.

Innis, S.M. (1996) Essential Dietary Lipids, 168, 58-66

International Labour Organization **(**2007) Employment by Sector. In *Key Indicators of the Labour Market (KILM)* Chapter 4, *5th edition*. Author. Available at:www.ilo.org/public/english/employment/strat/kilm/download/kilm04.pdf

Isirimah, N.O., Dickson, A.A., Igwe, C. (2003) Introductory Soil Chemistry and Biology for Agriculture and Biotechnology Portharcourt: OSLA Int'l Publishers, 270

Jaiyeoba, I.A (1986) Analysis of Relationship between Soil Properties and Soil Forming Factors in the Nigerian Savannah. Ph.D Dissertation, Department of Geography, A.B.U., Zaria.

Jaiyeoba, I.A (1988) Build Up of Organic Matter and Nutrients under Fallow in Tropical Rainforest Environment, Nigeria. *Malaysian Journal of Tropical Geography* 18: 10-16

Jaiyeoba, I. A (2011) Soils: Nature and Physical Properties. Lecture notes. Department of Geography, Ahmadu Bello University, Zaria, Nigeria

Janssen, B.H. (1993) Integrated Nutrient Management: The Use of Organic and Mineral Fertilizers. In: Van Reuler, H; Prins, W (Eds) The Role of Plant Nutrients for Sustainable Food Production in Sub Saharan Africa, Leidschendam: VKP, 86-106

Jenny, H (1941) Factors of Soil Formation: A System of Quantitative Pedology Mc-Graw Hill Book Company Inc, New York, USA, 10-22.

Jones, M. J. and Wild, A. (1975) Soils of the West African Savanna. The Maintenance and Improvement of their Fertility, Common-wealth Agricultural Bureaux, Slough, UK, 55-145

Kabata-Pendias, A. and Mukherjee, A.B. (2007): Trace Elements from Soil to Human.-1, Berlin ed.; 550.

Kærgaard, T. (2003) A Plant That Changed the World: The Rise and Fall of Clover 1000–2000, *Landscape Research* 28: 41–49.

Kehrer, J.P., Smith, C.V. (1994) Free Radicals in Biology: Sources Reactivites and Roles in Etiology of Human Health and Diseases, ed Frie B, 2: 25-62p. San Diego: *Academic* pp588

Kiple, K. (ed) (1993) Cambridge World History of Human Disease. Cambridge: Cambridge University Press, 978

Kitz, C., Ebert, R., Jacob, F., Raab, P. (2012) Presentation on Rickets in Nigeria- Not a Disease of the Past

Kloesel, M.R. (2002) Rare, Genetic Form of Rickets treated at Shriners Hospital. *Texas Medical Centre News* Vol. 24, No.3

Kowal, J.M., and Knabe, D.T (1972): An Agroclimatic Atlas of the Northern States of Nigeria. Ahmadu Bello University, Zaria, 111.

Kuru, A. (1990) Roots of Deforestation Problems in Ethiopia. In: Matt, P et al. (ed) *Deforestation or Development in the Third World*? Vol III. Helsinki.

Laditan, A.A.O. and Adeniyi, A. (1975) Rickets in Nigerian children: Response to Vitamin D. *Journal Tropical Medicine Hyg,* 78: 206-209

Lal, R. (1976) Soil Erosion Problems in Alfisols in Western Nigeria and Their Control. *IITA Monograph* 1, Ibadan, Nigeria, 206

Lamberg-Allardt, C., H. Karp, H. and V. Kemi, V (2010) Phosphorus and Bone, in *Nutritional Influences on Bone Health*, P. Burckhardt, B. Dawson-Hughes, and C. Weaver, Eds., Springer, New York, NY, USA, 87–97.

Landon, J.R., (1991) Ed., Booker Tropical Soil Manual: A Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics, Longman Scientific and Technical, New York, NY, USA, 472.

Lilley, B.,Lammie, P., Dickerson, J. and Eberhard, M. (1997) An Increase in Hookworm Infection Temporarily Associated with Ecological Change. *Emerg Infect Dis* 3:391–393. Soil Degradation as a Reason for Inadequate Human Nutrition http://www.springerlink.com/content/v16rj23l57444812/fulltext.html[24/10/2012 10:54:56].

Linder, M.C. (1991) Nutritional Biochemistry and Metabolism: with Clinical Applications. New York. *Elsevier*, pp 603 2nd ed.

Marvin, G. (2012) Investigation into Soil Quality and Occurrence of Rickets in Kaduna, Nigeria. Unpublished M.Sc Thesis in Physical Geography and Landscape Ecology at the Leibniz University of Hannover, Germany.

Mid-Atlantic Water Program (2006) The Mid- Atlantic Nutrient Management Handbook. Basic Soil Fertility by Hansen, DJ and Mullins, G Chap. 4, 45-87. Author.

Milford, H.B., McGraw, E.J.A., Nixon, K.J (2001). Soil Data Entry Handbook for the NSW Soil and Land Information System (SALIS), 3rded, New South Wales Department of Land and Water Conservation Resource Information Systems Group, Parramatta, 30-32.

Morel, R and Quantin, P (1964) Fallowing and Soil Renegeneration under the Sudan-Guinea Climate in Central Africa. *Agron. Tropi*, Paris, 19, 105-136.

Mosley, S. (2001) The Chimney of the World. A History of Smoke Pollution in Victorian and Edwardian Manchester, Cambridge, The White Horse Press, 16.

MRC Human Nutrition Research (2013) Review Nutritional Rickets around the World. *Journal of Steroid Biochemistry and Molecular*, MRC Human Nutrition Research, Author, Cambridge, United Kingdom.

Mughal, M.Z. (2011) *Rickets Current Osteoporosis Reports* 9, 291-299.

Nazif, W., Perveen, S., Saleen, I. (2006) Status of Micronutrients in Soils of District Bhimber (Azad Jammu and Kashmir) *Journal of Agricultural and Biological Sciences* 1 (2), 1-10

Nelson, D. W. and Sommers, L.E. (1982): OrganicCarbon. In Page, A.L., Miller, R.H. and Keeney, D.R. (eds). Methods of Soil Analysis.Part 2 *Agron* 9. Madison, WI. 538-580.

Netting, R.M. (1993) Smallholders, Householders. Stanford, CA: Stanford University Press. Author.

Nye, P.H. and Greenland D.J. (1960) The Soil Under Shifting Cultivation. *Commonwealth Agricultural Bureax*

Odeka, E. (2005) Nutritional is increasingly diagnosed in children of ethnic origin, *Archives of Disease in Childhood* 90, 1203-1204

Odunze, A.C. (2006): Soil properties and Management Strategies for Some Sub –humid Savanna Zone Alfisols in Kaduna State, Nigeria. Samaru, *Journal of Agricultural Research* 22:3-14.

Official Gazetter (2007) Federal Republic of Nigeria. *Official Gazette*, Vol 94 No 24. Lagos, Federal Government Printer.

Ogini, L.W. Worsfold, M., Oyelami, O.A., Sharp, C.A., Powell, D.E., Davis, M.W.J. (1996). Etiology of Rickets in Nigerian Children. *Journal of Pediatrics* 128: 692-694

Ojo, O (1977) *The Climates of West Africa*. Heinemann, Fakenham, 219.

Okonofua, F., Gill, D.S., Alabi, Z.O., Thomas, M., Bell, J.L. and Dandona, P. (1991) Rickets in Nigeria Children: A Consequence of Calcium Malnutrition. *Metabolism* 40 (2): 209-213

Oranasionwu, G.E., Thacher, T.D., Sunday, D.P.,Pettifor, J.M. and Adams, S.A. (2008) Adaptation of Calcium Absorption during Treatment of Nutritional Rickets in Nigeria Children. *British Journal of Nutrition* Vol 100: 387-392.

Oyeniyi, B. (2013) The Impact of Cooperative Society in Empowerment of Rural Women (A Case Study of Some Selected Cooperative Societies in Chikun Local Government. Posted on 15th October, 2013 at 09:43 at http://kayoworld-bukky.blogspot.com/2013/10/the impact-of-cooperative-society-in html.

Parfitt, R.L., Theng, B.K.G., Whitton, J.S., and Shepherd T.G (1997) Effects of Clay Minerals and Land Use on Organic Matter Pools. *Geoderma*, 75, 1-2.

Pearce, S.H., and Cheetham, T.D. (2010) Diagnosis and Management of Vitamin D Deficiency. BMJ. Jan 11; 340:b5664. doi: 10.1136/bmj.b5664.

Perklin, J. (1989) A Forest Journey: The Role of Wood in the Development of Civilization. New York: W.W. Norton.

Pettifor, J.M., Ross, P., Wang, J., Moodley, G., Couper-Smith, J. (1978). Rickets in Children of Rural Origin in South Africa: Is Low Dietary Calcium a Factor? Journal of Pedatrics 92: 320-324

Pettifor, J.M. (2004) Nutritional Rickets: Deficiency of Vitamin D Calcium or both? *The American Journal of Clinical Nutrition* (80): 1725-1729.

Pettifor, J.M. (2005) Rickets and Vitamin D Deficiency in Children and Adolescents. *Endocrine Metabolic Clinic North America* 34: 537-553

Pettifor, J.M. (2006). Nutritional Rickets around the World: Causes and Future Directions. *Annal of Tropical Paediatrics*Vol 26: 1-16.

Pettifor, J.M. (2012) Nutritional rickets, In: Glorieux, F; Jueppner, H; Pettifor, JM (eds) Paediatric Bone- Biology and Disease 2nd ed, *Elsevier Science*, Chennai, India

Pieri, C. (1995) Long-term Soil Management Experiments in Semiarid Francophone Africa In: Lal, R., Stewart, B. (Eds) Soil Management Experimental Basis for Sustainability and Environmental, Quality. *Adv. Soil Sci*. CRC Lewis Publishers, Boca, Raton, FA, USA 225-266

Pimentel, D.,Cooperstein, S.,Randell, H.,Filiberto, D.,Sorrentino, S., Kaye, B.,Nicklin,C., Yagi, J., Brian, J.,O'Hern, J.,Habas, A., Weinstein, C. (2007) Ecology of Increasing Diseases; Population Growth and Environmental Degradation. *Hum Ecol* 35:653–668

Prentice (2008) Vitamin D Deficiency: A Global Perspective, *Nutrition Review* 66, 153-164 Prentice.

Qi, J., Yang, L. and Wang, W. (2007) Environmental Degradation and Health Risks in Beijing, China. *Archives of Environment and Occupational Health* 62:33–37

Rajakumar, K. (2003). Vitamin D, Cod-Liver Oil, Sunlight, and Rickets: A Historical Perspective. *Pediatrics*, 112(2): 132-135.

Raji, B.A., Malgwi, W.B., Berding, F.R., and Chude, V.O. (2011) Integrating Indigenious Knowledge and Soil Science Approaches to Detailed Soil Survey in Kaduna State. *Journal of Soil Science and Environmental Management.* 2 (33): 66-73

Raubenheimer, E. J and Noffke, C. E.E., (2011) Vitamin D and Health –A Historical Overview *Basic Medical Science Article, S .A, Orthopaedic Journal,* Winter (10) No 2, 39- 43

Rekacevicz, P. (2005) Global Soil Degradation, *UNEP/ Arendal*.

Rekacevicz, P. (2008) Global Soil Degradation, *UNEP/ Arendal*.

Retallack, G.J. (2008) Soils of the Past: An Introduction to Paleopedology (2nd ed). John Wiley and Sons, UK, 207

Rhoades, J.D. (1982) Cation Exchange Capacity. In: Page, A.L., Miller, R.H and Keeney, D.R (ed) Methods of Soil Analysis Part 2. *Agronomy Monography*, 9, American Society of Agronomy, Madison, W.I 149-157.

Robbins, P. (2001) Tracking Invasive Land Covers in India, *Annals of the Association of American Geographers* 91 (2001): 637–659

Saka, A.R., Phomebya, H.S.K., Itimu, O.A., Jones, R.B., Minae, S. and Snapp, S.S. (1995) *Agroforestry Commodity Team Annual Report*, 90. Dept. Agric. Research, Malawi Ministry of Agriculture, Lilongwe, Malawi

Salunkhe, D.K., Desai, B.B. (1987) Effects of Agricultural Practices, Handling, Processing, and Storage on Vegetables. In *Nutritional Evaluation of Food Processing*, ed. Karma, E and Harris, R.S. New York: AVI 3rd 3: 23-71

Scarbrook, C.E. (1965) Nitrogen availability, in Soil Nitrogen, ed. Bartholomew, W.V. and Clark, F.E. *American Society of Agronomy*, Madison, Wisconsin.

Schoemakers, I., Laskey, M.A., de Bono, S., Ginty, F., Goldberg, G.R. (2006). Nutrition and Bone Growth and Development, *Proceedings of the Nutrition Society* 65, 348-360

Schulin, R., Johnson, A. and Frossard, E. (2010) Trace Element Deficient Soils, in *Trace Elements in Soils*, P. Hooda, Ed., Blackwell, Chichester, UK, 175–197.

Semmel, A. (1991) Relief, Gestein, Boden-Grundlagen der Physischen Geographien I. Wissenschafliche Buchgesellschaft Darmstadt, Darmstadt, 148 In: Marvin, G. (2012) Investigation into Soil Quality and Occurrence of Rickets in Kaduna, Nigeria. Unpublished Ph.D Thesis in Physical Geography and Landscape Ecology at the Leibniz University of Hannover, Germany.

Shackleton, CM; Mc Garry, D; Fourie, S; Gambiza, J; Shackleton, SE; Fabricius, C (2007) Assessing the Effects of Invasive Alien Species on Rural Livelihoods: Case Examples and a Framework From South Africa, *Human Ecology* no. 35:113–127

Sing, D.B. and Sing, C.F. (2008) Soil and Human Health. In: Lal R (ed) *Encyclopedia of Soil Science*. Taylor and Fromes, New York.

Steinmetz, K.A., Potter, J.D. (1996) Vegetables, fruit and cancer prevention: A Review. *J. Am Diet. Assoc.* 96: 1027-39

Stocking, M. and Murnaghan, N. (2001) Handbook for the Field Assessment of Land Degradation, Earthscan, London.

Sultan, B. and Janicot, S. (2000) Abrupt Shift of ITCZ over West Africa and Intra-Sesonal Variability. *Geophysical Research Letters* 27(20): 3353-3356

Tangney, C.C. (1997) Vitamin E and Cardiovascular Disease. *Nutri. Today* 32: 13-22

Tassin, J; Rangan, Hand Kull (2012) CA Hybrid Improved Tree Fallows: Harnessing Invasive Legumes for Agroforestry, *Agroforestry Systems* 84:417–428.

.Thacher, T.D.,Ighogboja, S. I., and Fischer, P. R. (1997) Rickets without Vitamin D Deficiency in Nigerian Children. *Ambul Child health*, 3: 56-64

Thacher, T.D., Glew, R.H., Ischei, C.O., Lawson, J.O., Scariano, J.K., Hollis, B.W., and Vaderget F (1999) Rickets in Nigerian Children: Response to Calcium Supplementation. *Journal of Tropical Paediatrics*, 45:202-207

Thacher, T.D (2003) Calcium-Deficiency Rickets. In: Hochberg Z, editor. Vitamin D and Rickets. Basel: Karger, 105-125

Thacher, T.D., Fischer, P.R., Strand, M.A., Pettifor, J.M. (2006) Nutritional Rickets around the World: Causes and Future Direction. *Annals of Tropical Paediatrics*, (26): 1-16.

Thacher, T.D., and Abrams, S. A. (2010). Relationship of Calcium Absorption with 25(OH) D and Calcium Intake in Children with Rickets. *Nutrition Review*, 68(11), 682-688.

The Stationery Office (2007) Scientific Advisory Committee on Nutrition, Update on Vitamin D, *The Stationery Office, London,* Author.

Thomas, G.W. (1982) Chemical Microbiological Properties 159-162 *Agronomy Monograph* 9.2.In Page, AL (ed) Method of Soil Analysis 2nd Edition. American Society of Agronomy. Madison, W.I

Tiessen, H., Cueva, E. and Chacon, P (1994) The Role of Soil Organic Matter in Sustaining Soil Fertility. *Nature*, 371: 783-785

Tinker,P.B., Durall, D.M. and Jones, M.D. (1994) Carbon Use Efficiency in Mycorrhizas: Theory and Sample Calculations. *New Phytologist* 128, 115-122.

Unanaonwi, O.E. (2009) Acidity, Organic Carbon and Nitrogen Status of Soils under Acacia Senegal L (Wild) Plantation and Natural Forest in Gummi Forest Reserve, Zamfara State, Nigeria. *Nigeria Journal of Forestry,* 38 (2) 91-99.

Unanaonwi, O.E. and Chinevu, C. N (2013) Physical and Chemical Characteristics of Forest Soil in Southern Guinea Savannah of Nigeria. *Global Journal of Science Frontier Research Agriculture and Veterinary*, 13.

Van Reuler, H., Prins, W (eds) (1993) The Role of Plant Nutrients for Sustainable Food Crop Production in Sub Saharan Africa, *Leidschendam*: VKP, 86-106

Walkey, A., Black, I. A., (1934) Soil Science. 37: 29-38

World Cancer Research Fund (1997) Food Nutrition and the Prevention of Cancer: A Global Perspective. Washington DC. *Am. Inst. Cancer Res.* Author.

World Health Organization (2004) Vitamin and Mineral Requirements in Human Nutrition, Report of Joint FAO/WHO Experts Consultation, 2nd Edition, Bangkok, Thailand, 21st - 3oth Sept 1998.

www.nbsdirect.wales.nhs.uk/encyclopaedia/article/rickets accessed on 5th March, 2013.

Young, A. (1976) Tropical Soils and Soil Survey. N.Y: Cambridge University Press. Cambridge, 468