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Comparative Analysis on the Implications of Charcoal Production Processes on Soil Physico-Chemical Properties of Sudan Savanna Ecosystem, Bauchi Nigeria

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Abstract
A comparative analysis on the implication of charcoal production processes on soil physico-chemical properties of a community forest in Sudan Savanna region of Bauchi state was carried out. Soil Samples from three randomly located points where charcoal were locally produced was analyzed and compared with a control site using purposeful sampling techniques. Soil structures, nutrient retention capacity as well as carbon contents of the soil was analyzed in addition to bulk density and soil physico-chemical analysis. The results revealed that the production site was more sand (82.8%), less silt (8.56%) and clay (8.64%) respectively while the control site has less sand (72.80%), high silt (14.56%) and clay (12.64%). The findings established more acidity in the production site than the control site with pH value of 6.30 and 6.72 respectively. Additionally the bulk density analysis result indicated lower value of 1.19Mg^{-3} and higher porosity of 55.10Mgm^{-3} with reddish black color soil in the production site while the control site has higher bulk density of 1.29Mg^{-3} and lower porosity of 51.10Mg^{-3} with reddish grey soil. The organic carbon content of the soil increased at the production site to 1.12% and decreased at the control site to 0.30%. Similarly, nitrogen and CEC decreases respectively at the production site with a value of 0.063Mgm^{-3} and 3.94 C mol(+) kg^{-1}, in the same vain available Phosphate increases five times at the production site than the control site with a value of 34.80Mgk^{-1} and 6.39Mgk^{-1}. However, there is a decreased of

Exchangeable Base at the production site compared to the control site with a value of Ca (1.62 : 3.56 Cmol(+) kg^{-1}), Mg (0.45 : 0.73 Cmol(+) kg^{-1}), K (0.12 : 0.19 C mol(+) kg^{-1}), Na (0.06 : 0.12 Cmol(+)kg^{-1}). Additionally, an increase of micronutrients Fe and Mn (4.87 and 13.87 $Mgkg^{-1}$) was established and a decreased of Cu and Zn (0.35 and 0.48 $Mgkg^{-1}$) at the production site was also revealed. However, this paper established that in-situ-charcoal production has a serious negative impact on a natural ecosystem, soil chemistry and structure compared to the control site. Which ironically, reduce the soil vigor in supporting plant growth and development and further make it vulnerable to erosion. The paper recommended that appropriate poverty reduction policies should be put in place to provide alternative livelihood for the inhabitants of the community.
Keywords: *Charcoal, Livelihood, Nutrient, Ecosystem and Inhabitant*

INTRODUCTION

Humans produce and use charcoal as fuel for cooking and grilling since the Stone Age. Charcoal in Bauchi State is still widely used by urban and rural people as a smokeless domestic cooking and grilling fuel with a high heating value. The traditional charcoal production method is mainly of two types. Wood is put in dug – out earth pits, lit and covered with earth. The combustion of part of the wood produces enough heat to carbonize the remainder. Alternatively, heaps of wood are covered with earth and lit through opening in the earth cover (earth kilns) Plate2 and 3. These opening could be judiciously opened and closed and new ones could be made to control the in late of air. Barnawa village and its neighboring communities, are located in Bauchi local government area, the inhabitants of these communities have been engaged in the production of charcoal for a long period of time. The demand for charcoal is not only in Barnawa but also in Bauchi metropolis and neighboring states.

However charcoal production is one among the major agents of deforestation and can contribute significantly to the greenhouse gasses into the atmosphere such as carbon monoxide (CO) and carbon dioxide (CO_2) which substantially contribute to global warming. About 95% of carbon dioxide is released to atmosphere during charcoal production;

only 5% is temporarily retained in the soil (Amos, 2000). Thus, soil holds more organic carbon than that held by the atmosphere as carbon dioxide (CO_2) and vegetation, yet the role of the soil in capturing and storing carbon dioxide is poorly understood when considering the importance of the land in mitigating climate change.

Charcoal production however, affects entire ecosystems flora and fauna, as well as the atmosphere and soil. Research on the effects of charcoal production to date has focused primarily on the former, whereas its effects on the soil system have received less attention. During burning, plant cover and litter layers are consumed, and mineral soil is heated. There by altering the physical characteristics of soils as well as its ability to support life (Plant and animals). Hence there is the need to better understand the physical and chemical implications of charcoal production processes on soil. The study was therefore conducted to investigate the effects of these production processes on soil physical and chemical properties on Sudan Savanna ecosystem.

MATERIALS AND METHODS

Study Area

The study was conducted in Barnawa community in Bauchi local government area. Barnawa Community is situated 5km North West of Bauchi metropolis, characterized as an agric based community with 75% of the population practicing subsistence agriculture. Bauchi states is located between latitudes 10° $15'$ and 10° $30'$ north of the equator and longitudes 9° $45'$ and $10'$ east of the green which meridian. The annual total rainfall ranges from 500-1000mm. The state is bordered by seven states: Kano and Jigawa to the north, Taraba and Plateau to the south, Gombe and Yobe to the east and Kaduna to the west. Bauchi State occupies a total land area of 492,359 km^2, representing about 5.3% of Nigeria's total landmass. (BSADP, 2000).

The climate of Bauchi State, like any other parts of Nigeria, is controlled by the oscillation of the boundary between two major air masses. These are the moisture-laden tropical maritime (MT) air mass, which originates from the Atlantic Ocean, and the dry, dust-laden tropical continental (CT) air mass, which originates from Sahara desert.

The boundary between these two air masses, the inter-tropical discontinuity (ITD) is significant because it separates two distinct patterns of weather on either side. Local physiographic features also affect the climate of Bauchi States. Temperatures are generally high in Bauchi State. During the hot seasons (March and April) daily maximum temperature could be as high as 37.6°C. With the onset of the wet season, the daily maximum temperature drops, reaching 29.2°C in July and August. The start of the dry season is marked by a rapid drop in daily minimum temperature to 11.7°C in December and January and rises to about 24.70°C in April and May. Radiation is fairly even throughout the year. However, it is relatively higher in March to May. The sunshine hours range from 5.1 hours in July to 8.9 hours in November. Indeed, October to February usually record the longest sunshine hours in the state.

Collection and Analysis of Sample

Three composite samples were collected from the identified charcoal production sites and control site using purposeful sampling technique. Soil samples were collected using soil auger at the depth of 0 – 15cm at production sites and control site respectively. The collected samples were properly kept in a well labeled polythene bags and taken to the laboratory for analysis. Sample were air-dried in the laboratory, grinded and passed through 2 mm sieved. The sieved samples were used for laboratory analysis. Particle size distribution was determined by hydrometer method (Gee and Bauder, 1986), while Sand, Silt and Clay fractions were determined by dispersing the soil samples in a reciprocation electric mixer for particle size distribution and determination with the aid of Bouyoucous hydrometer at progressive time intervals. The texture classes were determined with the aid at USDA textural triangle. Similarly Bulk density was determined using Clods method (Black, et al, 1986) where the Clods was saturated with Kerosene after taking initial weight in air. The volume of saturated clods was measured by displacement in a known volume of kerosene.

Soil pH was determined using water and 0.01m $CaCl_2$ at a ratio of 1:1 and 1:2 soil water and soil $CaCl_2$ suspension, using pH meter mode cyber scan pH[20] and organic carbon content was determined by wet

oxidation method at Walkley and Black as described by Nelson and summer (1986). The reaction was activated with the addition of concentrated Sulphuric acid as a catalyst.
Total Nitrogen was determined using the micro – Kjeldahl technique as described by Breimmner (1982). Free ammonia is liberated from the solution by steam distillation in the presence of Sodium hydroxide and was trapped by H_3BO_3 acid. However, available phosphorous in the solution was extracted using Bray -1 method (Bray and Kurtz, 1945), colourimetrically by measuring the intensive colour of the phosphor – molybdate complex (Blue Colour) using ascorbic acid as a reducing agent (Murphy and Riley, 1962). The exchangeable bases Ca, Mg, K and Na were extracted with IM ammonium acetate (IN NH_4 AOC) solution buffered at Pit 7.0 as described by Anderson and Ingram (1998). Potassium and Sodium (K and Na) in the extract were read on Jenway Flame photometer model PFp7. The Calcium and Magnesium Ca and Mg were read on VGP, model 210 bulk Scientific Atomic Absorption Spectrophotometer (A.A.S.) at their appropriate wavelengths.

Equally, Cation exchange capacity of the soil was determined with ammonium acetate, buffered at pH 7.0 (Chapman, 1985). The excess acetate was removed by repeated washing with alcohol. The absorbed ammonium ion was distilled by Kjeldahl method (Brammer, 1982). The soil extractable micronutrients were extracted using dilute hydrochloric acid (0.1m HCl) as described by IITA manual (1982) and their respective concentrations is determined by atomic absorption spectrophotometer (A.A.S) model VGP 210, Bulk scientific at their appropriate wavelength.

RESULTS AND DISCUSSION

Table 1 shows the distributions of individual soil separates in the study area (Barnawa community). The production site recorded a higher value of sand (82.80%), less silt (8.56%) and clay (8.64%) than the control site72.80% Sand, 14.56% Silt and 12.64% Clay respectively; this was attributed to the intense burning which invariably affects the soil organic matter and clay which together aids in binding the soil separate. However, increase in sand fraction among the separate led to an increased in hydraulic conductivity, consequently led to erosion and the unproductivity of the soil. On the other hand, as rightly observed by De Bono,(1998), in a study conducted to determine the effect of fire on soil, he deduced that burning the soil can induce the formation of water repellent soil layer, which blocks water infiltration (less than 350° C) and constitute to runoff. However, his findings were further buttressed by Wells, et. al (1979) who reported that charcoal production can affect soil hydrology by reducing water-retentive properties of the soil and vice-versa and can make a sandy soil behave like clay by addition of charcoal particles. This has ecological significance in bottom land where it can constitute poor drainage and water logged conditions. While Wondzell, *et. al.*, (2003) stressed that both clay and silt particles in the soil on exposure to high temperature fuse to form sand-sized particles resulting in a loosely structured soil.

The results of the bulk density analysis indicated that the bulk density range from 1.19Mgm^{-3} at the production site to 1.29 Mgm^{-3} at the control site (Table 2). Production site recorded lower Bulk density than the control site. This was largely due to intense burning of the soil surface which destroyed the soil organic matter that aids in aggregating soil separates, therefore the destruction of organic matter will lead to poor soil structure, by reducing the bulk density and enhancing soil erodibility. This finding agreed with what Robichard, et. al (2000) observed in his study that charcoal production reduces the bulk density of a soil by about 8% compared to the unburned area. The percentage of pores space (Table 2) at the production site indicated 55.10% total porosity when compared with 51.10% found at the control site. This indicates higher porosity due to fire influence, meaning when soil surface are heated during charcoal production it destroys the cementing agents leading to the loss of surface formation of the immediate soil surface, which therefore become susceptible to agents of denudation. Consequently, these leads to higher hydraulic conductivity and infiltration rate in the soil which eventually leads to erosion and alleviation with the formation of E-horizon. This was confirmed by Fisher, (2000) who reported that charcoal production increased soil porosity by affecting the aggregated stability agents of the soil.

However, the color of the soil at the production site revealed that the color stand as 7.5R (Hue), 2(Value) and 1(chroma), Table 2 while the control site had the color of 10R (Hue), 5 (values) and 1(chroma), using standard color chart by Munsell, the production site had a color of Reddish black where control site has a color of Reddish grey respectively. When organic materials were burned on soil surface, it normally affects the color, that is to say the Black soil color observed at the production site was due to increase in carbon source control site which had less carbon materials.

This finding was confirmed by De bono, et. al (1998), that soil color becomes darkened under charcoal kilns with hue, value and chroma decreasing by 8%, 20% and 20%, respectively. The effect of heating processes on soil is as a result of burning severely; value is determined by the peak temperatures and duration of fire (Bryant, et. al 2005). Low to medium fire severely resulted in darkening of topsoil while high-severely fires (>600° C) cause pronounced reddening of topsoil (Bryant et al, 2005). Further Munsell Hue, value and chroma at the charcoal production site at the temperature of about 600°C could be due to charring of organic matter. Other studies also showed a relationship between a deep black soil colour and the presence of charred organic matter Well et al. (1979). The pH in water (1:1) mean value at the production and control sites were 6.30 and 6.72 respectively. The result indicated that production site recorded lower value than the control site. It is proven that production site is classified slightly acidic whereas control site was Neutral. High pH value found at the production site could be due to combined materials (carbon) that correlated Fe and Al oxides that occupied the colloidal sites, thus making the soil acidic (Table 3).

The percentage of organic carbon of both the production and control sites were 1.12% and 0.34% (Table 3). It can be clearly seen from the results that, the amount of organic carbon at the production site is by far more than that of the control site. It is well known with the fact that, soil at the production site tends to only accumulate high levels of organic carbon near the surface and have lower levels in the sub-soil (at 15cm depth). Also one reason why the control site has lower organic carbon was as a result of excessive deforestation; no leaf litter and decaying wood from limbs and trees that accumulate at the soil surface. The total Nitrogen content of the study areas ranges from 0.063% found at the production site to 0.143% found at the control site (Table 3). The nitrogen content was rated as low at the production site and medium at the control site (Esu, 1991, NIHOR, 1998). Low Nitrogen content found at the production site could be due to non humified carbon which mineralization increased the Nitrogen content at the soil. On the other hand, high or medium total Nitrogen found at the control was due to humified organic materials which mineralized the total Nitrogen in soil. As a result of application of fire during charcoal production on soil, most of the organisms were killed and the total Nitrogen rated low at the production site. on the other hand, the control site has as high rate.

The result of the available phosphorus content at the production site revealed highest at 34.80 $Mgkg^{-1}$, which is rated high according to Esu (1991) rating. On the other hand, lower value of 6.39 $Mgkg^{-1}$ was found at control site and rated low (Esu, 1991). High amount of phosphorus was due to intense burning, which make phosphorus to be released from the organic-phosphorus content free in the soil. This corresponds with the findings of Kutiel, et. al (1993) and De Bono, et. al (1978) that plant residues turn into the soil as ash after intense fire, which significantly increased phosphorus content of soils. Table 4, shows the results of Cation Exchange Capacity (CEC) content of soil at production site and control site. The result indicated that production site had lower CEC value at 3.94 Cmol (+) kg^{-1} compared to 10.01 Cmol (+) kg^{-1} found at the control site. The CEC content was rated low (production site) and Medium (control site) according to Esu, (1991). Lower CEC value could be due to increase in sand content and low clay and silt content found at the production site. High sand and low clay and silt content affect the overall exchange of soil that has the ability and capacity to hold most of the exchangeable bases that increases the CEC value. The production site content carbon that was not oxidized compared to the oxidized form of carbon found at the control site. This finding therefore agreed with the work of Creighten, et. al (2003), that burning increases exchangeable bases, which had direct effect of CEC content of soil.

The exchangeable bases (Ca, Mg, K and Na) at production and control sites were shown in Table 4. The amount of bases recorded at the production and the control site were in ordered Ca, Mg, K and Na value of 1.63, 0.45, 0.12 and 0.06 (Production site) and 3.56, 0.73, 0.19 and 0.12(control site) respectively. The results indicated that the charcoal production site recorded the lowest amount of exchangeable bases compared to the control site. This could be described as the intense fire effect on the textural properties. Increase in sand content affect the surface area and charges, which has the ability to absorb and retain most of these bases. Fire affects the exchange site of soil by direct effect on organic matter and clay. This finding contradicted the findings of Hermondez, et. al (1998), which reported that Exchangeable bases values at burn plots were greater than un-burned plot.

The extractable micronutrients; Zinc (Zn), Copper (Cu), Iron (Fe), and Manganese (Mn) at production site and an adjacent site (control) were showed in Table 5. Generally their content varied with sites. The amount of Zinc and Copper was highest at the control site than the production site. On the other hand, production site recorded the highest value of Iron and Manganese than the control site. Thus, high value of copper and Zinc at the control site could be due to increase in silt and clay content. On the other hand, high value recorded for Iron and Manganese at the production site than the control, this was attributed to the higher sand and lower silt and clay content, Burning activities affect the distribution of cementing agents that hold most of the bases, this allows the surface/exchange site of soil to be dominated with Iron, Aluminum and Manganese that have potential acidity.

CONCLUSION AND RECOMMENDATION

If forest and forest products are to be sustainably developed and maintain, all stakeholders in conservation and other environmental profession needs to take synergistic and proactive conservation measures for the remaining patches of savanna ecosystems considering their ecological and economic significance. The multiple environmental threats associated with savanna ecosystem ranging from over grazing, deforestation, farming, urbanization and climate change among others further marginalized the multiple functions that savanna ecosystem is providing for livelihood sustenance. However, Environmental Management principle envisages that management of environment should be sustainable. This therefore means that, the existing natural resources are getting depleted through human's exploitative acts. Thus, the remaining natural resources left should be properly manage and maintain for prosperity. They should be given the opportunity to survive because they have functions which they perform and nature has made it possible that we most coexist and complement the need and services of one another. Like any other ecosystem, savanna has a specific function which it performs and no other ecosystem can do that. In particular it serves as life support system of most herbivores on earth which mankind depend upon it as a source of food (Animal Protein).

From the findings of this research, it is established that the north eastern Savanna ecosystem is badly threaten by deforestation and habitat fragmentation due farming, urbanization and rural-rural migration and are going on alarming rate (Plate 1 and 2). This is a big threat. Thus, if the remaining patches of the savanna ecosystems are to be save and preserve, conservation strategies needs to target the following;-

1. There should be a shift from government (LGA) being responsible for land allocation or issuance of resident/logging permit/or license to immigrant (internally Displaced persons) to community-based management of the area and natural resources, so that the bulk of the economic burden and responsibility of management will fall into the hands of the community itself who uses the resources of the area for sustaining household livelihoods. Directly or indirectly other institutions and stakeholder can have direct link to the affected group/community identify the problems and proffer solutions immediately and the impact will be seen immediately.

2. Conservation practitioners (Government, NGO"S, and Individuals) must not impose uniform conservation strategies across the Country. Rather, they must recognize the regional/zonal and complex differences in culture and institutional roles and power between sub regions of the country.

3. It is increasingly recognized that it is unacceptable for all tear of government being it local government, state government or federal government of any country to disempower or impoverish their resident communities living adjacent to virgin forest because of the possible implications of their actions on the remaining existing forest for livelihood sustenance. These points were emphasized at the 2003 World Parks Congress in Durban (Cernea, 2003) enshrined in its Recommendations and later reaffirmed by the Convention on Biological Diversity Programme, 2004 (CBD) of Work on Protected Areas activity 2.1.1 of goal 2.1 and activity 2.2.5 of goal 2.2. therefore it is the responsibility of government to provide nonagricultural livelihoods to reduce the dependency of local people on forest resources thereby improving the unlimited ecosystem services

4. Stringent legislative act must be put in place to regulate anyone who wishes to carry out any project (being it charcoal production, mining or quarries that might have significant effect on the environment) to obtain consent for the work from the forestry department of the local government area or the state ministry of environment and forestry. The applicant or proposer must submit an environmental statement in support of his proposals stating categorically clear the intended project, mode of operation, its environmental impact and mitigations measures to be used among others. In addition, there should be a provision of alternative energy source at a subsidized rate and farm inputs to the local people.

5. There is a need for urgent intervention by the government at all levels (i.e Local, State, and federal government) in order to address the persistent increase in the price of other energy sources. The country needs to have an integrated and comprehensive gas project that will be intended to address local domestic energy need of the people.

Table 1: Particle Size Distribution of Soil at Barnawa Community.

Sites	Sand	Silt	Clay
	←	%	→
Production	82.80	8.56	8.64
Control	72.80	14.56	12.64

Source: Field Survey, 2010

Table 2: Effect of Charcoal Production on Bulk Density, Total Porosity and Colour on Soil at Barnawa Community, Bauchi

Site	Bulk Density	Total Porosity	Colour
	→ Mgm^{-3} ←		
Production	1.19	55.10	Reddish Black
Control	1.29	51.10	Reddish Grey

Source: Soil Analysis, 2010

Table 3: Fertility Indicators as Affected by Charcoal Production at Barnawa Community, Bauchi

Site	pH_1	Organic Carbo	Total Nitrogen	A. Phosphorus
	←	%	→	← $Mgkg^{-1}$ →
Production	6.30	1.12	0.063	34.80
Control	6.72	0.34	0.143	6.39

Source: Soil Analysis, 2010.

Table 4: Exchangeable Bases and Cation Exchange Capacity of Soils at Barnawa Community, Bauchi

	Ca	Mg	K	Na	CEC
Site	← Cmol (+) Kg^{-1} →				
Production	1.62	0.45	0.12	0.06	3.94
Control	3.56	0.73	0.19	0.12	10.01

Source: Soil Analysis, 2010.

Table 5: Extractable Micronutrient at Barnawa Community Soil.

	Zn	Cu	Fe	Mn
Site	← Mgkg →			
Production	0.48	0.35	4.87	13.87
Control	1.33	0.62	3.93	10.15

Source: Soil Analysis, 2010.

Plate 1

Use of Power Chain Saw Machine in Clearing Forest For Commercial Chacoal Production in Barnawa Community, 2010
Source: Field Survey, 2010

Plate 2

Heaps of Logs Stacked for Earth Kiln for Chacoal Production at Barnawa Community, 2011
Source: Field Survey, 2010

Plate 3

Earth Kiln Burning Wood for Charcoal Production, Barnawa Community

Source: Field Survey, 2010

Plate 4

Site after Charcoal Being Produced Barnawa Community, 2011

Source: Field Survey, 2010

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Economic Impact of Fuel Subsidy on Road Transportation in Adamawa State

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Abstract

This paper focuses on the economic impact of fuel subsidy on Nigerian road transport. According to this paper, fuel subsidy is a financial assistance granted by the government to support the production of oil in order to maintain the price of oil to a certain level. The purpose of this work is to find out how subsidizing fuel helps road transporters by reducing prices and making it reliable and affordable especially to the poor people of the society. The findings revealed that although fuel is being subsidized in Nigeria, not everybody is feeling the impact rather; the money is embezzled leaving the purpose of the subsidy useless. The subsidy money ends up enriching the few politicians leaving Nigeria poor as ever and oil price still high. In addition, subsidy helps to lower transportation cost and therefore should not be removed because it will lead to high oil prices making it not affordable to the poor people of the community. Recommendations were made on how government can ensure that the money given for fuel subsidy is being used for that purpose, providing alternative to road transport, resuscitating the old refineries and building new refineries.

Keywords: *Economic Impact, Fuel Subsidy, Road Transport, Adamawa State*

INTRODUCTION

Since the production of petrol started in commercial quantities in 1960s, it has fed the country and increased government revenue. Nevertheless, oil boom of 1960s increased oil prices which led to over dependence on oil revenue for infrastructural projects in the country (Akov, 2015). The acceptance of a structural adjustment programme (SAP) changed the prices of petrol. Phasing out subsidy was one of the stipulations of SAP, and it has been a cause of disagreement between the government and other institutions. The pump price of petrol per liter did not increase until 1976. Corresponding to SAP prescriptions, petrol price increased from 8.4/5kobo to 15.30 kobo in 1978 making an increase of 73.86% (Elumide, Asaolu and Adereti, 2006).

The pump price increased again from 15.30 kobo to 20 kobo per liter in 1982. Price of petrol increased five times during Ibrahim Babangida's regime. In 1986, there was an increase in price from 20 to 39.5 kobo indicating 80% increase. Once more, the price increased from 39.5 to 42 kobo in 1988. Again, in 1989, there was an increase from 42 kobo to 42/60 kobo (42 for commercial vehicles and 60 for private vehicles). Same year, it was increased to 60 kobo across the board. Finally in 1993, government of Ibrahim Babangida increased price ₦7 per liter. Nonetheless, the interim national government (ING) reversed the price to gain legitimacy (Akov, 2015).

In a short period, the ING increased fuel pump price to 5 naira per liter from 70 kobo. The Abacha regime reduced the price to 3.25 naira per liter and increased it again to 15 naira indicating 361.5% increase in 1994 (Akov, 2015). The price was reviewed back to 11naira per liter as a result of labour action and protests. This pump price was retained until General Abdulsalami Abubakar in 1988 increased the price to 15 naira per liter. In 1999, the administration increased the price to 20 naira per liter. Obasanjo's administration increased pump price six times. The first was in 2000 and it rose to 30 naira from 20 naira. The national assembly, State Governors and NLC were not consulted before the increase. This led to protests and was later reviewed from 30 naira to 25 naira. However, there was a further reduction to 22 naira due to rejection by organized labour (Akov, 2015). Once again, the price rose again to

₦26 per liter in 2002. This price was further increased to ₦40 in 2003. There was a rapid increase to ₦70 per liter in 2007 which was later reduced to ₦65 per liter. Finally, in 2012, President Goodluck increased the price from ₦65 to ₦140 representing 115% increase. This has led to serious burst of public bitterness in Nigeria since 2003 (Akov, 2015).

STATEMENT OF PROBLEM

Oil is a controversial issue globally as well as in Nigeria. Crude oil is the major source of energy and wealth in the global economy. The discovery of oil in Nigeria has led to the neglect of the agricultural sector, which contributed 80% of the GDP. Presently, 99% of Nigerians foreign exchange earnings come from crude oil making Nigeria too dependent on it. Nigeria is a large net importer of oil and is ranked low in human development indicators. Frequent world oil price fluctuations and harsh economic realities gave rise to the introduction of subsidy in Nigeria (1980s).

In Nigeria, there are so many problems hindering the effectiveness of this subsidy. They include corruption and poor regulation. The assumed trillions of naira paid for subsidy is not used efficiently because oil price kept on increasing leading to un-affordability of road transport. High cost of fuel has crippled economic activities in Adamawa State. A survey carried out shows that high prices of transportation are caused by scarcity of fuel (high fuel price). They complained that transportation cost of materials and commodities from place of production to place of business is high leading to increase in the price of the goods, which in turn leads to low return due to low patronage. In addition, transporters complained about lack of fuel and how they patronize the black market at a very high cost which leads to higher transportation costs. This problem affects everybody including civil servants, students, business owners and others. It is as a result of this that the researcher wants to examine the economic impact of the above problems due to increase in fuel price on road transportation.

AIM OF STUDY

To investigate the economic impact of fuel subsidy on road transportation in Adamawa state

Objectives of Study

Fuel subsidy is an interesting topic for people because of its direct effect in the lives of the citizens. Due to this, this paper examines and reports the following: people's awareness of fuel subsidy, problems of fuel subsidy, the impact of fuel subsidy on road transportation in Nigeria, change in fuel price due to subsidy, and efficiency of the government towards the implementation of subsidy.

Scope of Study

This paper is limited to economic impact of fuel subsidy on road transportation in Adamawa State. The State is located in the North-Eastern part of Nigeria.

LITERATURE REVIEW

In this section, information from the various literatures reviewed has been grouped under the following sub-headings:

- Concept of fuel subsidy
- Road transport in Nigeria
- Fuel subsidy, Road Transportation and Economic Development
- Effects of fuel subsidy

The Concept of Fuel Subsidy

Subsidy is any measure that keeps the prices that consumers pay for a product below market levels for consumers or for producers. According to Ifegbuyi Yemi (2012), fuel subsidy is a program created by the government to reduce the prices of petroleum products, which include petrol, diesel and kerosene and to protect the citizens from crude oil instability in the international market. Fuel subsidy is common in oil producing countries such as: Venezuela, Iran, Saudi Arabia, Egypt, Burma, Malaysia, Kuwait, China, Taiwan, South Korea, Trinidad and Tobago, and Brunei.

According to (Adebiyi, 2011), energy subsidies and particularly fuel subsidies have a long history and have been applied in different forms with differing outcomes internationally. It is estimated that more than 25 African countries reportedly had one form of energy subsidy or another before 2010-2011, which consumed an average of 1.4 percent of

GDP in public resources (Coady, et al., 2010). Subsidy is computed by subtracting pump price from the market price. Market price is the price set by the government to be sold to the petrol wholesalers. Pump price is price that is sold at the filing stations. The government subsidizes the market price to get the pump price.

Road Transport in Nigeria

Transportation is an important part of human activity and forms the basis for all socio-economic interactions. Truly, without a viable means of movement no two locations will interact effectively. In many developing countries, transport facilities are inadequate. Therefore, to support economic growth and development, a good transport system is vital. Since 1960, the major problem of road transports is bad roads coupled with dearth of trained transport managers and planners, delay in capital restructuring, serious issues of institutional reforms and ineffective traffic regulations. Today, road transport is the commonly used mode of transportation in Nigeria. Road traffic depends on the pattern of human settlements, accounting for more than 90% of the sub-sector's contribution to GDP. Road transport activities involve the conveyance of passengers en masse or in small numbers, the transportation of animals, merchandise, farm produce and rendering of mobile services (banks, clinics and libraries). Road transport is more predominant in Nigeria than in most African countries because of the poor state of alternative means of transportation.

Fuel Subsidy, Road Transportation and Economic Development

Promoting economic activity by production and consumption is the sole aim of establishing subsidies. For businesses, reduction in the cost of productive activities is the benefit of subsidy while for consumers gaining access to goods and services that would have been out of their reach is the benefit of subsidy. Fuel subsidy was introduced in Nigeria to help reduce price of oil related products including reducing the price of road transports. When road transportation is reliable, efficient and affordable, it provides adequate access to other regions where there is efficient operation of economic activities. Transportation promotes economic growth because it helps to utilize natural resources, foods and other finished goods by distributing them to other parts of the country.

In a global economy, economic development is highly related to mobility of information, people and goods, which is done by transportation (Mustapha 2011). When transportation system is efficient, it provides social benefits and opportunities that result in employment and accessibility to markets, which can lead to economic growth.

Effects of Fuel Subsidy
Fuel subsidy helps to reduce fuel price and make transportation cheaper. Low transportation cost brings about economic opportunities. However, if there is no fuel subsidy, fuel price will be so high that average citizens might leave their private cars and resort to public transport while poor citizens will find it difficult to move around since they cannot afford it. It might also lead to low productivity in small villages because these peasants have no way of taking their goods to the market. High fuel price can lead to inflation and poverty.

METHODOLOGY
Research Design
The paper adopted a survey research design to evaluate the economic impact of fuel subsidy on road transportation. This approach is chosen as a means of producing reliable empirical data in which recommendation and conclusion is based.

Population of Study
The population of study is made of civil servants, traders, business owners, servants and students concerned with fuel affairs.

Sample and Sampling Technique
The research employed a simple random sampling technique. A sample of 40 persons was selected at random, 5 business owners, 5 professionals, 10 students, 5 civil servants, 5 business owners, 5 transporters and 5 traders.

Instrument for Data Collection
The instrument was a survey questionnaire that is grouped into three: personal information, awareness of fuel subsidy, and impact of fuel

subsidy on road transportation. The research objective informed the questionnaire. Personal observations were also used.

Method of Data Collection

Structured questionnaires and personal observation were employed in the collection of data. The researcher personally administered the questionnaires. This accounts for the 100% response rate recorded. The data collected were arranged in tables and analyzed using simple percentage.

DATA PRESENTATION AND ANALYSIS

In this section, the data collected were presented and analyzed using tables and figures.

Table 1: Age Group

Age Group	Frequency	Percentage
Below 25 years	16	40
25 years-40 years	21	52.5
41 years- 60 years	3	7.5
Above 60 years	0	0

In table 1, 16(40%) of the respondents are below 25 years, 21(52.5%) are between 25-40 years, 3(7.5%) are between 41-60 years and none is above 60 years. This shows that majority of the respondents are between 25-40 years of age.

Figure 1: Age Group

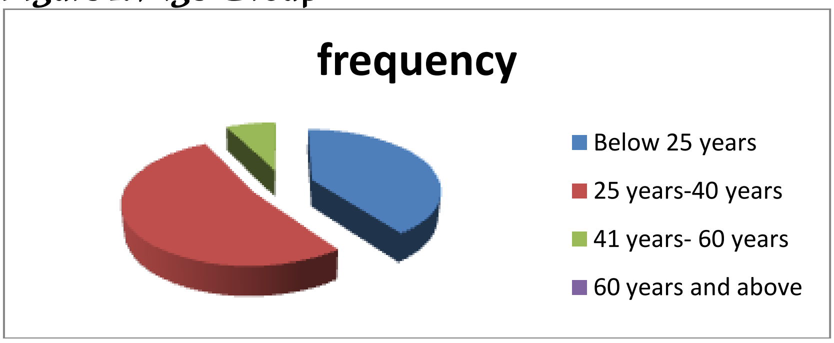


Table 2: Gender and Marital Status

Gender	Frequency	Percentage
Male	32	80
Female	8	20

Table 2 above shows that 32(80%) of the respondents are male while 8 (20%) are female.

Table 3: Marital Status

Marital Status	Frequency	Percentage
Single	26	65
Married	14	35

This table shows that 26(65%) of the respondents are single while 14(35%) are married.

Figure 2: Marital Status of the Respondents

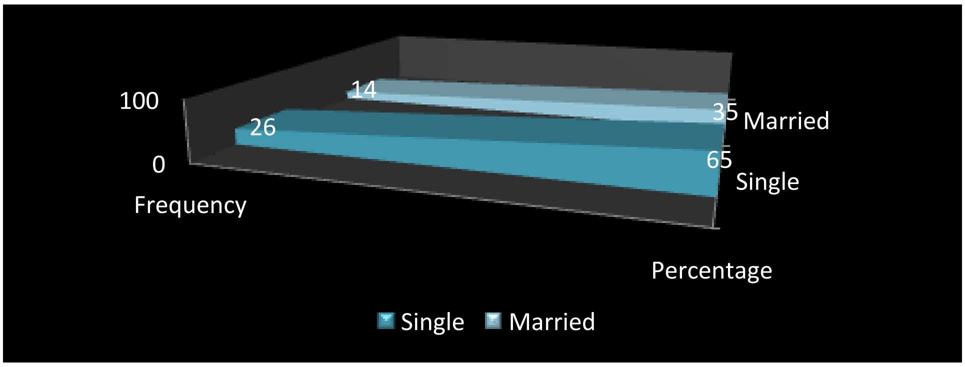


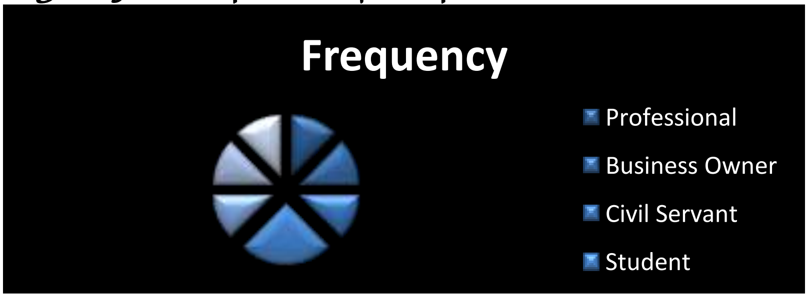
Table 4: Occupation

Occupation	Frequency	Percentage
Professional	5	12.5
Business Owner	7	17.5
Civil Servant	5	12.5
Student	10	25
Trader	7	17.5
Transporters	6	15

Table 4.4 reveals that 5 (12.5%) of the respondents have professional jobs, 7(17.5%) are business owners, 5(12.5) are civil servants, 10(25%) are students, 7(17.5%) are traders, 6(15%) are transporters. This study used

people from different occupational distributions because all of them use road transportation in the study area.

Figure 3: Occupation of Respondents



Majority of the respondents are students. They account for 25%. Others account for 5% each.

Table 5: Household Income

Household income	Frequency	Percentage
Below ₦20,000	28	70
₦21,000-₦100,000	9	22.5
Above ₦100,000	3	7.5

In table 4.5, 28(70%) earn income below 20,000 naira, 9(22.5%) earn between 21,000-100,000 naira and 3(7.5%) earn above 100,000 naira. This shows that the income group that suffers more from this transportation cost is the low-income group (below 20,000 naira).

Figure 4: Income of the Respondents

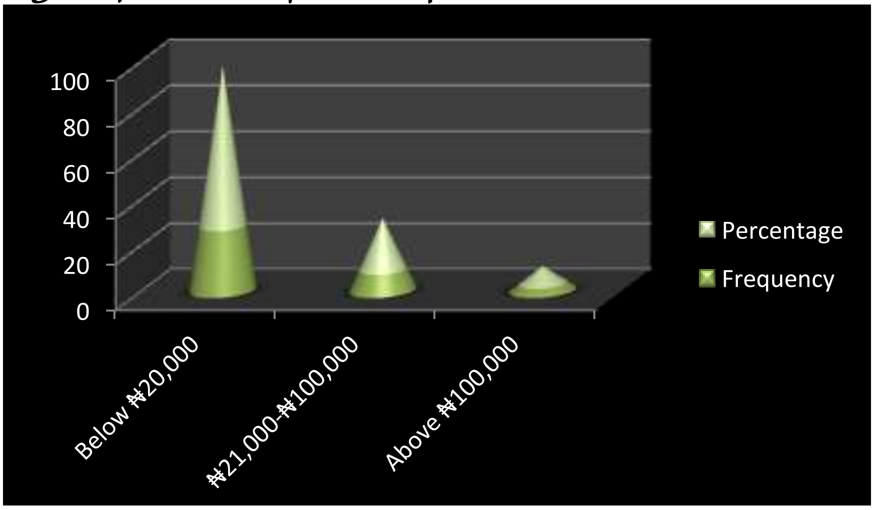


Table 6: Understanding Fuel Subsidy

Do you understand the issue concerning fuel subsidy	Frequency	Percentage
Yes	33	82.5
No	7	17.5
Level of understanding	Frequency	Percentage
Do not understand	7	17.5
Fair understanding	11	27.5
Clear understanding	22	55

Table 4.6 shows that those that understand the issue concerning fuel subsidy are 82.5% while 17.5 percent do not understand. This implies that most of the respondents understand the issue at hand. A great number (55%) has a clear understanding of the issue, 27.5% has fair understanding of fuel subsidy while 17.5% do not understand what fuel subsidy means, which corresponds with the 17.5% that said they do not understand the issue concerning fuel subsidy.

Figure 5: Level of Understanding of Fuel Subsidy

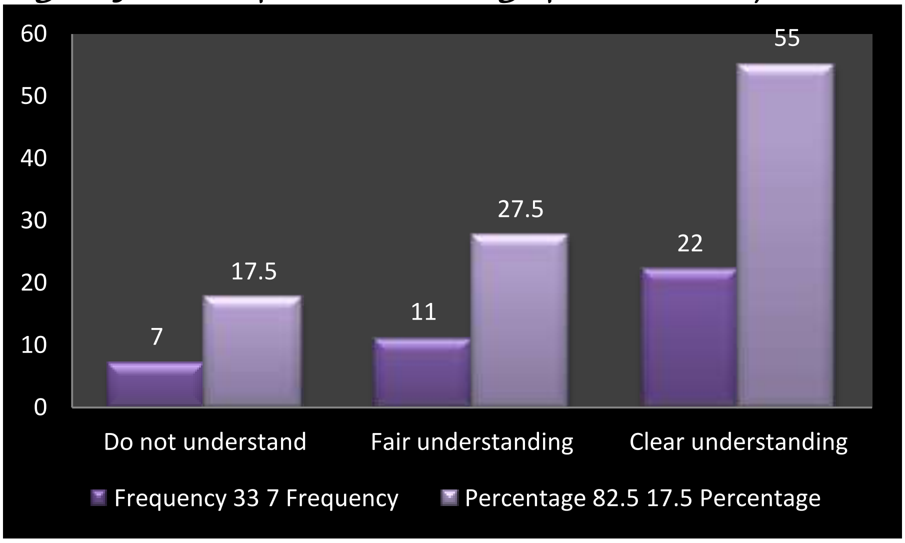


Table 7: Support of Fuel Subsidy

	Yes	%	No	%
Do you support fuel subsidy	24	60	16	40

Figure 6: Support of Fuel Subsidy

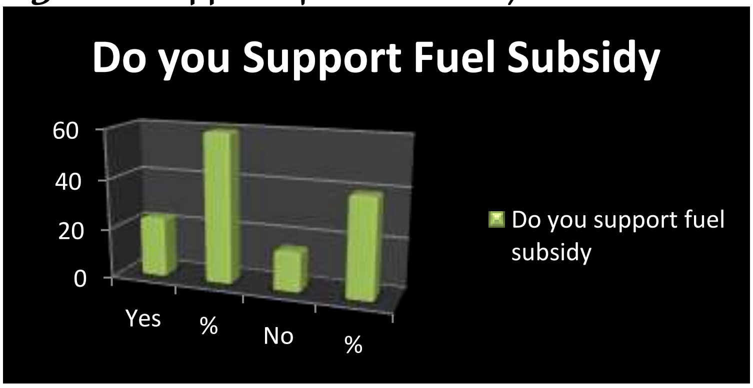


Table 4.7 reveals that 24(60%) are in support of fuel subsidy while 16(40%) are not in support of it. Those in support of fuel subsidy believe that it helps to reduce transportation costs making it more affordable for the people. The ones against it says that the subsidy money is not used for that purpose, rather it is used to enrich the rich leaving the cost of fuel still high.

Table 8: Effect of Fuel Subsidy on Road Transportation

	Positive Effect	%	Negative Effect	%	No Effect	%
If yes, what is the likely effect on Road Transportation	18	45	1	2.5	5	12.5
If no, what is the likely effect on road transportation	1	2.5	13	32.5	2	5

In table 4.8, among those in support of subsidy, 45% said it has positive effect on road transportation, 2.5% said it has negative effect on road transportation while 12.5% said it has no effect on road transportation. Among those that are not in support of fuel subsidy, 2.5% said removing subsidy has positive effect on road transportation, 32.5% said removing subsidy has negative effect on road transportation while 5% said removing subsidy has no effect on road transportation. This shows that majority of the respondents are in support of fuel subsidy (60%) and believes it has positive effect on road transportation (45%).

Figure 7: Effects of Fuel Subsidy on Road Transport

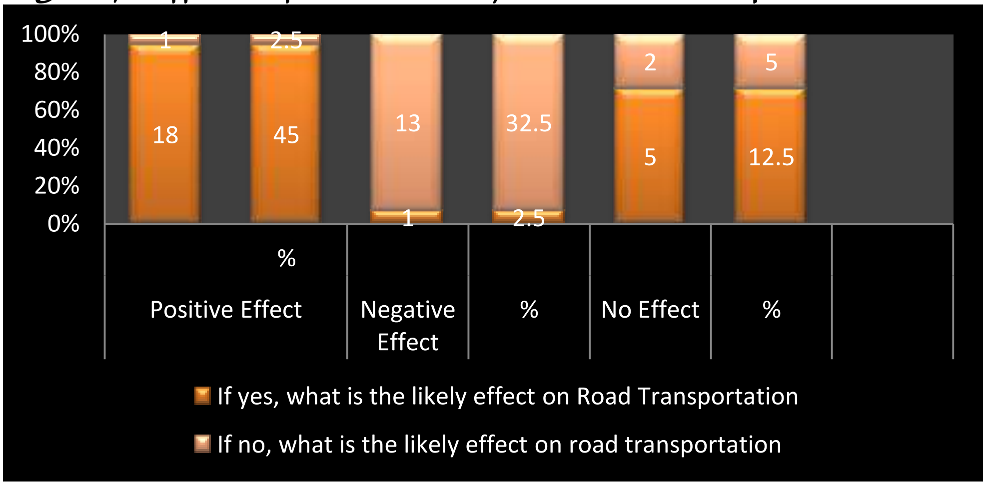


Table 9: Impact of Fuel Subsidy

Do you think fuel subsidy will decrease Transportation Price	Frequency	Percentage
Yes	31	77.5
No	9	22.5

In the table above, 77.5% of the respondents think fuel subsidy will decrease transportation price while 22.5% think it will not reduce transportation price. In relation to table 4.6, most of the respondents in support of fuel subsidy said it has a positive effect on the price of transportation making it cheaper and more affordable.

Figure 8: Impacts of Fuel Subsidy on Transportation Cost

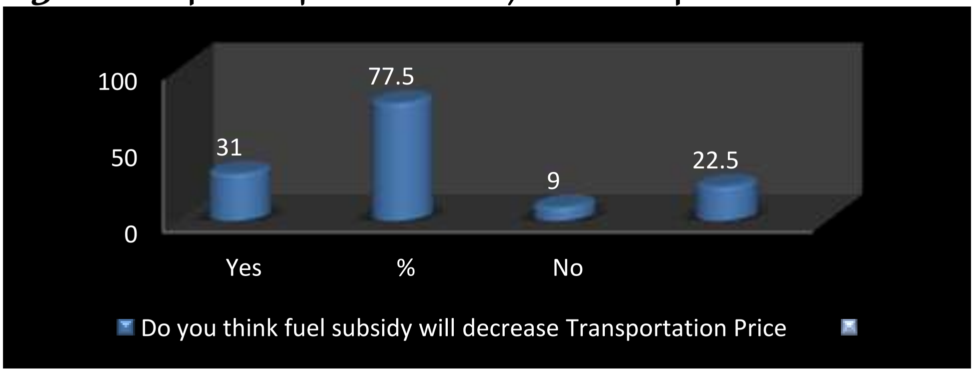


Table 10: Removal of Fuel Subsidy by the Government

Do you think government should remove fuel subsidy	Frequency	Percentage
Yes	12	30
No	28	70

This table shows that a great number of people said government should not remove subsidy (70%) while 30% think government should remove subsidy. One of the reasons they gave is that the rich benefit from fuel subsidy at the expense of the poor. This means that rich politicians embezzle the monetary allocations for subsidy leaving the price of oil constant. (There is no difference between sustaining the subsidy and removing the subsidy). In addition, some said that government should not remove subsidy because it will make fuel too expensive for the low-income earners to afford.

SUMMARY OF THE FINDINGS

This study investigated the economic impact of fuel subsidy on road transportation in Adamawa State. 40 questionnaires were distributed to people from different occupations. A sample of 40 is collected from each of them. Data collected were analyzed using simple percentages.

The findings of the study show that there is a high correlation between fuel subsidy and road transportation in Adamawa state. Fuel subsidy helps reduce transportation price. This is obvious given the character of the sample whereby majority have a good knowledge of fuel subsidy.

Lastly, a good number of the respondents are of the opinion that government should retain subsidy because it helps to make oil products cheaper for the poor members of the society. Some that are of the opinion that government should remove subsidy gave the reason that the money allocated for subsidy is not used for that purpose making the idea of subsidy futile.

CONCLUSION

This paper critically reviewed the economic impact of fuel subsidy on road transportation in Nigeria. The result shows that fuel subsidy affects transportation price in Adamawa state. Evidently, oil discovery in Nigeria has both positive and negative consequences in the economy and society. Though the discovery has led to marginal infrastructural improvements, the losses are still much. Furthermore, considerate amount of oil-generated wealth are in the hands of the few rich, while a significant amount turn out to be profits for smugglers. A great number of Nigerians still wallow in abject poverty even in the midst of oil-generated abundance.

Fuel subsidy regime was instituted with the sole aim of lessening the effect of high prices for oil product on the poor and helpless group and yet the Nigerian economy is sinking. This is largely due to the corrupt activities of those charged with fuel importation. In addition, subsidized fuel has been smuggled to neighboring countries for sale (at international prices) by smugglers leading to scarcity at home. Oil marketers have mismanaged Nigeria's oil revenue ($6 billion) in the past years (Akov, 2015). Removing fuel subsidy to stop the activities of oil marketers and smugglers and make money available for development will worsen the economic conditions of Nigerians especially the poor. Removing it will lead to an enormous increase in fuel pump oil price, together with increase in cost of food, transport, rent and others.

RECOMMENDATIONS

This study recommends:

a. Proper regulation in the oil sector
b. If government wants to remove subsidy, it should review the real wages of workers upwards to enable them meet up with the hard conditions caused by fuel price increase.
c. There is need to reorganize Nigeria's anti-corruption activities in other to make it more active in the prosecution of those found guilty of oil corruption. This will enhance accountability and transparency and increase peoples trust in the government and its policies.

d. The government should maintain the already existing refineries and build new ones. Overdependence on petroleum product importation will be addressed. In this regard, government should collaborate with major oil companies like Shell, Chevron, Exxon Mobil and others to build refineries in the country.
e. Government should pursue the revival of railways as alternative for road transport.

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Application of Compost Cushioned Temperature-Rise Effects on Toxic-Metal Uptake by *Telafairia occidentallis*: Mitigation of Effects of Global Warming on Food Safety

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Abstract

In this study, the ameliorative effect of compost on impact of rising temperature on metal uptake by plant, a case study of a green leafy vegetable (Fluted pumpkin: Telfairia occidentalis) was studied under a controlled environment of screen house. Temperature regimes were varied in the range of 30 to 41°C and crops were grown for approximately 3 months (95 days). Uptake of Cd and Pb, phyto-metal interactions (level in tissues, translocation factor and bio-concentration factor: BCF) were determined using standard methods. Metal concentrations were measured using a calibrated Atomic Absorption Spectrophotometer. Soil and plant parameters varied significantly at $P \leq 0.05$ for the different temperature ranges. Increasing temperatures from 33-41 °C increased root uptakes of Pb by 24-67 %. Shoot uptake of Pb increased by 6.5-27 % with increase in temperature from 33-38 °C. However, shoot uptake of Pb decreased by 0.63 % and 16 % at the temperature range of 30-32 °C and 39-41 °C. In contrast, Cd roots uptake increased by 40-177 % while the shoot uptake decreased by 11-22 % with increased temperature from 30-41 °C. Temperature rise enhanced plant total metal uptakes and BCFs by 24-177 % and 3.8-61 % respectively. Translocations decreased (12.12-48.48 %) for Pb and (34.78–69.13 %) for Cd. With increase in temperature, plant concentrations of Cd and Pb were higher and were above FAO allowable limit of 0.3 mgkg-1 and 0.2 to 0.3 mg/kg respectively thus putting food safety at risk while soil amendment with compost reduced metal *uptake and enhanced plant nutrient release and growth. Study showed that threat on food security by rising temperature could be ameliorated by the use of compost demonstrating the environmental and agricultural benefits of proper solid waste management.*

Keywords: *Global Warming, Toxic Metal, Compost, Bio-Concentration and Translocation*

INTRODUCTION

Global warming is a worldwide environmental issue. A wide variety of events such as sea level rise, increase in amount and pattern of precipitation, lowering of ocean pH, oxygen depletion in oceans, expansion of subtropical deserts, retreat of glaciers and sea ice, shrinkage in rainforests, increases in the intensity of extreme weather events, species extinctions and changes in agricultural yields have been attributed to global warming (IPCC, 2007).The impact of global warming on agriculture could be direct, by causing instant plant death, seed death, leaves burning or indirect by impacting factors that have bearing on crop productivity and soil sustainability (Adeyeye et al.,2016). And this implies that the increase, sustainable and safe food production agenda of nations is at stake. In most developing nations, sites previously utilized as dump sites are often converted to farmlands without any pre-treatment.

Plants grown in such soils take up toxicants such as metals as reported by Adekunle *et al.,* (2010).Plants have evolved highly specific and very efficient mechanisms to obtain essential micronutrients from the environment, even when present at low ppm levels (USDE, 1994). Plant roots, aided by plant-produced chelating agents and plant induced pH changes and redox reactions, are able to solubilize and take up micronutrients from very low levels in the soil, even from nearly insoluble precipitates. These same mechanisms are involved in the uptake, translocation, and storage of toxic elements, whose chemical properties simulate those of essential elements (USDE, 1994).There are several factors which can affect the uptake mechanism of heavy metals from the soil, these include plant species characteristic (Burken et al., 1996), properties of the medium such as pH, organic matter, and by the addition of biodegradable physicochemical factors, such as chelating agents and micronutrients (Ginnekan et al., 2007), the root zone which can absorb contaminants and store or metabolize it inside the plant tissue and vegetative uptake which is affected by the environmental conditions such as temperature (Burken et al., 1996).

Experimental evidence is lacking but according to Cubadda, (personal communication), climate change can potentially alter the transfer and the bioavailability of trace elements from the soil to the plant meaning that increasing global temperature could enhance plant metal uptake and accumulation in their tissues, resulting in phyto-toxicity and ultimately, reduced crop productivity.

Toxic metal pollution has harmful effect on biological systems and does not undergo biodegradation (Pehlivan et al., 2009). It is well known that heavy metals cannot be chemically degraded and need to be physically removed or be transformed into nontoxic compounds (Grau et al., 2004). Heavy metals, with soil residence times of thousands of years, pose numerous health dangers to higher organisms. They are also known to have effect on plant growth, ground cover and have a negative impact on soil microflora (Roy et al., 2005). These metals are known to exert harmful effects on physiology and biochemistry of plants, lowering yields and may cause health hazards in food chain.

Important heavy metals posing threats to soil quality and human health include Cd and Pb. They are used for a wide variety of industrial, urban and agriculture applications, and can be very toxic to man (Forstner, 1995; Kabata- Pendias, 1992).Soil can be contaminated with lead from other sources such as leaded fuels, old lead plumbing pipes, or even old orchard sites in production where lead arsenate is used. Lead and cadmium are known to be very toxic to humans, animals, and plants (Alloway, 1995).They could be very lethal because of their tendency to bio-accumulate in human tissues. Exposed to low levels of Cd over time may incur kidney damage as well as lung, bone, cardiovascular system, liver, and reproductive system damage (USEPA, 1992). Pb^{2+} is not biodegradable, once soil has become contaminated with it; it remains a long-term source of Pb^{2+} exposure (Pehlivan et al., 2009). Lead accumulates in the upper 8 inches of the soil and is highly immobile

(Traunfeld J. H. and Clement D. L., 2001). Recent concerns regarding the environmental contamination have initiated the development of appropriate technologies to assess the presence and mobility of metals in soil (Shtangeeva et al., 2004)

On the basis of the metal contents in surface soils from many parts of the world, the average value lies between 0.07 and 1.1 $mgkg^{-1}$ for Cd, above 0.5 $mgkg^{-1}$ usually reflect anthropogenic inputs and 10 $mgkg^{-1}$ for Pb (Kabata-Pendias and Pendias, 1992). Accumulation of toxic metals in crop plants due to global warming or any other factors may results in decline in food safety and security.

Hence this study aims at assessing temperature variation effect on phyto-availability of toxic metals (Cd and Pb) in fluted pumpkin (Telfariaoccidentallis) and the impact of compost on the effect of temperature.

MATERIALS AND METHODS

Study Area

The research was carried out in a modern screen house in the College of Environmental Resources Management, University of Agriculture Abeokuta along Alabata road in Odeda local government area of Ogun State, Southwestern Nigeria. It is situated between Latitude 7.9°N and 7.8°10′N and Longitude 3° 23′E and 3° 24′E, with average daily minimum and maximum temperature of about 21 °C and 35 °C respectively. Abeokuta itself within the state is located in this moderately hot, humid tropical climatic zone of southwestern Nigeria. There are two distinct seasons in the area, namely, the rainy season which lasts from March/April to October/ November and the dry season which lasts from October/November till March/April. The temperature is relatively high during the dry season with the mean around 30 °C. Low temperatures are experienced during the rainy season, especially between July and August when the temperatures could be a low as 24 °C.

Description of the Temperature Chambers

Temperature chambers were constructed with wooden material wrapped with aluminum foils, and glass materials. Temperature variations during the experiment were achieved via installation of incandescent (240CV2 JUNSGAMO) electric bulbs of varying wattage (60 watts, 100 watts, 200 watts and 300 watts). For instance, where possible, two bulbs were connected together to obtain the desired temperature regime. Each of the temperature chambers was 7 cm in length, 5.5 cm in breath and with height of 7.5 cm, giving a volume of 288.7 cm^3. The chambers were constructed with the view that each would contain four experimental pots. A detailed description has been reported in Adeyeye *et al* (2016).

The systems comprised of (i) Soil alone, kept outside of the chamber, whose temperature range was between the range of 27-29 °C (ii) composted soil, also kept outside the chamber whose temperature range was obtained as 27-29 °C, (iii) composted soil placed inside the temperature chamber with a temperature range of 30-32 °C, (iv) composted soil placed inside the temperature chamber with a temperature range of 33-35 °C, (v) composted soil placed inside the temperature chamber with a temperature range of 36-38 °C, and (vi) composted soil placed inside the temperature chamber with a temperature range of 39-41 °C, making a total of six chambers.

Suitable Crop for the Experiment

Adeyeye *et al* (2016) has established that the crop with highest thermophilic potential suitable for the experiment was *Telfairia occidentalis*. From their preliminary investigation, the crops' thermophilic potential decreased in the order: *Telfairia occidentalis*> *Zea maize* >*Abelmoschus esculentus*> *Solanum melongena*> *Amaranthus hybridus*> *Celosia argentea*. Hence, *Telfairia occidentalis* evolved as the crop with highest thermophilic potential suitable for the experiment.

Soil Procurement

In order to have metal contaminated soil, without artificial spiking by chemical salts, soil samples were procured from land area at Ajibode, Ibadan, previously utilized as waste dumpsite, reported by Adekunle *et* *al.,* (2010) to have elevated heavy metal levels. About 120 kg soil samples were collected at depth 0-15 cm. Sub-samples of soil obtained from different segments of the waste dumpsite were pooled to constitute the 120 kg composite from the site, which was then conveyed to the study site at the University of Agriculture, Abeokuta. Soil sample preparation was as reported by Adeyeye *et al* (2016). The soil samples were then transferred to designated plastic pots of 5 L capacity, at 3 kg of soil per pot, watered at appropriate field capacity and allowed to stand for 21 days. This was followed by mixing with 0.5 % (w/w) compost made from poultry droppings and saw-dust per pot. There must be a source of cellulose (carbohydrate for energy), protein (the nitrogen source), lignin (the raw ingredient for humus formation) and water. The carbon to nitrogen ratio was between 25:1 and 35:1. If there is insufficient nitrogen, the process will be too slow. Thus the mixing ratio of poultry and saw dusts. After seven days, sub-samples were collected from each pot and analyzed, using standard procedures described by IITA (1979) for the following parameters:, pH, particle size distribution, organic compost, content, organic carbon, cation exchange capacity, electrical conductivity, the heavy metals (Cd and Pb).

Screen House Experiment

Twenty four pots were set up for the experiment, consisting of 6 treatments with 4 replicates. After filling each pot with 3 kg soil, the pots were transferred to the screen house. Each temperature chamber contained four replicates of a given system (Adeyeye *et al.,* 2016). To prevent loss of matter from the pots, no real drainage was made but to avoid flooding, soils were watered at the required field capacity. After the initial watering, four viable seeds of fluted pumpkin (*Telfairia occidentalis*) were sown in each pot and later pruned to one plant per pot after germination. Watering was carried out as required by the crop. The growth season lasted from October 2009 to January 2010. Soil metal concentrations were re-analyzed after crop harvest.

Metal Determination in Soil

One gram (1 g) of soil sample was weighed into a 125 ml Erlenmeyer flask (which had been previously washed with distilled water); 2 ml of $HClO_4$, 4 ml of conc.HNO_3 and 25 ml of H_2So_4 were added in a fume hood. The contents were mixed and gently heated at low to medium heat on a hot plate under the fume hood. Heating was continued until dense white fumes appeared. It was boiled for a half a minute, allowed to cool and 50 ml of distilled water was added. It was boiled for half a minute on the same plate at medium heat, after which it was cooled and the solution filtered completely into 100 ml Pyrex volumetric flask. It was then made up to mark with distilled water. The solution was analyzed for metal using atomic absorption spectrometer (Buck Model 200A). Wavelengths used in the determination of the different elements were 228.8 and 283.3 nm for Cd and Pb respectively.

Metal Determination in Plant

Exactly 1 g of plant sample was weighed into a 125 ml Erlenmeyer flask (which had been previously washed with distilled water); 2 ml of $HClO_4$ and 4 ml conc. HNO_3 and 25 ml conc.H_2SO_4 were added in a fume hood. The contents were mixed and gently heated at low to medium heat on a hot plate under the fume hood. Heating was continued until dense white fumes appeared. It was then heated strongly for half a minutes, allowed to cool and 50 ml of distilled water was added. It was boiled for half a minute on the plate at medium heat, after which it was cooled and the solution filtered completely into 100 ml pyrex volumetric flask. It was then made up to mark with distilled water. The solution was analyzed for Cd and Pb using the atomic absorption spectrometer (Buck Model 200A) at the wavelengths 228.8 and 283.3 nm respectively.

Translocation Factor

Translocation of Cd and Pb from shoot to root was measured as given below:

$$\mathrm{TF} = \frac{\mathrm{C\ shoot}}{\mathrm{C\ root}}$$

Where Cshoot and Croot are metals concentration in the shoot (mg kg) and root of plant (mg/kg), respectively.

TF>1 implies that translocation of metals was made effectively from root to the shoot (Baker and Brooks, 1989).

Bioaccumulation Factor

BAF of Cdand Pb was calculated as:

$$BAF = \frac{\text{C shoot}}{\text{C soil}}$$

Where Cshoot and Csoil are metals concentration in the plant shoot (mg/kg) and soil (mg/kg), respectively.

BAF was categorized further as hyper-accumulators (> 1 mg/kg), accumulator and excluder (< 1 mg/kg) to those samples which accumulated metals (Cluis, 2004).

Assessment of Temperature Variation

Temperature measurement was in three phases: the atmospheric or ambient temperature, the chamber temperature and the soil temperature. Temperature measurement was carried out using a series of mercury graduated thermometers; each chamber with a designated thermometer. The atmospheric temperature was determined by direct measurement of the ambient condition. Each of the chamber temperature was measured by inserting the thermometer into the chambers for 2 or 3 minutes while the reading was recorded. The soil temperature was measured at 15 cm depth using the 100 °C graduated thermometer. For the three temperature measurement phases, reading were taken 3 times daily at 5-hours intervals; one in the morning, afternoon and in the evening.

Statistical Analysis

Statistical analysis was carried out using SPSS version 16.0 for windows. Data were subjected to descriptive statistics: the mean, mode, median and standard deviation. Data were also analyzed by ANOVA. Pearson correlation coefficient was used to determine the relationship between temperatures variations and plant metal interactions.

RESULTS AND DISCUSSION

Daily Temperature Variation

Generally, the daily temperatures varied from 23- 27 °C for mornings, 29 - 41 °C in the afternoon and 29 - 35 °C for evenings respectively. The mean values were found in the range of 27- 32 °C. The maximum chamber temperature of 41 °C was obtained in the chamber equipped with electric bulb of 300 watts showing that as the light intensity in the chamber increases, the temperature increased which gave the expected simulated temperature variation range for the studies. The correlation of the prevailing atmospheric temperature versus soil temperature showed the following correlation coefficients values (r): + 0.439 and + 0.369 for systems Soil-alone (27-29°C) and Soil + compost (27-29°C) respectively. The correlation coefficients for the remaining four systems were: + 0.434 for Soil + compost (30-32°C), + 0.628 for Soil + compost (33-35°C), +0.438 for Soil + compost (36-38°C) and +0.463 for Soil + compost (39-41°C) respectively. Correlation is significant at $P < 0.001$and 0.05. From the linear regression model, the change in soil temperature for unit change in prevailing atmospheric temperature ranged from 0.30- 0.67 °C. Comparative evaluations of the mean temperature values showed that the maximum (29-33.3 °C) and the minimum (25-29.5 °C) mean temperature were obtained in Soil + compost (39-41 °C) and Soil-alone (27-29°C) respectively. The mean temperatures (air and soil) of the systems increased with increasing temperature.

The result showed that ambient temperature is a function of the soil temperature. Thus, soil nutrients, pollutants fate and processes could be affected with increasing air temperature (Burken et al.,, 1996). A strong association was obtained for the air temperatures and soil temperatures. The result also showed that soil morning temperatures was significantly ($P < 0.05$) different from afternoon and evening regimes. No significant difference was observed between the soil temperature in the afternoon and evening at $P \leq 0.05$. Ambient temperatures (morning, afternoon and evening) became significantly different in Soil+compost (36-38°C) and Soil+compost (39-41°C) systems.

The result generally indicated that metal uptake was influenced by metal type, temperature, soil factors and plant parts. Lead concentrations ranged from 37.5 to 102.0 mg/kg before planting and 25.5 to 67.7 mg/kg after the experiment. Soil amendments with organic compost raised soil Pb concentration by 16.78 % showing that Pb becomes more available with organic compost addition. This suggests that organic compost enhanced this metal instability, thus its increased bioavailability. Increasing temperature from 32-41 °C gave 24-67 % increase for root uptake of Pb. The 67 % increase (22.0 ±8.4 mg/kg) observed for Pb root uptakes at elevated temperature of Soil+compost (30–32°C) showed that Pb desorption, solubility and bio-availability was maximum at this temperature range while the least (13.15 ± 14 mg/kg) was in Soil+compost (27-29°C).

Average root Pb concentration increased with increasing temperatures (Figure 1). The low tolerance of root Pb accumulation could also be attributed to its bioavailability with compost addition. Increase in temperature increased root activities and tendency to accumulate in the cell wall without penetration into the protoplast (Bowen, 1991. Hooda and Alloway (1993) indicated that Pb uptakes did not require any energetic expense as Pb can be taken up from the surrounding solution against concentration gradients and deposited in large amount in the cell roots and that Pb uptakes increased with increasing temperatures.

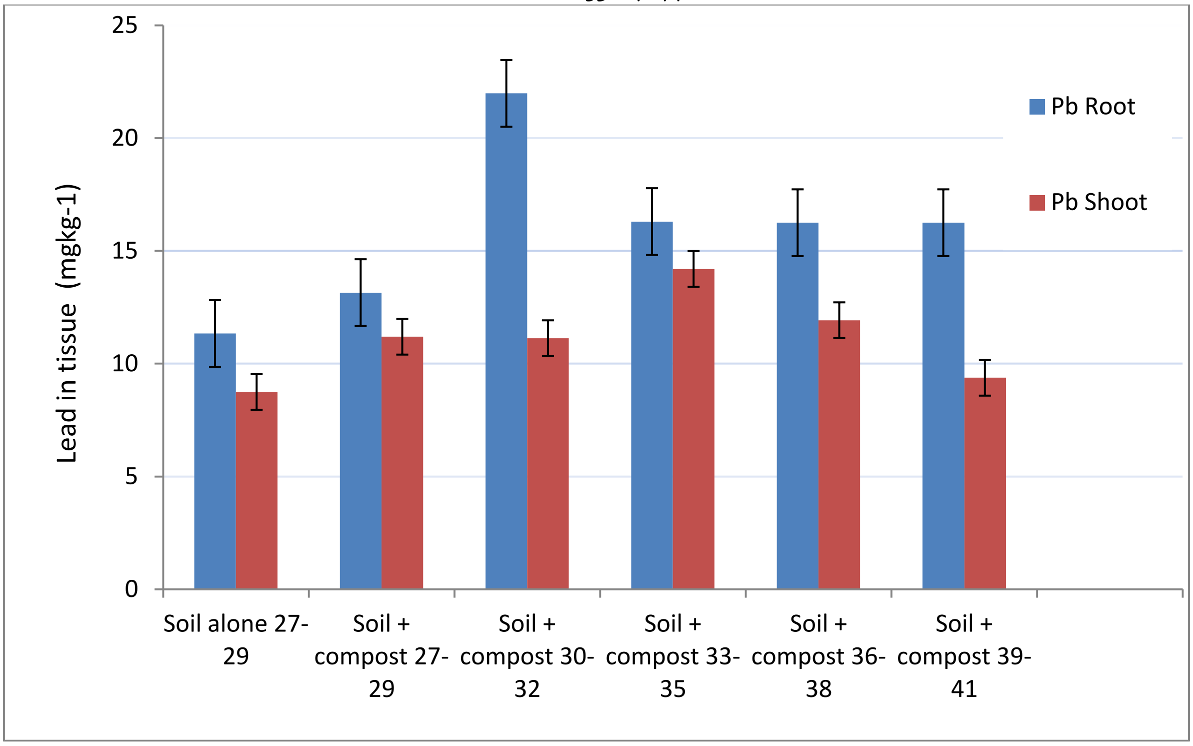

Figure 1. Variation in Pb Tissue Concentration of *Telfairiaoccidentalis*

The shoot uptakes of Pb increased by (6.5-27 %) with increased temperatures from 33-38 °C. However, this decreased by 0.63 % and 16 % at the temperature range of 30-32 °C and 39-41 °C respectively. Organic compost increased shoot uptakes of Pb by 28 % showing that addition of compost aids root assimilation, concentration and translocation of this metal (Swift *et al.*, 1991). The 6.5-27 % increase in shoot uptakes at 33-35 °C showed that the metal was readily translocated at this temperature range. Organic compost with temperature effect was positive on both shoot and root uptake of lead.

Translocation Factor (TF) increased with compost addition. Temperature effect with organic compost addition decreased TF for this metal (TF < 1).

Bioaccumulation Factor (BCF) was < 1, which shows that *Fluted pumpkin* could be an excluder of Pb. Temperature effect with organic compost addition increased BCF value for the metal.

The result showed that with slight increase in temperature as simulated in this study, this metal concentration in plants can be enhanced and this is consistent with the reports of Marschner (1995) and Hooda and Alloway (1993) that Pb uptake increased with increasing temperature. At $P \leq 0.05$, average root and shoot Pb concentration was not significant. With regards to toxicological implication, data showed that in this vegetable, Pb concentration was more than the permitted level (0.3 $mgkg^{-1}$), and that it is not suitable for consumption. (FAO//WHO, 2001)

Cadmium concentrations ranged from 2.25$\pm$ 0.30 to 6.24$\pm$ 0.76 and 3.25$\pm$ 2.18 to 5.075$\pm$0.6 4 (mg/kg) for root and shoot concentrations respectively. Soil amendment with organic compost (Soil +compost at 27-29°C) decreased root uptake of Cd by 53 %. This showed that with organic compost amendment, Cd root uptake decreased. Application of poultry manure has been reported to increase the concentration of available Cd in soil (Fritoff *et al.,* 2005), via increased mobility of Cd in the root zone thus resulting to higher uptake by plant; but under this experimental condition, root uptake decreased probably due to formation of insoluble organic complex or that they are not readily available in the root zone. Shoot translocation was higher in all the fertilized pot compared with Soil-alone (27-29°C). Also root uptake of cadmium decreased with organic compost addition while translocation to the shoot increased (Figure2).

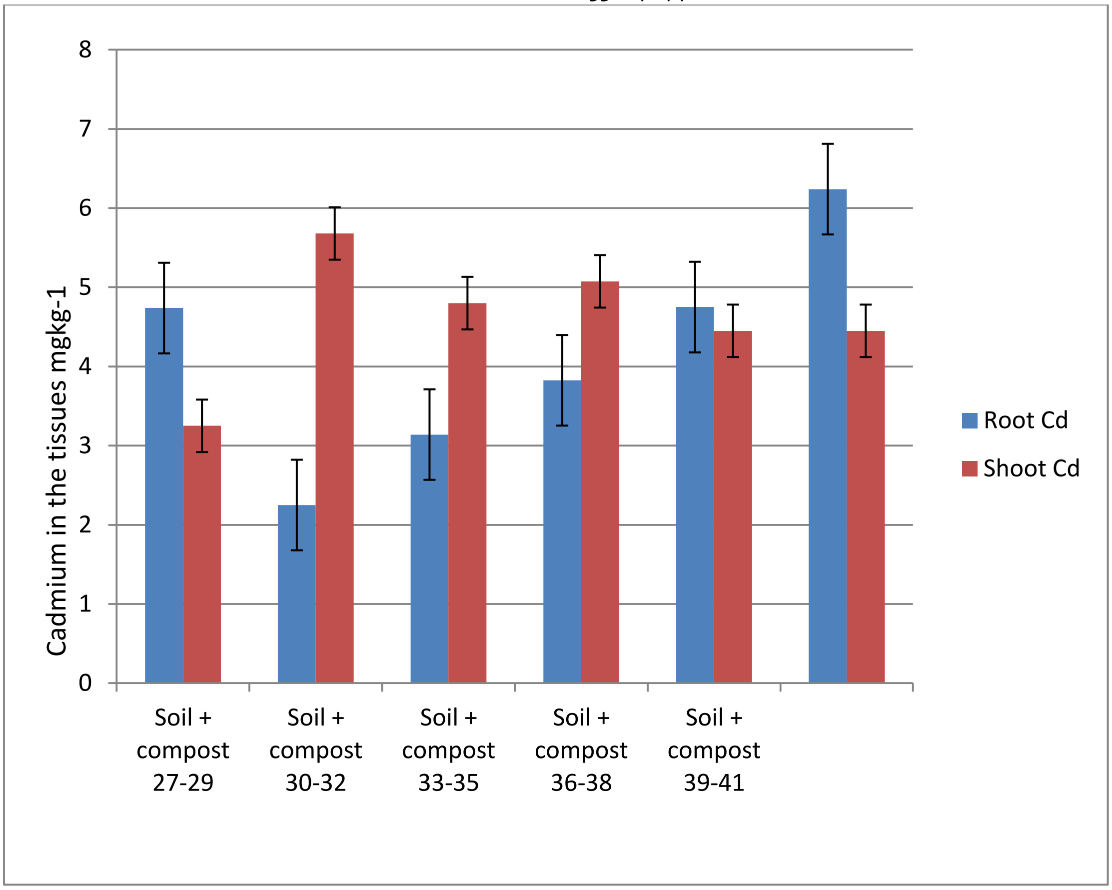

Figure 2: Variation in Tissue Cd concentration of Telfairia Occeidentallis

Increasing temperature from 30-41 °C increased Cd root uptake by 40-177 % while shoot uptakes decreased by 11-22 %. Cd was least concentrated in Soil + compost at 27-29°C (2.3$\pm$ 0.3 mg/kg) while the highest was noted in the temperature range of 39-41 °C (6.2$\pm$ 0.8 mg/kg). This trend in root uptake of Cdagrees with Hanč *et al.* (2008) that with organic increasing temperatures, cadmium accumulation by plant increased significantly.

The BCF for this metal was greater than 1. BCF values for root cadmium increased by 61 % with compost treatment. Temperature effect with organic compost addition increased the BCF factor for cadmium (BCF > 1).TF increased with organic compost addition and the temperature effect with organic compost addition increased translocation factor for this Cd. With increasing temperature, cadmium translocation was highest compared with Pb.

The difference in root and shoot uptakes can possibly be explained by the fact that normal function of the root is to selectively acquire ions from the soil solution whereas shoot tissues does not normally play this role. Also, high concentration of dissolved organics may promote trace metal adsorption to the root surface (McBride, 1995) and that plant roots are also able to liberate trace metals from dissolved organo-metallic complexes once they are associated in the root zone. Furthermore, root growth is often limited by low (sub-optimal) and (supra-optimal) soil temperatures, hence, as soil temperature increases toward optimal, root activities of the crop itself increased with temperature, thus increased root growth becomes an important factor for the surface for trace metal absorption and the uptake is expected to increase accordingly. The ability of the crop to accumulate and tolerate Cd has also been attributed to uptake capacity and intracellular binding sites, concentration and affinities of chelating molecules, as well as the presence and selectivity of transport activities affecting metal accumulation rates (Clemens *et al.*, 2002). At $P \leq 0.05$, the average cadmium root uptake was highly significant. Most of the plants showed symptoms of cadmium toxicity since the concentration ranged from 3.25 - 5.64 mg/kg, the values which fall within the critical phyto-toxic levels (5-30 mg/kg) (Kabata - Pendias and Pendias, 1992), but exceeded the acceptable limit (0.2 to 0.3 mg/kg) for cadmium in vegetables (FAO/WHO., 2001).

A look at plant metal concentrations revealed that root accumulation was greater than shoot concentration in all cases. This agrees with the findings of some authors (Korozeniowka *et al.*, 2003; Schmidt, 2003; Das *et al.*, 1998; and Salim *et al.*, 1993) that heavy metals usually accumulate in the root than the shoot.

Finally, nitrogen and phosphorus contents of the plant increased with organic matter addition; thus reduced the impact of increased temperature on this crop and enhanced plant growth. This study showed that crops grown in contaminated sites are important avenue for heavy metal entry into the food chain and with increase in global temperature there may be increasing hazards of heavy metals contaminations in food crops.

CONCLUSION
The study showed that increasing temperature potentially alters the fate of Cd and Pb in the environment and increases their bio-concentration in plants thus putting food safety at risk; and that, threat on food safety and security by rising temperature effect on contaminants such as Cd and their consequent inclusion into the food chain could be ameliorated by the use of recycle source segregated biodegradable organic wastes, demonstrating the environmental and agricultural benefits of proper solid waste management.

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Strengthening the Ecological base of Food Supply in Nigeria

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Pp 62-78

Abstract
The Nigerian environment is ecologically complex, being a product of natural and human-induced processes which have generated serious environmental problems among which are: deforestation, drought and desertification, soil and coastal erosion, water pollution, oil pollution, loss of biodiversity, flooding, urban decay and industrial pollution. Millions of people in U.S, Africa, Southern Europe and many others have been affected by these menaces in decades. The Northern Nigeria has also been a victim of this in recent time. Food production increases have not kept pace with population growth resulting in rising food imports and declining levels of national food self-sufficiency. When the effects of climate change are taken into consideration, the challenge for food production becomes even more daunting, thus delimiting edible food supply in the country. However, adopting ecological approaches can help build resilient food systems in the pursuit of food security such as water conservation and water harvesting; soil and nutrient management; restoration of degraded landscapes; efficient plant harvesting; and early transformation of products to reduce post-harvest losses.

Keywords: *Ecological, Climate Change, Food Supply and Sustainable Agriculture.*

INTRODUCTION

As the world enters the second decade in the new millennium, humanity faces a very dangerous threat fuelled by human-induced forces which have been unleashed by development and manipulation of the environment. The effects of urbanization and climate change are converging in dangerous ways which threaten to have unprecedented negative impacts upon food production, quality of life, economic and social stability (UN-Habitat Report, 2011). It has been estimated that the population of the world will rise to nine billion by 2050 (UNEP, 2012). If the world is to feed seven billion people, rising to over nine billion by 2050, there must be sufficient production of quality food in a way that will keep humanity's footprint within planetary boundaries. There are several factors that underpin food security, including access to food and availability but researchers' are seeing the environment as perhaps the missing, underpinning pillar. The environment supports agriculture in two fundamental ways; Natural resources such as fertile land and adequate supplies of freshwater and planet's ecosystem services such as the nutrient recycling and soil stabilization provided by forests and biodiversity (UNEP Report, 2012).

Loss of biodiversity is now a common trend in all ecological zones of Nigeria and this trend only make natural resource-dependent communities more vulnerable. Drought in the north, for example, has led to poor crop yields, water scarcity, and forced migration. In the south, sea level rise increases the risk of flooding, salt water intrusion and displacement of people and livestock (NEMA, 2012). On the other hand farming systems, technologies, cultural values, and norms of communities have a constructive and beneficial influence on the urban landscape. For instance, soils have been ruined by direct and indirect actions, which interfere with the delicate balances of nature. Water resources have been diverted, polluted or silted. Cultivation methods have led to serious erosion and considerable annual destruction of the soil, fish, wildlife, and useful vegetations have been indiscriminately harvested and/or destroyed (Ibeanu, 2000).

The World Food Summit defines food security as the condition when "all people, at all times have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". Although efforts have been made by Government to boost food supply in recent years through the establishment of Agricultural intervention programmes, the task of these Agencies seems to be a more daunting couple with urbanisation which has increased competition for land, water and currently, threats from climate change. These attributes make the Nigerian environment to be ecologically complex, generating serious environmental problems among which are: deforestation, drought and desertification, soil and coastal erosion, water pollution, oil pollution, loss of biodiversity, flooding, urban decay and industrial pollution. Considering the enormity of the above outlined issues on food production capacity, this paper seeks to adopt ecological approaches to help build resilient food systems in the pursuit of food security in Nigeria; examine ecological problems; ecological base of food production and its threats and finally options that can strengthen the ecological base of food supply in Nigeria.

GLOBAL OVERVIEW OF FOOD SYSTEM

Many International Agencies have presented a global picture of the food system and its implication on the developing countries. The US Department of Agriculture (2011), estimates that the number of 'food-insecure' people (as of 2010) in 77 developing countries stood at 861 million. Meanwhile, the UN says that the world population is likely to reach 9 billion by 2050. Most of these billions will live in developing countries and have higher incomes, which in turn will further increase the demand for food. Although food production has increased, many have been left behind, with some 925 million people still counted as undernourished as of 2010 (FAO 2010; IFRC 2011). Meanwhile, the growth in cereal productivity has been declining since the 1980s (OECD/FAO 2012), and the FAO estimates that 40% more cereal will need to be produced by 2050 to feed the nine billion people expected by that year (FAO 2009).

The implication is that food production has to grow still further over the next half-century to cover this new demand. When the effects of climate change are taken into account the challenge for food production becomes even more daunting. For instance, the Intergovernmental Panel on Climate Change (2007) noted that some African countries could face reductions in yield of up to 50% by 2020 if they fail to adapt to the changing climate. The Food and Agriculture Organization (FAO) and International Energy Agency (2008) have estimated that around 2 to 5 million hectares of land in the world continue to be lost each year to land degradation, mostly related to soil erosion. Also, the availability of water is already taken to be a limiting factor in many agricultural areas.

Another possible limiting factor is phosphorus, which is a critical fertilizer input to modern agriculture. The remaining lifetime of worldwide phosphorus reserves is being hotly debated, as noted in a recent UNEP report (2011).

ECOLOGICAL SUSTAINABILITY

A society is ecologically sustainable when it conserves ecological life support systems, biological diversity; ensures that the use of renewable resources is sustainable, minimises the depletion of non-renewable resources and keep within the carrying capacity of supporting ecosystem (Ivbijaro, 2011). The life support system is an ecological process that sustains productivity, adaptability and capacity for renewal of lands, waters and /or the biosphere as a whole. Ecological sustainability requires that the prevention of pollution is combined with restoration and maintenance of the integrity of the ecosystems. It requires that we conserve the ecological processes that keep the environment fit for the life of people in the country. These processes are the natural processes that shape the climate, cleanse air and water, regulate water flow, recycle essential elements, create and regenerate soil and enable the ecosystem to renew themselves (FEPA, 1992).

SUSTAINABILITY IN THE USE OF RENEWABLE RESOURCES IN NIGERIA

Renewable resources include soil, wild and domesticated organisms, forests, rangelands, cultivated lands, marine and freshwater ecosystem and their fisheries (FEPA, 1992). A use is sustainable if it is within the resource's capacity for regeneration (Ivbijaro, 2011).

Data on the status of biodiversity in Nigeria according to (FEPA, 1992, FME, 1992) shows that out of a total number of 5,081 plant species, 8.5% are endangered and 0.4% are threatened. Also, of the 22,090 animal species, 0.22% are endangered and 0.14% are threatened. The Nigeria's total geographic area is 923,769km^2, out of which forest account for 9.61% and over 43% of the forest land is lost to human activities. Consumption of fuelwood contributes immensely to a huge loss of vegetation cover in Nigeria. It is, therefore, pertinent to say that neither the use of renewable resources nor the use of non-renewable resources (crude minerals, gas, oil, and coal) in Nigeria is sustainable.

ECOLOGICAL PROBLEMS AND EFFECT ON FOOD SUPPLY NIGERIA

These ecological problems occur in form of soil degradation, flooding, drought, industrial pollution, erosion, biodiversity loss and take their toll on the quality of the Nigerian environment, human health, and economic growth.

Soil Degradation

Soil degradation is ranked high by the World Bank (1990) because of its impact on the sustainable income of Nigerians, on a large number of people, the poor and overall environmental integrity. Soil degradation may occur in form of nutrient loss, loss of soil microorganism of agricultural land, pollution of surface and ground water, soil erosion and loss of human settlements, and other infrastructures. According to Ivbijaro, (2011), it is estimated that over 8 percent of the total land area of Nigeria is degraded by severe sheet, rill and gully erosions. The consequence of this is arable agricultural land are now being used for development of houses especially in urban areas, thus reducing food production capacity of the urban farmers.

Flooding

Nigeria has recently experienced serious flooding linked to intensive seasonal rainfall and releases of water from dams (Lagdo, Jebba, Kanji and Shiroro dams) according to the National Emergency Management Agency (NEMA) and the Humanitarian Affairs of the United Nation (OCHA) (2012) the flood incidence of 2012 affected people, infrastructures and farm lands.

In Kogi State, an estimate of 152,575 hectares of farmland was destroyed and 1.35 million people were affected. Before the flood in 2012, the Nigerian Metrological Agency (NIMET) predicted the heavy rains urging authorities and residents to prepare for mitigation measures. Same in 2013, 2014 and in 2015 late onset of rain was predicted which further exposed some part of the country to the problem of flooding. In spite of the late onset of rain, flooding was reported in many parts of the country between June and September. For instance, severe floods were reported in Lagos and its environs in June due to days of consecutive downpours. Isolated cases of a flash flood caused by measurably heavy rainfall of short duration also affected other states, such as Adamawa, Kano, Ogun, Edo, and Cross River (NIMET, 2015). This year, the rainy season in Nigeria will be characterised by "late onset, early cessation and lower-than-normal rainfall in many parts of the country, especially in the northernmost parts (NIMET, 2016). It is necessary to state that the expected lower-than-normal rainfall in parts of the country does not rule out the possibility of isolated flash floods due to high-intensity rainfall at the peak of the season, especially in places that are naturally prone to flooding. It is, therefore, pertinent to put proper and timely actions in place to reduce the menace that flooding could cause which is detrimental to food production and food safety in Nigeria.

Drought

Northern Nigeria is witnessing consistent drought and gradual encroachment of desert. In the region rainy season has dropped from an average of 150days to 120days with desert advancing southwards, resulting in loss of vegetation and displacement of settlement (Ogboi, 2011). Nigeria loses about 350,000 hectares of land that support agriculture and other economic activities yearly to desert encroachment (Ogboi, 2011). According to the National Action Programme to combat Desertification (NAP, 2000) report; between 50-75 percent of 11 northern states comprising Bauchi, Borno, Gombe, Jigawa, Kano, Katsina, Sokoto, Yobe, Adamawa, and Zamfara are affected by desertification. Its consequences include a severe threat to surface and underground water and drop in yields, indicating a grave danger to food security in the country. The summary of NIMET's prediction is that all things being equal, there will be low moisture and heightened dryness in Nigeria this year. Also , knowing that most of NiMet's predictions proved to be accurate, we must prepare for the above scenario at the same time the long time effect of climate change which the situation may trigger massive population migration, as Fulani herdsmen will seek new grazing lands which will result in communal clashes in some communities as witnessed in most part of the country.

Industrial Pollution

Nigeria has witnessed industrial pollution especially in the Niger Delta Region where there are serious oil exploration activities. With the increasing oil theft in the region, the rate of the oil spill has risen drastically. The spill has polluted ground water, damaged crop farming and degraded the soil.

Erosion

Gully erosion has become a serious source of concern in many parts of the country. There are over 2,000 active gully erosion sites in Nigeria with Anambra and Enugu States alone having over 500 active gully sites some of which are over 100meters long, 20 meters wide and 15 meters deep(Ivbijaro, 2011). Gully erosion is particularly severe in Abia, Anambra, Borno, Delta, Enugu, Ebonyi, Edo, Imo, Kogi, Jigawa and Ondo State. It has dislocated families, reduced agricultural land, biodiversity and threatened the security of life and properties. According to World Bank Report, (1990) Nigeria needs about 1000 million US dollars annually to mitigate the impact of gully erosion on the environmental integrity, human health, and renewable resources.

Biodiversity Loss

The major threat to biodiversity in Nigeria is habitat destruction and overharvesting of wildlife, fisheries and plant species. Of the 1.4 million species of plants and animals identified in Nigeria, insects, comprising approximately 751,000 species account for 53.6percent. Higher plants species account for 15.7%, fishes 19,000 species (1.3% and mammals 4000 species (0.28%) (FEPA, 1992). Habitat loss in Nigeria has led to the extinction of many animals.

THREATS TO FOOD PRODUCTION IN NIGERIA

Pressure on Water needed for Agriculture

In Nigeria especially in the North, farmers have supplemented the supply of rainfall for crops with irrigated water. Irrigation has always made a substantial contribution to food production and will continue to have a substantial impact. But considering the pressure on the use of water by other users, it is believed that the future food demand needs to be met by additional irrigated land. The FAO has estimated that developing countries are likely to expand their irrigated area from 202 million hectares in 1997/99 to 242 million hectares by 2030 (FAO 2003), with sub-Saharan Africa having the highest growth of 21 and 27% respectively. Even with the present irrigation efforts, Madu, *et al* (2010) noted that Nigeria has not developed irrigation to the same extent as other developing nations. Only about a million hectare is currently irrigated in Nigeria. It, therefore, means that Nigeria has to increase her irrigated farm to boost food production in the nearest future.

Pressure on Land available for Agriculture

Another threat from food supply comes from other land use which competes with agricultural land. In Nigeria, there are no strict adherences to zoning practices and there is a substantial encroachment on agricultural land especially in urban areas. This poses a serious threat to food production in the country. According to World Bank (2005), cities will grow by 2.5 times in area by 2030 covering some 100million hectares or 1.1% of the total land areas of countries with the possibility of extending into as much as 5-7% of the total arable land. This is a serious concern for urban managers as they need to protect land uses through proper zoning.

Fertilizer loading alters the Cycling of Nutrients

A characteristic of modern agriculture is the intensive use of fertilizers that supplement the nutrients available to plants from internal cycling within soils. A fertilizer provides three major nutrients (nitrogen, phosphorus, and potassium). The problem is not the application of fertilizer but Nitrogen loadings which often cause contamination of groundwater and bio-accumulate in the food chain (UNEP, 2007). It has also been ascertained that a large fraction of applied nitrogen ends up being released to the atmosphere in the form of nitrous oxide, a powerful greenhouse gas which makes a substantial contribution to global warming (Barker et al. 2007). It is, therefore, pertinent for farmers to imbibe the application of fertilizer in a sustainable fashion and watch out for inconsistencies in fertilizers so as not to undermine the cycling of nitrogen, phosphorus, and other nutrients in the soil.

Excessive Tillage compacts Soil and Inhibits Soil Formation

Soil tillage in excess often leads to the destruction of the natural soil structure and sometimes soil degradation. It also leads to increasing aeration of soils which causes the mineralization of organic matter which thus, reduces soil biodiversity. This hampers the natural nutrient recycling processes and makes the soil dependent on external inputs.
In Nigeria, Deep tillage of vulnerable soils, in most northern part of the country, can expose layers with high concentrations of salts, which greatly increases the risk of soil salinization. It also buries the soil cover that protects the surface from the erosive effect of water, leading to erosion and eventually land degradation.

Deforestation and Pesticide Contamination

Deforestation and pesticide contamination of lands adjacent to farmland can degrade "off-farm biodiversity", including the destruction of organisms responsible for pollination of crops or natural pest control.

Traditional Agricultural Practices

Traditional agriculture does not require the high artificial inputs (fertilizer, energy, and water) unlike the conventional agriculture, but if practised inappropriately (cultivation of steep slopes, overgrazing) it can lead to severe land degradation.

Climate Change

The impacts of climate change will compound the preceding threats to agriculture, generating a shift in crop-growing zones. While there will be an initial increase in crop productivity in cooler climates and an initial decrease of crop productivity in warmer climates, eventually crop productivity everywhere will decrease. The IPCC reported that by 2020, potential rain-fed crop yields could fall by up to 50% in some African countries.

OPTIONS FOR STRENGTHENING ECOLOGICAL BASE FOOD SUPPLY IN NIGERIA

Food security can be enhanced by strengthening the long-term ecological foundation of food supply. This includes ensuring the long-term sustainability of fish stocks, promoting ecologically-sound cropland intensification, and reducing waste such as post-harvest losses in the food system. The options adopted include:

Building Sustainable Food Systems is a means to secure the Ecological Base of Food Security

Sustainable food systems enable the production of sufficient, nutritious food while conserving the resources that the food system depends on and lowering its environmental impacts. Such systems are based on the idea that all activities related to food (producing, processing, transporting, storing, marketing and consuming) are interconnected and interactive.

Sustainable Agriculture is a viable option for enhancing both Food Security and Food Safety

Sustainable agriculture is the practice of farming ecologically, rather than focusing only on the economic viability of the crops. Sustainable agriculture also involves using non-renewable resources effectively, growing nutritious foods and enhancing the quality of life of the farmers (Benson, 2004).

Sustainable agriculture involves a wide range of actions, which includes:

Improve Soil Systems as the Basis for Production and Ecosystem Health

One way to effectively manage soil systems is through conservation agriculture (CA). Key elements are: minimizing mechanical soil disturbance (no tillage), maintaining permanent soil cover, and diversifying crop rotations. Permanent ground cover and cessation of ploughing reduces water and wind erosion of soil, maintains soil structure, and enhances biological activity in the soil, thereby improving the fertility and sustainability of soil systems and restoring degraded lands.

Make Water Resource Management more Comprehensive and Efficient

Some of the ways water can be managed by farmers are through water conservation and water harvesting. To harvest water, it is gathered from a catchment area and channelled to the farmland where it is needed while water conservation entails reducing the loss of water through surface runoff by holding it off and keep it falling where it is needed.

Green water is rainfall that infiltrates into soils and is stored there and in vegetation and plant root zones, both on and off farms. In contrast, blue water is what flows overland or underground through streams, rivers, and aquifers, and is held in ponds, lakes, and reservoirs and is available for diverse uses (Falkenmark and Rockström 2010). Both sources need to be managed purposefully. The supply and availability of green water can be maximised, for example, through sound soil management that conserves soil moisture. This can increase the economic efficiency of farming by enabling more crop production for less water usage. It also increases the environmental efficiency of farming because less water is required per hectare, meaning lower water withdrawals for irrigation and less polluting runoff from fields. Improvements in the functioning of agricultural watersheds, for example, by maintaining well-forested upland areas that slow down the runoff from precipitation, can help augment overall water supplies for human and ecosystem needs (Achouri 2002; Milder et al. 2011).

Increase Plant Efficiency through Integrated Nutrient Management and Modified Crop Management

Conventional agriculture depends heavily on the use of inorganic fertilizers. As an alternative approach, Integrated Nutrient Management (INM) reduces dependence on these fertilizers by building on the techniques of good soil management. INM aims to better utilize nutrient cycles in the soil and relies more on organic means of fertilization, supplemented with selective, careful use of inorganic fertilizers on soils that require them. To raise and maintain agricultural productivity, it is essential to building up soil organic matter, particularly where soils are relatively infertile. Green manures, cover crops and nitrogen fixing trees enrich the soil and lower soil temperatures for the benefit of soil organisms while inhibiting weed growth.

Agroforestry: Grow Perennials On-farm for Food Security, Income and Ecosystem Benefits

Trees, shrubs, and palms integrated into a farm can provide year-round vegetative cover that reduces soil disturbance and can often provide habitat for wild species, including crop pollinators. The practice of using perennial trees and shrubs within a farm system is referred to as "agroforestry" Agroforestry can improve rainfall use efficiency (Sileshi et al. 2011). Trees serving as windbreaks can improve micro-environments for crop production reduce evapotranspiration and improve soil water utilization. Diverse tree species can provide food, proteins, vitamins, bioenergy, building materials, medicines and raw materials for local enterprises, and replace the extraction of wood from forests and natural habitats (Dewees et al. 2011).

Undertake Integrated Livestock Systems Management

More integrated production systems would reduce livestock wastes and greenhouse gas emissions, and increase input and resource efficiency. Farmers could take advantage of synergies among plants, trees, and animals. Livestock would produce manure for enhancing soil fertility and the non-marketable biomass from crop production could be used to feed livestock. This style of farming would also reduce the water pollution and waste problems that arise from the intensive rearing of cattle, pigs, chickens and other animals.

Manage Pests and Diseases through Biological Control and Ecosystem Management

Natural control of crop diseases and pests is carried out by organisms living inside and outside the boundaries of cropland. Pesticides applied to crops sometimes spread to the vicinity of these organisms and destroy them. One important way of protecting these helpful organisms is through "Integrated Pest Management. IPM relies not only on biological control methods and ecosystem management but also on better monitoring and understanding of pests.

Sustainable Agriculture can be scaled up by:

- Supporting farmers' and community learning, by educating a new generation of agricultural extension workers well-versed in the techniques of sustainable agriculture.
- Extending land tenure rights to farmers to encourage their stewardship of the landscape.
- Providing access to credit facilities for farmers willing to invest in more sustainable practices.
- Rewarding farmers and farming communities for ecosystem stewardship.
- Developing a "common vision" among stakeholders about how agriculture and food systems can be managed in a region.
- Strengthening national and international institutions, as well as private organisations, for the certification of sustainably grown farm products.

All of these steps would strengthen the ecological basis of the food supply and make it safer and more reliable for consumers and at the same time reduce the problem of food security in the country.

CONCLUSION

The prevailing low productivity in agriculture gives causes for much concern. Looking inward to increased agricultural production remains an absolute necessity for ensuring satisfactory food supply to the citizenry. It should be noted that the underlying message is that the security of food supply will diminish unless we realize the central importance of the ecological foundation of the food system. To this extent, farmers, policy makers, government and non-government agencies concerned with agricultural development must respond positively to the considerable challenges of achieving self –sufficiency in food production and providing agricultural raw materials for an industrial economy.

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Vegetation Communities and Tree Species Composition in Marbe Forest Reserve, Zamfara State Nigeria

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Abstract
A lot of attention had been directed in the past towards the description of the current Marbe vegetation composition after years of anthropogenic interference have depleted the forest of its resources. The major objectives of the study were to determine tree species composition and diversity as well as the different type of vegetation sub-communities in Marbe Forest Reserve. Extensive field work and Google Earth satellite imagery analysis were employed. Thus, a Google Earth Pro image with pixels that are 32 meter in diameter on the ground and are located to an accuracy of + 0.5 pixels was studied. Ten quadrants were used to identify the type of vegetation species and communities in the Forest Reserve. 10m x 10m (100 m^2) quadrants were used to know what species were present, what their distribution is and what the relative abundance is. Five vegetation sub communities were identified; savannah wood lands, degraded forests and Scrubland, grass land, other areas were completely non-vegetated. Out of the 39 confirmed tree species within the Marbe Forest, 20 were captured in 10 quadrats analysis, while 19 did not fall within any of the quadrants. Only one quadrant recorded a high tree density, with two having moderate tree density and the remaining seven recording low tree densities.

Keywords: *Vegetation Communities, Forest reserve, Tree Species, Tree Density, Land Cover, Land Use, Quadrant, Deforestation*

INTRODUCTION

The United Nation's Food and Agriculture Organization (FAO) declared during the 1990s that the world annually lost millions of hectares of natural forest (Awake, 2000). The organization's estimates shows that the tropics lost more than 10 million hectares of forest cover annually. Agricultural activities, particularly shifting cultivation is responsible for almost 70% of deforestation in developing countries. The situation is worst in tropical Africa, where deforestation exceeds the projected rate of afforestation or tree planting by a ratio of 29:1 (Kang et al., 1990). There are 445 gazetted forest reserves located in different parts of Nigeria. Only about 137 of these reserves are located in the forest region harbouring the bulk of the natural forest wealth of the country (UNEP, 1992). Of the 560 species of trees present in these reserves in Nigeria, only 60 species are considered commercially important with attention restricted to about 35 of them (Nwoboshi, 1982). This has resulted in the overexploitation of the few commercially available species. The current global attention on the conservation and sustainability of biodiversity particularly in the tropical forests is a consequence of the threat posed by overexploitation.

Societies are continuing to invest resources into acquiring and managing protected areas, believing that they are the backbone of biodiversity conservation and that they deliver a range of other social, economic and environmental benefits (Oduntan et. al, 2013). Since over 12 % of the earth's terrestrial surface is now in nationally designated protected areas (UNEP-WCMC, 2008), it is ironical that global biodiversity continues to decline at an alarming rate (Butchart, 2010; Mulugeta, 2014). There is therefore, a need to evaluate the extent to which these reserves really do protect their values and deliver benefits to the community (Southworth, 2006; Timko and Innes, 2009).

In Nigeria, conservation of diversity of wildlife species are maintained at the optimum level commensurate with other forms of land use in order to ensure the continued existence of wildlife for the purpose of their sustainable utilization for benefit of the people and this is among the objectives of national park services (Ejidike and Ajayi, 2013).

In Marbe Forest Reserve in particular and Zamfara State and Northern Nigeria in general, the rapid disappearance of vegetal cover through long term anthropogenic activities has endangered many tree species and vegetation communities in the forest. Today, many tree species have become extinct; many others are in short supply and at the verge of total extinction. Many economic trees with commercial, historical, medicinal, agricultural and environmental value have disappeared from the forest. It is against this backdrop that this paper assessed what is left of the vegetation communities a well as the tree species in the forest.

STUDY AREA

The Marbe Forest Reserve is shared between Tsafe and Gusau Local Government Areas of Zamfara State. The forest reserve lies between latitude 11° 50^{1} to 11° 83 ^{1} North and 6° 40 ^{1} to 6° 67 ^{1} East. It is situated about 30 kilometres south of Gusau town on the left and right hand side of the tarred road from Gusau to Magami (Kaltho, 1997). The forest reserve covers approximately 347.32 square kilometres. The reserve is bounded in the west by the tarred road from Wanke to Danjibga village and by feeder roads linking Kwaren-Ganuwa through Sami-naka, Nassarawa, Tsauri (Marbe) and Tofa, all in the southern part. It is also bounded in the North by feeder road from Nassarawa (in Katsina state) to Kuyambana; and in the east by the tarred road from Magami to Kuyambana forest reserve. Two major streams form part of the boundary. These natural boundaries are Gagagare and Zamfara streams in the west (Zamfara Forestry Department, 2015). Generally, the land use characteristics of the study area include forestry, farming, grazing, quarrying, hunting and gathering. These activities form important part of the economy of the area.

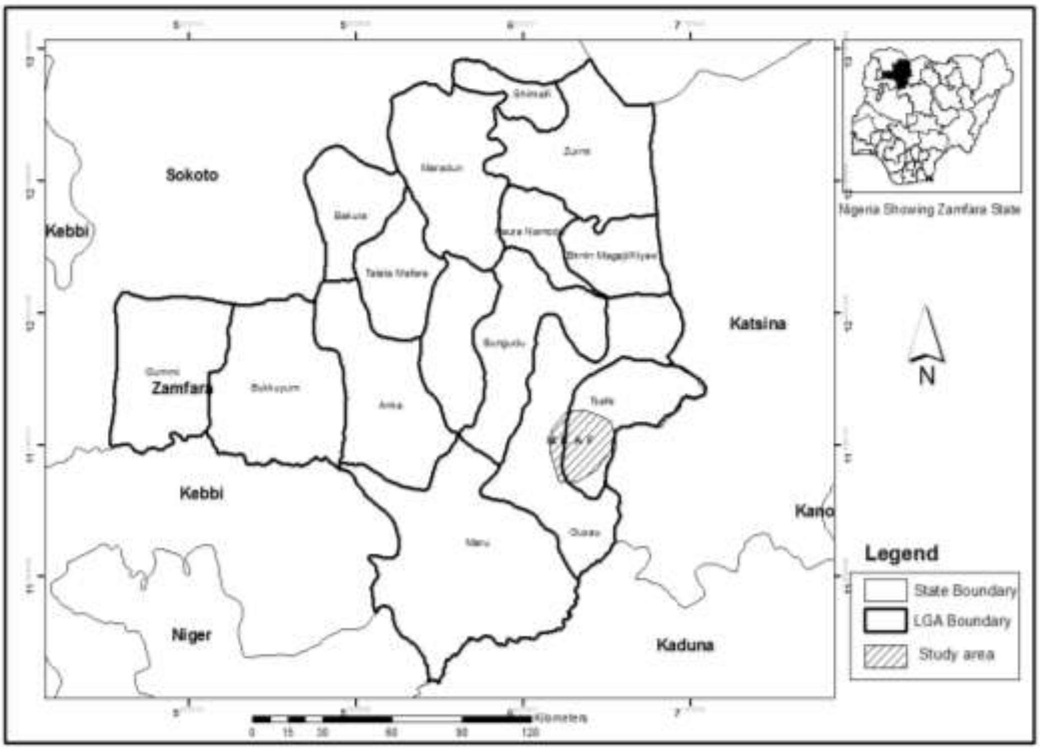

Fig 1: Map of Zamfara State showing Marbe Forest Reserve
Source: Department of Geography, BUK (2014)

MATERIAL AND METHODS

Suitable areas were identified for the establishment of quadrants. Data collected about tree species diversity and density from all the quadrants were analysed and the results of these analyses were interpreted and differences were established.

Sampling Frame and Technique

The **Purposive Sampling** technique was adopted for this study. This was because of the insecurity situation in the forest area which is harboured by cattle rustlers and armed robbers in the State at the time of data collection. As such, only areas that are safe and devoid of any security threat were considered for the location of quadrants.

Vegetation Characterization Using Quadrants

Ten (10) 10m x 10m (100 m^2) quadrants were used to know what species were present, what is their distribution and what is the relative abundance? Justice and Townshend (1981) suggested the application of a model that makes use of the attributes of the spatial image to define a sampling size. The model estimates the size of any sample quadrant as function of the pixel size and the expected geometric accuracy of the images.

$A = [PD\ (1+2PG)]^{2}$

Where:

A = Area to be sampled

PD =Ground diameter of a pixel

PG =Geometric accuracy of the image.

Thus, a Google Earth Pro image with pixels that are 32 meter in diameter on the ground and are located to an accuracy of + 0.5 pixels, the sample plot size used for the study is 0.4096 hectares or 64meter by 64meter. Locating of sampling points was achieved with the aid of a GPS receiver (Garmin GPS MAP 76). Selected points were determined to the nearest minute. At the center of the point, a 64 meter tape was laid. Demarcation of the sample plot boundaries is established by measuring 32 meters each side of the center transect; marked by ranging poles, and aligned with the aid of prismatic compass.

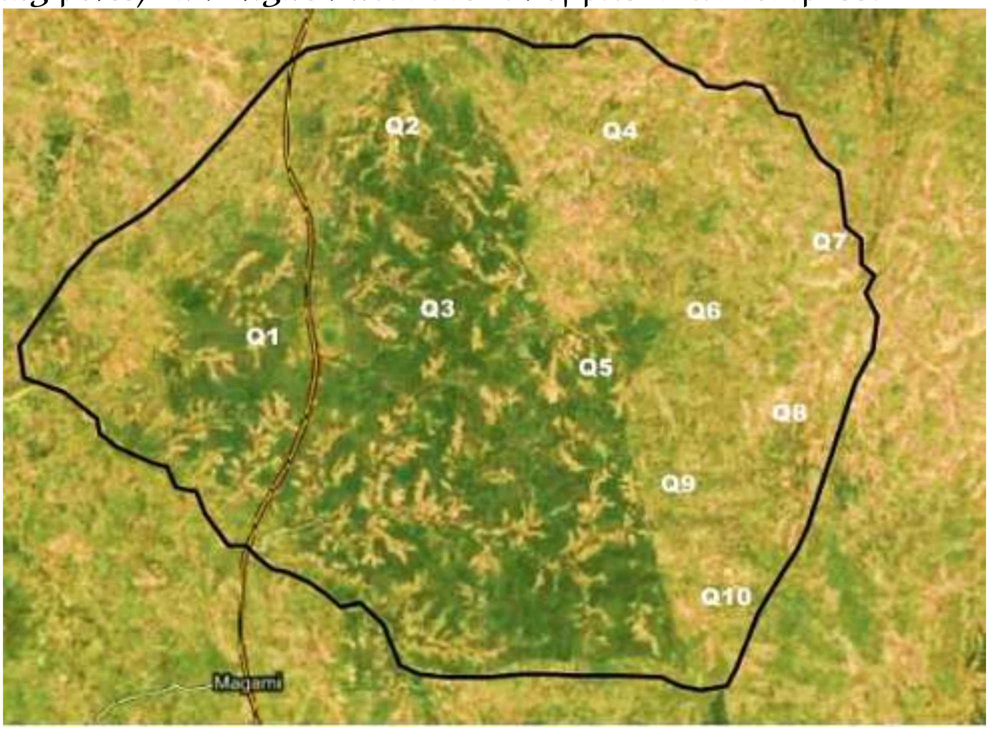

Plate I: Marbe Forest Showing the location of sampled quadrats
Source: Google Earth 2014

Tree Species Density and Diversity: The degree of concentration and frequency of tree species in a particular area.

Method: Enumerating and recording total number of trees more than three meters in height and respective species found within the sample plot (Eyre et al 2006).

$$\text{Density} = \frac{\text{Total number of species in quadrant}}{\text{Size of quadrant}}$$

RESULTS AND DISCUSSIONS

General Land Cover in Marbe Forest Reserve

The Marbe Native Authority Forest Reserve is not only covered by trees and vegetation. Other physical features that occupy the forest include rocks, bare land surface and river channels. Vegetation cover in the forest including trees, shrubs and grasses and crops (which forms part of the existing dominant land use) constitute the major land cover after bare land surfaces. Although vegetation has seriously declined in the forest, it still forms the most important component of land

If one considers the original area of the Marbe Forest Reserve, it can easily be concluded that bare land surfaces constitute the most significant land cover (fig 2). This is primarily due to consistent deforestation activities over the last 30 years. Presently, only the deep interior of the forest reserve consist of trees of some significant density. Most of the areas surrounding the forest as well as sections of the forest interior have been reduced to bare and exposed land surfaces, with some being cultivated and others left with nothing but old and partially decomposed stumps.

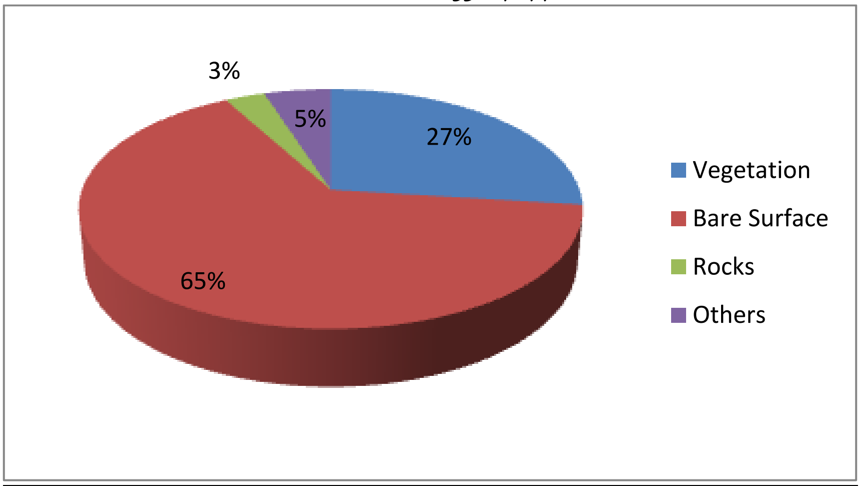

Fig 2: Pie chart showing distribution of land cover in Marbe Forest
Source: Field work 2015 and data from Zamfara State Department of Forestry

THE PRESENT VEGETATION COMMUNITIES OF THE FOREST RESERVE

Savannah Woodland

This is a deciduous and semi deciduous woodland where settlements are absent. The vegetation consists of climax vegetation that has undergone anthropogenic modifications. The Savannah woodland occur either as continuous or discrete entity throughout the reserve. (See Plate II below). Observations have shown that it is characterized by average tree height of 19 meters and crown cover of about 57%, and composed of tree species such as *Tamarindus indica* and *Adansonia digitata*. Others are *Acacia albida, Khaya senegalenesis, Parkia bigloboza* and *Pterocarpus erinaceus*. Grass species include *Rhynchelytrum repens, Panicum kerstingii, Setaria pallide-fusca, Aristida.*

Plate II: Savannah Woodland near Dogon daji Village in the forest

Degraded Forest

These are areas covered by scattered trees, separated by other low lying ground cover vegetation. The vegetation community has emerged as a result of anthropogenic interference, evidenced by fallen tree stumps and branches and young regenerating trees (Plate III below). It is characterized by average tree height of 17 meters and crown cover of 37%. The vegetation community occurs in patches all over the reserve, however it is more pronounced at the perimeter of the forest reserve. Tree species found are similar to those of the Savannah woodland though with lower species diversity and density.

Scrubland or Shrub Savannah

The vegetation community consists typically of shrubby coppice and sucker regeneration from stumps and rootstocks that have not yet been eliminated by cultivation. Average tree height is about 17 meters with crown cover of 19%. It occurs as patches mostly close to the perimeter of the reserve (Plate IV below). They are associated mainly with areas of intense human disturbance and on areas whose indurated laterites are close or lying on the surface. Common species includes remnants of the Savannah woodland. *Pennisetum polystachyon* and *P. pedicellatum* grasses are common in the early stages of newly fallowed land, but typically perennial *Andropogoneae* soon follows these.

Plate III: Remaining forest being degraded gradually near Tofa

Plate IV: Newly regenerated shrubs near Danjibga Village

Grassland

Where livestock grazes or fuel wood cutting have eliminated the tree stands and bottomland sites are dominated by grassy and herbaceous vegetation. The few isolated trees found may form crown cover of 10% with average tree height of 18 meter. The morphology of the grasses varies with the water depth and soil condition, but composed of various combinations of species including *Echinochloa pyramidalis, Phragmites mauritianus, Saccharum spontaneum, Oryza barthii* and *Vetiveria nigritana*. Widely scattered species of low tree such as *Mitragyna inermis, Syzigium guineense and Terminalia glaucescens* often dot the community. Where livestock grazing or fuelwood cutting have eliminated the tree stands, typically low and creeping grasses, such as *Paspalum commersonii, Sacciolepis* spp., *Brachiaria jubata, Setaria sphacelata* and *Panicum repens,* remain and mostly predominates at the edges of the forest reserve.

Completely Non-Vegetated Areas

Areas with scanty or no vegetation cover including rock outcrops, farmlands and low growing grasses form a distinct vegetation community characterized by economic trees with average height of about 11 meters and crown cover of 4%. They are confined mostly to the edges of the reserve, road sides and around the encroaching settlements (See Plate V below).

Plate V: Bare land surface Near Nassarawa Village

Others include the north eastern section of the forest where crop production is taking place. Crops planted include maize, millet, rice, sorghum and some vegetables.

Tree Characteristics of the Forest Reserve

Across the 10 sampled quadrants in the Marbe forest, only 39 tree species were identified, with all 39 (See Appendix III) being indigenous. This clearly signifies a decline in species richness of the forest which forestry department revealed to contain more than 71 tree species as at 1980. This shows that about 32 tree species has been removed by deforestation.

Species Composition and Tree Diversity

Out of the 39 confirmed tree species within the Marbe Forest, 20 were captured in 10 quadrants analysis (Table 1), while 19 did not fall within any of the quadrants. This shows that the most of the 19 species which are not captured in table 7 occur mostly in isolation in cleared areas and are on the verge of becoming extinct because of their relative low number and unavailability.

Table 1: Composition of Trees Species per Quadrant in Marbe Forest

SN	Species	Local Name	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
1	*Isoberlina doka*	Doka	1	2	11	1	4	10	2	0	7	1	**39**
2	*Anogeisus leocarpus*	Marke	2	4	20	1	5	9	4	0	3	1	**49**
3	*Khaya senegalensis*	Madaci	1	2	4	3	6	8	2	2	1	4	**33**
4	*Parkia biglobosa*	Dorawa	0	1	1	0	7	6	1	2	1	4	**23**
5	*Acacia nilotica*	Bagaruwa	0	1	1	5	7	5	1	2	1	4	**27**
6	*Pterocarpus erinaceus*	Madobiya	2	4	1	5	6	11	4	2	1	4	**40**
7	*Boswawellia papyrifera*	Hano	4	2	1	5	5	12	2	2	1	4	**38**
8	*Fardherbia albida*	Gawo	1	2	1	5	4	6	2	1	1	2	**25**
9	*Adansonia digitata*	Kuka	0	0	0	4	0	2	1	6	0	12	**25**
10	*Detarium microcapum*	Taura	2	1	6	1	2	1	1	1	1	2	**18**
11	*Combretum glutinosum*	Taramniya	2	1	3	5	2	15	1	1	1	2	**33**
12	*Entada sudanica*	Tawatsa	1	5	2	5	2	15	5	1	2	2	**40**
13	*Butyrospernum*	Kadanya	0	1	3	0	6	2	4	2	4	4	**26**

	parkii												
14	*Piliostigma reticulatum*	Kalgo	0	6	17	5	6	35	10	1	5	2	**87**
15	*Tamarindus indica*	Tsamiya	0	5	7	5	6	3	0	1	5	2	**34**
16	*Mitragynainemis*	Giyayya	0	3	10	5	6	2	0	1	5	0	**32**
17	*Borassus aethiopium*	Giginya	0	0	2	1	0	0	0	2	1	4	**10**
18	*Terminalia macroptera*	Kandare	1	3	1	5	6	3	3	1	5	2	**30**
19	*Diosphyros mespiliformis*	Kanya	0	1	2	10	6	10	1	1	0	2	**33**
20	*Lannea acida*	Faru	3	1	2	4	4	10	1	1	0	2	**28**
	TOTAL		**20**	**45**	**95**	**75**	**90**	**165**	**55**	**30**	**45**	**60**	***680***

Source: Fieldwork, 2015

From the table above, it can be seen that only 8 trees species were present across all 10 quadrants while 12 tree species were found but not in all of the quadrants. The table also shows that the tree that registered the most presence in the forest is *Piliostigma Reticulatum* (Kalgo) with 87 counts in 10 quadrants while *Borassus Aethiopium* (Giginya) tree registered the least presence with 10, an average of 1 per quadrant. The 6th quadrant had the most number of trees with 165 with 19 out of the 20 species all found within the quadrant while the 1st quadrant recorded the least number of trees with 20. At least one to three species were missing in all 10 quadrants; that is, no single quadrant had all 20 tree species within it. It can also be observed trees like *Borassus Aethiopium* (Giginya) and *Adansonia Digitata* (Kuka) mostly grow in isolation as they were found missing in most of the quadrants while shrub-like trees like *Piliostigma Reticulatum* (Kalgo) growing mostly close to each other as 35 of them were recorded in one quadrant.

Distinctions of Tree Composition between Cleared and Non-cleared Sections of the Marbe Forest per Hectare

The quadrants in the relatively uncleared forest supported a higher number of tree individuals and species richness, while this is lower in the cleared forest due to the fact that majority of the number of trees species has been removed by deforestation. The uncleared forest also contained some 'unique' species, found only there at the time of conducting this research, *Isoberlina doka, Anogeisus leocarpus, Parkia biglobosa, Fiscus plataphylla,* were species found only in the uncleared forest but completely removed in the cleared area due to their high demand by fuel wood and timber collectors. These species of trees according to one of the fuel wood collectors have a higher market value. A renowned timber species in the area (*Isoberlina doka*) could have been depleted in the cleared forest due to high demand of this specie by timber collectors and over use of this species by rural communities for traditional medicinal purposes; this statement is supported by the fact that only 3.31% of total individuals of tree species were found in the uncleared forest.

Table 2: Composition of Trees Species per Hectare

SN	Species	Local Name	Uncleared Area	Cleared Area
1	*Isobernia doka*	Doka	5 (3.31%)	0 (0.0 %)
2	*Anogeisus leocarpus*	Marke	8 (5.30%)	1 (1.85%)
3	*Khaya senegalensis*	Madaci	12 (7.95%)	3 (5.55%)
4	*Parkia biglobosa*	Dorawa	15 (9.93%)	6 (11.11%)
5	*Acacia nilotica*	Bagaruwa	21 (13.91%)	5 (9.26)
6	*Pterocarpus erinaceus*	Madobiya	25 (16.55%)	6 (11.11%)
7	*Boswawellia papyrifera*	Hano	13 (8.61%)	3 (5.55%)
8	*Fardherbia albida*	Gawo	18 (11.92%)	4 (7.41%)
9	*Adansonia digitata*	Kuka	34 (22.52%)	26 (48.15%)
	TOTAL		**151 (100%)**	**54 (100 %)**

Source: Fieldwork, 2015

A total of 151 individual trees were recorded in the uncleared forest and 54 trees in the cleared forest (Table 2) *Adansonia digitata* was the most abundant species followed by *Parkia biglobosa* in both study sites. An average of 18 tree species are found in uncleared forest and 6 species in cleared forest area were recorded from the sampled area.

Tree Density

Tree density was obtained by dividing the size of the quadrant (100m²) by the number of trees in each quadrant. This was used to categorize the forest into areas of low, moderate and high tree densities.

Table 3: Analysis of Quadrats showing Tree density in Marbe Forest

Quadrants	Trees		
	Number	Density (m^2)	Remark
1^{ST}	20	0.2	Low density
2^{ND}	45	0.45	Low density
3^{RD}	95	0.95	Moderate density
4^{TH}	75	0.75	Low density
5^{TH}	90	0.9	Moderate density
6^{TH}	165	1.65	High Density
7^{TH}	55	0.55	Low density
8^{TH}	30	0.3	Low density
9^{TH}	45	0.45	Low density
10^{TH}	60	0.6	Low density

Source: Field work 2015

Dividing the total number of trees in all 10 quadrants (680) by the total size of the 10 quadrant ($100m^2$ x 10), the whole tree density of the Marbe Forest would be 0.68. This shows that, on the average, we have less than one tree (0.68) in every $100m^2$ of the Marbe Forest Reserve land. Furthermore, from Table 9 above, 7 out of 10 quadrants recorded a low tree density, as 2 recorded moderate tree densities and only 1 with high tree density. This can be used to conclude that the whole forest has a low tree density.

FURTHER DISCUSSION OF RESULTS

The types of vegetation communities identified in the forest reserve are those that have been shaped and reshaped by anthropogenic activities over the years. The communities are far from their original natural status. We have the Savannah Woodland dominated by deciduous and semi deciduous woodland which has undergone anthropogenic modifications and is characterized by average tree height of 19 meters and crown cover of about 57%. Other communities are degraded forest covered by scattered trees, separated by other low lying ground cover vegetation; Shrub Savannah consisting typically of shrubby coppice and sucker regeneration from stumps and rootstocks that have not yet been eliminated by cultivation; Grassland where livestock grazing or fuel wood cutting have eliminated the tree stands and bottomland sites are dominated by grassy and herbaceous vegetation. Areas with scanty or no vegetation cover including rock outcrops, farmlands and low growing grasses where also identified. Abdullahi (2009) recorded anthropogenic influences on the vegetation communities of Kpashimi Forest Reserve of Niger State.

Across all the 10 sampled quadrants in the Marbe forest, only 39 tree species were identified in total, all of which are indigenous. This shows that afforestation and reforestation programme which will make way for the introduction of exotic tree species is lacking in the forest. It also clearly signifies a decline in species richness of the forest which forestry department revealed to contain more than 71 tree species as at 1980. This shows that about 32 tree species has been removed by deforestation. In terms of tree density, seven out of the ten quadrants revealed a low density of trees, two quadrants recorded moderate density while only one recorded high density. This signifies the extent of tree loss in the forest and the large sections of virtually bare surfaces in the reserve. From the quadrant analyses, the most available vegetation specie is *Piliostigma reticulatum* or *Kalgo* as locally called. Whereas *Borassus aethiopium* or *giginya* as locally called is the least available in the forest.

CONCLUSION AND RECOMMENDATION

Deforestation in Marbe forest decreased the number of tree species as well as individuals. Many tree species are now extinct and previously thickly vegetated areas are now sparse or reduced to bare surfaces. The study revealed that deforestation decreased the species number of trees, led to biodiversity loss, increased soil erosion and contributes to the occurrences of gullies and debris flow. An inventory of the most endangered plant species should be specially taken and measures of conservation of such species be put in place. Appropriate legislation spelling out specific punishments should be put in place to curb further destruction of natural forest and must be enforced.

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APPENDIX

List of tree species in Marbe forest as at 1980

S/N	Scientific Names	Local Names (Hausa)	S/N	Scientific Names	Local Names (Hausa)
1.	*Anogeisus leocarpus*	Marke	21.	*Azadirachta indica*	Bedi
2.	*Isoberlina doka*	Doka	22.	*Butyrospernum parkii*	Kadanya
3.	*Detarium microcapum*	Taura	23.	*Gardenia aqualla*	Gaude
4.	*Combretum glutinosum*	Taramniya	24	*Magnifera indica*	Mangwaro
5.	*Parkia biglobosa*	Dorowa	25	*Annona senegalensis*	Gwanda Daji
6.	*Ceiba pentandra*	Rimi	26	*Solerocarya birrea*	Danya
7.	*Ficus plataphylla*	Gamji	27	*Albizzia chevalieri*	Katsari
8.	*Parnari macrophylia*	Gawasa	28	*Ziziphus spina christii*	Kuma
9.	*Entada sudanica*	Tawatsa	29	*Acacia macrostachyta*	Gardaye
10.	*Acacia sieberina*	Farar kaya	30	*Hyphaene thebaica*	Goriba
11.	*Ficus polita*	Durumi	31	*Bambax buonopezense*	Kurya
12.	*Ficus thonningii*	Chediya	32	*Proposis Africana*	Kirya
13.	*Butyreospermus paradoxum*	Kade	33	*Boswellia papyrifera*	Hano
14.	*Balanite aegyptiaca*	Aduwa	34	*Lannea acida*	Faru
15.	*Diosphyros mespiliformis*	Kanya	35	*Piliostigma reticulatum*	Kalgo

16.	*Fardherbia albida*	Gawo	36	*Acacia nilotica*	Bagaruwa
17.	*Adansonia digitata*	Kuka	37	*Terminalia macroptera*	Kandare
18.	*Khaya senegalensis*	Madaci	38	*Acacia Senegal*	Dakwara
19.	*Tamarindus indica*	Tsamiya	39	*Bambax costatum*	Gurjiya
20.	*Mitragynainemis*	Giyayya	40	*Borassus aethiopium*	Giginya

Source: Dept. of Forestry Zamfara State as at 1980.

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Effects of Climate Change on Water Demand and Supply: A Case Study of Gusau Metropolis, Zamfara State

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Pp 99-114

Abstract.

Water is a social and economic necessity without which no socio-economic endeavor is possible. Water is important for socio-economic development of any area. Conversely, lack of or inadequate water supply has direct effect on the development, health, as well as growth of the population. Demand and supply are twin inter-connected issues in the effort to provide water supply. Balancing resources is the cornerstone in determining success or failure in the realization of an effective urban water delivery system. This study was designed to determine the demand and supply of water between the planning districts and town as a whole, vis a vis the effect of climate change on this variables with the aim to identifying causes of persisting water problem in Gusau metropolis. To achieve this aim, three (3) sources of water supply where selected for the research namely; Water Board, public Boreholes, and dug wells. 350 questionnaire where systematically and randomly administered in the planning districts in addition to the field work and data from Water Board. The analysis revealed that the production from water board is far from meeting the demand of the populace (i.e 44,070,300litres are demanded per day but only 10,00,000litres are supplied) and the per capita water supply is generally low (27.7litres) which is far below the WHO standard. In addition to this, disparity exist in water supply between the planning districts with Samaru having the highest per capita per day (31.7litres) and Gada Biyu planning districts having the lowest (25.7litres). Some effects of climate change where also analyze. Thus, it is recommended that, state government and other water related stakeholders (government and nongovernmental organization) to as a matter of urgency increase the capacity of the source from water board and other effective

sources to increase the efficiency and availability of safe and portable drinking water in the town.
Key words: Climate Change, Water, Demand, Supply, Gusau Metropolis

INTRODUCTION

Climate change is a long term change in the statistical distribution of weather pattern over period of time that range from decades to millions of years. Climate has been recognized as a major environmental problem facing the earth (Ifatokun, 2013).

Changes in weather and climate have been known to profoundly influence water resources, a factor that increases the vulnerability of humans to infection. Generally, water resources involve all forms of fresh water needs to drinking, washing and cleaning, to agricultural needs involving food processing and irrigation, to other uses. Climate is, with particular reference to water resources, known to be changing world wide and there has been growing concern as to the direction and efforts of these changes on the natural resources. Thus, hydrological resources such as streams, rivers and ponds are mainly rain-fed as the main sources of water supply are adversely affected by climate change. Rainfall is a renewable resource highly variable in space and time and subject to depletion or enhancement due to both natural and anthropogenic causes (Abaje, 2010).

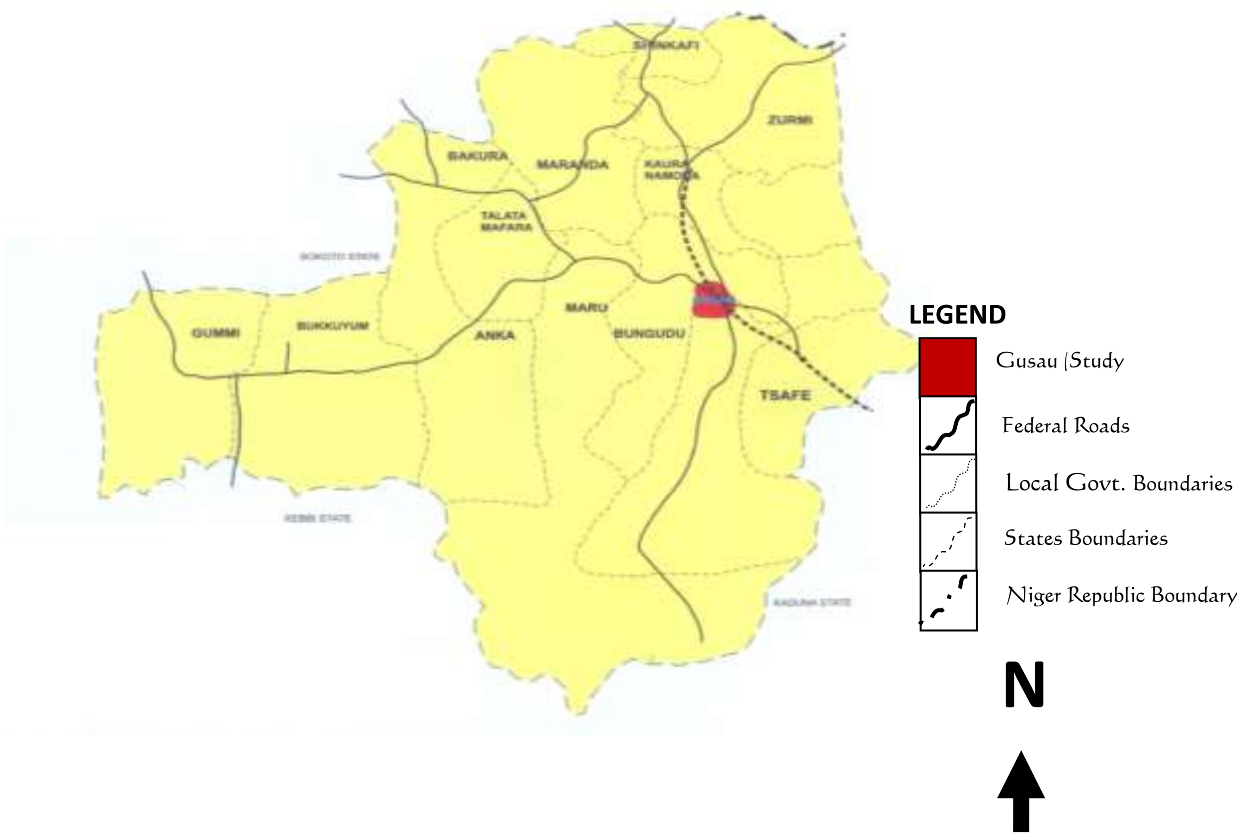
The impact of climate change cannot be felt equally across the world (Eboh, 2009). For instance, countries in sub-Saharan Africa are likely to suffer the devastating impact of climate change more; due to their geological location. Anyadike (2009) also observed that African countries are more susceptible to climate change for the fact that, they are exposed to the dangers of desertification, declining run off of river catchment e.t.c.

In spite of the importance of adequate water supply to humans, access to potable water supply in Nigeria cities lag behind demand. Furthermore, the joint report on water and sanitation by the WHO/UNICEF reveals that Nigeria and many sub-Saharan Africa countries are lagging behind achieving the millennium development goals and targets set for water and sanitation, as drinking water coverage in Nigeria decreased from 49% in 1990 to 48% in 2004, as against the expected 65% coverage (Odafivwotu, O. *et al 2014*). As of 1996 the estimated national annual consumption was 6,502million litres per day (ml/d) (Onyenechere, et al 2011). Climate change as occasioned by rainfall variability in Nigeria, would further compound the inability of the country to meets people demands for water.

BACK GROUND OF THE STUDY AREA

Gusau is one of the areas that emerged during the jihad of Sheikh Usmanu bn.Fodio in the 17*th* - 18th century. People of Gusau are Hausa/Fulani by ethnicity. Gusau is situated in the northern part of Nigeria. It is on the high plan of Hausa land on the bank of River Sokoto. Being in the north-western part of the country and situated in the Sudan Savanna has a distinct wet and dry season. The wet season lasts between the month of April and September and the dry season between the months of October and March. The two seasons are characterized by southwest and northeast trade winds respectively. The mean maximum temperature of the area is about 36-38 degrees centigrade. Gusau is part of the geological belt of Precambrian age formed as a result of Igneous Rock that formed smooth rounded hill. These hills occasionally rise to 200m.

Fig.1: Map of Zamfara State showing the Study Area:



METHODOLOGY

Cluster and systematic random sampling were adopted as the sampling techniques for administering questionnaires as it was administered to household heads. And for this purpose, the study area was divided into five (5) clusters (i.e. Five planning districts; Mareri, Samaru, Tudun Wada, Gada Biyu and Janyau).

A total of 367 households were selected from the total households in the town. With an average of 12 people per household, the questionnaires were administered to the entire chosen sample, out of which 350 questionnaires were collected back. The analysis was done based on the collected number of questionnaires (350). Separate questionnaire administered to the Water Board officials was also analyzed.

RESULT/DISCUSSION

Surface Water Sources : Gusau as the capital of Zamfara state receives it potable drinking water from Gusau new water works commissioned on 9th October, 1992 (as the main source). The water works comprise of a barrage (dam) located along Gusau-Magami road, and the pre-sedimentation unit with the treatment plant situated along Gusau-Zaria road. (See Fig2)The barrage is the principal source of raw water in Gusau and koramar Wanke. Beside this, there is Damba Dam, which serves as the alternative source of water for Gusau water works if the need arise.

Table 1: Capacity of Reservoirs and Treatment Plant.

Facilities	Initial Installed Capacity (L)	Current Capacity (L)	Location
Treatment Plant a. Old Reservoir b. New Reservoir	 3,000,000 >4,500,000	 >3,000,000	 Along Zaria

Source: Zamfara State Water Board, Gusau (2015)

Fig. 2: Gusau Municipal Water Distribution Facilities

The daily initial design production capacity is about 40,000,000litres. Presently the capacity of the treatment plant is about 10,000,000litres par day because the capacities of pre-sedimentation tanks are rather low, (silt filled them up). All these adversely affect the quantity of water supplies and necessitated the rationing of water in the town. It is revealed from the interview conducted with official of water board and some citizen that, the rationing is on sector-time basis, in which an area will have water supply at an interval of two (2) days and for only two hours on the average.

Under Ground Sources of Water

The second source of public water supply examined in the study is underground source. Of particular interest to this study are the public boreholes and wells. The aim at this point is to add the average quantity produce by well and boreholes (as public source) to the total production from the water board. To enable the study establish fully the total water production from the identified public sources of water under study and shortfalls in the town and in the districts. There are a total of 64 borehole and 47 well distributed within the planning districts.

Table 2: Distribution of Public Borehole in the Planning District of Gusau

Planning District	Function	Non-function	Total	%
Mareri	3	9	12	18.8
Samuaru	2	7	9	14.1
Tudun Wada	5	8	13	20.3
Gada Biyu	3	12	15	23.4
Janyau	4	11	15	23.4
Total	**17**	**47**	**64**	**100**

Source: Field Survey, (2015)

It reveals that, some of the boreholes were defunct, only 27% of the total are functioning. The reasons behind this include: lack of maintenance and the geological nature of some part of the town, especially in western apart, comprising Mareri and Gada Biyu planning Districts. The remaining functional boreholes in Gaada Biyu and Mareri are not operative in the dry season while boreholes in the remaining districts, function all year round, though the quantity reduced in the dry season drastically due to low recharge of water table.

Table 3: Distribution of Public Wells in the Planning District

Planning District	**Function**	**Non-function**	**Total**	**%**
Mareri	3	6	9	21.3
Samuaru	5	4	10	19.1
Tudun Wada	4	3	7	14.9
Gada Biyu	4	6	10	23.4
Janyau	6	5	11	23.3
Total	23	24	47	100

Source Field Survey, 2015

There are about 47 wells distributed across the planning districts, amongst which 24 are functional while 23 have dried up. As described in table 2&3, 24 wells out of the total are functioning though out the year but at low quantity during dry season. Most of the drying wells are accounting for on the basis of the geological nature of the area.

Table 4: Quantity Supplied by Wells and Boreholes in Deferent Seasons

Sources	**Quantity (Wet Season**	**Average**	**Quantity (Dry Season**	**Average**
Boreholes	150,000-200,000	175,000	100,000-150,000	125,000
Wells	4,000-5,000	4,500	3000-4000	3500
Total		**179,500**		**128,500**

Source: Field Survey, Zamfara State Water Board, Gusau (2015)

The average between the total production in dry and wet season is;
175000 + 125000 = 300,000litres (boreholes)
4500 + 3500 = 8000/2 = 4000litres (wells). Therefore, the study assumed a total of 150,000litres and 4000litres are produced every day from the function public boreholes and wells in the town respectively.

Table 5: Combined Water Supply in Gusau

Sources	Quantity	%
Water board	10,000,000	82.0
Boreholes	2,100,000	17.0
Wells	92,000	1.0
Total	**12,192,000**	**100**

Source: Field Survey, (2015)

82.0% of the present water supply in Gusau came from water board. The remaining 18.0% of the total is the contribution of public borehole and wells. The combination of these sources gives a total of 12,192,000litres. This is the quantity presently supplied to the town, which can satisfy only a fraction (27.7%) of the total population of the town on the basis of 100l/c/d which is erratic.

WATER DEMAND IN GUSAU

Table 6: Gusau, Water Demand, Quantity Supplied and Shortfalls

Population	Water Demand (100l/c/d)	Quantity Supplied (L) From The Water Board	Shortfalls
338,142	33,814,200	8,000,000	25,814,200
395,578	39,557,800	8,950,100	30,607,700
449,703	44,070,300	*10,000,000	34,070,300

Source: Gusau Master plan 2010, Zamfara State Water Board Gusau, (2015)

*This is just the supply form water Board, when added to the other sources the short fall for the year 2015 based on the on the estimated population of 440,703 people would be 31.878, 300litres. Based on 100litres per capital per day assumed by the study, 440,703,000 litres are required per day. The quantity supplied to the town from the combined sources is about 12,192,000 litres, which can satisfy only 27.7% of the demanded quantity in the town. Therefore, there is a shortfall of about 31,878,300 litres per day. Presently, the per capital consumption in the town is 27.7litres per day.

It is clear therefore that, water problem is acute, as the gap between what is demanded and what is supplied is too wide. Only about a quarter of the demanded quantity is supplied to the town.

Table 7: Gusau Water Demand, Supply and Shortfalls per District

District	Population	Demands Quantity (100/c/d)	Supplied Quantity (litres)	Shortfall (litres)	Demand Met (%)
Mareri	122.075	12,207,500	3,236,000	8,971,500	26.5
Samaru	54,206	5,420,600	1,700,000	3,720,600	31.4
T/Wada	75,60	7,580,100	2,336,000	5,244,100	30.8
Janyau	79,327	7,932,700	2,116,000	5,816,700	26.7
G/Biyu	109,294	10,929,400	2,804,000	8,125,400	25.7
Total	440,703	44,070,300	12,192,000	31,878,300	27.7

Source: Field Survey, (2015)

Fig 3: Gusau, Water Supply Per District per Day

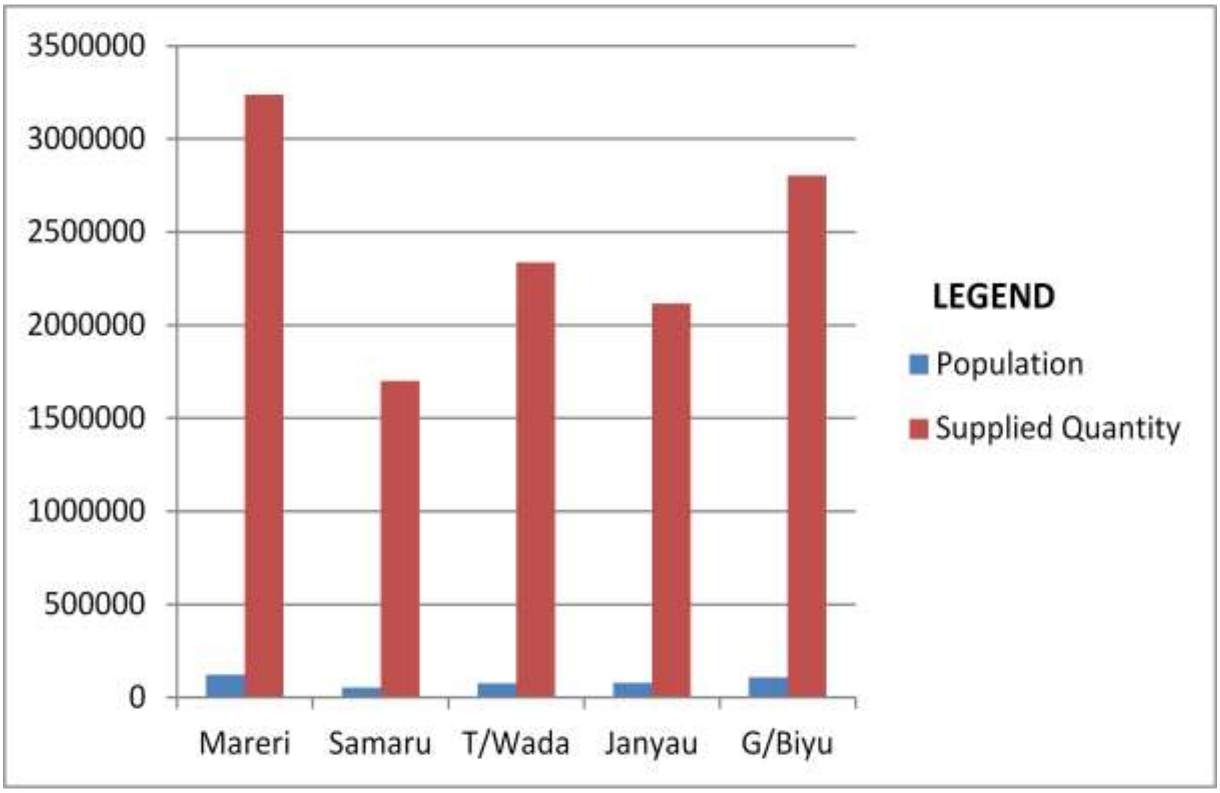
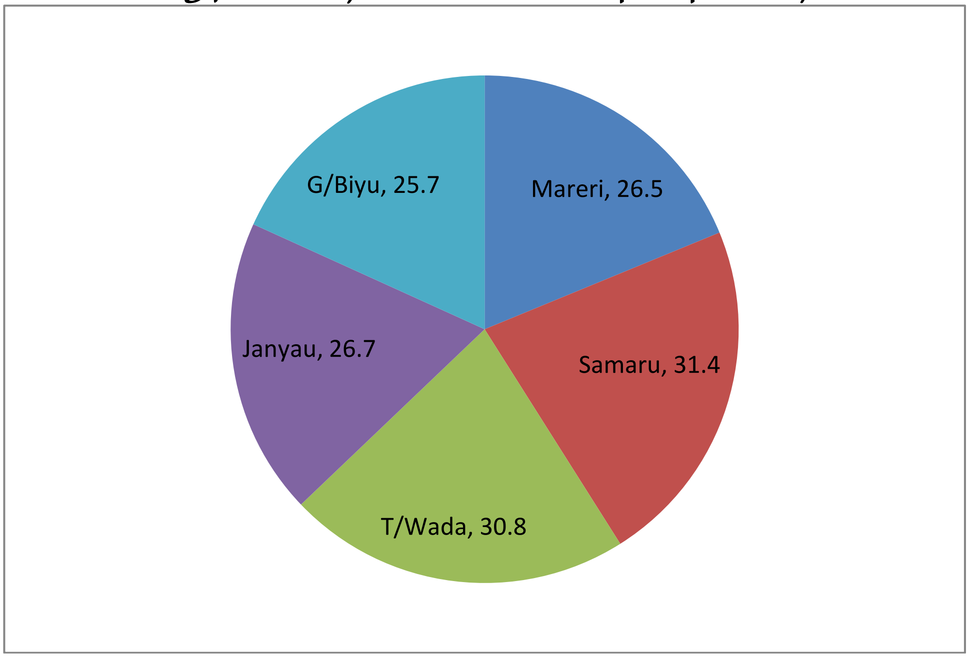


Fig4. Gusau, District Per Capita per Day



It is established in Fig.4 that, Samaru and Tudu Wada have the highest per capita in the planning district, in fact above the general figure of the town (27.7litres). It also reveals that there is variation in the degree of water shortage across the planning district, which could be attributed to variation in the population density between the districts.

Table 8: Average Duration of Water Supply in the Planning District

Planning District	Average Supply (Day/Month)	Average Supply (Hrs/Day)
Mareri	6	2
Samaru	10	4
Tudun wada	8	2.5
Janyau	7	2
Gada Biyu	7	1.5

Source: Field Survey, Zamfara State Water Board, Gusau (2015)

Table 8 depicted that there is variation in the duration of water supply between the district with Samaru having the highest flow duration (in days and hours). The average flow duration in the town established from the survey is Eight (8) days in a month and 2.5 hours per day. This is another indication of water shortages in the town where by the duration of water flow is for just some hours and days that are very insignificant to satisfy the demand.

Rainfall Condition in Gusau

In the study area, the beginning of the rainy season is April, usually characterized by slight rain which last for a short duration depositing about 2.2mm to 19.0mm. The annual rainfall statistics collected from Nigeria Meteorological services Gusau, which is our reference station for the study area, showed that rainfall has not been consistent especially with reference to its volume (see table10). There is no variability in the annual mean of temperature and rainfall.

There is also some level of variability with reference to decadal rainfall. In this regard the 1st decade is the most rainy decade having decadal mean volume of 747.8mm with the second decade (2001-2010) having 744.0mm decadal mean volume. It can be deduced therefore that, there is a slow downward trend; a fact corroborated with the study carried out by Ngongondo (2006) on rainfall variability and ground water availability in southern Malawi.

Table10: Mean Annual Rainfall in Gusau

Year	Mean Annual Rainfall (mm)	Decades	Decadal Total Mean Annual Rainfall (mm)	Decadal Mean Annual Rainfall (mm)
1991	909.7	1991-2000	747.8	62.3
1992	1344.2			
1993	1242.5			
1994	767.5			
1995	767.5			
1996	1074.2			
1997	791.1			
1998	644.8			
1999	957.2			
2000	862.1			
2001	733.2	2001-2010	744	62.0
2002	904.6			
2003	1095.8			
2004	752.4			
2005	926.3			
2006	966.9			
2007	615.8			
2008	954			
2009	909.2			
2010	89.1			

Source: Nigerian Meteorological Agency, Gusau, (2015)

RULE:

Shortage rainfall: 600mm – 700mm
Enough: - - - - - - 700mm – 900mm
Flood Expectation: - - - 900mm – 1000mm and above

Table13: Rainfall Variability, 1991 - 2010

S/No.	Status	No. of Year	Percentage
1.	Shortage (600mm-700mm)	2	10
2.	Enough (700mm-900mm)	7	35
3.	Flood Expectation (900mm-1000mm & above)	11	55
Total		20	100

Source: Nigeria Meteorological Agency, Gusau

Thus, it reflect from the table above that, Gusau received substantial rainfall throughout the decades (expected to be enough for urban consumption throughout the year) with only 2years (10%) having shortage in rainfall. Therefore, it can concluded that climate change (Rain fall) has no or little impact in the persistent water shortage in Gusau. In agreement with the above, Abaje et al (2012) in a study carried out on "*Recent Trend and Fluctuation of Annual Rainfall in the Sudano-Sahelian Ecological Zone of Nigeria: Risk and Opportunities*" stated that, the 30 year overlapping sub-period analysis of the occurrence of wet and dry years, for the sub-period 1969 – 1998, was significantly drier than the long term mean for all the station except Yelwa and Gusau that had normal condition.

CONCLUSION AND RECOMMENDATION

Attempt was made to appraise the present situation of potable water supply system in Gusau. Water demand and the supply side was established in the planning districts and town in general as well as the comparism between the two, to establish the shortfall. In addition, rainfall condition in the town was also discussed. Thus, it was recommended by the study that, consorted effort should be made by the people, civil societies, government as well as NGOS for the amelioration of the adverse effect of water shortage in Gusau, by inculcating water usage discipline for proper conservation of the resources.

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Agroforestry: A Way Forward for Organic Agriculture and Environmental Sustainability

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Pp 115-128

Abstract

The paper highlights on the importance of agroforestry as a form of multiple land-use system on organic farm management and other ecosystem services. The study was conducted in Ibesikpo Asutan Local Government Area of Akwa Ibom State, Nigeria. It also emphasizes on the environmental importance of agroforestry practice especially climate change mitigation. Some of the indigenous agroforestry tree species which can enhance organic matter availability in the soil through their prunings were also highlighted. This paper also showed that agroforestry fosters numerous benefits to man and other components of the environment such as animal husbandry, organic manure, crop production, environmental protection, timber production and other benefits which may be the provision of livefences, provision of staking materials for climbers, provision of aesthetic values to the environment and nutrient recycling. The paper shows how the organic farming systems can be carried out without involving the application of inorganic substances either for the supply of required nutrients by plants to the soil such as inorganic fertilizers, or for the control of insects, pests and diseases in the farm in the form of herbicides, rodenticides, fungicides and other agrochemicals. The paper stressed that organic agriculture should be encouraged by using the organic materials of biological origin which do not deplete the ecosystem but rather encourage sustainable management of the environmental resources and its utilization.

Key words: Agroforestry, Organic Agriculture, environment.

INTRODUCTION

From time immemorial, the existence of man and other animals on planet earth were without a threat of food insecurity and environmental pollution. But due to increase in population, urbanization and development have led uncontrollably to destruction of the natural forest and other vegetations that ensured soil organic matter and environmental protection (Etuk *et al.*, 2009). There are two major factors that may lead to the drastic change in our environment. These factors are natural and artificial otherwise called anthropogenic factors. The natural factors are those that are not initiated by man such as lightening, thunder storm, earthquake, volcanic eruption, flooding, disease outbreak, wind storm, etc. On the other-hand, anthropogenic factors are human induce factors such as poor agricultural practices including bush burning, continuous cropping and overgrazing (Etuk, 2015). Others are application of excessive inorganic fertilizers and fumigation of the environment with toxic chemicals such as herbicides and insecticides as well as dumping of toxic wastes in our ecosystems (Etuk, 2016). Apart from these, there are also the excavation of soil for sand, clay and gravel and also through mining activities. All these result at the destruction of natural vegetation which is a vital component of the ecosystem that would ensure soil protection and stability against agents of destruction such as erosion (Iwena, 2002).

It is on this background that the introduction of agroforestry is very vital in order to enhance the organic farming practice. Agroforestry is relatively new term for an ancient practice of multiple land-use system that combines wood production or tree planting with agricultural crops and/or animal production so as to obtain high productivity, more economic returns, and social benefits on sustainable basis than obtained from monoculture on the same piece of land (Etukudo, 2000). Simply put, agroforestry is a form of multiple land-use system which involves a deliberate integration of trees and shrubs in crop and livestock production system. Vegetative cove and biological diversity are not only essential to the maintenance of stable environment, but also important in the maintenance of agricultural systems (Udofia, 2011).

In monoculture, farming can be extensively protective but it requires intensive management, heavy application of fertilizers to replenish the continual drain of nutrients and careful attention must be paid to disease outbreaks and predation which can wipe out the entire crop population (Udo, 2001). The limited nature of the land area has posed a serious threat to such orthodox farming methods such as bush fallow and shifting cultivation which could have been of immense benefit in maintaining and enhancing the fertility and stability of the soil. The adoption and intensification of agroforestry in our farming systems may be the only substitute in raising the agricultural production in the country, replenishing of soil nutrients and checking the desertification threats especially in the northern parts of Nigeria (Glover, 1989).

The cultivation of fast growing species of leguminous trees and shrubs species could be the alternative source of nutrient to the soil which may fit within the existing farming systems and be adopted to economic realities of the farmers. Leguminous trees and shrubs have been used for generations as multipurpose resources (food, fibre, fodder, timber, wood, organic matter, nitrogen fixation, nutrient recycling and livefences) across all the agro-ecological zones of sub-saharan Africa (Smith *et al.,* 1997).

The unique abilities of some indigenous and exotic agroforestry tree species such as *Anthonotha macrophylla, Lonchocarpus griffonianus, Dactyladenia barteri, Leucaena leucocephala, Gliricidia sepium, etc.,* are to fix nitrogen to the soil, ensure soil organic matter, replenish soil nutrient status as well as protecting the soil against erosion and other environmental hazards (Etuk, *et al.,* 2010). They act as major source of organic manure to farmers (Etukudo, 2003). This natural ability to fix N to the soil is due to the possession of root nodules which provides living habitat for the N-fixing bacteria such as *Rhizobium leguminosarum,* Azotobacter, Nitrobacter and Clostridium. These bacteria are capable of tapping free N from the atmosphere into root nodules of legumes, which when they die, the nutrient returns to the soil for plant growth (Giller and Wilson, 1991; Nwoboshi, 2000).

Besides nodulation, which supplies direct N to the soil, the prunnings from these species also supply diverse quantities of macro and micro-nutrients to the soil for high yield and productivity of crops as well as acting as ornamentals, windbreakers, shade trees, stabilization of hill slopes and other environmental services (Etuk *et al.,* 2010).

The term organic farming or organic agriculture, is a practice that is environmentally friendly, it is a farm practice which involves the cultivation of crop without the use or application of chemical substances such as fertilizers, herbicides, fungicides, pesticides, rodenticides, etc., as a source of supply of required nutrient elements to crops or protection against pests and diseases (Udoh *et al.,* 2016). This system of farming involves the use of plant and animal residues such as dead leaves, branches, stems and roots of plants as well as animal remains and dungs. These form the organic matter content of the soil, thereby improving the nutrient status of the soil when decayed. It also increase the population and activities of soil micro-organisms as well as control of soil erosion and leaching (Udofia and Okeke, 2015).

MATERIALS AND METHODS

The study was conducted in Ibesikpo Asutan Local Government Area of Akwa Ibom State. The LGA has two (2) clans which are Ibesikpo and Asutan Ekpe clans. Each clan was stratified into four (4) segments, making a total of eight (8) segments, out of which two (2) segments from each clan were randomly selected for enumeration, totalling four (4) segments. Field survey/Oral interviews were conducted in the area which formed the major sources of information from the selected areas. The identification of some important agroforestry leguminous tree species in the area that can be used for organic manure, were identified. Several literatures from text books, internet, magazines and journals were used for more information on this study.

RESULTS AND DISCUSSION

Results

Table 1 result showed that there are both exotic and indigenous agroforestry tree species in the study area. The table also identified and classified the species into scientific name, family, origin, life forms, ethnic names and common names.

Table 1: Some Species of Plants that can be Used for Organic Farming in Agroforestry Identified in Study Area

Plant species	Family	Origin	Form	Ethnic name	Common name
Leucaena leucocephala	Mimosaceae	Exotic	Tree/shrub	Ama uto	Lead tree
Gliricidia sepium	Mimosaceae	Exotic	Tree/shrub		
Cassia siamea	Caesalpiniaceae	Exotic	Tree	Adaiya okon	Candle bush
Pentaclethra macrophylla	Mimosaceae	Indigenous	Tree	Ukana	African oil bean
Tetrapleura tetraptera	Mimosaceae	Indigenous	Tree	Uyayak	
Anthonotha macrophylla	Caesalpiniaceae	Indigenous	Shrub	Nya	
Longocarpus griffonianus	Papilionaceae	Indigenous	Shrub	Ududu	
Baffia nitida	Papilionaceae	Indigenous	Shrub	Ofuo	
Delonix ragia	Mimosaceae	Exotic	Tree		Flame of the forest
Acassia auricoliformis	Mimosaceae	Exotic	Tree	Nseto	Darwin black
Chromolaena odorata	Asteraceae	Exotic	Shrub	Owodowo	Siam weed
Tectona grandis	Verbenaceae	Exotic	Tree	Tik	Teak
Xylopia aethiopica	Annonaceae	Indigenous	Tree	Ata	African pepper
Dacryodes edulis	Burseraceae	Indigenous	Tree	Eben	Bush butter
Persia americana	Lauraceae	Exotic	Tree	Eben mbakara	Avocado pear
Khya ivorensis	Meliaceae	Indigenous	Tree	Enangeto	
Canarium schweinfurthii	Burseraceae	Indigenous	Tree	Eben etidong	African canarium
Pygnanthus angolense	Myristicaceae	Indigenous	Tree	Abakang	African walnut
Nauclea diderichii	Rubiaceae	Indigenous	Tree	Opepe	Opepe
Chrysophyllum albidum	Sapotaceae	Indigenous	Tree	Udara	African star apple
Alstonia boonei	Apocynaceae	Indigenous	Tree	Ukpo	Stool wood
Terminalia catarpa	Combretaceae	Exotic	Tree	Mbansang mbakara	Almond tree

Gmelina arborea	Verbenaceae	Exotic	Tree	Eto udaikang	Gmelina
Vigna ungoiculata	Papilionaceae	Exotic	Climber	Okoti ekpo	Mecuna beans
Irvingia gabonensis	Irvingiaceae	Indigenous	Tree	Uyo	Bush mango
Elaeis guineensis	Arecaceae	Indigenous	Tree	Eyop	Oil palm tree
Coula edulis	Sterculiaceae	Indigenous	Tree	Ekom	

Fig1 showed that agroforestry tree species can provide forage species for feeding livestock, it can be used to generate organic manure as well as timber and crop production. It also revealed that agroforestry tree species can protect the environment.

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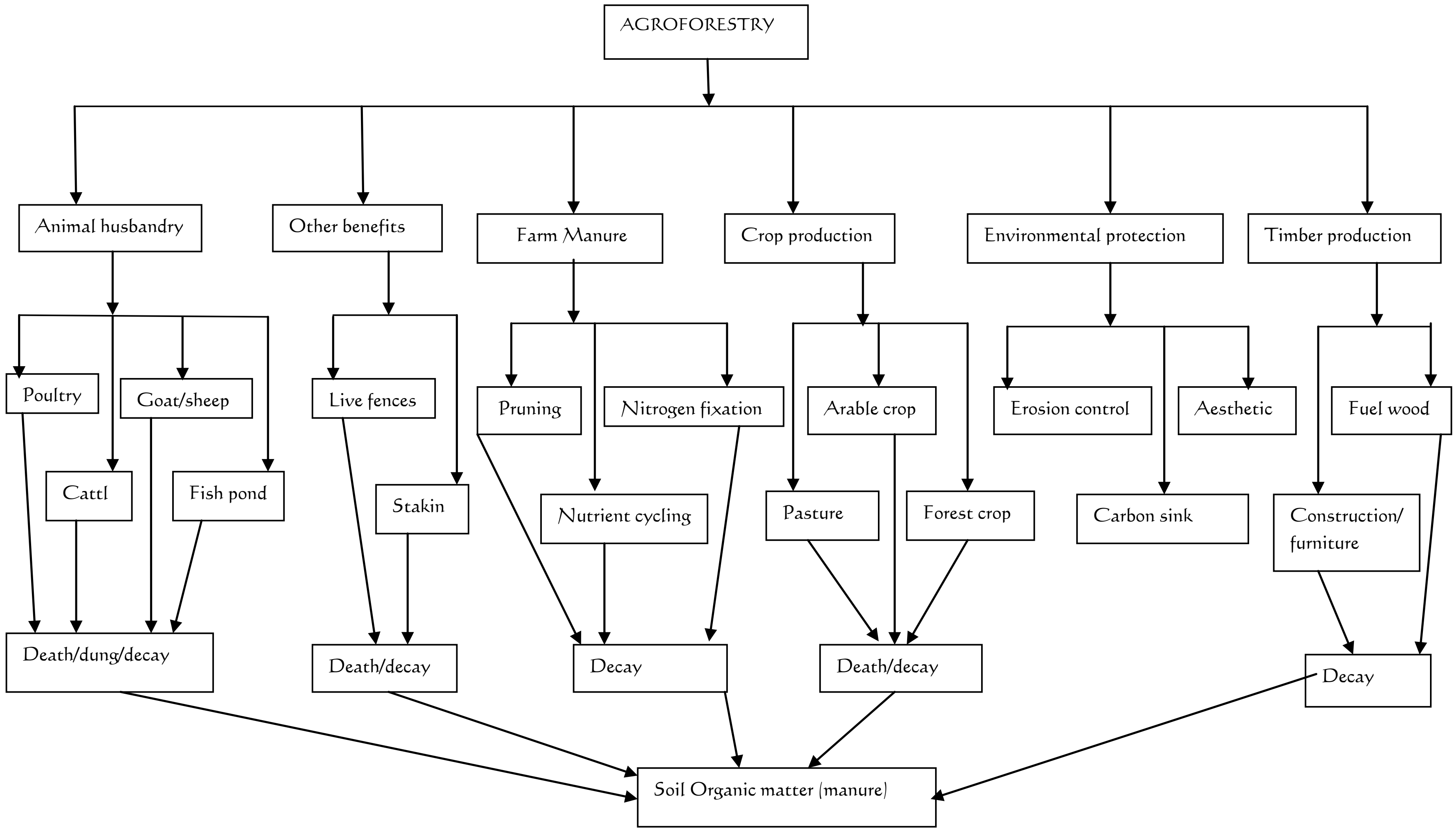

Fig. 1: Organogram illustrating the organic matter formation in organic farming

DISCUSSION

Animal Husbandry: Agroforestry practice enhances the management of animals (livestock) on the same piece of land. There are many breeds of animals which can be raised along with tree crops under agroforestry system such as rearing of cattle, goat, sheep, poultry, fishery, snailery, apiary, etc. In this system, some of the agroforestry species which serves as forages are pruned and given to the animals such as *Palisota hirsota, Dactyladenia barteri,* and *Gmelina arborea, etc.* Under this system of management, the dungs and litters through prunnings and dead plant parts can be used as organic manures in the farm.

Other Benefits: Agroforestry provides increase benefit to our environment such as the provision of live fences and staking materials. This is a system whereby some selected species of agroforestry tree species in which some of them are legumes which can fix free nitrogen to the soil. These species are mostly use for boundary demarcation as well as staking for our crops such as *Dioscorea spp*. They are commonly used by our rural dwellers who may not afford constructing concrete fencing in order to demarcate one land or compound from the other. These species of live fences such as *Anthonotha macrophylla, Longocarpus griffonianus, Dactyladenia barteri, Bafia nitida, Snestis ferruginia, Newbouldia leavis, etc.,* can survive under difficult environmental condition in which most of them are shrubs. Their remains are very good sources of organic manure which can enrich our farms with required nutrients by augmenting soil fertility status.

Manure: Some of the agroforestry tree species can be grown on a piece of land for the augmentation of nutrient status. Most of these species are fast grown leguminous species which are capable of fixing free nitrogen to the soil. The legumes have the unique ability of fixing nitrogen to the soil through their root nodules. Nitrogen fixing bacteria such as *Rhizobuim leguminosarum* and, Asotobacta and Clostridium, tap free N from the atmosphere and live in root nodules of leguminous plants. In this case, they operate in both symbiotic and non-symbiotic associations whereby the leguminous plants provide habitat for nitrogen fixing bacteria while the bacteria provide the legumes with free N (Iwena, 2012). This N is released to the soil for plant use, when root nodules die (Etuk *et al.*, 2010).

In relation to this, forest tree species can also enrich the soil with plant nutrients through the nutrient recycling process. This process is enhanced by the species because of the possession of long tap root system that can penetrate to the deeper layer of the soil. The root system of these species through the osmotic process will absorb in solution the nutrient elements which had gone beyond the root zones of shallow feeder crops and translocate to all parts of the plant especially the leaves. When the leaves and other parts of the plants are dead and fallen, they return the nutrients to the upper layer of soil through the decaying process by bacteria and other soil organisms.

Crop Production: Crop production is another opportunity obtained from the practice of agroforestry. This system ensures the production of arable crops, pasture crops for feeding livestock as well as forest crops such as *Gnetum africanum, Heinsia crinata, Lasienthera africana,* and *Gongronema latifolium.* Apart from conquering hunger and poverty in the society, it also helps immensely to improve soil nutrient capacity. This is possible when crops under agroforestry system are harvested and the remains in the farm are dead and decayed by soil organisms (Etim *et al.,* 2009).

Environmental Protection: Environmental protection and safety are unique benefits derived from agroforestry. Different parts of plants such as leaves, stems, roots and fruits have different functions to perform towards environmental amelioration. The agroforestry trees species and other vegetations in our environments contribute immensely in the protection of soil against erosion. The root systems of plants are capable of providing a barrier against the movement of materials by erosion from one location to another. It helps to stabilize the soil particles against run-off especially in difficult terrain. The leaves of plants prevent the direct velocity of rain drops from splashing the soil particles mostly when the canopies of the tree species are closed.

Plants also ensure the absorption of carbon (iv) oxide (CO_2) from the atmosphere. Although deforestation has drastically and dramatically reduced the population of plants that could serve the biosphere from destruction, yet its role in environmental amelioration cannot be over-emphasized especially its ability to sequester carbon (Cannel and Milne, 1995). Plants have the potential to absorb CO_2 from the atmosphere and returns oxygen (O_2) to the atmosphere in which all animal life forms depend on (Cunningham and Cunningham, 2002). Plants also provide habitat for wild animals, ensure genetic bank through in-situ and ex-situ conservation. It also protects the soil against agents of erosion, leaching, and flooding. About 70% of the drugs are produced from the plants, therefore, extracts from plants are used by both traditional and conventional medical practitioner for the treatment of various types sicknesses (Obute, 2005). Plants provides micro-climate, ensures ecosystem stability and sustainability as well as biodiversity conservation and preservation. Some plants are effectively used in soil rehabilitation, restoration and reclamation. These are enhanced by some fast grown leguminous tree species especially during this era of climate change.

Plants species are also used as ornaments for the beautification of our environment, some plant species and their parts can be used effectively in landscape technologies such as *Hybiscus surathensis, Psisalpinea pulcherima, Pinus caribea,* date palms, etc. They provide aesthetic values to our environments and other ecosystem services (Iwena, 2002).

Timber Production: Timber is another valuable product obtained from agroforestry practice. Timber provides materials such as rafters, poline, planks, etc., for building and construction companies. It also offer raw materials for pulp and paper industries. Timber provides useful by-products used as fuel wood for generation heat energy in both domestic and industrial uses. Trees from agroforestry also supply raw materials for the construction and production of furniture. In this case, the organic farming can also be enhanced because the ashes from burnt wood, wood wastes and saw dusts used on our poultry can be applied to the farm to reduce soil acidity as well as adding nutrients required by plants to the soil.

CONCLUSION

The organic farming is a practice which ensures soil nutrient augmentation without polluting the ecosystem. Unlike the application of chemical or inorganic fertilizers which involves the introduction chemicals that can be toxic to the environment and its components. These toxic materials can be absorbed by plant roots in solution through the osmotic process and be distributed to all parts of the plant, when the plants are harvested and consumed by man and other livestock, may be injurious to health. Also, agroforestry ensures a better atmosphere for conservation of biodiversity through in-situ and ex-situ conservation strategies. The organic farming intensification through agroforestry practices will to a larger extent ensure environmental amelioration and sustainability. Therefore, organic farming should be practiced and farmer should be encouraged by training on the management of their farms with the generation and use of organic materials in their farms. This will reduce high cost of purchasing inorganic fertilizers, ensures high productivity in sustainable basis and ecosystem safety.

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