EFFECTS OF DEVEGETATION ON AGRICULTURAL SOIL QUALITY AT NNEWI NORTH LOCAL GOVERNMENT AREA OF SOUTH EASTERN NIGERIA

BY

CHUKWUMA, NONYE C. (PGD, FUTO)

(REG. NO: 20105771069)

A THESIS SUBMITTED TO

POST GRADUATE SCHOOL

FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI.

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF TECHNOLOGY (M.TECH) IN ENVIRONMENTAL TECHNOLOGY

JUNE, 2016

CERTIFICATION

This is to certify that this work **"EFFECTS OF DEVEGETATION ON AGRICULTURAL SOIL QUALITY AT NNEWI NORTH LOCAL GOVERNMENT AREA OF SOUTH EASTERN NIGERIA"**. was carried out by **CHUKWUMA, NONYE C.** with Registration Number: **20105771067** in partial fulfillment of the requirements for the award of Master of Technology (M.Tech) degree in Pollution Control in the Department of Environmental Technology, School of Environmental Sciences, Federal University of Technology, Owerri (FUTO).

.... 08/08/2016
Prof. (Mrs.) C. G. Okoli **Date**
(Supervisor)

.... 29/8/16.
Dr. C. O. Nwoko **Date**
(Head of Department)

....
Prof. (Mrs) R. N. Nwabueze **Date**
(Dean of SOES)

....
Prof. (Mrs) N. N. Oti **Date**
(Dean PGS)

....
(External Examiner) **Date**

DEDICATION

This research is dedicated to Almighty God for his divine support and protection throughout the period of this project.

ACKNOWLEDGMENT

I am highly indebted to my supervisor, Prof. (Mrs.). G.C. Okoli for assiduous supervision and monitoring of this project. I equally thank in a very special way, the Head of Department, Dr. C.O Nwoko, Prof. E. Oguzie, for graduating and giving us the moral support that made us graduates successfully. The coordinator, Dr. E. Ihejirika for his supporting role throughout the period of the research program; others are my academic adviser, Dr. Henry Ogbuagu for his meticulous & masterly articulation of this research work. I will also thank my spouse Dr. Chukwuma Chukwuemeka for helping me emotionally, financially, morally and spiritually during the research work.

I will be committing unpardonable offence if I fail to thank my Director in the office, Dr. Mrs. Ezeike for her enormous support and the permission granted me during the course of this project research.

Finally, my gratitude goes to my friends, Mrs. Mgbenwelu P.I.; Laz Ikwa and others for their encouragement to me when the pressure to back out of the program was high on me; my course mates in the 2010/2011 academic session were also there for me. I appreciate them all. I also thank my friend Joseph Chima for his valuable time and efforts in making sure that I succeeded. To all my wishes who I did not mention their names for want of space, May God reward all.

TABLE OF CONTENTS

CHAPTER THREE

CHAPTER FOUR

CHAPTER FIVE

LIST OF TABLES

Table **Page**

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDIXES

ABSTRACT

This study evaluated the Impact of Devegetation on Soil environment of Nnewi North LGA in South East- Nigeria. It is caused by increasing demand for land with its consequences on disruption of soil ecology, climate change, breakdown of nutrient cycle and increase in soil erosion, siltation of dams and reservoirs, destruction of wildlife habitats, and loss of plant and genetic diversity. Soil samples for analysis were obtained in the study area from depth 0-15 cm, 15- 30 cm and 30-45 cm respectively. Conventional analytical methods were employed for the determination of selected physicochemical parameters: pH, NPK, organic carbon,% sand, silt and clay; charged ions such as Ca^{2+}, Mg^{2+}, Na^{+}, Al^{3+}, Fe^{2+}, $Mn^{3+,}$ and Zn^{2+}. Heavy metals in the soil samples were analyzed using Atomic Absorption Spectrophotometer (AAS). The pH values in all the sites had a mean concentration of 4.69, indicating acidity of the soil. Organic carbon concentration ranged between 0.45-0.60%, indicating low microbiological activities in the soil and hence increase in the concentration of carbon dioxide in the atmosphere. Mineral nitrogen had (0.06033 $Mgkg^{-1}$) phosphorus (5.10–7.80 $Mgkg^{-1}$) and potassium (0.05767 $Mgkg^{-1}$) respectively. The soil may require some amendment to boost crop production. In general, there was heavy concentration of the mean values of sand (75.67 %), silt (5.300 %) and clay (19.0233 %) as well as low calcium and magnesium ion concentration in the soil, contributing to low fertility status at the area. The study recommended afforestation and integrated agriculture as a tool for sustaining the environment.

Keywords: Devegetation, Soil quality, Nnewi North L.G.A., Deforestation, Edaphic variables

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Deforestation and land degradation are now seriously affecting both agricultural crop yields in the tropics and availability of productive land (Leakey, 2014).

This, together with the abject poverty of many smallholders has made it difficult for them to purchase artificial fertilizers and pesticides to boost crop yield. Soil degradation due to land mismanagement has further threaten economic and rural development, especially in south east Nigeria (Ofomata, 2010). Apart from the problems enumerated above, increasing demand for land has also intensified deforestation with its consequences on disruption of soil ecology, breakdown of nutrient cycling and increase in soil erosion, siltation of dams and reservoirs, destruction of wildlife habitats, and loss of plant and genetic diversity (World Bank, 2008). Hence experts have advocated for a system that will support sustainable use of the environment. The integration of trees with monoculture crops, and animal rearing is considered an appropriate strategy that is capable of bringing about a balance in the ecosystem, especially in an already degraded environment, and also in areas already threatened by land degradation as a result of large-scale and often uncontrolled anthropogenic activities. (Ikwa, 2015). A major effect of deforestation in south east Nigeria is increased soil erosion which has displaced people from their native homes, led to destruction of lives and property and collapse of infrastructural facilities in some parts of the state.

(Ubuoh, *et al.,* 2013). This conversion could leave the land more susceptible to soil degradation, including high soil bulk density, lower hydraulic conductivity and higher soil erosion (Spaans, 1989). A large body of information is now available that shows clearly severe damage to the soil quality and increased soil erosion caused by agricultural practices in the forest areas (Knuti *et al.,* 1979). Mohammed *et al.,* (1997) reported extensive nutrient losses (particularly NO_3-N and Ca) following deforestation. Mroz *et al.,* (1985) mentioned that total tree harvesting may have severe effects on forest - nutrient removal, increased erosion rates and percolation, losses of nutrients, and also soil compaction. Soil degradation due to land mismanagement is another major factor that threatens economic and rural development, especially in the third-world countries (El-Swaity, 1994). To check this trend therefore, it is important to check Soil quality to enhance sustainability of the global biosphere and developing agricultural practice (Wang and Gong, 1998). Monitoring of soil quality provides an opportunity to evaluate soil and land management system. This study therefore focuses on assessing the impact of deforestation on soil quality in order to suggest ways to minimize soil erosion menace for enhance agricultural productivity in the area.

1.2 Statement of the Problem

The subject of environmental degradation and its associated menace has become a matter of concern in Nigeria today. It has undoubtedly become known as a potential hazard to almost every community in Nigeria. This menace affects soil properties and the potential of soil resource in many communities all over the federation are being destroyed.

Nnewi North Local Government Area is one of the areas that have been developing fast in Anambra State and like other communities in Nigeria is not free from high rate of deforestation with its attendant negative effect on soil quality and agriculture started the high rate. A lot of deforestation activities are currently going on in the Local Government and includes cutting down of trees and clearing of land for building of houses and construction of industries, roads and markets. These activities no doubt could have negative implications on soil quality. However, there is paucity of data on the impact of deforestation in soils of Nnewi North Local Government Area and this study attempted to fill the gap and contribute to knowledge by determining the characteristics of soil in the Local Government Area impacted by resultant erosions from deforestation.

1.3. Aim and Objectives

The aim of the study was to determine possible effects of devegetation on soil quality in Nnewi North Local Government Area of Anambra State. The aim was achieved through the following objectives:

- **i.** Determination of edaphic variables of soils of Nnewi North Local Government Area impacted by erosion caused by deforestation
- ii. Determination spatial variations in edaphic variables of the study area.

iii. Determination of possible relationships between the edaphic variables

iv. Suggestion of recommendations, based on findings, on measures to control deforestation in the area.

1.4 Significance of the Study

Results from this research work could bring to light the effects of deforestation on soil quality of Nnewi North Local Government Area of Anambra State. The study will also provide qualitative and quantitative data for policy formulation that will fill this obvious gap in scientific information. The work will be useful to researchers and students, individuals, as well as governments and non-governmental organizations interested in the conservation of forests resources and ensure environmental sustainability. It is also expected that the implications of this study would have broader policy implication for most states in the country which have similar problems.

1.5 Scope and Delimitation

This research work characterized the soils of the study area based on the following edaphic variables only - pH, organic carbon, organic matter, total nitrogen, bulk density, available phosphorus, exchangeable cations (Na^+, K^+, $Mg^{2+,}$ Ca^{2+}), CEC, sand, silt, clay and moisture content. It was conducted in the Nnewi North Local Government Area of Anambra State, south eastern Nigeria during the farming season months of 2013.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 CAUSES OF DEFORESTATION

Myers (1992) pointed out that “we still have half of all tropical forests that ever existed”. The struggle to save the world’s rainforests and other forests continues and there is a growing worldwide concern about the issue. Distinguishing between the agents of deforestation and its causes is very important in order to understand the major determinants of deforestation. The agents of deforestation are those slash and burn farmers, commercial farmers, ranchers, loggers, firewood collectors, infrastructure developers and others who are cutting down the forests. Causes of deforestation are the forces that motivate the agents to clear the forests. However, most of the existing literature typically distinguishes between two levels of specific factors: direct and indirect causes of deforestation. According to Panayotou (1990) and Barbier *et al.* (1994), direct agents and causes of deforestation are relatively easy to identify but Humphreys (2006) and Sands (2005) stated that the indirect causes which are usually the main divers of deforestation are the ones that cause most disagreement and the ones that are hardest to quantify. Similarly, Pearce and Brown (1994) identified two main forces affecting deforestation. They are: Competition between humans and other species for the remaining ecological niches on land and in coastal regions. This factor is substantially demonstrated by the conversion of forest land to other uses such as agriculture, infrastructure, urban development, industry and others; Failure in the working of the economic systems to reflect the true value of the environment. Basically, many of the functions of tropical forests are not marketed and as such are ignored in decision making. Additionally, decisions to convert tropical forests are themselves encouraged by fiscal and other incentives. The former can be regarded as the direct and latter as indirect cause of deforestation.

2.2 Direct Causes

2.1.1 Expansion of Farming Land

The World Bank (1991) estimated that about 60 per cent of the clearing of tropical moist forests is for agricultural uses and the World Resources Institute (1994) added that logging and other activities like road construction, urbanization and fuel wood account for the rest. Tropical forests are one of the last frontiers in the search for subsistence land for the most vulnerable people worldwide (Myers, 1992). Millions of people live on the tropical forest with less than a dollar a day where a third of a billion are estimated to be foreign settlers. However, as the land degrades, people are forced to migrate, exploring new forest frontiers and increasing deforestation (Wilkie *et al*., 2000; Amor, 2008). Deforestation is proxied by the expansion of agricultural land. This is because agricultural land expansion is generally viewed as the main source of deforestation contributing around 60 per cent of total tropical deforestation (Myers, 1994., World Bank, 1991). Shifting agriculture, also called slash and burn agriculture is the clearing of forested land for raising or growing the crops until the soil is exhausted of nutrients and/or the site is overtaken by weeds and then moving on to clear more forest. It is been often reported as the main agent of deforestation. Smallholder production in deforestation and the growing number of such producers, notably shifting cultivators, were reportedly the main causes of deforestation (FAO, 1990; Dick, 1991; Ross 1996). Mostly all reports indicate shifting agriculture as responsible for about one half of tropical deforestation and some put it up to two-thirds. Shifting agriculture was greatest in Asia(about 30 per cent) but only about 15 per cent over the whole tropical world. It appears that the proportion of direct conversion of forest to agricultural land is increasing and the proportion of shifting agriculture is decreasing with time.

2.1.2 Forest and other Plantations

Plantations are a positive benefit and should assist in reducing the rate of deforestation. The fact that plantations remove the timber pressure on natural forests does not translate eventually into less, but rather into more deforestation. Millennium Ecosystem Assessment (2005) and Cossalter and Pye-Smith (2003) stated that, it is feared that agricultural expansion which is the main cause of deforestation in the tropics might replace forestry in the remaining natural forests, while Kartodihardjo and Suprionorss (2000) concluded that the impact of timber plantations could thus turn out to be quite detrimental to tropical forest ecosystems. Tree crops and rubber in particular plays a more important role in deforestation in Indonesia than subsistence-oriented shifting cultivation (Chomitz and Griffiths, 1996). Unfortunately about one-half of the plantations in the tropics are established on native forests cleared for the purpose. Moreover plantation scan promote deforestation by constructing roads that improve access of the shifting cultivators and others to the forest frontier.

2.1.3 Logging and Fuel Wood

Putz, *et al.,* (2001) suggested that logging does not necessarily cause deforestation. However, logging can seriously degrade forests (Chomitz, *et al.* 2007) .Logging in Southeast Asia is more intensive and can be quite destructive. Logging provides access roads to follow-on settlers and log scales can help finance the cost of clearing remaining trees and preparing land for planting of crops or pasture. Logging thus catalyzes deforestation. Fuelwood gathering is often concentrated in tropical dry forests and degraded forest areas. Fuel wood is not usually the major cause of deforestation in the humid tropics, although it can be in some populated regions with reduced forest area such as in the Philippines, Thailand, and parts of Central America. Fuel wood gathering was considered to be the main cause of deforestation and forest degradation in El Salvador (Repetto, 1990). In the drier areas of the tropics, fuel wood gathering can be a major cause of deforestation and degradation.

2.1.4 Overgrazing

Hays (2008) narrated that overgrazing could lead to soil erosion. Stripping trees to provide fodder for grazing animals can also be a problem in some dry areas of the tropics but is probably not a major cause of deforestation. For example, clear cutting and overgrazing have turned large areas of Qinghai province in China into a desert. Overgrazing are causing large areas of grasslands north of Beijing and in Inner Mongolia and Qinghai province to turn into a desert. One man who lived in a village on the eastern edge of the Qinghai-Tibet plateau that was being swallowed up by sand told the New York Times, "The pasture here used to be so green and rich. But now the grass is disappearing and the sand is coming." Huge flocks of sheep and goats strip the land of vegetation. In Xillinggol Prefecture in Inner Mongolia, for example, the livestock population increased from 2 million in 1977 to 18 million in 2000, turning one third of the grassland area to desert. Unless something is done the entire prefecture could be uninhabitable by 2020. Overgrazing is exacerbated by sociological phenomena called "the tragedy of the common." People share land but raise animals for themselves and try to enrich them by raising as many as they can. This leads to more animals than the land can support for example, grassland in Qinghai that can support 3.7 million sheep had 5.5 million sheep in 1997. Animals remove the vegetation and winds finished the job by blowing away the top soil, transforming grasslands into desert. When a herder was asked why he was grazing goats next to a sign that said "Protect vegetation, no grazing," he said, "The lands are too infertile to grow crops – herding is the only way for us to survive."

2.1.5 Fires

According to Repetto (1988) and Rowe *et al*. (1992), fires are a major tool used in clearing the forest for shifting and permanent agricultural pastures. Fire is a good servant but also a bad master. This is because fire used responsibly can be a valuable tool in agricultural and forest management but if abused, can be a significant cause of deforestation. FAO (2010) estimated that based on the data available from 118 countries representing 65 per cent of the global forest area, an average of 19.8 million hectares or one per cent of all forests were reported to be significantly affected each year by forest fires. Carvalho *et al.* (2001) and Nepstad *et al.* (2001) stated that deforestation due to road pavements in Brazil had also led to higher incidences of forest fires.

2.1.6 Urbanization/industrialization and infrastructure

Mather (1991) and Sands (2005) concluded that expanding cities and towns require land to establish the infrastructures necessary to support growing population which is done by clearing the forests. Tropical forests are a major target of infrastructure developments for oil exploitation, logging concessions or hydropower dam construction which inevitably conveys the expansion of the road network and the construction of roads in pristine areas. Kaimowitz and Angelsen, (1998) stated that the construction of roads, railways, bridges, and airports opens up the land to development and brings increasing numbers of people to the forest frontier. Whether supported or not by the governmental programmes, these settlers have usually colonized the forest by using logging trails or new roads to access the forest for subsistence land (Wilkie *et al.*, 2000; Amor, 2008; Amor and Pfaff, 2008). IPCC, (2001) wrote that the development of these infrastructure projects are of worldwide concern, since tropical forest clearing accounts for roughly 20 per cent of anthropogenic carbon emissions, destroying globally significant carbon sinks and causing around 21 per cent of tropical forests to be lost worldwide since 1980 (Bawa, 2004).

2.1.7 Air pollution

Air pollution is associated with degradation of some European and North American forests. The syndrome is called "Waldsterben" or forest death. According to Raloff (1989), eight per cent of all West German trees exhibited damage that rose to about 52 per cent by 1987 and half of the trees were reported dying of Waldsterben in the Alps. High elevation forests show the earliest damage, including forests in the north-east and central United States.

2.2 Indirect Causes

World Rainforest Movement (1990) noted that the World Rainforest Movement's 'Emergency Call to Action for the forests and their Peoples' asserts that "deforestation is the inevitable result of the current social and economic policies being carried out in the name of development". It is in the name of development that irrational and unscrupulous logging, cattle ranching, large dams, colonisation schemes, the dispossession of peasants and indigenous peoples and promotion of tourism is carried out. Harrison Ngau, an indigenous tribesman from Sarawak, Malaysia and winner of the Goldman Environment Award in 1990 puts the cause of tropical deforestation like this, “the roots of the problem of deforestation and waste of resources are located in the industrialized countries where most of our resources such as tropical timber end up. The rich nations with one quarter of the world’s population consume four fifth of the world’s resources. It is the throw-away culture of the industrialized countries now advertised in and forced on to the Third World countries that is leading to the throwing away of the world. Such so-called progress leads to destruction and despair”. Such a development leads to overconsumption which is the basic underlying cause of deforestation.

2.2.1 Colonialism

Erstwhile colonies of countries like Britain, France, Spain and Portugal are now the Third World Countries or the developing nations. They mostly have the tropical rainforests except Australia and Hawaii and were exploited for their natural resources by these colonial powers who also destroyed their indigenous people’s right. All these countries have indigenous populations who had their own system of land management and/or ownership in place for thousands of years before the intervention of colonists from rich industrialized nations. Colonialism turned previously self-sufficient economies into zones of agriculture export production. This process continues even today in different form of exploitation and the situation is worsening according to Colchester and Lohmann (1993).

2.2.2 Exploitation by Industrialized Countries

Wealthy countries or the erstwhile colonial powers having deficit of their own natural resources are mainly sustaining on the resources of the financially poorer countries which are generally rich in natural resource. Twenty per cent of the world's population is using 80 percent of the world's resources. Unfortunately also, the governments of these poor, resource-rich countries had generally adopted the same growth-syndrome as their western neighbours or their erstwhile colonial master, giving emphasis on maximizing exports, revenues and exploiting their rich natural resources unsustainably for short-term gains, amidst corruption in government, that impacts the economy negatively. Colchester and Lohmann (1993) added that these problems are worsened by the low price of most of the third World's exports in the international market.

2.2.3 The Debt Burden

Pursuing the guided development agenda, the financially poorer countries are on a heavy international debt and now feeling the urgency of repaying these huge debts due to escalating interest rates. Such a situation compels these debt ridden poorer countries to exploit their rich natural resources, including their forests partly to earn foreign exchange for servicing their debts. For instance, construction of roads for logging operations in some South-east Asian countries was funded by Japanese aid which allowed the Japanese timber companies to exploit the forests of these countries. Understandably, these timber companies profitably exploited the forests while the South-east Asian countries were left owing Japan money for construction of their roads (Colchester and Lohmann, 1993).

2.2.4 Overpopulation and Poverty

The role of population in deforestation is a contentious issue according to Mather (1991) and Colchester and Lohmann (1993). The impact of population density on deforestation has been a subject of controversy. Poverty and overpopulation are believed to be the main causes of forest loss according to the international agencies such as FAO and intergovernmental bodies. It is generally believed by these organizations that they can solve the problem by encouraging development and trying to reduce population growth. Conversely, the World Rainforest Movement and many other NGOs hold unrestrained development and the excessive consumption habits of rich industrialized countries as directly responsible for most forest loss. However, there is good evidence that rapid population growth is a major indirect and over-arching cause of deforestation. More people require more food and space which requires more land for agriculture and habitation. This in turn results in more clearing of forests. Arguably, increasing population is the biggest challenge of all to achieve sustainable management of human life support systems and controlling population growth is perhaps the best single thing that can be done to promote sustainability. Overpopulation is not a problem exclusive to the Third World countries. An individual in an industrialized country is likely to consume in the order of sixty times as much of the world's resources as a person in a poor country. The growing population in rich industrialized nations are therefore responsible for much of the exploitation of the earth and there is a clear link between the overconsumption in rich countries and deforestation in the tropics.

Poverty and overpopulation are inextricably linked. Poverty, while undeniably responsible for much of the damage to rainforests, has to a large extent been brought about by the greed of the rich industrialized nations and the Third World elites who seek to emulate them. Development is often regarded as the solution to world poverty, but seldom helps those whose need is greatest. Thus, it is often the cause rather than the cure for poverty. The claim that overpopulation is the cause of deforestation is used by many governments and aid agencies as an excuse for inaction. In tropical countries, pressure from human settlement comes about more from inequitable land distribution than from population pressure. Generally, most of the land is owned by small but powerful elite which displaces poor farmers into rainforest areas. Colchester and Lohmann (1993) added that so long as these elites maintain their grip on power, lasting land reform will be difficult to achieve and deforestation continues unabated. Therefore poverty is well considered to be an important underlying cause of forest conversion by small-scale farmers and naturally forest-dense areas are frequently associated with high levels of poverty. The population also often lacks the finance necessary for investments to maintain the quality of soil or increase yields on the existing cleared land. Deforestation is affected mainly by the uneven distribution of wealth. Shifting cultivators at the forest frontier are among the poorest and most marginalized sections of the population. They usually own no land and have little capital. Consequently, they have no option but to clear the virgin forest. Angelsen (1999) concluded that deforestation, including clearing for agricultural activities is often the only option available for the livelihoods of farmers living in forested areas.

2.2.5 Transmigration and Colonisation Schemes

Transmigration of people to the forest frontier, whether forced or voluntary, due to development policy or dislocation from war, is the major indirect cause of deforestation (Mather, 1991). Moreover, governments and international aid agencies earlier believed that encouraging colonisation and transmigration schemes into rainforest areas could alleviate poverty of the areas in the financially poorer countries. Such schemes have miserably failed but hurted the indigenous people and the environment. In Indonesia, the Transmigrasi Program of 1974 had caused annual deforestation of two lakh hectares (Colchester and Lohmann, 1993). Dispossessed and landless people bring increased population pressure to the forest frontier. Further, new migrants in the area increase demand for food and other agricultural products which can induce the farmers at the forest frontier to increase their agricultural production by expanding agricultural land through clearing of the forests (Levang, 2002). Moreover, the new migrants may not care for conservation of the forests in their new home, which further accelerates deforestation of the area.

2.2.6 Land rights, land tenure and inequitable land distribution and Resources

Mather (1991) opined that cultivators at the forest frontier often do not hold titles to land (absence of property rights) and are displaced by others who gain tenure over the land they occupy. This means they have to clear more forest to survive. Poorly defined tenure is generally bad for people and forests (Chomitz *et al.*, 2007). In many countries, government have nominal control of forests but are too weak to effectively regulate their use. This can lead to a tragedy of the commons where forest resources are degraded. In frontier areas, deforestation is a common practice and legalized way of declaring claim to land and securing tenure according to Schneider (1995).

2.2.7 Corruption and Political Cause

The FAO (2001) identified forest crime and corruption as one of the main causes of deforestation in its 2001 report and warned that immediate attention has to be given to illegal activities and corruption in the world's forests in many countries. According to Contreras-Hermosilla (2000, 2001), illegal forest practices may include the approval of illegal contracts with private enterprises by forestry officers, illegal sale of harvesting permits, under-declaring volumes cut in public forest, under pricing of wood in concessions, harvesting of protected trees by commercial corporations, smuggling of forest products across borders and allowing illegal logging, as well as processing forest raw materials without a license.

2.3 Effects of Deforestation

2.3.1 Climate Change

Gupta *et al.*(2005) and Dickinson (1981) stated that it is essential to distinguish between microclimates, regional climate and global climate while assessing the effects of forest on climate, especially the effect of tropical deforestation on climate, while Pinker (1980) concluded that deforestation can change the global change of energy not only through the micrometeorological processes but also by increasing the concentration of carbon dioxide in the atmosphere because carbon dioxide absorbs thermal infrared radiation in the atmosphere. Moreover deforestation can lead to increase in the albedo of the land surface and hence affects the radiation budget of the region (Rowntree, 1988; Gupta *et al.*, 2005).

Deforestation affects wind flows, water vapour flows and absorption of solar energy, thus, clearly influencing local and global climate (Chomitz *et al*., 2007). Deforestation on lowland plains moves cloud formation and rainfall to higher elevations (Lawton *et al.,* 2001). Dregne (1983) wrote that deforestation disrupts normal weather patterns, creating hotter and drier weather, thus increasing drought and desertification, crop failures, melting of the polar ice caps, coastal flooding and displacement of major vegetation regimes. In the dry forest zones, land degradation has become an increasingly serious problem resulting in extreme cases of desertification. Desertification is the consequence of extremes in climatic variation and unsustainable land use practices, including overcutting of forest cover (Indonesia Environmental Forum, 1994).Global warming or global change includes anthropogenically produced climatic and ecological problems such as recent apparent climatic temperature shifts and precipitation regimes in some areas, sea level rise, stratospheric ozone depletion, atmospheric pollution and forest decline. Tropical forests are shrinking at a rate of about five per cent per decade as forests are logged and cleared to supply local, regional, national and global markets for wood products, cattle, agricultural produce and bio fuels (FAO 2010). According to Houghton (2005), one of the most important ramifications of deforestation is its effect on the global atmosphere. Deforestation contributes to global warming which occurs from increased atmospheric concentrations of greenhouse gases (GHGs) leading to net increase in the global mean temperature as the forests are primary terrestrial sink of carbon. Thus deforestation disrupts the global carbon cycle by increasing the concentration of atmospheric carbon dioxide. Tropical deforestation is responsible for the emission of roughly two billion tonnes of carbon (as CO_2) to the atmosphere per year. Asdrasko (1990) estimated that the release of the carbon dioxide due to global deforestation is equivalent to an estimated 25 per cent of emissions from combustion of fossil fuels.

2.3.2 Water and Soil Resources Loss and Flooding

According to Bruijnzeel (2004), deforestation also disrupts the global water cycle. With the removal of part of the forest, the area cannot hold as much water, thus creating a drier climate. Deforestation Technical Support Package (1994) and Bruijnzeel, *et al.* (2005) wrote that water resources affected by deforestation include drinking water, fisheries and aquatic habitats, flood/drought control, waterways and dams affected by siltation, less appealing water related recreation, and damage to crops and irrigation systems from erosion and turbidity. Urban water protection is potentially one of the most important services that forest provides (Chomitz *et al.,* (2007). Filtering and treating water is expensive. Forests can reduce the costs of doing so either actively by filtering runoff or passively by substituting for housing or farms that generate runoff (Dudley and Stolton, 2003). Deforestation can also result into watersheds that are no longer able to sustain and regulate water flows from rivers and streams. Once they are gone, too much water can result into downstream flooding, many of which have caused disasters in many parts of the world. This downstream flow causes soil erosion, thus also silting of water courses, lakes and dams. Deforestation increases flooding mainly for two reasons. First, with a smaller 'tree fountain' effect, soils are more likely to be fully saturated with water. The 'sponge' fills up earlier in wet season, causing additional precipitation to run off and increasing flood risk. Second, deforestation often results in soil compaction unable to absorb rain. Locally, this causes a faster response of stream flows to rainfall and thus potential flash flooding. Moreover deforestation also decrease dry season flows. The long term effect of deforestation on the soil resource can be severe. Clearing the vegetative cover for slash and burn farming exposes the soil to the intensity of the tropical sun and torrential rains. Forest floors with their leaf litter and porous soils easily accommodate intense rainfall. Bruijnzeel

(2004) wrote that the effects of deforestation on water availability, flash floods and dry season flows depend on what happens to these countervailing influences of infiltration and evapotranspiration- the sponge versus the fountain. Deforestation and other land use changes have increased the proportion of the basin subject to erosion and so, over the long run have contributed to siltation. Heavy siltation has raised the river bed, increasing the risk of flooding especially in Yangtze river basin in China, the major river basins of humid tropics in East Asia and the Amazonian basin (Noordwijk *et al.*, 2006).

2.3.3 Decreased Biodiversity, Habitat Loss and Conflicts

Forests, especially those in the tropics serve as storehouses of biodiversity and consequent deforestation, fragmentation and degradation destroys the biodiversity as a whole and habitat for migratory species including the endangered ones, some of which have still to be catalogued. Myers and Mittermeier (2000) estimated that tropical forests support about two thirds of all known species and contain 65 per cent of the world's 10, 000 endangered species. According to the World Health Organization, about 80 per cent of the world's population relies for primary health care at least partially on traditional medicine. The biodiversity loss and associated large changes in forest cover could trigger abrupt, irreversible and harmful changes. These include regional climate change including feedback effects that could theoretically shift rainforests to savannas and the emergence of new pathogens as the growing trade in bush meat increases contact between humans and animals according to

Millennium Ecosystem Assessment (2005). Another negative effect of deforestation is increasing incidents of human-animal conflicts hitting hard the success of conservation in a way and alienating the people's participation in conservation. For example, the elephant habitat located at northern West Bengal in India is part of the Eastern Himalaya biodiversity hotspot which is characterized by a high degree of fragmentation. The heavy fragmentation of this habitat has resulted into an intense human-elephant conflict causing not only loss of agricultural crops but also human and elephant lives. Mortality of about 50 persons and 20 elephants was reported due to these severe human-elephant conflicts from this hotspot area annually (Mangave, 2004).

2.3.4 Economic Losses

The tropical forests destroyed each year amounts to a loss in forest capital valued at US $ 45 billion (Hansen, 1997). By destroying the forests, all potential future revenues and future employment that could be derived from their sustainable management for timber and non timber products disappear.

2.3.5 Global Rate of Deforestation

According to Professor Norman Myers, one of the foremost authorities on rates of deforestation in tropical forests, "the annual destruction rates seems set to accelerate further and could well double in another decade" (Myers, 1992). Mostly, deforestation has occurred in the temperate and sub-tropical areas. Deforestation is no longer significant in the developed temperate countries now and in fact many temperate countries now are recording increases in forest area

(FAO, 2010). In most instances, developed nations are located in temperate domains and developing nations in tropical domains. However deforestation was significantly less in tropical moist deciduous forest in 1990-2000 than 1980-1990, but using satellite imagery it was found that FAO overestimated deforestation of tropical rainforests by 23 per cent (IPCC, 2001). However the definition of what is and what is not forest remains controversial. The tropical rainforests capture most attention, but 60 per cent of the deforestation that occurred in tropical forests during 1990-2010 was in moist deciduous and dry forests. However, extensive tropical deforestation is a relatively modern event that gained momentum in the 20th century and particularly in the last half of the 20th century. The FAO FRA 2001 and 2010 reports indicate considerable deforestation in the world during 1990-2010, but this was almost entirely confined to tropical regions (FAO, 2010). A summary of deforestation during the decades (1990-2010) is given in Tables 2.1 and 2.2. These tables show that there was considerable deforestation in the world during 1990-2010, but that this was almost entirely confined to tropical regions. Rowe e*t al*. (1992) estimated that 15 per cent of the world's forest was converted to other land uses between 1850 and 1980. Deforestation occurred at the rate of 9.2 million hectares per annum from 1980-1990, 16 million hectares per annum from 1990-2000 and decreased to 13 million hectares per annum from 2000-2010. The net change in forest area during the last decade was estimated at 5.2 million hectares per year, the loss area equivalent to the size of Costa Rica or 140 km^2 of forest per day. This was however lesser than that reported during 1990-2000 which was 8.3 million hectares per year equivalent to a loss of 0.20 per cent of the remaining forest area each year. The current annual net loss is 37 per cent lower than that in the 1990s and equals a loss of 0.13 per cent of the remaining forest area each year during this period. By contrast, some smaller countries have very high losses per year and they are in risk of virtually losing all their forests within the next decade if current rates of deforestation are maintained. Indeed some 31 countries do not even make the list because they have already removed most of their forests and what remains are seriously fragmented and degraded. The changes in area of forest by region and sub region are shown in Table 2.1.

Table 2.1 Annual Change in forest area by region and sub region, 1990-2010

Region/sub region	1990-2000		2000-2010	
	1 000 ha/year	%	1 000ha/year	%
Eastern and Southern Africa	-1841	-0.62	-1839	-0.66
Northern Africa	-590	-0.72	-41	-0.05
Western and Central Africa	-1637	-0.46	-1535	-0.46
Total Africa	-4067	-0.56	-3414	-0.49
East Asia	1762	0.81	2781	1.16
South and Southeast Asia	-2428	-0.77	-677	-0.23
Western and Central Asia	72	-0.17	131	0.31
Total Asia	-595	-0.10	2235	0.39
Russian Federation (RF)	32	N.S	-18	N.S
Europe excluding RF	845	0.46	694	0.36
Total Europe	877	0.09	676	0.07
Caribbean	53	0.87	50	0.75
Central America	-374	-1.56	-248	-1.19
North America	32	N.S	188	0.03
Total North and Central America	-289	-0.04	-10	0.00
Total Oceania	-41	-0.02	-700	-0.36
Total South America	-4213	0.45	-3997	-0.45
World	-8327	-0.20	-5211	-0.13

(Source: FAO forestry paper 2010)

South America with about four million hectares per year suffered the largest net loss of forests during the last decade, followed by Africa with 3.4 million hectares annually and the least, Oceania with seven lakh hectares annually. Oceania suffered mainly due to Australia where severe drought and forest fires from 2000 AD had exacerbated their loss. Both Brazil and Indonesia had the highest net loss of forest during the decade of 1990 but has significantly reduced their rate of loss after this decade. Brazil and Indonesia dominate, accounting for almost 40 per cent of net forest loss over the decade of 1990s. Even though Brazil was the top deforesting country by area, the forests in Brazil are so extensive that this represents a loss of 0.4 per cent per year. The forest area in North and Central America remained stable during the past decade. The forest area in Europe continued to expand although at a slower rate of seven lakh hectare per year during the last decade than in the 1990s, with nine lakh hectares per year. Asia lost some six lakh hectares annually during 1990s but gained more than 2.2 million hectares per year during the last decade. The ten countries with the largest net loss per year in the period 1990-2000 AD had a combined net loss of forest area of 7.9 million hectares per year. In the period 2000-2010 AD, this was reduced to six million hectares per year as a result of reductions in Indonesia, Sudan, Brazil and Australia (Table 2.1.). There were 28 countries and areas which have an estimated net loss of one percent or more of their forest area per year. The five countries with the largest annual net loss for 2000-2010 AD were Comoros (-9.3 per cent), Togo (-5.1 per cent), Nigeria (-3.7 per cent), Mauritania (-2.7 per cent) and Uganda (-2.6 per cent). The area of other wooded land globally decreased by about 3.1 million hectares per year during 1990-2000 AD and by about 1.9 million hectares per year during the last decade. The area of other wooded land also decreased during the past two decades in Africa, Asia and South America.

Table 2.2 Countries with largest annual net loss of forest area, 1990-2010

Country	Annual change 1990-2000		Country	Annual change	
	1 000 ha/ year	%		1000 ha / year	%
Brazil	-2890	-0.51	Brazil	-2642	-0.49
Indonesia	-1914	-1.75	Australia	-562	-0.37
Sudan	-589	-0.80	Indonesia	-498	-0.51
Myanmar	435	-1.17	Nigeria	-410	-3.67
Nigeria	-410	-2.68	Tanzania	-403	-1.13
Tanzania	-403	-1.02	Zimbabwe	-327	-1.88
Mexico	-354	-0.52	Thailand	-311	-0.20
Zimbabwe	-327	-1.58	Myanmar	-310	-0.93
Congo	-311	-0.20	Bolivia	-290	-0.49
Argentina	-293	-0.88	Venezuela	-288	-0.60
Total	-7926	-0.71	Total	-6040	-0.53

Source: FAO Forestry Paper, 2010

2.4 Rates of Deforestation in Nigeria

Nigeria has the world's highest deforestation rate of primary forest according to revised deforestation figures from the Food and Agriculture Organization of the United Nations (FAO, 2005). Between 2000 and 2005, the country lost 55.7 percent of its primary forests – defined as forests with no visible signs of past or present human activities. According to Akinsanmi (2006), Nigeria is witnessing an unprecedented rate of deforestation, thereby undermining economic growth, exacerbating poverty, and contributing to environmental degradation. FAO (2005) stated that deforestation is a serious problem in Nigeria, with forest loss occurring at a rate of 3.3% per year. The food and Agricultural Organization further stated that since 1990, the country has lost over 6 million ha or 36% of its forest cover. The most biodiverse ecosystem, the old growth forests are disappearing at an even faster rate; between 1990 and 2005, 79% of these forests were lost. Since 2000, Nigeria has been losing an average 11% of its primary forests each year. These figures give Nigeria the highest deforestation rate of natural forest in the world. The FAO (2005) report shows that primary forests are being replaced by less biodiverse plantations and secondary forests. Due to significant increase in plantation forests, forest cover generally has been expanding in North America, Europe and China, while diminishing in the tropics. Industrial logging, conversion for agriculture (commercial and subsistence), fuel wood collection by rural poor, and forest fires- often purposely set by the people – are responsible for the bulk of global deforestation today.

Analysis of the FAO report by mongabay.com shows that the developing countries generally suffered the worst rates of forest loss between 2000 and 2005. Of the 10 countries with the highest deforestation rate during that period, all were considered developing and nine were tropical. Four of the six were located in south or South East Asia (Table 2.3). The average annual global rate of forest loss is shown in Table 2.3.

Table 2.3: Countries with the Highest Rate of Deforestation between 2000 and 2005

COUNTRY	AVERAGE RATE (HECTARES)
1. Brazil	3,446,000
2. Indonesia	1,447,800
3. Russia	532,200
4. Mexico	395,000
5. Guinea	250,200
6. Peru	224,600
7. United States of America	215,200
8. Bolivia	135,200
9. Sudan	117,807
10. Nigeria	82,000

(**Source:** *News.mongabay.com, accessed on 18 March, 2011)*

Though a lot of work has been carried out on deforestation particularly in developing countries, rate of deforestation continues to increase rapidly in spite of global concern on the consequences.

2.5 Strategies to Reduce Deforestation

Ways to reducing deforestation must go hand in hand with improving the welfare of cultivators at the forest frontier. Any policy that does without the other is unacceptable. There are no general solutions and strategies since these will vary with region and will change over time. All strategies require cooperation and goodwill. Effective implementation is essential including stakeholder participation, development of management plans, monitoring and enforcement. The strategies should be such that on one hand they should recognize the critical roles of national, state and municipal governments and on other hand empower the civil society and the private sector to take a pro-active role in reducing deforestation, often working in conjunction with government.

2.5.1 Reduce Population Growth and Increase Per Capita Incomes

Reduction of population growth is pivotal in reducing deforestation in the developing countries. If the population reduces, there will be increase in per capita income as a result of increased income and literacy rates. These will reduce pressure on the remaining forests for new human settlement and land use change.

2.5.2 Reducing Emissions from Deforestation and Forest Degradation

Many international organizations, including the United Nations and the World Bank have begun to develop programmes to curb deforestation mainly through reducing emissions from deforestation and forest degradation which use direct monetary or other incentives to encourage developing countries to limit and/or roll back deforestation. Significant work is underway on tools for use in monitoring developing country adherence to their agreed targets, as observed by Chomitz *et al*. (2007).

2.5.3 Increase in Area and Standard of Management of Protected Areas

The provision of protected areas is fundamental in any attempt to conserve biodiversity (Myers, 1994). Protected areas alone, however, are not sufficient to conserve biodiversity. They should be considered alongside, and as part of, a wider strategy to conserve biodiversity. The minimum area of forest to be protected is generally considered to be 10 per cent of total forest area. It is reported that 12.4 per cent of the world's forest are located within protected areas. Tropical and temperate forests have the highest proportions of their forests in protected areas and boreal forests have the least. The Americas have the greatest proportion while Europe the least proportion of protected areas as observed by FAO (2010).

2.5.4 Increase in Area of Forest Permanently Reserved for Timber Production

IMAZON (2007) stated that the most serious impediment to sustainable forest management is the lack of dedicated forests specifically set aside for timber production. If the forest does not have a dedicated long-term tenure for timber production, then there is no incentive to care for the long-term interests of the forest. FAO (2001) found that 89 per cent of forests in industrialized countries were under some form of management but only about six per cent were in developing countries. If 20 per cent could be set aside, not only could timber demand be sustainably met but buffer zones could be established to consolidate the protected areas. This would form a conservation estate that would be one of the largest and most important in the world.

2.5.5 Promotion of Sustainable Management

Chomitz*et al*. (2007) and FAO (2010; 2011) attributed that in order to promote sustainable forest management, it must be sustainable ecologically, economically and socially. Achieving ecological sustainability means that the ecological values of the forest must not be degraded and if possible they should be improved. This means that silviculture and management should not reduce biodiversity, soil erosion should be controlled, soil fertility should not be lost, water quality on-and off-site should be maintained and that forest health and vitality should be safeguarded. However, management for environmental services alone is not economically and socially sustainable. It will not happen until or unless the developing nations have reached a stage of development and affluence that they can accommodate the costs of doing so. Alternatively, the developed world must be prepared to meet all the costs. There are vast areas of unused land as discussed earlier, some of which is degraded and of low fertility. Technological advances are being made to bring this land back into production. This should be a major priority since a significant proportion of cleared tropical forest will eventually end up as degraded land of low fertility.

2.5.6 Participatory Forest Management and Rights

In frontier areas, much of the forest is nominally owned by the state, but the reach of government and the rule of law are weak and property rights insecure. In order for forest management to succeed at the forest frontier, all parties with an interest in the fate of the forest should be communally involved in planning, management and profit sharing. But forest ownership and management rights are almost always restricted and restrictions on ownership and use define alternative tenure systems. The balance of rights can be tilted strongly toward society in the form of publicly owned strictly protected areas. State ownership and management can be retained but with sustainable timber extraction allowed. As of now, much of the world's tropical forest are state owned but community participation in forest ownership and management needs to be encouraged with restrictions on extraction and conversion. Colchester and Lohmann (1993) concluded that land reform is essential in order to address the problem of deforestation. However an enduring shift in favour of the peasants is also needed for such reforms to endure. Moreover, the rights of indigenous forest dwellers and others who depend on intact forests must be upheld. Therefore, the recognition of traditional laws of the indigenous peoples as indigenous rights will address the conflicts between customary and statutory laws and regulations related to forest ownership and natural resource use while ensuring conservation of forest resources by the indigenous communities. Central to this is the right to 'Prior Informed Consent ensuring the indigenous communities to know what they are agreeing to. A means must be found to reconcile conservation and development by involving local/indigenous populations more closely in the decision-making process and by taking the interactions between 'societies' and forest resource more fully into account Chakravarty *et al* (2008).

2.5.7 Support and Reforms

Aid organizations like the World Bank have traditionally favoured spectacular large-scale developmental projects. In all cases when such projects are proposed, there has been a massive opposition from local people. Reducing the demand for southern-produced agribusiness crops and alleviating the pressure from externally-financed development projects and assistance is the essential first/primary step (Colchester and Lohmann, 1993). Campaigns opposing such developments and the campaigns to reform the large aid agencies which fund such schemes should be supported. Local campaigns against specific mining, dams, industrial and tourist developments should be supported. Further reform of the World Bank and other such organizations is largely the demand of time.

2.5.8 Increase Investment in Research, Education and Extension

Training and education of stakeholders help people understand how to prevent and reduce adverse environmental effects associated with deforestation and forestry activities and take appropriate action when possible. Research substantiates it and helps to understand the problem, its cause and mitigation. This arena is lagging behind for paucity of funds and investments. There is a lack of knowledge and information in the general community about forests and forestry. Forest managers and those developing forest policies need to be comprehensively educated and need to appreciate the complexity of the interacting ecological, economical, social, cultural and political factors involved.

2.5.9 Improved Information Base and Monitoring

Information on the global distribution of biodiversity and forest poverty is inadequate. Knowledge of how much forest, where it is and what it is composed of seems to be straightforward but surprisingly this most basic information is not always available. It is not possible to properly manage a forest ecosystem without first understanding it. New remote sensing technologies make it feasible and affordable to identify hotspots of deforestation. The international community could undertake monitoring efforts that would have immediate payoffs. A priority is to fund and coordinate basic monitoring on the rate, location and causes of global deforestation and forest poverty along with the impacts of project and policy interventions. Without this information, policy makers are flying blind and interest groups lack a solid basis for dialogue (Chomitz *et al.* 2007).

2.5.10 Policy, Legislative and Regulatory Measures-Enforcement and Compliance

A wide variety of policy statements and legislative and regulatory measures have been established to protect forests but need to be effectively enforced. New modifications/adjustments are of course needed for site specific conditions. Laws, policy and legislation should be such that they encourage local people and institutional participation in forestry management and conservation, along with safeguarding indigenous people's traditional rights and tenure with rightful sharing of benefits. Many formal and informal enforcement/compliance mechanisms are used to prevent deforestation and environmental problems from forestry activities. These approaches include negotiation, warnings, cancelling work orders, notices of violation, fines, arrests, and court action.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Nnewi Municipal area is politically known as Nnewi North Local Government Area of Anambra state. The local government is made up of four large communities namely- Otolo, Umudim, Uruagu and Nnewichi. Each of these communities is made up of several villages. It is situated in the southern part of Anambra state and bounded in the north by Nnobi, Awka Etiti and Amichi towns; in the East by Ukpor and Utuh towns; in the west by Ichi and Ojoto towns; and in the south by Ozubulu and Oraifite towns. The area lies between longitudes 6^{o} 55^{1}E & 6^{o} 91^{1}E and latitudes 6^{o} 10^{1}N& 6^{o} 16^{1}N (Wikipedia, 2014). The 2006 national population and housing survey put the population of Anambra State at 4,182,032 and the population density at 863/Km^2 (NPC, 2006). It has an average annual rainfall of about 2000mm and mean temperature of 27^{o}C. The months of April to October experience heavy rain falls, while low rainfalls, higher temperatures and low humidity characterize the months of November to February. The area is in the tropical rainforest zone, with its evergreen vegetation (plate 1). There are two rivers in the area, namely Ubu in the East and Eze Rivers in the North.

Geographically, Nnewi falls within the tropical rain forest region of Nigeria. Though it suffers from soil leaching and erosion which has reduced the soil in some areas to a porous sandy terrain, it remains an area of rich agricultural produce and the epicenter of business trade. The city is located east of the Niger River, and about 22 kilometers south east of Onitsha in Anambra State, Nigeria (Wikipedia, 2015).The main occupation of Nnewi people is trading and farming, therefore they depend mainly on agriculture and commerce for their daily livelihood. Most Nnewian have Mbubo (home gardens) and Ubi (out-station gardens) were they usually cultivate their farm products. These crops when they are harvested are usually taken to the market for sale. Most of the prime cash crops include oil palm, raffia palm, groundnut, melon, cotton, cocoa, rubber, maize, et cetera. Food crops such as yam, cassava, cocoyam, breadfruit, and three-leaf yam are also produced in large quantities. The location of Nnewi within the tropical rainforest gives it the ecological basis for production of a wide range of tropical agriculture crops with widespread potential for industrial convention. Industrially, the area is a home to many indigenous companies thus contributing enormously to land degradation of the area.

3.2 Field Study

The field work was conducted for a one year planting seasons between the months of May 2013- July, 2014 with reconnaissance survey for familiarization with the terrain of the study area. Soil profile pits were dug along the topographic –sequence of the area according to the method of Ubouh, *et al.,* (2013). Three profile pits were sited along the transverse to include the designation: SSN/01 (Upper slope), SSN/02 (Middle slope), and SSN/03 (Lower slope). Soil samples were collected for routine analysis. Soil samples were collected from the three types of soils categorized according to depth. Soil depth category of 01: 0 - 15; 02: 15 -30cm and 03: 30-45cm. The soil samples were bagged in sampling bag, labeled and transported to the laboratory for analysis. Soil samples were collected from the profile pits at different horizons starting from the bottom to avoid contamination from the top soil at different depths.

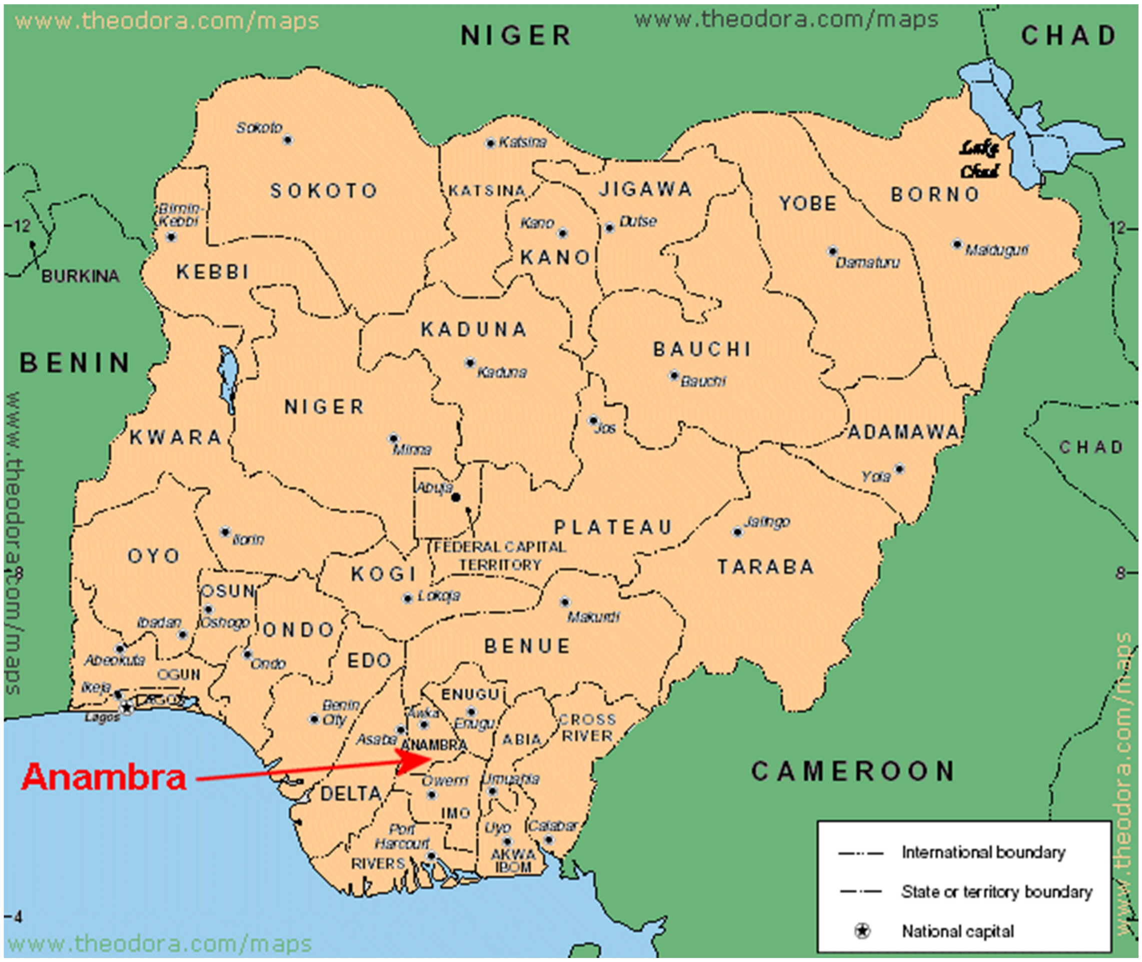

Fig. 3.1 Map of Nigeria showing Anambra State

Fig. 3.2 Map of Anambra State showing study area

Legend

	Minor Road
	Express Road
P1	**Edorji Uruagu**
P2	**Abubo Nnewichi**
P3	**Umudim**

Figure 3.3. Map of Nnewi North local government area Anambra state, Nigeria Showing sampling stations.

***Source*: Ministry of Land & Survey, Awka, 2014.**

Plate 1: View of the non-cleared vegetation Nnewi North LGA

The population of Nnewi North Local Government is about 115,443 (NPC, 2006) and it is a major centre of business in Anambra state; with many industries as well as the biggest motorcycle and motor spare parts market in Eastern Nigeria. There are many other markets in the area, even though many of the people are also farmers. The high population density and anthropogenic activities arising from industrialization have led to serious deforestation of the rain forest in the area. Many locations in the LGA have therefore become exposed to soil erosion activities (Plate 2).

Plate 2: View of the deforested erosion prone land in Nnewi North LGA

3.3 Sampling Stations

Two sampling locations include (Edoji Uruagu and Abubo Nnewichi) were established within devegetated (erosion prone) area (plate 2) and one(Umudim) within vegetated (forested) area (plate 1). These communities are mainly agrarian. Cottage industries within these communities include; cassava processing and oil palm mills. The vegetated area was taken to be the control. Replicate samples were taken from each of sampling locations to obtain a representative.

3.4 Soil Analysis

In the laboratory, the samples were air-dried, ground and sieved through 2mm mesh size sieve and subjected to physical and chemical analysis.

3.5 Soil Samples Collection

At each sampling location, three soil profile pit dug and samples soil obtained from 0 -15cm, 15 -30cm and 30 – 45cm depths using auger to prevent contamination. This was done during the rainy season. The samples were thereafter composited and sent to the laboratory in labelled polythene bags for specific agricultural soil nutrients analysis.

3.6 Soil Physical Analysis

3.6.1 Détermination of Particules Size Distribution

This was carried out by the Bouyoucos hydrometer method (Day, 1965).The soil sample was dispersed with solution of Sodium hexametaphosphate (Calgon 44g/l) and Sodium Carbonate (8g/l). The pH of the solution was maintained at about 8.3. After the percentage sand, silt and clay has been determined, the soil was subjected to a textural class using the USDA textural triangle as shown in figure 3.4.

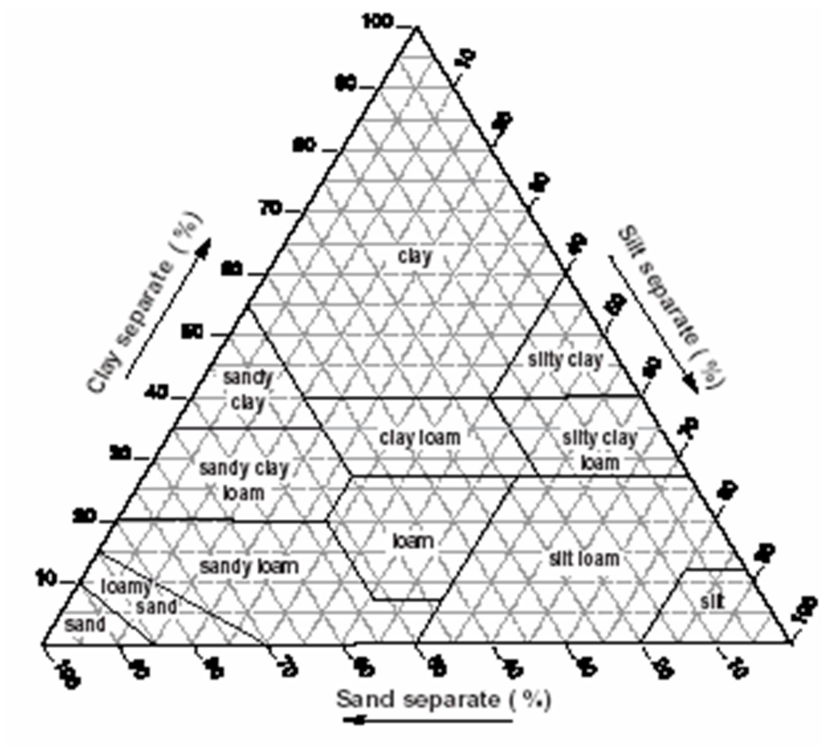

Fig. 3.4. USSD Soil Textural classification triangle.

NOTE: Dispersing solution was obtained by dissolving 40g of sodium hexametaphosphate [$(NaPO_3)_{13}$], and 10g sodium carbonate (Na2CO3) were dissolved in DI water and brought to a volume with DI water.

3.6.2 Determination of Silt and Clay

Soil suspension was mixed in a hydrometer jar, using a special paddle. Then the paddle was carefully withdrawn, and the hydrometer was immediately inserted. Froth, on the surface of the jar was removed, and one drop of amyl alcohol was added, the hydrometer reading was taken 40 seconds after withdrawing the paddle. The hydrometer reading gave (R_{sc}). Percentage silt plus clay was then calculated using the formula

$$\%[\text{silt} + \text{clay}](w/w) = (R_{sc} - R_b) \times \frac{100}{\text{Oven-drysoil(g)}} \text{.......................(4)}$$

R_c = Hydrometer reading

R_{sc} = Hydrometer reading 40 seconds after withdrawing the paddle.

3.6.3 Determination of Clay

A sample of soil suspension in the hydrometer jar was mixed with paddle, and withdrawn from the hydrometer jar with care, and the suspension was left undisturbed. After 4 hours, the hydrometer was inserted, and hydrometer reading, R_C, was taken. Percentage clay and silt in the soil was calculated using the formula below.

$$\%\text{clay}\ (w/w) = (R_c - R_b) \times \frac{10}{\text{Oven-drysoi (g)}} \text{.............................(5)}$$

R_b = Hydrometer reading

R_C = Hydrometer reading after 4 hours inserting hydrometer

%silt (w/w) = [%silt+ clay (w/w)] – [%clay (w/w)]. ....(6)

3.6.4 Determination of Sand

After taking readings required for clay and silt, the suspension was poured quantitatively through a 50µm sieve. The sieve was washed until water passing the sieve became clear. Then, sand was quantitatively transferred from sieve 50 ml beaker of a known weight. The sand was allowed to settle in the beaker and excess water was discarded. The beaker was dried with sand overnight at 105^0c.The beaker and its content was cooled in a desiccators. Thereafter it was re-weighed. The percentage sand in the soil was calculated with the formula below: %Sand (w/w) = Sand weight x $\frac{100}{\text{Oven}-\text{drysoil(g)}}$ ....(7) Where, Weight of sand also was calculated subtracting the weight of the beaker from the weight of the soil and beaker. Thus the following: Sand weight (g) = [Beaker + Sand (g)] – [Beaker (g)] ....(8)

3.6.5 Determination of Moisture Content

Soil moisture content was determined by using an oven dry method in which samples were dried to constant weight (Ahuja *et al*, 1976) and the difference in mass of wet and dry samples recorded and expressed in percentage. In doing this, about 20g of wet soil sample placed in a container was weighed and its mass, M recorded. The soil sample was then dried in an oven (105 -110^0C) for about 24 hours when it becomes perfectly dry. Its dry mass, Md was then determined and the water content calculated from the relation.

$$W = \frac{Ww}{Wd} x \ 100\% \ ....(1)$$

$$Mc = \frac{Ww-M}{Wd-M} x \ 100\% \ ....(2)$$

$$\text{Mois ture Content} = \frac{Ww-M}{Wd-M} \ X \ 100\% \ \ldots\ldots\ldots\ldots.. (3)$$

Where mass of the empty container = M(kg)

Mass of wet soil + empty container = Ww

Mass of oven dry soil + empty container = Wm

3.6.6 Determination of Bulk Density

Soil bulk density was determined using the Core method of Grossman and Reinch (2002). The sampler was pressed not too far as compressing the in the confined space of the sampler. Then, the sampler and its contents were carefully removed so as to preserve the natural structure and the packing of soil. The two cylinders were then separated, retaining the undisturbed soil in the inner cylinder. The soil extending beyond each end of the sampler holder were also trimmed and flushed with each end with a straight edge knife. At this time, the soil sample volume was established to be the same as the volume of the sample holder. The soil was then transferred to a container, weighed and placed in an oven at 105^0C. The soil sample was weighed and reweighed again until a constant weight was reached. The bulk density was then calculated as the ratio of the oven dry mass of the soil sample to the sample volume.

Bulk density was calculated using the formula;

ℓb = MS/Vt ....(9)

Where

Ms = Mass of oven dry soil (g)

Vt = Total soil volume (cm^3) assumed to be equal to volume of cylinder; and this was calculated from the formula

$Vt = \pi r^2 h$

Where:

π = 22/7

r = radius

h = height

3.7 Soil Chemical Analysis

3.7.1 Determination of Soil pH

This was determined according to the method of McLean (1982). The twenty grams of air dried soil was weighed into a 100ml of glass beaker. 20 ml of distilled water was added using a graduated cylinder. The suspension was thoroughly mixed with a glass rod and allowed to stand for 30 minutes to maintain equilibrium. And during this period, the suspension was stirred every 10 minutes using a glass rod for one hour. Then the electrode of the pH meter was inserted into the partially settled suspension (to the depth of 3cm) and the pH reading was taken.

3.7.2 Determination of Organic Carbon and Organic Matter

This was determined using the wet digestion method of Blacks (1965). A representative sample was taken, ground and passed through a 0.5 mm sieve. Soil samples were weighed out in duplicates and transfer to 250ml Erlenmeyer flask. 10ml of 1N $K_2Cr_2O_7$ solution was pipetted accurately into each flask and swirled gently to disperse the soil. 20 ml of concentrated H_2SO_4 was added rapidly using an automatic pipette, directing the stream into the suspension. Immediately the flask was gently swirled until soil and reagents are mixed, and then swirled vigorously for 1 minute. The flask was allowed to stand on a sheet of asbestos for about 30 minutes. 100 ml of distilled water was added after standing for 30 minutes. 3 drops of indicator was added and titrated with 0.5 $FeSO_4$ solutions. As the end point approached, the solution turned a greenish cast and then changes to dark green. At this point $FeSO_4$ was added drop by drop until the colour changes sharply from green to red, Blank titration was also made in the same manner, but without soil, to standardize the dichromate. The result was calculated using the following formula:

$$\%\text{Organic C} = \frac{(\text{Mek}_2\text{Cr}_2\text{O}_7 - \text{FeSO}_4) \times 0.003 \times 100 \times f}{\text{g of air} - \text{dry soil}} \quad \text{................(11)}$$

Where:

Correction factor, f = 1.33

Me= Normality of solution x ml of solution used

Calculation of percentage organic matter:

Percentage organic matter was calculated by multiplying the percentage organic matter with Van denmelen's correction factor, % organic matter = % organic carbon x 1.724**;** where 1.724 is the Vandenmelen's correction factor.

3.7.3 Determination of Available Phosphorus

One gram of air-dried soil sample was weighed into a 15ml centrifuge tube and 7ml of the extraction solution was added into it. This was shaken for 1minute on a reciprocating shaker after which the suspension was centrifuged at 2000rpm for 15minute. 2ml of the clear supernatant was pipette out into a 20ml test tube. Then 5ml distilled water and 2ml of ammonium molybdate solution was added. The contents were properly mixed and 1ml of $SnCl_2.2H_2O$ dilute solution was added and mixed again. After 5 minute, the percentage (%) transmittance was measured on the electrophotometer at a wave length of 660nm. The standard curve was prepared with 1µgP/ml (or ppm P). The optical density (OD) of standard. Pansu and Gautheyrou (2006).

3.7.4 Determination of Exchangeable Cations

Exchangeable cation (Na^+, K^+, Mg^{2+}, Ca^{2+}) were extracted according to the Ammonium acetate extraction method of Blacks (1965) as modified by Pansu and Gautheyrou (2006). 30ml of 1N NH_4OAC was added into 5g of air dry soil and this was shaken on a mechanical shaker for 2hours. Then the suspension was centrifuged at 2000rpm for 10minute, the clear supernatant was carefully decanted into a 100ml volumetric flask. Another 30ml of NH_4OAC solution was added and shaken for 30minute, centrifuged and the supernatant was transferred into the same volumetric flask. This was repeated again and the suspension was centrifuged and the clear supernatant was again transferred into the same volumetric flask. The solution was made up to mark by adding more NH_4OAC solution. K and Na were determined on a flame photometer while Mg and Ca were determined on an atomic absorption spectrometer.

3.7.5 Determination of Total Nitrogen

Nitrogen was determined using Macro Kjeldahl method of Bremmer and Mulvaney 1982. 10g of air dryed soil was weighed into a 500ml macro kjeldahl flask and 250ml of distilled water was added and swirled for 30 minutes and then allowed to stand for 30 minutes. 1 tablet of 1g of K_2SO_4 – HgO mixture catalyst and 10g of K_2SO_4 were added to the suspension. Then 30ml of concentrated H_2SO_4 were also added through an automatic pipette. The flask was heated cautiously at low heat on the digestion stand. When the water has been removed and frothing has ceased. The temperature was increased until the digest has cleared. Then the mixture was boiled for 5hours. During boiling, the heating was regulated to prevent condensation of about half up to the neck of the flask. The flask was allowed to cool then 100ml of water was added to the flask. The content in the flask was carefully transferred into another clean Macro-kjeldahl flask (750ml). All sand particles were retained in the original digestion flask sand residue was washed 4 times with 50ml of distilled water and the aliquot was transferred into the same flask. 50ml H_2BO_3 indicator solution was then put into a 500ml Erlenmeyer flask which was paced in the condenser of the distillation apparatus. The 750ml of the kjeldahl flask was attached to the distillation apparatus. Then 150ml of 10N NaOH was poured through the distillation flask opening the funnel stop cock and distillation process was commenced. The condenser was kept cool by allowing sufficient cold water to flow through and regulate heat to minimize frothing and preventing suck back. 150ml distillate was collected and distillation was stopped. NH_4-N in the distillate was determined by titrating with 0.01N standard HCl using a 25ml burette graduate at 0.1 interval, the colour change at the end point was green to pink.

3.7.6 Electrical Conductivity

To prepare a soil suspension, l0g of air dried soil sample was added to 50 ml of double glass distilled water (1:5 w/v), according to the method of ASTM D383-80 with slight modification. The suspension so obtained was kept over shaker for 1hour. The sample was allowed to stabilize and then the electrical conductivity measured using conductivity meter. (Jenway 430 model). The result was read off in µs (Teles *et al*, 1998).

3.7.7 Bulk Density and Porosity Determination

A cylinder and an aluminium plate were weighed. A sample of activated colour was placed into the cylinder, reweighed and transferred into the aluminium plate and then even dried to a constant weight at a temperature of 105^0C for 60mins. The weight of dried sample was recorded after drying. A cleaned, well dried cooked density bottle was weighed. A small quantity of sample of activated carbon was taken and grounded to powder, sieved using 110µm mesh size and gradually put into the density bottle with a little amount of water added and weighed. The volume of void (Vo) was obtained by first determining the total volume of the cylinder ($vt = \pi r2h$) used for the experiment and also determined by the volume of the AC used.

3.8 Statistical Analysis

Univariate and bivariate analyses were used to analyse data. Descriptive statistics was used to compute means standard errors, ranges, etc of the edaphic variables. The Pearson correlation(r) was used to determine possible relationships between the edaphic variables. The single factor Analysis of Variance (ANOVA) was used to determine homogeneity in mean variance of the soil parameters and post-hoc structure of group means detected with means plots at the 95% confidence interval. Variation plots were used to represent levels of the edaphic parameters.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Statement of Results

Table 4.1 Results of Pysicochemical Parameters of Soils from the Devegetated and Water Eroded Sites at Nnewi

Parameters	Minimum	Maximum	Range	Mean	SE
pH	4.56	4.80	0.24	4.6933	0.07055
Organic Carbon (%)	0.45	0.60	0.15	0.5233	0.0433
Organic Matter(%)	0.81	1.02	0.21	0.8933	0.06438
Total Nitrogen(%)	0.048	0.078	0.030	0.06033	0.009062
Avail. P(mg/kg)	5.10	7.80	2.70	6.1000	0.85440
Sodium(cmol/kg)	0.140	0.162	0.022	0.15233	0.006489
Potassium(cmol/kg)	0.050	0.062	0.012	0.05767	0.003844
Magnesium(cmol/kg)	2.40	5.10	2.70	3.4333	0.84130
Calcium(cmol/kg)	4.50	9.80	5.30	6.5000	1.66233
CEC (cmol/kg)	5.80	17.10	11.30	9.7667	3.67076
Bulk Density (g/cm^3)	1.62	1.26	0.20	1.7433	0.006227
Sand (%)	75.65	75.70	0.05	75.6767	0.07453
Silt(%)	18.5	19.42	0.92	19.0233	0.27303
Clay(%)	1.30	2.10	0.80	1.6667	0.23330
Moisture Content	1.30	2.10	0.80	1.6667	0.23330

SE: Standard Error of Mean, CEC = Cation Exchange Capacity

4.1.1 Spatial Variations in Edaphic Variables

The concentrations of the edaphic variables measured in soils of Nnewi-North Local Government Area (LGA) under study are shown in Appendixes 1a-1c. The concentrations of available Phosphorus (range=2.70mg/kg), Mg^{2+} ions (range =2.70cmol/kg), Ca^{2+} ions (range =5.30cmol/kg) and cation exchange capacity (CEC) (range =11.30cmol/kg) varied widely while those of the other parameters had narrow variations. The levels of pH, organic Carbon and organic matter varied from 4.56-4.80 (4.63 ± 0.07), 0.45 - 0.60 (0.052 ± 0.04)% and 0.81- 1.02 (0.89 ± 0.06)% respectively (Table 4.1). Total Nitrogen, bulk density and available phosphorus varied as follows; 0.048 - 0.078 (0.060 ± 0.009)%, 1.62- 1.82 (1.74 ±0.06)g/cm^3 and 5.10 - 7.80 (6.10 ± 0.85)mg/kg respectively. Na^+, K^+ and Mg^{2+} ions varied from 0.140 - 0.162 (0.152 ± 0.006), 0.050 - 0.0062 (0.058±0.004) and 2.40 - 5.10 (3.43 ± 0.84)cmol/kg respectively.Ca^2+ ions varied from 4.50 - 9.80 (6.50 ± 1.66)cmol/kg, CEC varied from 5.80 - 17.10 (9.77 ± 3.67) cmol/kg while moisture contents varied from 1.30 - 2.10 (1.67 ± 0.23)%. However, the compositions of sand, silt and clay varied from 75.65 - 75.70 (75.67 ± 0.0145), 4.90 - 5.80 (5.30 ± 0.204) and 1.30 - 2.10 (1.66 ± 0.23) %.

4.1.2 Relationship between Edaphic Variables

The Pearson correlation (r) between the parameters measured in soils of the study area are shown in (appendix 8).at $P < 0.05$, organic matter correlated positively with Mg^{2+} (r=0.999) and Ca^{2+} ions (r=0.998).However, the other parameters did not show significant correlations with organic Carbon, organic matter and total Nitrogen.

4.1.3 Spatial Variations in Edaphic Parameters

Variations were observed in the levels of the edaphic parameters measured across the sample locations (SSEA 1, SSEA 2 and SSFA). Minimum level of pH (3.90), Organic carbon (0.52%) and organic matter (0.89%) were recorded in SSEA 2 , SSEA 1 and SSEA 1 respectively while their maximum levels of 5.03, 1.92% and 3.14% were all recorded in SSFA (appendice 4,and 5).Minimum levels of total Nitrogen (0.068%), Sodium (0.52 cmol/kg) and potassium ions (0.058cmol/kg) were all recorded in SSEA, while their maximum levels of 2.33%, 1.12cmol/kg and 1.88cmol/kg were all recorded in SSFA (appendices).Minimum levels of Bulk density (1.19g/cm^3), moisture content (1.5%) , and available phosphorus (6.10mg/kg) were recorded in SSFA, SSEA 2 and SSEA 1, while their maximum levels of 1.77g/cm^3, 4.2%, and 14.70mg/kg where recorded in SSEA 2, SSFA and SSFA respectively (appendices 4, 2).

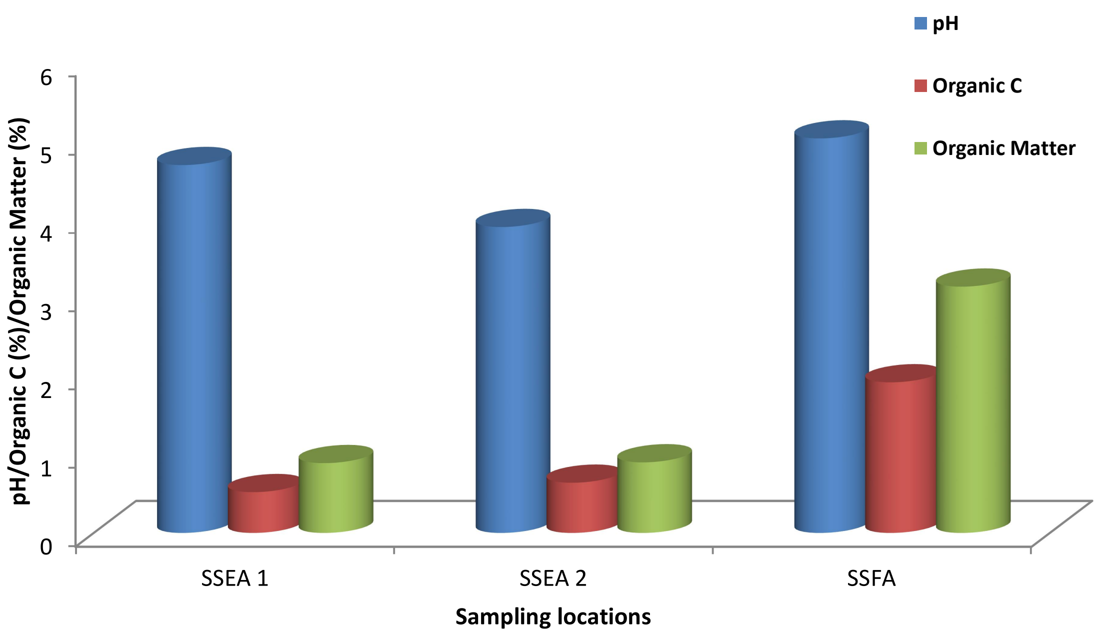

Fig. 4.1. Spatial variations in mean pH, organic carbon and organic matter of soils of Nnewi-North LGA impacted by erosion

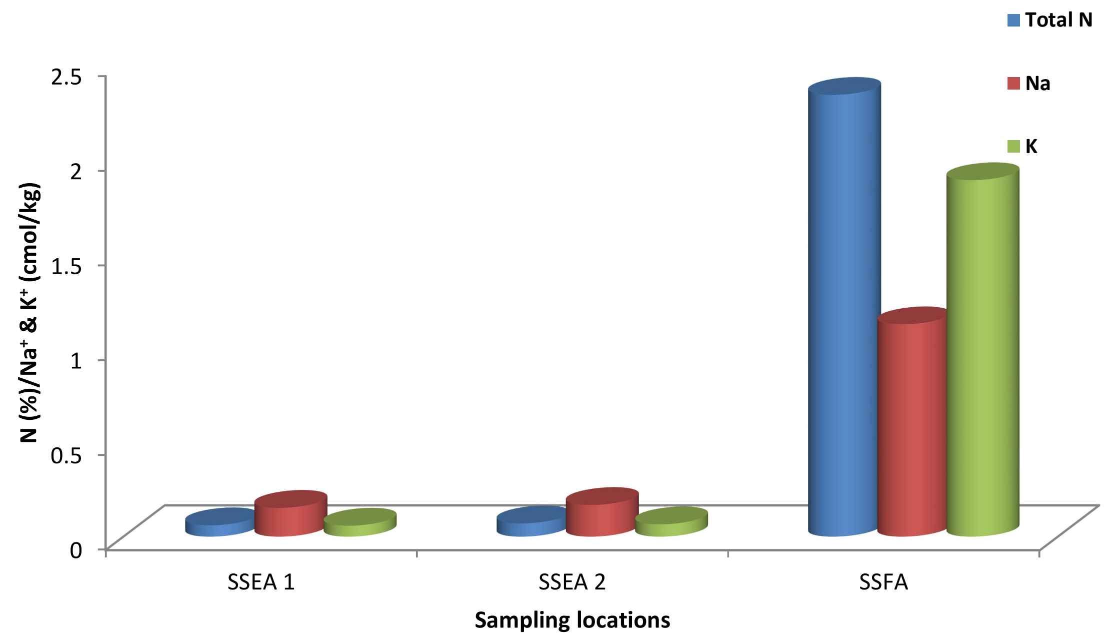

Fig. 4.2. Spatial variations in mean total N, Na and K ions of soils of Nnewi-North LGA impacted by erosion

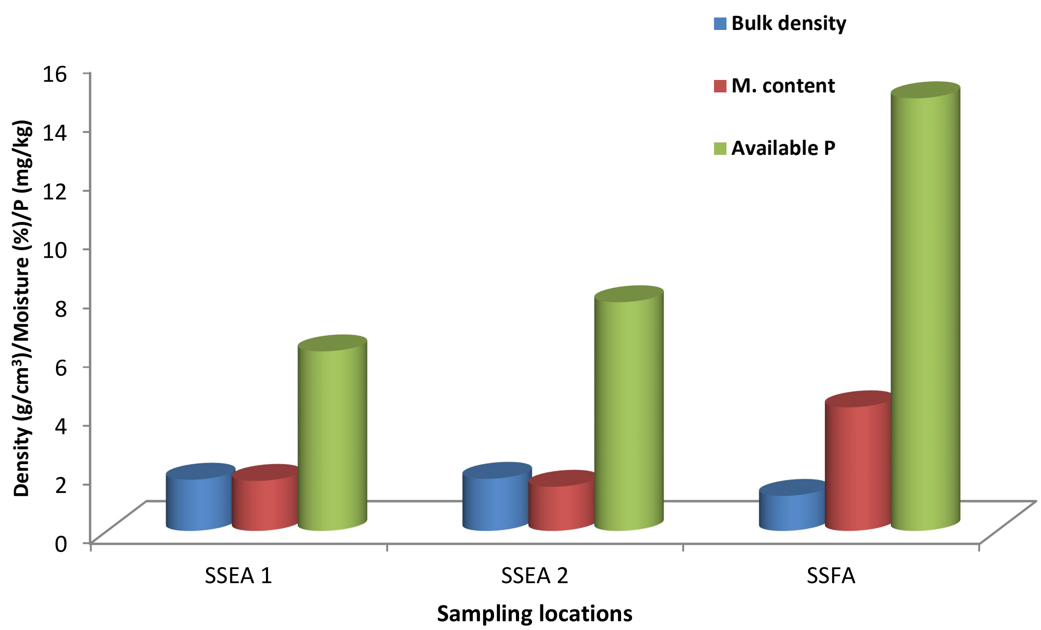

Fig. 4.3. Spatial variations in mean bulk density, moisture contents and available P of soils of Nnewi-North LGA impacted by erosion

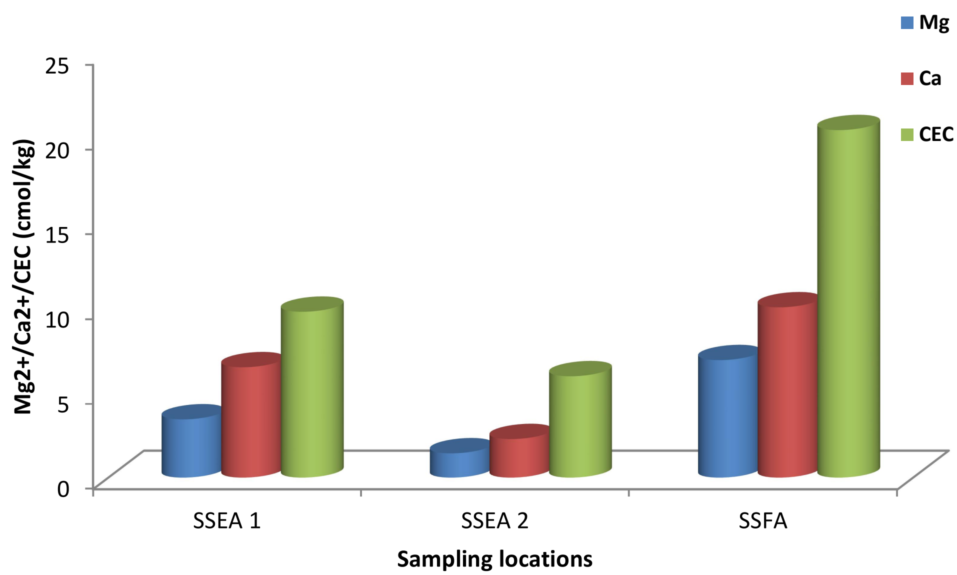

Fig. 4.4. Spatial variations in Mg & Ca ions and cation exchange capacity of soils of Nnewi-North LGA impacted by erosion

Minimum levels of Magnesium (1.43cmol/kg), Calcium (2.27cmol/kg) and cation exchange capacity (5.90 cmol/kg) where recorded in SSEA 1, SSEA 2 and SSEA 2 respectively while their maximum levels of 6.92cmol/k, 10.03cmol/kg, 20.47cmol/kg where all recorded in SSFA (appendice). Minimum compositions of sand (67.12%), silt (5.30%) and clay (17.19%) where recorded in SSFA, SSEA 1 and SSEA 2 while their maximum levels of 75.68%, 8.60% and 24.88% where recorded in SSEA 1, SSEA 2 and SSFA respectively (appendices 5).The test of homogeneity in mean variance of levels of the edaphic variables measured across the sampling locations revealed significant difference (Sig. F = 0.0000) at $P < 0.05$ (Appendix 2).A post-hoc structure detection of group means that utilized the control sampling location (SSFA) as predictor variable revealed that in SSEA 1 (appendice 5) and SSEA 2 (appendix4), Clay (24.880) and Sand compositions (67.120) contributed the observed heterogeneity most.

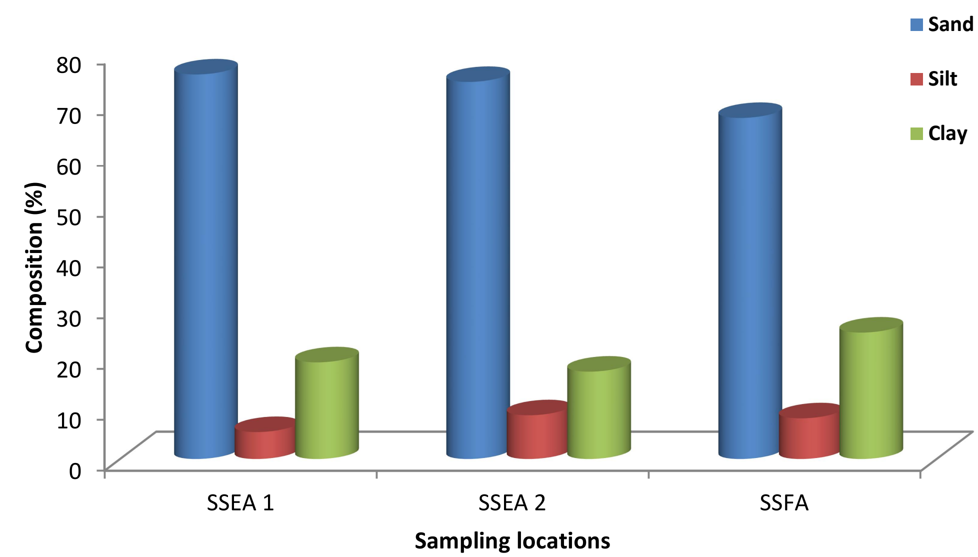

Fig. 4.5. Spatial variations in sand, silt and clay compositions of soils of Nnewi-North LGA impacted by erosion

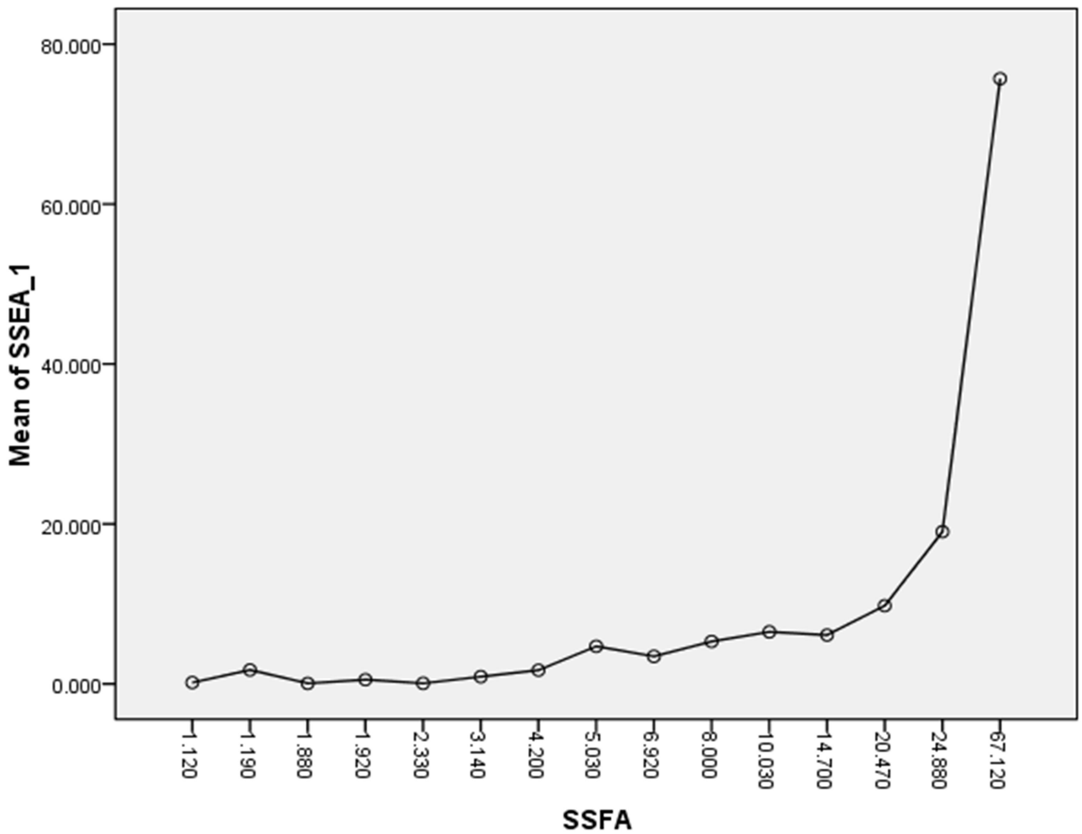

Fig. 4.6: **Means Plot in Edaphic variables between the controls (SSFA) and SSEA 1 locations**

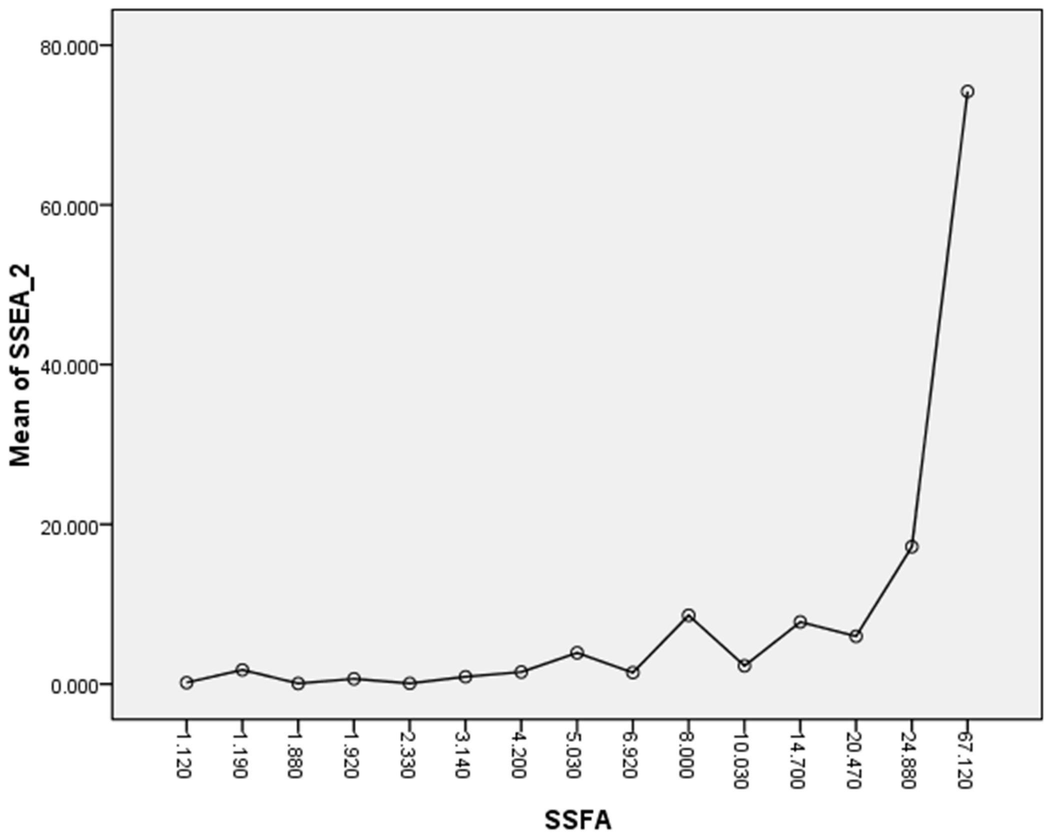

Fig. 4.7: **Means Plot in edaphic variables between the control (SSFA) and SSEA 2 locations.**

4.2 DISCUSSIONS

Deforestation is a major stressor on the forest resources of our terrestrial ecosystem. The principle of sustainability requires that resources be used in a perpetual way for the ever-increasing future generations (Andrew *et al*., 2002) and soil degradation from such activities as deforestation could threaten economic and rural development in, especially third world countries like Nigeria.

In the current study, sand composition in the deforested areas was generally high, with the forested area having relatively lower values. Ubuoh *et al*. (2013) had made similar observations in soil pedons of Nnewi-South Local Government Area of Anambra State. This could portend ease of infiltration of pollutants from surface origins to deeper profiles and subsequently, groundwater aquifers of the area (Ogbuagu *et al.,* 2013).

Low silt and clay contents were also recorded in the deforested areas. Going by Ubuoh *et al.* (2013) classification, this clay content indicates low to medium composition and may have resulted from the movement of clay and other finer materials from the top between 2 -10% that fluctuates among the depths of all soils by an overland flow. Adekayode and Akomolafe (2011) had also made similar observation.

Bulk densities, the dry mass (weight) of soil per bulk volume (Michael and Donald, 1996) decreased with depths in the deforested areas. This observation is desimilar to that of Ubuoh *et al* (2013). However, bulkier soil densities have been associated with recent weathering and deposition of eroded materials in soil pedons. Bulk densities above 1.75g/cm^3 for sands are quoted by de Geus (1973) as causing hindrance to root penetration in soil pedons.

4.2.1 Soil pH

The soils are generally strongly acidic for pH in the deforested areas having low values. A times, the pH values increased with depth. The results are in tune with the findings of Ubuo (2013), Akamigbo and Igwe (1990) who observed that low acidity values are recorded in humid soils due to soil erosions which is responsible for low to high Calcium and Magnesium contents of the soil.

4.2.2 Soil Organic Carbon and Soil Organic Matter

Soil fertility is closely linked to soil organic matter, whose status depends on biomass input and management, mineralisation leaching and erosion (Roose and Barthes, 2001, Nandiva, 2001). The results are consistent with the findings of Morgan (1981) who reported that organic matter and organic Carbon in humid soils are generally low due to leaching and severe sheet erosion, banal of top soils by tillage and mineralization of organic matter by high temperature.

4.2.3 Total Nitrogen

The total Nitrogen status of any soil is closely associated with the soil organic matter (Graham, 2010). Total Nitrogen contents were recorded very low in the deforested area. However, the values of Nitrogen of the soil were found to decrease with an increased depth which was observed due to erosion of nitrates on the top soils. This result is consistent with the finding of Graham (2010) in the Savannah zone of Nigeria. The total Nitrogen in the soils was also as very low compared to ratings of Esu (1991). The reduced microbial activities caused by low pH can affect Nitrogen availability in the soil (London, 1991).

4.2.4 Available Phosphorous

Losses of Phosphorous contents are recorded very low in the devegetated area due to the removal by crops (Enwezor, 1981). In acidic soils, much of the Phosphorus become fixed up by reaction with Iron (Fe^3), Aluminium (Al^3), and Manganese to form insoluble compounds.

4.2.5 Exchangeable Bases

The exchangeable bases in the soils include Na^+, K^+, Mg^{++} and Ca^{++}. The results showed that the values of exchangeable bases ranged between low to medium values in pedons (Esu, 1991). The results of the most of the exchangeable bases indices such as Sodium, Potassium, Magnesium and Calcium decreased with depths. The results are in consistent with the finding of Akamigbo (1993) who observed low Ca/Mg ratio in soil of Ukpor. Also, exchangeable bases have been observed as inherently low on the eroded soils of South Eastern Nigeria (Enwezor, 1986; 1987). The low exchangeable bases in the soils show heavy leeching of soil nutrients. According to Enwezor (1981) pointed out reaching of Calcium and Magnesium are largely responsible for the development of acidity in the soil due to high rainfall with porous nature of the soil texture and parent materials. This was supported by Mbagwu (1986).

4.2.6 Cation Exchangeable Capacity

From the results, the values of CEC ranged recorded very low in the deforested area.

The low CEC is suspected due to the type of clay mineral present in the soil according to Ubuoh *et al* (2013).

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

It is then concluded that the soils of Nnewi North Local Government Area of Anambra State are predominantly sandy loamy in texture with low levels soil nutritional values such as organic matter, organic Carbon, total Nitrogen available, Phosphorus and exchangeable CEC that were lost by leeching. The soil were also strongly acidic due to consistent wearing away of the top soils by sheeting erosion which later resulted to gully that are accelerated by anthropogenic activities.

5.2 RECOMMENDATIONS

1. **Reforestation programme**

   Biological soil conservation methods are more acceptable to most farmers and institutes exist to educate farmers on these methods and to implement them in their farms. For example, planting of exotic trees like *Eucalyptus*, *Acacia*, Cashew and *Gmelina* for soil rehabilitation are recommended as the tree stands would serve to protect the land from degradation and also enrich the soil with available Nitrogen.

2. **Integrated Nutrient Management Options**

   Integrated Nutrient Management options, crop residue management and seed bed preparation methods can play an important role in sustaining the productivity of these soils for crop growth. This can be achieved in reduced tillage systems through the use of crop residue mulches, *insitu* mulches from cover crop, and Tor hedgerow pruning from alley farming. Mulch also protects the soil against high temperatures, soil erosion, and run-off, thereby preventing the breakdown of soil structure and the resultant soil compaction and reduce run off and soil erosion (Keng and Juo, 1986).

3. Effective Public Enlightenment Campaign and Government Interventions

Effective public enlightenment campaign about the advantages of soil conservation should be encouraged. Since poverty bolsters deforestation and the resulting soil degradation, effort should be made to satisfy the basic survival needs of the people. This can be done through poverty alleviation programmes and interventions. Government should create jobs and empower the people, in addition to providing critical infrastructural facilities such as electricity which will drive the creation of more jobs. Both the state and local governments should formulate and implement policies that enhance conservation of forest resources. This should include economic, demographic and land tenure policies.

REFERENCES

Adekayode, F.O. and Akomolafe, D.T. (2011), Creating a soil data base in a reconnaissance soil fertility study of an encroached forest reserve in Northern Nigeria for a reforestation programme. *African Environ. Sci. Technol.* 5(9):748 754. Agriculture. *Soil Sci. Amer. Jr*. 48: 828 – 833.

Ahuja, L. R., El-Swaify, S. A, And Rahman, A. (1976). Measuring hydraulic properties of soil with a double-ring infiltrometre and multiple-depth tensiometres. *Soil sci. Soc. Am. J.,* 40: 494–499.

Akamigbo, F.O. and Igwe, C.A. (1990), Physical and Chemical Characteristics of four Gully Soil Locations in Anambra State, Nigeria. *Agric. Jr.* 7: 33–48.al (ed.) 8th *Int. Soil Conservation Conference, New Delhi, India* 4-8 December, 1994.

Andrew, S.S, Karlen, D.L, and Mitvhell, J.P. (2002), A Comparison of Soil Quality Indexing methods for Vegetable Production Systems in Northern California Agriculture. *Ecosystem and Environment* 90: 25– 45.

Anyanwu J. C., Egbuche C. T., Amaku. G. E., Duruora J. O., Onwuagba, S. (2015) The Impact of Deforestation on Soil Conditions in Anambra State of Nigeria. *M. Journal of science publishing group for agriculture, forestry and fisheries* Vol. 4, No. 3, pp. 64-69.

Bennett, H.H. (1939), Soil Conservation, McGraw Hill, New York, 993p.

Black. C. A (1965). Method of soil analysis; American society of Agronomy, Madison WI., p978.

Blanco, H. and LAL, R. (2008), *Principles of Soil Conservation and Management,* Springer, New York, 617p.

Bremmer, J. M. and Mulvaney, C. S. (1982). Total-Nitrogen. In: *Méthodes of soil analysis,* part 2. Page, A. L, Mille, R. H and Kecney, D. R. (eds). American society of Agronomy. Madison, pp 595 - 624

Day, P. R. (1965). Particle fractionation and particle size analysis. Chap 43 in method of soil analysis, Part 1. Black, C. A (ed). American society of Agronomy, *Madison*. Pp 545–567 development and production., *Jr. Ind. Asson. Sedimentologists*, v.22

El –Swaify, S.A. (1994), Problems of Land Degradation in humid and Sub-humid regions. P 24 – 33. In L.S. Bhushan *et al* (ed.) 8th Int. *Soil Conservation Conference*, New Delhi, India 4-8 December, 1994.

El –Swaify, S.A. "Problems of Land Degradation in humid and Sub-humid regions". Pp 24 – 33. In L.S. Bhushan et al

Enwezor, W.O. (1986), Sulphur Deficiencies in Soils of South eastern Geoderma, 15: 401 – 411.

Esu, I.E. (1991), Detailed Survey of NIHORT Farm at Bunkure, Kano State, Nigeria. IAR/ABU, Zaria. for Soil of South eastern Nigeria. *Soil Science* 123: 110 – 116.from Francophone Research. *Nutrient Cycling in Agro ecosystems*. 61:

Gaston, G., Brown, S., Lorenzini, M., and Singh, K. D. (1998). *State and change in carbon pools in the forests of tropical Africa*. *Global Change Biology*, Vol. 4, pp. 97-114

Graham, W.B.R. (2010), Characteristics of the Soils of Gayi, North western Nigeria. *Nigerian Jr. Sci. Technol.* 6(1): 1 -14.

Grossman, R. B., and Reinsch, T. G. (2002). Bulk density and linear extensibility. In Dane, J. H., and Topps, G. C. Eds. Methods of soil analysis, Part 4 SSSA Nadison, WI. Pp 201–254.

Ikwa, I.L.O (2015) Implications Of Agro Forestry Gaps In Food Security In Selected States Of South Eastern Nigeria.An unpublished PhD thesis in the department of Forestry and Environmental Management, MOUAU.

Kang, B.T. and Juo, A.S.R. (1986), Effect of forest clearing on soil ecosysytem

Klute, A. (1986), Methods of Soil Analysis, Part 1: Physical and in Imo State, Nigeria. *Intern. J. Multidisciplinary Sci. Engin.* 3(1): 42-45.

Lal, R. (1974). Role of mulching techniques in tropical soils and water management. *Technical Bulletin I.* Ibadan, Nigeria: IITA.

London, J.R. (1991). Booker Tropical Soil Manual. Longman Scientific and Technical Essex. *Longman Group Ltd*. London. Pp. 39 – 41.

McLean, E. O. (1982). Soil pH and Lime requirement. In: Page, A. L, Miller, R. H, and Keeney, D. R (eds). Methods of soil analysis. Part 2. Agron. Monogr. 9, *Am, soc, Agron, Madison WI*. p. 199–223.

Medugu, N.I., Rafee, M.M., Johar, F. and Choji, I.D. (2010), The role of afforestation programme in combating desertification in Nigeria. *Int. Jr. Climate Change Strat. Manage.* 2(1):3–47.

Michael, J.S. and Donald, N.M. (1996), Soil: An Introduction, 3rd Ed. Mineralogical Properties. *Am. Soc. Agron*., Madison, Wisconsins.

Moffat, A.J. and Boswell, R.C. (1990), Effect of tree species and species mixtures on soil properties at Gisburn Forest, Yorkshire. *Soil Use Manage*. 6(1):46-51.

Morgan, R.P.C. (1981), Tropics in Applied Geography: Soil Erosion *Natl Sem Env and Disaster Management*, Goa, Sovenir Volume, p. 5-9.

Ofomata, G.E.K (2001) missing link in the management of soil erosion problems in Nigeria in: Geographical perspectives on environmental problems and management in Nigeria.

Pansu, M and Gautheroy, J. (2006). Handbook of soil analysis: mineralogical, organic and inorganic methods. *Springer-verlag*. pp.49-57.Prentice-Hall Inc.

Roose, E. and Barthes, B. (2001), Organic Matter Management for Soil Conservation and Productivity Restoration in Africa: A Contribution Sahu, B.K. (2003a), Modelling petroleum reservoirs: exploration,

Sahu, B.K. (2005), Statistical models in earth sciences, *BS Publications*, Hyderabad, 211p.

Sahu, B.K. (2009), Sustainable Development: Principles and Challenges.,

Sahu, B.K. (2003b), Time Series Modelling in Earth Sciences AA Balkema, Lisse, Netherlands, 284p.

Tulu, T. (2001). Soil and Water Conservation: Theory and Practice. Rostock University Printing Press, Rostock, Germany, 262 pp.

Tulu, T. (2002), Soil and Water Conservation for Sustainable Agriculture. *CTA/Mega Publishing Enterprise*. Addis Ababa.

Tulu, T. *Soil and Water Conservation for Sustainable Agriculture,* CTA/Mega Publishing Enterprise: Addis Ababa, Ubuoh, E. A.;Akhionbare, W. N; Oweremadu, E.A(2012):Characterization of soil quality in erosion prone environment of Ukpor, Nnewi-South L.G.A. of Anambra State, Nigeria. Basic Research Journal of Soil and Environmental Science Vol. 1(2) pp. 12-19

Walkey, A., Black, I.A. (1934), An Examination of the Dejtjarelt Method for Determining Soil Organic Matter and Proposed Modification of the Chromic Acid Titration Method. *Soil Science* 37; 29 -38.

Wang, X. and Gong, Z. (1998), Assessment and Analysis of Soil Quality Changes after years of Reclamation in Sub-tropical China. *Soil and Tillage Research*. 48: 339 -335.

World Bank Document. (2008). Republic of Nigeria, Niger Delta Social and Economic Conflict Analysis. Sustainable Development Department African Region, pp. 12-14

Sahu, B.K. (2010b), CO_2 sequestration for Environmental Protection. *Natl Sem, ISM*, Dhanbad, p143-148.

Sahu, B. K. (2010a), Impacts of Climate Change on GW Resources Management and National Policy. Nat. Sem. Panjab Univ, Chandigarh, Pp 18 - 22.

Ofomata, G.E.K (2001) missing link in the management of soil erosion problems in Nigeria in: Geographical perspectives on environmental problems and management in Nigeria

APPENDIXES

Appendix 1: Soil physical characteristics at SSEA1 (Edorji Uruagu Nnewi)

Sample ID: SSEA 1

S/No	Edaphic Variables	Soil Depth (cm)			Mean (cm)
		0 -15	15 – 30	30 - 45	
1	**Bulk Density (g/cm^3)**	**1.82**	**1.79**	**1.62**	**1.74**
2	**Sand (%)**	**75.70**	**75.65**	**75.68**	**75.68**
3	**Silt (%)**	**5.80**	**5.20**	**4.90**	**5.30**
4	**Clay (%)**	**18.50**	**19.15**	**19.42**	**19.02**
5	**Moisture Content (%)**	**1.3**	**2.1**	**1.6**	**1.67**

Appendix 2: Soil Chemical characteristics at SSEA1 (Edorji Uruagu Nnewi)

Sample ID: SSEA 1

S/No	Edaphic Variables	Soil Depth (cm)			Mean (cm)
		0 -15	**15 – 30**	**30 - 45**	
1	pH	4.56	4.80	4.72	4.69
2	Organic C (%)	0.60	0.52	0.45	0.52
3	Organic Matter (%)	1.02	0.85	0.81	0.89
4	Total N (%)	0.048	0.055	0.078	0.060
5	Available P (mg/kg)	5.40	7.80	5.10	6.10
6	Na^{+} (cmol/kg)	0.162	0.155	0.140	0.152
7	K+ (cmol/kg)	0.062	0.050	0.061	0.057
8	Mg^{2+} (cmol/kg)	5.10	2.80	2.40	3.43
9	Ca^{2+} (cmol/kg)	9.80	5.20	4.50	6.50
10	CEC (cmol/kg)	17.10	5.80	6.40	9.77

Appendix 3: Soil physical characteristics at SSEA2 (Abubo Nnewichi)

Sample ID: SSEA 2

S/No	**Edaphic Variables**	**Soil Depth (cm)**			**Mean (cm)**
		0 -15	**15 – 30**	**30 - 45**	
1	Bulk Density (g/cm^3)	1.85	1.76	1.70	1.77
2	Sand (%)	75.72	72.40	74.50	74.21
3	Silt (%)	9.20	8.50	8.10	8.60
4	Clay (%)	15.08	19.10	17.40	17.19
5	Moisture Content (%)	1.4	2.0	1.1	1.5

Appendix 4: Soil Chemical characteristics at SSEA2 (Abubo Nnewichi)
Sample ID: SSEA 2

S/No	Edaphic Variables	Soil Depth (cm)			Mean (cm)
		0 -15	15 – 30	30 - 45	
1	pH	3.85	3.90	3.95	3.90
2	Organic C (%)	0.70	0.65	0.58	0.64
3	Organic Matter (%)	1.00	0.85	0.84	0.89
4	Total N (%)	0.04	0.09	0.07	0.06
5	Available P (mg/kg)	7.10	8.20	8.00	7.77
6	Na^{+} (cmol/kg)	0.190	0.160	0.150	0.17
7	K^{+} (cmol/kg)	0.090	0.060	0.045	0.065
8	Mg^{2+} (cmol/kg)	1.40	1.80	1.10	1.43
9	Ca^{2+} (cmol/kg)	2.50	2.20	2.10	2.27
10	CEC (cmol/kg)	6.450	5.610	5.850	5.97

Appendix 5: Soil physical characteristics at SSEA3 (Umudim Nnewi)
Sample ID: SSFA

S/No	Edaphic Variables	Soil Depth (cm)			Mean (cm)
		0 -15	**15 – 30**	**30 - 45**	**1.19**
1	Bulk Density (g/cm^3)	1.15	1.20	1.22	67.12
2	Sand (%)	67.55	67.20	66.60	8.00
3	Silt (%)	7.80	8.10	8.11	24.88
4	Clay (%)	24.65	24.70	25.29	4.23
5	Moisture Content (%)	4.5	4.2	4.0	4.2

Soils were deep, well drained, dark reddish brown to reddish brown and yellowish red of the Munsell colour notation. This observation was similar to that of Ubuoh *et al* (2013) in soils of the neighbouring Nnewi South Local Government Area.

Appendix 6: Soil Chemical characteristics at SSEA3 (Umudim)
Sample ID: SSFA

S/No	Edaphic Variables	Soil Depth (cm)			Mean (cm)
		0 -15	15 – 30	30 - 45	
1	pH	4.80	5.10	5.20	5.03
2	Organic C (%)	2.11	2.10	1.56	1.92
3	Organic Matter (%)	3.40	3.20	2.82	3.14
4	Total N (%)	2.41	2.30	2.29	2.33
5	Available P (mg/kg)	13.88	15.42	14.80	14.70
6	Na^+ (cmol/kg)	1.09	1.00	1.26	1.12
7	K^+ (cmol/kg)	1.79	1.84	2.00	1.87
8	Mg^{2+} (cmol/kg)	5.80	7.50	7.45	6.92
9	Ca^{2+} (cmol/kg)	10.50	9.85	9.75	10.03
10	CEC (cmol/kg)	19.20	21.40	20.80	20.47

Soils were deep, well drained, dark reddish brown to reddish brown and yellowish red of the Munsell colour notation. This observation was similar to that of Ubuoh *et al* (2013) in soils of the neighbouring Nnewi South Local Government Area.

Appendix 7: Test of Homogeneity in mean variance using One-way Analysis of Variance (P < 0.05)

S/N	ANOVA		Sum of Squares	df	Mean Square	F	Sig.
1	**SSEA**	Between Groups	5106.992	14	364.785	-	-
		Within Groups	.000	0	-		
		Total	5106.992	14			
2	**SSEA**	Between Groups	4935.634	14	352.545	-	-
		Within Groups	.000	0	-		
		Total	4935.634	14			

Appendix 8: Relationship between edaphic variables of soils of Nnewi North LGA

	PH	Bulk Density	AV.P	Na	K	Mg	Ca	CEC	Sand	Silt	Clay	M. Content
Organic Carbon	-0.683	-0.912	0.063	0.970	0.113	0.940	0.935	0.862	0.432	0.989	-0.981	-0.407
Organic Matter	-0.871	0.747	-0.239	0.852	0.406	0.999*	0.988*	0.974	0.683	0.988	-0.994	-0.662
Total Nitrogen	0.403	-0.996	-0.390	-0.996	0.222	-0.775	-0.765	-0.645	-0.110	-0.883	0.861	0.081

***Significant at P<0.05, B. Density = bulk density, AV.P= available Phosphorus, CEC = Cation Exchange Capacity**