

PROCEEDINGS OF THE FIRST INTERNATIONAL CONFERENCE OF THE INTERNATIONAL SOCIETY OF TROPICAL FORESTERS, NIGERIA CHAPTER

**THEME: SUSTAINABLE PRODUCTION
AND CONSUMPTION OF FOREST
PRODUCTS**

Held at the FORESTRY RESEARCH INSTITUTE OF NIGERIA FROM 14TH TO
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THEME

***SUSTAINABLE PRODUCTION AND
CONSUMPTION OF FOREST PRODUCTS***

Proceedings of the 1st International Conference the International Society of Tropical Foresters, Nigeria Chapter

Held in Ibadan, Oyo State, Nigeria
14th – 16th February 2023

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Welcome Address of the President

The Director General, Forestry Research Institute of Nigeria. The Keynote Speaker: Professor S. O. Akindele. All special guests. Members of the high table. Members of the International Society of Tropical Foresters (Nigeria Chapter and Global). Members of the Press. Distinguished Ladies and Gentlemen.

It is with gratitude and great pleasure that I stand before you to welcome you and speak about a journey that has been tough but fruitful. This is the first international conference of the ISTF-Nigeria Chapter. The conference has been tagged : Sustainable Production and Consumption of Forest Products.

I want to give a quick background on how I came to be part of ISTF, because I know this might be of interest to you. I joined ISTF as an undergraduate student in the early 2000s, when the internet was still a luxury and sending emails were challenging. For many years, the Society was inactive and had no strong presence in Nigeria. But in 2019, Sheila Ward the Coordinator of ISTF Global got in touch with many of us asking us to fill a form to indicate our interest in forming a Nigerian Chapter. This led to the formation of a steering committee which initiated the process of creating a chapter.

The steering committee appointed me to coordinate the process and this led to the drafting of a set of byelaws for the Nigerian chapter. The byelaws were ratified after a long process by 98 members on 26 August 2020. This allowed us to organize an election which led to the emergence of the current executive on 30th November 2020.

The COVID 19 pandemic, the fact that we were starting from the scratch and the need to establish structures meant that we had a very slow start. However, these challenges have helped us to create a virtual space and an active virtual community where our members have continued to interact. We have attempted many programmes but the major achievement so far has been the organization of this conference. The executive has been working on the registration of the Chapter with the Corporate Affairs Commission and the process is about to enter a critical phase.

ISTF-Nigeria has experienced remarkable growth in membership with over 485 people, from across Nigeria, registering their interest to be part of the chapter. However, we plead for more support from our members because we can only achieve our goals, if we are committed and dedicated. For example, only 37 people are financial members and have paid their membership dues in 2023. We have so much to do and we want to work together to push the frontiers of forestry to greater heights.

Our aim at ISTF Nigeria is to promote collaboration across the globe, among foresters and to ensure that Nigeria is not left behind in the realization of the sustainable development goals (SDGs). We all know that tropical forests continue to play a significant role in the actualisation of the SDGs, with at least 4 SDGs strongly linked to forests. Hence our objectives are to:

- Promote better understanding of tropical forestry and sustainable land use practices
- Facilitate the exchange of information and build awareness on tropical forest science
- Promote research and dissemination of scientific knowledge
- Contribute to the sustainable management of tropical forests
- Promote equitable and ecologically sustainable land use practices
- Cooperate and collaborate with other organizations
- Respect diversity in all its cultural, religious, economic and personal manifestations
- Maintain fairmindedness by not being involved in, sponsoring or carrying out (partisan) political activities.

First International Conference of ISTF Nigeria Chapter

We will continue to work hard and strive to ensure that stakeholders in Nigeria, pay attention to the urgent need for sustainable production and consumption of forest products. We know that this is key to the realization of **sustainable management of renewable forest resources. If we must combat climate change, alleviate poverty and contribute to the progress, prosperity and well-being of the current and future generations.**

In this conference, there are over 30 scientific papers to be presented by forest scientists from different sectors in the country. This is a positive development considering that the conference is a first of its kind. We are indeed grateful to the Director General and management of Forestry Research Institute of Nigeria, for accepting to host this conference. The Director General (Professor Sola Adepoju) and his team provided tremendous support and encouragement, that ensured we have all made history, today.

We also thank the Keynote Speaker (Professor S. O. Akindele), who not only accepted to be our speak, but also graciously agreed to become a member of our Board of Trustees. The confidence and trust reposed in our ability to do great things is greatly appreciated.

We appreciate Sheila Ward and Leaders of ISTF-Global, particularly the Secretary of ISTF-Global (Michael Adedotun Oke) for their support. I want to thank the members of the steering committee (Prince Usoro Evansley, Mr. Bolanle-Ojo O. T., Dr Olusola Johnson, Dr. Francis Okosodo, Dr. Joseph Okpotu, Mr. Adamu Abubakar, Mrs. Nkechi Isienyi, Dr. Ademola Olatunji, Dr. David Ladipo, Dr. Jerry Oyewo, Dr. Titus Ampitan, Mr. Michael Adedotun); their cooperation, while we worked out the structure of ISTF-Nigeria.

We appreciate the Conference, Scientific and Local Organising Committees for making the conference a reality. To members of the executive, you have all been excellent. To fellow scientists and stakeholders in forestry, I once again ask that, we look at the way forward. How can we be proactive in institutionalizing sustainable forest management in Nigeria?

Thank you for listening and I wish you all a successful conference.

Samuel Olajuyigbe
President
ISTF-Nigeria Chapter

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WELCOME ADDRESS: DIRECTOR GENERAL, FORESTRY RESEARCH INSTITUTE OF NIGERIA

PROTOCOLS!

I am delighted to welcome you all to the 1st International Conference of the International Society of Tropical Foresters Nigeria Chapter, holding today in the Institute. The theme of the Conference tagged ***‘Sustainable Production and Consumption of Forest Products’*** is a matter of global discourse considering the unwholesome and exploitative interaction of man with the environment. This counterbalance interaction of man with the environment has contributed substantially to the various environmental challenges the whole world is experiencing today. Nevertheless, the theme of the conference calls for renewed collected actions dedicated to building a green, healthy and resilient future with forests.

You may recall that overtime, Nations around the world including Nigeria have committed to various international agreements and global sustainable treaties including Paris Agreement on Climate Change, 2030 Agenda for Sustainable Development, the Global Forest Goals, United Nations Decade on Ecosystem Restoration, 2050 Vision for Biodiversity, 2021 Glasgow Declaration among others. Recently, COP 27 in Egypt resulted in the breakthrough agreement to provide “loss and damage” funding for vulnerable countries hit hard by climate-related disasters, while COP 15 in Montreal Canada birthed the adoption of the Kunming-Montreal Global Biodiversity Framework targeted at halting and reversing biodiversity loss by the end of the decade. All these agreements and treaties are geared towards one common goal, which is **saving the green planet from mostly human induced disruptive activities threatening human existence, while ensuring harmonious co-existence of man and nature.**

However, advancing sustainable production and consumption within the context of forests and forest products would require turning declarations, treaties and pledges into concrete actions. These far-reaching and more inclusive actions must respond to prevalent and future challenges to drive the kind of transformative changes required to ensure sustainable management of forests for people and for the planet.

Distinguished ladies and gentlemen, as we all know, forests underpin life on Earth and have a key role in sustainable development. Forestry sector remains an important natural capital asset in the attainment of national development objectives, particularly in boosting economic activities, employment creation, income generation, provision of goods and services, poverty alleviation, environmental security and sustainability. It further provides a win-win nature-based solution with environmental, social and economic resilient benefits for protecting, restoring and sustainably managing ecosystems toward addressing critical planetary environmental challenges. The benefits of forests to human existence are innumerable. As well as producing forests and forest products, forests provide solutions to challenges including poverty eradication, environmental sustainability, food security and agriculture, energy, clean

water and watershed protection, biodiversity conservation, climate change, desertification and land degradation, and disaster risk reduction. Unfortunately, the valuable forest ecosystems of the country are under increasing pressure from deforestation, advances in industrialization, encroachment, degradation and unsustainable practices.

Forests cover nearly a third of the earth's surface and support the livelihoods of more than 1.5 billion people around the world. Yet, 80% of natural forests have either been cleared or degraded with the world losing over 12 million hectares of primary forests between 2019 and 2020. Particularly, it is worrisome to note that the world's human population is increasing at an alarming rate. This is unfortunately accompanied with heightened dependencies on and demand for the finite and depleting forests and forest resources, especially the production and consumption of forest-based products. This is consequently associated with lopsided imbalance on sustainable production and consumption without due consideration for the present and future generation.

At this juncture, let me stress that achieving sustainable consumption and production of forests and forest products is hinged on efficiency and productivity gains, while ensuring that human activities remain within the carrying capacity of the planet, as well as respecting the rights of future generations. Consequently, one way forward of ensuring sustainable production and consumption of our inherent forest products involve technological improvement in the utilization of these products as well as introduction of policies to support legally and sustainably produced forest products in consumer markets in the country. Also, implementing sustainable production by developing a production system that increases resource efficiency and reduces biodiversity loss, ozone layer depletion, greenhouse gas emissions, waste management, and deforestation, is another advancement to ensure sustainability.

Distinguished Ladies and Gentlemen, without much ado, permit me to congratulate the organizers of this international conference, holding for the first time in Nigeria and hosted by the Institute. Finally, I wish you all fruitful deliberations with progressive outcomes.

1ST ISTF CONFERENCE, IBADAN 2023

ORDER OF PROGRAMME FOR THE OPENING CEREMONY

10.00 - 10.05am	Opening Prayer	
10.05 - 10.10am	National Anthem	
10.10 - 10.15am	Welcome Message from COC Chairman	Dr. J. A. Olusola
10.15 - 10.20am	Opening Remarks	Sheila Ward (Coordinator, ISTF Global)
10.20 - 10.30am	Welcome Speech	President, ISTF-Nigeria Chapter (Samuel Olajuyigbe)
10.30 - 10.40am	Host's Opening Remark / Declaration of Conference Open	Director General, FRIN (Professor A. O Adepoju)
10.40 - 10.45am	Goodwill Messages	
10.45 – 11.30am	Keynote Address	Professor S. O. Akindele
11.30 - 11.40am	Response/Presentation of Gifts	
11.40 – 11.55am	Group Photographs	
11.55 – 12.05pm	Inauguration of new branches	President ISTF Nigeria Chapter
12.05 -12.15pm	Announcements/Vote of thanks	Dr. Jerry Oyewo
	Closing	



Nitrogen Mineralization Rate in Soil Amended with Organic and Inorganic Fertilizer for Production of *Morinda citrifolia* L.



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Abstract

Nitrogen (N) plays a key role in agriculture systems by increasing crop yield. An understanding of the rate of N mineralization in the soil for *Morinda citrifolia* production will help to achieve a cost effective N fertilizer application. Hence, an incubation study was conducted to investigate the effects of organic amendments on soil N release. The experiment was a 2 x 8 factorial experiment: top soil and river sand amended with 160 kg N ha⁻¹ biochar, biochar + Poultry manure (PM), PM, N:P:K 15:15:15, biochar + N:P:K, PM + N:P:K, biochar + PM + N:P:K and control. Data collected were subjected to Analysis of Variance (ANOVA) using Genstat statistical software package. Significant means were separated using Duncan's Multiple Range Test at $p < 0.05$. Results indicated that top soil had a significantly higher level of NH_4^+ N mineral release than river sand throughout the 98 days of incubation period. Soil with N: P: K 15:15:15 (10.02 mg/kg) at 14 days after incubation (DAI) had the highest. However, at 98 DAI, soil amended with PM (1.45 mg/kg of NH_4^+ N) was significantly higher ($p < 0.05$) compared to all other amendments. Top soil for raising seedlings increased the release of NH_4^+ - N, while River sand increased the release of NO_3^- -N. It was recommended that poultry manure could be used for soil amendment and Noni in top soil will sustain the release of NH_4^+ -N and NO_3^- -N mineral to the plant over a longer period of time.

Keywords: Soil, Nitrogen, Amendment, Fertilizer, *Morinda citrifolia* and Mineralization

INTRODUCTION

Organic inputs used in soil fertility management commonly consist of livestock manures, crop residues, woodland litter, biochar, household organic refuse, composted plant biomass harvested from within or outside the farm environment for purposes of improving soil productivity (Blair and Crocker, 2000). Organic resources have multiple functions in soil, ranging from their influence on nutrient availability to modification of the soil environment in which plants grow. Apart from providing essential plant nutrients, they contribute directly towards the building up of soil organic matter (SOM) and its associated benefits (Blair and Crocker, 2000). Nitrogen is the first nutrient of concern to farmers and scientist, with regards to soil testing and fertilizer application (Massignam *et al.*, 2009). Nitrogen plays a key role in agriculture by increasing crop yield (Massignam *et al.*, 2009). Nitrogen not only enhances the yield but also improves the food quality (Ullah *et al.*, 2010). Optimum, rate of N increases photosynthetic processes, leaf area production, as well as net assimilation rate (Ahmad *et al.*, 2009). Available N is the inorganic form that can be readily absorbed by plant. The main forms absorbed directly are NO_3^- and NH_4^+ (Adepetu *et al.*, 2014). *Morinda citrifolia* - A tree in the family Rubiaceae commonly known as Noni or Indian mulberry and a variety of other names in various regions, is a small evergreen tree or shrubs that originated from Indonesia and spread to the Pacific Basin, Philippines, Japan, China, and Australia. Its fruit and leaves are a major staple or famine food in some locations and medicine or dyes in other places. It contains several

medicinal active compounds, e.g. anthraquinones, terpenoids, alkaloids, sitosterol, carotene, flavones and glycosides that exhibit various therapeutic effects such as anti-bacterial, anti-viral and anti-cancer activities (Wang *et al.*, 2002). The noni tree reaches a height of 3-10 m at maturity and it start flowering within 9 months on the field when planted. An understanding of the rate of nitrogen mineralization from fertilizer in the soil for noni production will help to achieve a successful, cost effective and environmental friendly farming of the crops. Hence the need to determine the effect of organic and inorganic fertilizer on the nitrogen release pattern of the soil used for noni production.

MATERIALS AND METHODS

Nitrogen mineralization from organic and inorganic fertilizer in two media was determined in an incubation study in the laboratory in which top soil and river sand collected from arboretum for raising seedlings in the Forestry Research Institute of Nigeria (FRIN), Ibadan were used. 100g air-dried sample of each media which had been passed through 2 mm sieve were dispensed into each incubation vessel (100ml). Poultry Manure, biochar, NPK and their mixtures were applied at rate of 160 kg N ha⁻¹ (Table 1) for each treatment separately into each plastic, mixed and kept at field capacity with deionized water. Each treatment was replicated four times and these were kept inside a laboratory incubator at 27°C for 98 days. The experiment was a 2 x 8 factorial combination with 4 replicates laid out in a Completely Randomized Design (CRD). Factor-1: Media (Top soil and River sand) and Factor-2: Amendments: T1: Control, T2: Poultry manure (PM), T3: N:P:K 15:15:15, T4: PM + N:P:K 15:15:15, T5: *Gliricidia sepium* (Gs) Biochar, T6: Gs Biochar + (PM), T7: Gs Biochar + N:P:K 15:15:15, T8: Gs Biochar + PM + N:P:K 15:15:15.

Laboratory Study

The top soil used for the study was analysed to determine the soil chemical properties. The soil pH was determined in 1:2 soil: water suspension. Ten grams of 2 mm sieved soil sample was weighed into the sample bottle and 20 ml of distilled water was added to it. The samples were stirred with glass rod for some minutes and were left to equilibrate for 30 minutes. At the end of 30 minutes the pH of the soil was taken using a standard calibrated electrode pH meter (Thomas, 1996). Total soil organic carbon was determined using acid dichromate wet-oxidation procedure of Walkey and Black method, as described by Nelson and Sommers (1996). Soil organic matter was derived by multiplying the value of SOC by a Bemmelen's factor of 1.724 (Nelson and Sommers, 1996). Total nitrogen was determined using micro-Kjeldahl method (Nelson and Sommers, 1996). Available P was determined using Bray-1 method. The available P was extracted using Bray-1 extractant and the concentration of the available P in the extract was determined by the molybdate blue method using spectrophotometer at 882 nm wavelength (Kuo, 1996). Soil samples were also extracted with 1 N NH₄OAc and Na and K were determined using flame photometer while Mg and Ca were determined from the extract with atomic absorption spectrophotometer (AAS 210-VGP) (Thomas, 1982). Soil micronutrients were analysed using atomic absorption spectrophotometer (AAS). The chemical properties of the soil amendments (biochar and poultry manure) were also determined. 0.5 g of soil amendments were weighed and digested using Sulphuric acid and selenium catalyst and N was determined by Kjeldahl method. Also, phosphorus contents of the digested organic amendments were determined by the vanado-molybdate method using spectrophotometer at 410 nm wavelength, while Na and K were determined using flame photometer. Whereas, Mg and Ca were determined from the digest with atomic absorption spectrophotometer (AAS 210-VGP) (Thomas, 1982).

Incubation study

Samples were taken at 1, 3, 7, 14, 28, 49 and 98 days after incubation and were extracted with 2M KCl for determination of ammonium – nitrogen, nitrate and nitrite - nitrogen release (Dai *et al.*, 2008; Medina *et al.*, 2009; Wang *et al.*, 2010) using the procedure of Macgill Environmental Research laboratory (MERL) 2000; where 5 ml of the filtrate from KCl was taken into a 50 ml beaker and 2.5 ml of alkaline phenol, 1 ml sodium potassium tartrate and 2.5 ml sodium hypochlorate were added and the mixture was shaken well and read colorimetrically at 636 nm to quantify ammonium nitrogen in part

Table 1: Soil nutrient sources and application rate for Noni family member (Coffee) seedlings

Nutrient element	Fertilizer type	% Carrier	Quantity (kg/ha)	required	Quantity (mg)/2kg soil
N	(Urea)	46% N	160		142.73
P	(KH ₂ PO ₄)	22.7%P, 28.73%	50		44.6
K	(KCl)	60% K	70		62.44
B	(Sodium	99% B	0.5		0.45
Zn	(ZnO)	99% Zn	1		0.89
Ca	(CaO)	99% Ca	80		71.36
Mg	(MgO)	99% Mg	40		35.68

Kinoch: VOLHOUBARE LANDBOU, RSA. 1999

per million (ppm). Similarly, 10 ml of the filtrate from KCl was taken into a 50 ml flask and 2 ml of Brucine reagent and 10 ml of concentrated Sulphuric acid were added and mixed together. Then, the mixture was allowed to stand for 10 minute before making to mark with distilled water. The solution was read colorimetrically at 470 nm to quantify nitrate nitrogen (NO₃-N) in ppm. Also, another 10 ml from the filtrate from KCl was taken into another 50 ml flask and 2 ml of 2N HCl, 2 ml sulphanilic acid and 10 ml alpha-naphthylamine were added and read colorimetrically at 520 nm after 20 minutes to quantify nitrite nitrogen (NO₂-N) in ppm.

Statistical analysis:

Data collected were subjected to Analysis of Variance (ANOVA) using Genstat Statistical Software package. Means were separated using Duncan multiple range test (DMRT) at 5% level of significance.

RESULTS

The result revealed that the top soil had pH value of 6.47 and total N value of 0.14%. The available P value was 4.26 mg/kg, exchangeable bases (Cmol⁺ kg⁻¹); K⁺, Na⁺, Ca²⁺ and Mg²⁺ had the values 0.06, 0.09, 3.0 and 0.3 respectively. The micro-nutrients (mg kg⁻¹); Mn²⁺, Fe²⁺, Cu²⁺ and Zn²⁺ had the values 57.7, 20.8, 10.5 and 16.9, respectively (Table 2). The sand, silt and clay (g kg⁻¹) were 825, 105 and 70 respectively. The amounts of total N, P, K, Na, Ca, Mg and Organic Carbon in Poultry manure added to the soil at the rate of 160 kg N ha⁻¹ were 13, 8.1, 2.0, 1.6, 15, 15, and 151 g/kg respectively. However, *Gliricidia sepium* (GS) Biochar also applied at the rate of 160 kg N ha⁻¹ had total N, P, K, Na, Ca, Mg and OC of 10.3, 2.8, 4.0, 1.4, 1.7, 1.4 and 982.8 g/kg respectively (Table 3). There was no significant difference in the interaction of amendments applied with the media at Day 1 of incubation but the rate at which NH₄⁺-N was released in top soil (3.66 mg/kg) during this period was significantly higher than that released from river sand (2.11 mg/kg). Also, there was a significant difference in the release pattern of NH₄⁺-N from amendments applied; where biochar, biochar + Poultry Manure (PM) and Control (No amendment) with 2.17, 2.52 and 2.43 mg/kg respectively were significantly lower than those of PM, N: P: K (15:15:15), biochar + N: P: K, PM + N: P: K and biochar + PM + N: P: K with 3.08, 3.23, 3.07, 3.24 and 3.37 mg/kg, respectively (Table 4). By the third day after incubation (DAI), there was a significant difference in the interaction of amendment with the soil types. NH₄⁺-N released from top soil (5.56 mg/kg) during this period was significantly higher than that released from river sand (2.93 mg/kg) which also revealed a higher NH₄⁺-N release during this period compared to that of 1 DAI (Table 4). Furthermore, amendment with N: P: K alone in interaction with Top soil at 3 DAI with 7.27 mg/kg NH₄⁺-N released was significantly higher when compared with other amendments in interaction with both soil type during this period. While amendment with biochar alone and biochar + PM in interaction with river sand had 1.70 and 1.10 mg/kg NH₄⁺-N released respectively. These were the least when compared with other amendments in interaction with the medium, during the same period. Also at seven (7) DAI, there was a significant difference (P = 0.05%) in the interaction of amendment with soils till the end of the experiment. The combination of biochar + PM + N: P: K as soil amendment recorded a significantly

higher $\text{NH}_4^+\text{-N}$ released (5.77 mg/kg) compared with other treatments. There was no significant difference between the amount of $\text{NH}_4^+\text{-N}$ released from N: P: K (4.26 mg/kg) and that of PM + N: P: K (4.29 mg/kg), while $\text{NH}_4^+\text{-N}$ released from biochar, biochar + N: P: K and control (2.47, 2.34 and 2.41 mg/kg) respectively were significantly lower, compared to those released from other amendments during the same period (Table 4). Furthermore in Table 5, biochar + PM + N: P: K and PM + N: P: K from Top soil had $\text{NH}_4^+\text{-N}$ values of 7.38 and 6.98 mg/kg respectively. These were not significantly different from each other but were significantly higher than other amendment/medium interaction at 7 days after incubation.

Table 2: Physical and chemical properties of top soil used in the study

Property	Values
Sand (g/kg)	825
Clay (g/kg)	105
Silt (g/kg)	70
Textural class	Loamy sand
pH (H_2O)	6.47
OC (%)	1.7
TN (%)	0.14
Avail. P (mg/kg)	4.26
K (cmol/kg)	0.06
Ca (cmol/kg)	3.0
Mg (cmol/kg)	0.3
Na (cmol/kg)	0.09
Mn (mg/kg)	57.7
Fe (mg/kg)	20.8
Cu (mg/kg)	10.5
Zn (mg/kg)	16.9

Table 3: Chemical properties of the Biochar and Poultry Manure used in the Study

Chemical property	Biochar (g/kg)	Poultry manure (g/kg)
Organic Carbon	982.8	151.6
Total Nitrogen	11.3	13.0
C/N ratio	86.7	11.6
Avail. P	2.8	8.1
Ca	1.7	15
Mg	1.4	15
Mn	9.4	0.28
Fe	9.4	1.02
Cu	9.8	0.04
Zn	14.7	0.4

Also, biochar interaction with River sand and River sand (control) recorded significantly lower values of $\text{NH}_4^+\text{-N}$ released (0.17 and 0.14 mg/kg), when compared with amendment/medium interaction at 7 DAI. At 14 DAI, the values of $\text{NH}_4^+\text{-N}$ released was the highest throughout the period of incubation, where $\text{NH}_4^+\text{-N}$ released from top soil (9.21 mg/kg) was significantly higher than that released from river sand (1.68 mg/kg) (Table 4). The N:P:K release of $\text{NH}_4^+\text{-N}$ (10.02 mg/kg) at this period was significantly higher than that released from other amendments during the same period (Table 4). Furthermore, there was a significant difference in the release pattern of $\text{NH}_4^+\text{-N}$ from the soil types in interaction with

amendments applied. Top soil amended with N:P:K recorded the significantly highest value of $\text{NH}_4^+\text{-N}$ (14.80 mg/kg); followed by Biochar + N:P:K with 12.37 mg/kg, then PM with 10.06 mg/kg followed by PM + N:P:K with 9.19 mg/kg. these were all significantly higher than the amount released by N:P:K from River sand (5.23 mg/kg) (Table 5). From 28 DAI to 98 DAI, Top soil with amendments maintained a significantly higher $\text{NH}_4^+\text{-N}$ release compared with River sand with amendments but the values of $\text{NH}_4^+\text{-N}$ released was generally reduced across this period (Table 4). Amendment of Biochar + PM + N:P:K released a significantly higher $\text{NH}_4^+\text{-N}$ (6.33 mg/kg) at 28 DAI but at 49 DAI and 98 DAI, PM amendment released significantly higher $\text{NH}_4^+\text{-N}$ (Table 4). Also, the interaction of amendments with soil types reveals that biochar + N: P: K interaction with top soil released a significantly higher value of $\text{NH}_4^+\text{-N}$ (9.69 mg/kg) compared to all other interactions at 28 DAI while at 49 and 98 DAI, PM recorded significantly higher $\text{NH}_4^+\text{-N}$ (7.75 and 2.71mg/kg) respectively compared to all other interaction across the same period. The amount of $\text{NO}_3^- \text{-N}$ released in this study was lower when compared to that of $\text{NH}_4^+\text{-N}$, indicating that $\text{NO}_3^- \text{-N}$ was less available in the soil and amendments. There were significant differences in the interaction of amendments applied with the soil types from first day DAI to 98 DAI where River sand released significantly higher $\text{NO}_3^- \text{-N}$ than Top soil, except at 14 DAI where the difference was not significant but river sand still maintained a higher value of 0.44 mg/kg compared to top soil value of 0.42 mg/kg of $\text{NO}_3^- \text{-N}$. Also, the N:P:K amendment released a significantly higher amount of $\text{NO}_3^- \text{-N}$ compared to all other amendments in the study irrespective of the soil medium from 1 DAI to 98 DAI with the highest amount of release available at 3 DAI (1.39 mg/kg) followed by 7 DAI (1.23 mg/kg) while the least $\text{NO}_3^- \text{-N}$ released was 0.43 mg/kg at 98 DAI (Table 4). Control soil recorded the least amount of $\text{NO}_3^- \text{-N}$ from 3 DAI to 98 DAI and was also significantly lower than that released by soils with amendments (Table 6). River sand amended with N:P:K revealed a significantly higher release of $\text{NO}_3^- \text{-N}$ than all others from 1 DAI to 98 DAI (Table 4).

The highest value of $\text{NO}_3^- \text{-N}$ released from N:P:K with river sand was 1.78 mg/kg at 3 DAI followed by 1.76 mg/kg at 7 DAI, while the least amount recorded from the same interaction was 0.65 mg/kg at 98 DAI. The interaction of top soil with PM + N:P:K ranked 2nd from 14 DAI to 98 DAI whose $\text{NO}_3^- \text{-N}$ release values were significantly higher than other interactions during the same period except for the values obtained from river sand interaction with N:P:K (Table 5). The $\text{NO}_2^- \text{-N}$ recorded the least available values when compared with $\text{NH}_4^+\text{-N}$ and NO_3^- and the interactive effect of the soil types with amendments showed no significant difference in the release of $\text{NO}_2^- \text{-N}$ from 1 DAI to 98 DAI but the differences were significant from 3 DAI to 49 DAI. At 1 DAI, 7 DAI and 98 DAI, there was no significant difference in the rate at which $\text{NO}_2^- \text{-N}$ was released in River sand compared to Top soil while River sand recorded a higher value (0.016 mg/kg) than Top soil (0.011 mg/kg) at 1 DAI. But, at 3 DAI, 14 DAI, 28 DAI and 49 DAI, top soil recorded significantly higher amount of $\text{NO}_2^- \text{-N}$ released when compared to River sand. Furthermore, the interaction of PM + N:P:K with Top soil recorded a significantly higher value of $\text{NO}_2^- \text{-N}$ (0.06 mg/kg) released at 3 DAI compared to every other interaction during the same period. Likewise, the interaction of biochar + PM + N:P:K with Top soil also recorded a significantly higher value of $\text{NO}_2^- \text{-N}$ (0.14 mg/kg) at 7 DAI compared to other interaction. This was also the case at 49 DAI, where PM interaction with top soil recorded a significantly higher value of $\text{NO}_2^- \text{-N}$ (0.38mg/kg) compared with other interactions during the same period.

DISCUSSION

The Topsoil used for the research was loamy sand (USDA, 2010), which was deficient in total nitrogen (USDA-SCS 1974) and had low available P content (ENDMEMO 2015; Mallarino 2000). In this study, Top soil released a significantly higher $\text{NH}_4^+ \text{-N}$ concentrations from amendments compared to those of River sand throughout the duration of the experiment and this is because a higher population of ammonifying bacteria are expected in top soil with higher organic matter than that of river sand. The average amount of $\text{NH}_4^+ \text{-N}$ released at 14 days after incubation (DAI) from Top soil was the highest compared to River sand throughout the duration of the experiment while top soil with N:P:K at 14 DAI was significantly higher than every other interaction in the study but at 98 DAI, soil amended with poultry manure released a significantly higher $\text{NH}_4^+ \text{-N}$ compared to other interactions (Tables 3 and 4).

Table 4: Effect of growth medium and amendment on NH_4^+ – N mineralization during 98-day incubation period

Factor	LEVEL	DAY 1	DAY3	DAY7	DAY14	DAY28	DAY49	DAY98
Medium	River sand	2.11 ^b	2.93 ^b	1.63 ^b	1.68 ^b	2.40 ^b	0.89 ^b	0.27 ^b
	Top soil	3.66 ^a	5.56 ^a	5.41 ^b	9.21 ^a	5.60 ^a	3.42 ^a	1.24 ^a
Amendment	CONTROL	2.43 ^b	3.32 ^{cd}	2.41 ^e	2.59 ^d	2.14 ^d	0.45 ^c	0.19 ^e
	PM	3.08 ^a	4.12 ^b	3.64 ^c	5.69 ^c	4.04 ^c	4.15 ^a	1.45 ^a
	N:P:K	3.23 ^a	6.49 ^a	4.26 ^b	10.02 ^a	3.96 ^c	1.52 ^{bc}	0.76 ^c
	PM + N:P:K	3.24 ^a	5.16 ^b	4.29 ^b	5.54 ^c	4.96 ^b	2.48 ^b	0.65 ^{cd}
	BIOCHAR	2.17 ^b	2.80 ^d	2.47 ^e	2.56 ^d	1.99 ^d	2.27 ^b	0.63 ^{cd}
	BIOCHAR + PM	2.52 ^b	3.54 ^{cd}	3.01 ^d	5.17 ^c	3.50 ^c	2.33 ^b	1.09 ^b
	BIOCHAR + N:P:K	3.07 ^a	3.28 ^{cd}	2.34 ^e	6.87 ^b	5.09 ^b	1.44 ^{bc}	0.43 ^d
	BIOCHAR + PM + N:P:K	3.37 ^a	5.23 ^b	5.77 ^a	5.14 ^c	6.33 ^a	2.59 ^b	0.80 ^c
Interaction								
M	X	A	Ns	0.58	0.21	0.42	0.37	0.92
								0.16

Means followed by the same letter in each column are not significantly different from each other ($P>0.05$)

Table 5: Influence of growth medium with amendment on NH_4^+ – N mineralization during 98-day incubation period

Medium	Treatment	DAY3	DAY7	DAY14	DAY28	DAY49	DAY98
River sand	CONTROL	2.73 ^{cdef}	0.09 ^j	0.14 ^g	0.36 ^g	0.17 ^{fg}	0.10 ^g
	PM	2.49 ^{ef}	1.12 ^{hi}	1.33 ^f	1.54 ^f	0.55 ^{efg}	0.20 ^{fg}
	N:P:K	5.71 ^b	3.53 ^f	5.23 ^e	5.25 ^c	0.74 ^{ef}	0.28 ^{fg}
	PM + N:P:K	3.07 ^{cde}	1.60 ^g	1.90 ^f	4.40 ^d	1.00 ^e	0.21 ^{fg}
	BIOCHAR	1.70 ^{fg}	0.18 ^j	0.17 ^g	0.13 ^g	0.05 ^g	0.01 ^g
	BIOCHAR + PM	1.10 ^g	1.46 ^{gh}	1.41 ^f	1.58 ^f	0.58 ^{efg}	0.24 ^{fg}
	BIOCHAR + N:P:K	2.64 ^{def}	0.92 ⁱ	1.36 ^f	0.48 ^g	1.05 ^e	0.33 ^{fg}
	BIOCHAR + PM + N:P:K	3.99 ^c	4.16 ^{de}	1.87 ^f	5.50 ^c	2.94 ^c	0.79 ^{de}
Top soil	CONTROL	3.91 ^{cd}	4.73 ^c	5.05 ^e	3.91 ^d	0.74 ^{ef}	0.27 ^{fg}
	PM	5.76 ^b	6.15 ^b	10.06 ^c	6.54 ^b	7.75 ^a	2.71 ^a
	N:P:K	7.27 ^a	4.99 ^c	14.80 ^a	2.67 ^e	2.29 ^d	1.23 ^c
	PM + N:P:K	7.25 ^a	6.98 ^a	9.19 ^d	5.52 ^c	3.95 ^b	1.08 ^{cd}
	BIOCHAR	3.89 ^{cd}	4.75 ^c	4.94 ^e	3.84 ^d	1.99 ^d	1.24 ^c
	BIOCHAR + PM	5.98 ^b	4.57 ^{cd}	8.94 ^d	5.43 ^c	4.09 ^b	1.93 ^b
	BIOCHAR + N:P:K	3.92 ^{cd}	3.77 ^{ef}	12.37 ^b	9.69 ^a	1.84 ^d	0.52 ^{ef}
	BIOCHAR + PM + N:P:K	6.47 ^{ab}	7.38 ^a	8.40 ^d	7.17 ^b	2.24 ^d	0.81 ^{de}

Means followed by the same letter in each column are not significantly different from each other ($P>0.05$)

This could be attributed to ammonia volatilization (Meissinger and Jokela, 2000) from soil amended with N:P:K compared to poultry manure with slow releasing nutrient potentials. On the other hand, NO_3^- - N release during the 98-days incubation period from River sand was significantly higher compared to that of Top soil and the average amount of NO_3^- - N released was the highest at 3 DAI from river sand compared to top soil throughout the duration of the study. N:P:K from river sand release was significantly higher than every other interaction in the study from 1 DAI to 98 DAI, which showed that NO_3^- - N mineral in N:P:K 15:15:15 is ready available compared to all other amendments in the study (Tables 5 and 6) and the general decrease in NO_3^- - N concentration from 14 DAI to 98 DAI could be attributed to leaching (Tom 2002; Marco *et al.*, 2002). NO_2^- - N mineral in the soil amendments were available in lower concentrations compared to NH_4^+ - N and NO_3^- - N. The rate of NO_2^- - N release was higher in top soil compared to river sand throughout the 98 days incubation period and it was at 3 DAI that the highest values were recorded. NO_2^- - N release just like NO_3^- - N was available in N:P:K more than all other amendments till 28 DAI but a significantly higher value was recorded from poultry manure at 49 DAI compared to all other amendments used in the study (Tables 7 and 8). The low NO_2^- - N contents in soil applied with NPK fertilizer from 28 - 98 DAI compared with 14 DAI could be attributed to acidic properties of NPK fertilizer, because acidity reduces soil microbial activity and this would in turn reduce nutrient mineralization (Xu *et al.*, 2002).

CONCLUSION

The use of Top soil for raising seedlings increases the release of NH_4^+ - N while River sand increase the release of NO_3^- - N. The application of N:P:K 15:15:15 would stimulate microbial activities for early release of NH_4^+ - N from the Top soil, but Poultry Manure will in the long run sustain a continuous NH_4^+ - N release to the plant. N:P:K 15:15:15 in combination with poultry manure is also recommended for use, when NO_3^- - N mineral is required for Noni production in river sand at nursery stage.

RECOMMENDATION

It is recommended that poultry manure be used for soil amendment for Noni production in top soil to sustain the release of NH_4^+ - N and NO_2^- - N mineral to the plant over a longer period of time.

Table 6: The effect of growth medium and amendment on NO₃ – N mineralization during 98-days incubation period

Factor	LEVEL	DAY 1	DAY3	DAY7	DAY14	DAY28	DAY49	DAY98
Medium								
Amendment	River sand	0.54	0.93 ^a	0.88 ^a	0.44	0.30 ^a	0.28 ^a	0.24 ^a
	Top soil	0.49	0.82 ^b	0.72 ^b	0.42	0.18 ^b	0.20 ^b	0.20 ^b
	CONTROL	0.49 ^b	0.51 ^f	0.53 ^f	0.14 ^f	0.06 ^f	0.05 ^e	0.05 ^f
	PM	0.53 ^b	0.84 ^c	0.69 ^d	0.30 ^e	0.12 ^e	0.18 ^c	0.24 ^d
	N:P:K	0.63 ^a	1.39 ^a	1.23 ^a	1.18 ^a	0.66 ^a	0.58 ^a	0.43 ^a
	PM + N:P:K	0.50 ^b	1.00 ^b	0.77 ^c	0.46 ^c	0.29 ^b	0.32 ^b	0.33 ^b
	BIOCHAR	0.50 ^b	0.73 ^d	0.60 ^e	0.10 ^g	0.06 ^f	0.04 ^e	0.03 ^f
	BIOCHAR + PM	0.50 ^b	0.89 ^c	0.76 ^c	0.27 ^e	0.22 ^d	0.26 ^d	0.24 ^d
	BIOCHAR + N:P:K	0.50 ^b	0.97 ^b	1.12 ^b	0.61 ^b	0.25 ^c	0.18 ^c	0.17 ^e
	BIOCHAR + PM + N:P:K	0.46 ^b	0.66 ^e	0.69 ^d	0.40 ^d	0.25 ^c	0.31 ^b	0.29 ^c
Interaction								
M	X	A	0.045	0.048	0.033	0.03	0.01	0.014

Means followed by the same letter in each column are not significantly different from each other ($P>0.05$)

Table 7: Influence of growth medium with amendment on NO₃ – N mineralization during 98-days incubation period

Medium	Treatment	DAY 1	DAY3	DAY7	DAY14	DAY28	DAY49	DAY98
River sand	CONTROL	0.47 ^{cde}	0.55 ^{gh}	0.59 ^e	0.09 ^{hi}	0.06 ⁱ	0.02 ^l	0.01 ^k
	PM	0.55 ^{bc}	0.80 ^{de}	0.62 ^e	0.14 ^{gh}	0.11 ^h	0.16 ^h	0.20 ^{fg}
	N:P:K	0.75 ^a	1.78 ^a	1.76 ^a	1.74 ^a	1.10 ^a	0.93 ^a	0.65 ^a
	PM + N:P:K	0.50 ^{cd}	0.77 ^e	0.81 ^c	0.19 ^{fg}	0.25 ^{cd}	0.25 ^d	0.26 ^e
	BIOCHAR	0.55 ^{bc}	0.82 ^{de}	0.57 ^e	0.03 ⁱ	0.06 ⁱ	0.06 ^k	0.05 ^j
	BIOCHAR + PM	0.52 ^{bc}	0.80 ^{de}	0.71 ^d	0.28 ^e	0.26 ^c	0.32 ^c	0.32 ^{cd}
	BIOCHAR + N:P:K	0.61 ^{bc}	1.29 ^b	1.42 ^b	0.75 ^b	0.34 ^b	0.24 ^{de}	0.21 ^f
	BIOCHAR + PM + N:P:K	0.37 ^e	0.65 ^{fg}	0.58 ^e	0.27 ^e	0.25 ^{cd}	0.24 ^{de}	0.25 ^e
Top soil	CONTROL	0.52 ^{bc}	0.47 ^g	0.48 ^f	0.19 ^{fg}	0.06 ⁱ	0.09 ^j	0.08 ⁱ
	PM	0.51 ^{bc}	0.89 ^{de}	0.76 ^{cd}	0.47 ^d	0.14 ^g	0.20 ^{fg}	0.29 ^d
	N:P:K	0.52 ^{bc}	1.01 ^c	0.71 ^d	0.61 ^c	0.23 ^d	0.23 ^{ef}	0.21 ^f
	PM + N:P:K	0.50 ^{bcd}	1.23 ^b	0.72 ^d	0.73 ^b	0.33 ^b	0.39 ^b	0.40 ^b
	BIOCHAR	0.46 ^{cde}	0.65 ^{fg}	0.63 ^e	0.16 ^{gh}	0.06 ⁱ	0.02 ^l	0.02 ^{jk}
	BIOCHAR + PM	0.49 ^{cd}	0.97 ^{cd}	0.82 ^c	0.25 ^{ef}	0.19 ^e	0.19 ^g	0.17 ^g
	BIOCHAR + N:P:K	0.40 ^{de}	0.64 ^{fg}	0.82 ^c	0.47 ^d	0.16 ^f	0.13 ⁱ	0.12 ^h
	BIOCHAR + PM + N:P:K	0.55 ^{bc}	0.67 ^f	0.80 ^c	0.52 ^d	0.26 ^c	0.39 ^b	0.34 ^c

Means followed by the same letter in each column are not significantly different from each other ($P>0.05$)

Table 8: The effect of growth medium and amendment on NO₂ – N mineralization during 98-days incubation period

Factor	LEVEL	DAY 1	DAY3	DAY7	DAY14	DAY28	DAY49	DAY98	
Medium									
	River sand	0.016	0.019 ^b	0.043	0.15b	0.13b	0.10b	0.11	
	Top soil	0.011	0.028 ^a	0.065	0.18a	0.14a	0.16a	0.14	
Amendment									
	CONTROL	0.006	0.009 ^e	0.019 ^d	0.060 ^d	0.049 ^f	0.073 ^f	0.105	
	PM	0.027	0.023 ^d	0.039 ^{cd}	0.065 ^d	0.089 ^d	0.267 ^a	0.217	
	N:P:K	0.017	0.033 ^b	0.103 ^a	0.474 ^a	0.306 ^a	0.198 ^b	0.119	
	PM + N:P:K	0.012	0.039 ^a	0.059 ^{bc}	0.156 ^c	0.138 ^d	0.121 ^d	0.214	
	BIOCHAR	0.01	0.012 ^e	0.017 ^d	0.022 ^d	0.021 ^g	0.020 ^g	0.013	
	BIOCHAR + PM	0.01	0.020 ^d	0.030 ^{cd}	0.043 ^d	0.059 ^e	0.105 ^e	0.102	
	BIOCHAR + N:P:K	0.013	0.029 ^c	0.086 ^{ab}	0.320 ^b	0.252 ^b	0.156 ^c	0.125	
	BIOCHAR + PM + N:P:K	0.011	0.021 ^d	0.081 ^{ab}	0.169 ^c	0.170 ^c	0.121 ^d	0.114	
Interaction									
M	X	A	Ns	0.003	0.02	0.03	0.01	0.005	Ns

Means followed by the same letter in each column are not significantly different from each other (P>0.05)

Table 9: Influence of growth Medium with Amendment on NO₂ – N mineralization during 98-days incubation period.

Medium	Treatment	DAY3	DAY7	DAY14	DAY28	DAY49
River sand	CONTROL	0.01 ^h	0.01 ^d	0.09 ^e	0.06 ⁱ	0.09 ^g
	PM	0.02 ^d	0.04 ^d	0.07 ^{ef}	0.11 ^h	0.15 ^f
	N:P:K	0.05 ^b	0.11 ^{ab}	0.48 ^a	1.10 ^a	0.25 ^b
	PM + N:P:K	0.02 ^{def}	0.02 ^d	0.04 ^{ef}	0.25 ^{cd}	0.07 ^h
	BIOCHAR	0.01 ^{gh}	0.01 ^d	0.02 ^f	0.06 ⁱ	0.01 ^k
	BIOCHAR + PM	0.01 ^{fgh}	0.02 ^d	0.02 ^{ef}	0.26 ^c	0.05 ⁱ
	BIOCHAR + N:P:K	0.03 ^c	0.12 ^{ab}	0.41 ^b	0.34 ^b	0.14 ^f
	BIOCHAR + PM + N:P:K	0.01 ^{efg}	0.02 ^d	0.04 ^{ef}	0.25 ^{cd}	0.05 ⁱ
Top soil	CONTROL	0.01 ^{efg}	0.02 ^d	0.03 ^{ef}	0.06 ⁱ	0.06 ⁱ
	PM	0.03 ^c	0.03 ^d	0.06 ^{ef}	0.14 ^g	0.38 ^a
	N:P:K	0.02 ^d	0.10 ^{abc}	0.47 ^{ab}	0.23 ^d	0.15 ^{ef}
	PM + N:P:K	0.06 ^a	0.10 ^{bc}	0.27 ^{cd}	0.33 ^b	0.17 ^d
	BIOCHAR	0.02 ^{def}	0.02 ^d	0.03 ^{ef}	0.06 ⁱ	0.03 ^j
	BIOCHAR + PM	0.03 ^c	0.04 ^d	0.06 ^{ef}	0.19 ^e	0.16 ^e
	BIOCHAR + N:P:K	0.03 ^c	0.06 ^{cd}	0.23 ^d	0.16 ^f	0.17 ^d
	BIOCHAR + PM + N:P:K	0.03 ^c	0.14 ^a	0.30 ^c	0.26 ^c	0.19 ^c

Means followed by the same letter in each column are not significantly different from each other (P>0.05)

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Cholinergic and Antioxidant Properties of *Blighia sapida*: Potential as a Biological Pest Controlling Agent



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Abstract

Natural products which are capable of reducing the activities of cholinergic and metabolic enzymes are safer pest-controlling alternatives to synthetic ones. This study compared the ability of *Blighia sapida* stem-bark extract and Rambo, (a synthetic pesticide), to interfere with acetylcholinesterase (AChE), glutathione S-transferase (GST), and biomarkers in the brain, liver, and blood of Wistar rat. The brain and liver of rats were excised and blood was collected into heparinized tubes at the end of a 28-day experiment for biochemical investigations. The activities of AChE and GST decreased at a dose-dependent rate ($P < 0.05$). There was no significant difference in the alkaline phosphatase (ALP) of the treated groups and a dose-dependent increase in total protein concentration was detected. The stem-bark extract did not significantly alter liver biomarkers like ALT, AST, and ALP, particularly at repeated low doses of 50 and 100 mg/kg. The extract of *Blighia sapida* reduced AChE and GST activity; a property that could be exploited in the formulation of pest control agents.

Keywords: Hydro-alcohol extract, Acetylcholinesterase, Glutathione S-transferase, Biomarkers

INTRODUCTION

Since ancient times, man has engaged in agriculture to meet his food needs and used pesticides to prevent pre-and post-harvest losses of crops due to pests (Saroj *et al.*, 2020). Crop infestation by pests is a threat to global food security and its control with synthetic pesticides is associated with health and environmental problems (Wilson and Huber, 2021). Pesticides are chemicals formulated to destroy, control, or prevent pests but because their mode of action is not specific, they also affect non-target organisms including humans (Kaur *et al.*, 2019; Nartop *et al.*, 2020). Synthetic pesticides exhibit harmful effects such as neurological, behavioral dysfunctions, hormonal imbalances, kidney and liver disorders, genotoxicity, and others, due to their persistence in the environment and absorption by humans/animals (Ravindran *et al.*, 2016; Malhat *et al.*, 2018). The environmental and health effects of synthetic pesticides have led to the search for safer alternatives from natural sources (Chowdhary *et al.*, 2018).

Plants exhibit pesticide activity by interfering with cholinergic and antioxidant enzymes such as acetylcholinesterase and glutathione S-transferase in target pests. Acetylcholinesterase (AChE) terminates nerve impulses by catalyzing the hydrolysis of a neurotransmitter, acetylcholine into acetic acid and choline in the nervous system of various organisms, while GST play an important role in pesticide resistance and detoxification (Yang *et al.* 2008; Gullner *et al.*, 2018). The primary cytosolic enzymes known as glutathione S-transferases catalyze the conjugation of electrophile molecules with reduced glutathione (GSH), resulting in the transformation of potentially hazardous compounds into more water-soluble and less toxic ones (Dobritzsch *et al.*, 2020).

Culturally, *Blighia sapida* stem-bark powder is usually mixed with seeds of African finger (*Abelmoschus esculentus*) and pearl millet (*Pennisetum glaucum*) before sowing to prevent insect attacks. To the best of our knowledge, there is no scientific support for this practice, hence this study.

MATERIALS AND METHODS

Preparation of Hydro-alcohol extract

Blighia sapida stem bark was obtained, identified, authenticated, and milled to powder form using an electrical Grinding Machine (SR-14733, Marlex, Daman). The powder material (1066.71 g) was macerated in 70 % (v/v) ethanol/water for 72 hours at room temperature using the method of Handa *et al.* (2008). The resulting suspension was filtered and concentrated with a rotary evaporator at 40°C to yield a residue termed ethanol extract (EE).

Experimental Animals

Thirty Wistar rats, weighing between 150 and 220 g were obtained from the Department of Anatomy, University of Ibadan, Ibadan, Nigeria. The rats were acclimatized to the laboratory conditions for two weeks in the Animal House. Rats were fed with standard pellets obtained from Ladokun Feeds, Ibadan, Oyo State, Nigeria, and allowed free access to clean water. The principle of laboratory animal care (NIH publication No. 85–23) guidelines and procedures were followed for the study (NIH Publication Revised, 1996).

Experimental Design

Thirty (30) rats were randomly divided, following the method of Adekola *et al.* (2020), into five groups, and each group contained six rats.

Group 1–received 1.0 ml of distilled water; Group 2 –received Rambo pesticide 10% (w/v); Group 3 –received 50 mg/kg EE; Group 4 –received 100 mg/kg EE; Group 5 –received 150 mg/kg EE

Based on the result of the acute test (LD₅₀) conducted, three doses (50, 100, and 150 mg/kg) of *B. sapida* ethanol extract were chosen for the study. The rats were treated by gavage administration of the extract and insecticide ‘Rambo’, which was obtained from market, containing 0.6% permethrin (synthetic pesticide) every 2 days for 28 days. On the 28th day, the animals were made to fast overnight before being sacrificed under light chloroform anesthesia. The blood was obtained through the cardiac puncture, and organs of interest were excised. Collected blood samples were kept in separate heparinized tubes, while the organs were stored in plain sample bottles. The samples were labeled and used for the estimation of biochemical parameters.

Determination of biochemical parameters

In the liver and brain homogenates, the biochemical parameters were measured using the techniques outlined by Klein and Kaufman (1967) for ALP, Lowry *et al.* (1951) for total protein, Habig *et al.* (1974) for GST, and Voss and Sachsse (1970) for AChE.

Histopathological examination

Liver samples were cleared from adhering tissues, fixed in 10% formal saline, dehydrated through ascending grades of alcohol (50%, 70%, 80%, 90%, and 100%) - and cleared in xylene. The wax-infiltrated tissues were embedded in paraffin wax and 5µm thick sections were prepared from the tissues using a LEICA rotary microtome. These sections were floated in a water bath (45 °C) to allow spreading of the folded sections and mounted on glass slides. Dewaxed slide sections were then rehydrated in descending grades of alcohol (100%, 90%, 80%, 70%, and 50%) and stained with hematoxylin and eosin. Sections were differentiated in a mixture (1% hydrochloric acid in 70% alcohol) to remove excess dye from the tissues. The stained tissues were observed under the microscope (LEICA DM750) interfaced with a LEICA (ICC50) camera.

Statistical analysis

The data obtained were analyzed using one-way analysis of variance (ANOVA) followed by Tukey–Kramer multiple comparisons test using the software Graph pad Prism 5. The statistical significance was set at $p < 0.05$ level of significance. Values were expressed as mean $\pm$ standard error of the mean (SEM).

RESULTS

The acute toxicity test revealed that the extract was non-toxic at the highest dose (5000 mg/kg) tested. No toxic symptoms or mortalities were observed in the two phases of the acute toxicity test ($LD_{50} > 5000$ mg/kg). There was a significant decrease in AChE activities of the experimental animals that received a high dose (150 mg/kg). There was also a significant decrease in the plasma GST activities at 100 and 150 mg/kg extract administration (Table 1). The decrease in these enzymes was similar to that observed for the Rambo pesticide treatment, which was significant when compared to the control group. However, there was no significant difference in the activity of alkaline phosphatase in the test groups as compared to the control group. A dose-dependent increase in protein concentration was observed (Table 1). Histopathological investigation of liver sections in control rats showed normal cellular integrity and normal lobular architecture with central veins and radiating cords of hepatocytes, separated by blood sinusoids of the liver. However, no marked lesion or congestion was observed in the groups treated with 50, 100, and 150 mg/kg of *B. sapida* extract. Mild lesions and portal congestion were observed in the group that was administered with 10% (w/v) Rambo pesticide (Figure 1).

DISCUSSION

In this study, no death was recorded during the acute and sub-acute toxicity tests with graded doses of ethanol extract of *B. sapida*. No symptom of toxicity was noticed and no significant changes in appearances were observed when the treated groups were compared with the control group. The extract of *B. sapida* decreased the activity of cholinergic and antioxidant enzymes in Wistar rats administered with high doses in a similar pattern as a synthetic pesticide (Rambo). This effect is typical of botanicals that interrupt the proper functioning of insect nervous system, causing uncontrollable excitation, tremor, and, death as a result of an accumulation of acetylcholine (Malhat *et al.*, 2018).

Accumulation of acetylcholine at neuron synapses and neuromuscular junctions has been reported to cause effects such as paralysis and muscle weakness (Yilmaz *et al.*, 2016). Glutathione S-transferases (GST) is the main enzyme that catalyzes the conversion of foreign chemicals to hydrophilic, less toxic, and easily excreted materials from the system (Lee *et al.*, 2015; Dobritsch *et al.*, 2020). A low dose (50 mg/kg) of the extract exhibited no significant reduction in GST activities, however, higher doses of 100 mg/kg and 150 mg/kg caused a significant reduction in the activity of GST. The findings of this study are similar to that of Oni *et al.* (2019) in which administration of *Acalypha wilkesiana* extract reduced GST and caused mortality of *Callosobruchus maculatus*. Similarly, Ebadollahi *et al.* (2013) and Tarigan *et al.* (2016) have reported pesticidal activity of different botanical extracts that reduced GST activity. The observed effects of the *B. sapida* extract on the activities of AChE and GST indicate that the metabolites in the extract may serve as an effective botanical pesticide.

Alkaline phosphatase is a membrane-bound enzyme and it plays a critical role in the transportation of metabolites across the cell membrane, conditions such as liver damage and bone disease lead to its alteration which affects the transport of metabolites and membrane permeability (Simon *et al.*, 2019). Alkaline phosphatase has been referred to as a family of zinc metalloenzymes, and an increase in its activity is an indication of biliary process obstruction (Shirode *et al.*, 2019). The ALP activity of the rats treated with different doses of ethanol extract of *B. sapida* showed no significant difference when compared to the control rats. This indicates that the extract may not cause cellular leakage of the enzyme and obstruction of normal biliary process. The results of ALP in this study implied that phytoconstituents in the plant extract were neither toxic nor caused damage to the membrane at the doses considered, hence, the transportation of metabolite remains intact. This result was also confirmed by the histopathological examination of the liver (Figure 1), in which the micrograph of the liver of rats treated with different doses of the plant extract did not have lesions.

Table 1: Effect of hydro-alcohol extract of *Blighia sapida* on biochemical parameters of Wistar rats

Groups	Control	Synthetic	Extract	Extract	Extract
Parameters	0 mg/kg	10 % (w/v)	50 mg/kg	100 mg/kg	150 mg/kg
AChE (U/L)	240.14 ± 6.18*	175.67 ± 30.42***	226.85 ± 2.46*	224.43 ± 4.47*	210.16 ± 2.03**
GST (µmol/mg)	256.48 ± 12.73*	134.37 ± 7.42***	211.57 ± 7.06*	209.61 ± 20.09**	196.64 ± 8.44**
ALP (U/L)	0.022 ± 0.003	0.024 ± 0.008	0.017 ± 0.001	0.019 ± 0.001	0.022 ± 0.003
AST (U/L)	290.87 ± 5.83	302.94 ± 10.49	300.02 ± 11.48	302.37 ± 5.87*	308.19 ± 13.54*
ALT (U/L)	8.79 ± 1.09	19.07 ± 0.97**	9.46 ± 1.50	17.47 ± 1.30*	19.13 ± 0.84**
TP Liver (g/L)	126.26 ± 0.75	135.15 ± 6.58	103.79 ± 0.62**	117.42 ± 7.17*	125.03 ± 6.97

Values are presented as Mean ± SEM of seven (7) replicates.

Values with (*) are significantly different at $p < 0.05$ when compared to the control group (group 1).

AChE: Acetylcholinesterase, ALP: Alkaline phosphatase,

GST: Glutathione S-transferases, TP: Total protein,

AST: Aspartate aminotransferase, ALT: Alanine aminotransferase.

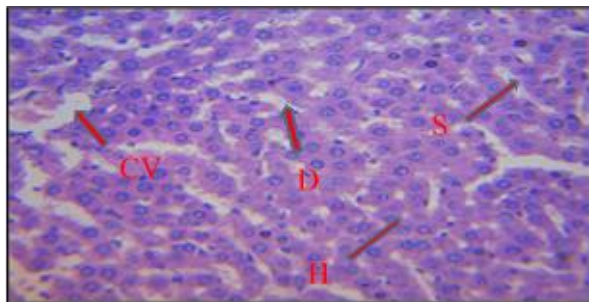


Plate 1A: Micrograph of the liver of rats in control group showing no lesion (x 300)

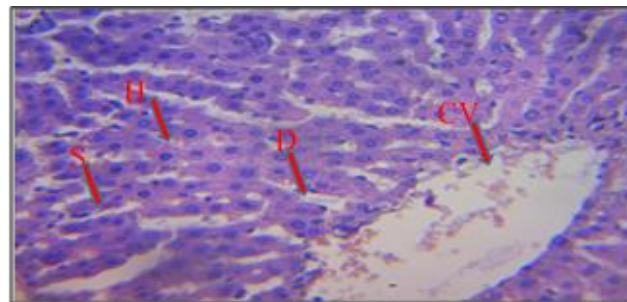


Plate 1B: Micrograph of the liver of rats treated with 10% synthetic Rambo showing mild portal congestion (x300)

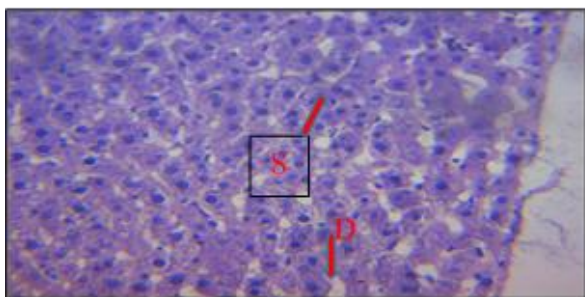


Plate 1C: Micrograph of the liver of rats treated with 50mg/kg of BSE showing no lesion (x300)

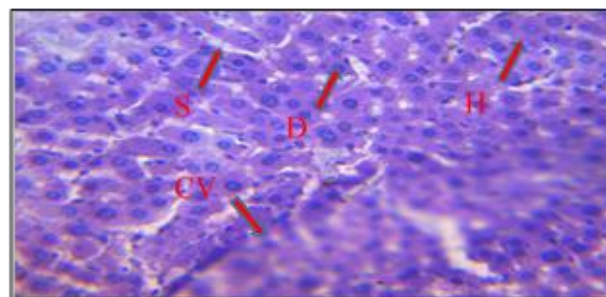


Plate 1D: Micrograph of the liver of rats treated with 100mg/kg of BSE showing no lesion (x 300)

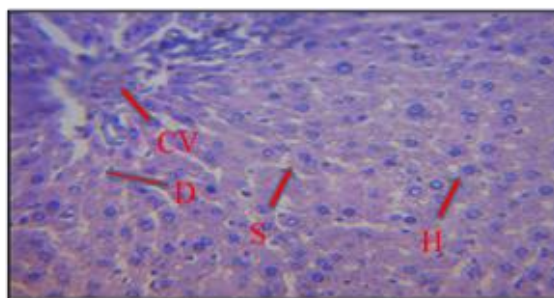


Plate 1E: Micrograph of the liver of rats treated with 150mg/kg of BSE showing no lesion (x300)

Figure 1: Photomicrographs of liver sections from control, 10% Rambo and *B. sapida* treated rats

NOTE: Central veins (CV), Hepatocytes (H), Sinusoids (S), Bile duct (D) and Magnification (x300)

Plasma alkaline phosphatase is one of the liver biomarker enzymes, whose evaluation provides details of pathological damage to the tissue (Mu'azu *et al.*, 2020). A high level of plasma ALP activity has been linked with hepatobiliary dysfunction, which is likely a result of hepatobiliary injury and cholestasis (Ore and Olayinka, 2015). The non-significant effects on ALP activities observed suggests that the doses of the extract considered may not affect the hepatobiliary function of the liver.

The liver is mainly involved in the synthesis of plasma protein, damage to which causes a reduction in the protein concentration (Adeoti *et al.*, 2017). A dose-dependent increase in protein concentration was observed in the groups that were administered with different doses of ethanol extract of *B. sapida* which implies that the extract is not toxic at the doses considered because a decrease in the level of total protein has been associated with damage to the liver function caused by toxicity (Simon *et al.*, 2019).

The histopathological examination of the liver in control rats showed normal cellular integrity and normal lobular architecture with central veins (CV) and radiating cords of hepatocytes (H), separated by blood sinusoids (S) of the liver. However, no marked lesion or congestion was observed in the groups treated with 50, 100, and 150 mg/kg of *B. sapida* extract. A mild lesion and portal congestion was observed in the group that was administered with 10% (w/v) Rambo pesticide. However, Adekola *et al.* (2020) reported distinct hepatocytes, clear central vein, and mildly congested sinusoids in rats administered with 250 mg/kg ethanol extract of *B. sapida*.

CONCLUSION

The hydro-alcohol extract of *B. sapida* lowered the level of acetylcholinesterase and glutathione-S-transferases activities. This suggest that *B. sapida* has a neurodegenerative ability peculiar to pesticide agents. Hence, the use of the plant extract as an agent for the mitigation of pests in agriculture could be employed.

ABBREVIATIONS

AChE: Acetylcholine esterase; GST: Glutathione S-transferases; ALP: Alkaline phosphatase; DEET: Diethyltoluamide; GSH: Glutathione; mg/kg: Milligram/kilogram; EE: Ethanol extract; w/v: Weight/volume; SEM: Standard error of the mean.

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Heavy Metals Contamination in Some Medicinal Plants from Onigambari Forest Reserve

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Abstract

Heavy metal toxicity related to the use of traditional medicines has been reported worldwide. Heavy metals may be introduced into medicinal plant products through various anthropogenic process such as mining, contaminated agricultural resources etc. Poisoning from heavy metal contamination of medicinal plant products has caused countless health challenges including liver and kidney failure and even death. Hence, monitoring the content of mineral elements in medicinal plants and their extracts is of particular importance. This study investigated the heavy metal contents of six medicinal plants obtained from Onigambari Forest Reserve Oyo State. Using an atomic absorption spectrophotometer, the heavy metals Lead (Pb), Zinc (Zn), Cadmium (Cd), Copper (Cu), Mercury (Hg), Chromium (Cr) and Magnesium (Mg) were assessed. Lead, Cd, Hg and Cr were absent in the medicinal plants analyzed in this study. The concentrations of Zn ranged from 0.20ppm in *Khaya grandifoliola* to 0.40ppm in *Khaya ivorensis* and 0.30 *Magnifera indica*. Copper concentration ranged from 0.015 ppm in *Khaya grandifoliola* to 0.23 ppm in *Garcinia kola*; while that of Mg was 0.55 ppm in *Kigelia africana*. The heavy metal content of most of the Medicinal plants were below WHO/FAO permissible limits.

Keywords: Heavy Metals, Medicinal Plants, Herbal Medicine, Metallophytes

INTRODUCTION

Herbal medicines have multiple physiological activities and could be used to treat varieties of diseases (Pieme *et al*, 2006). They could be administered in most disease states over a long period without proper dosage, monitoring and toxic effects consideration (Ogbonnia *et al*, 2010). Medicinal plants (used in manufacturing herbal medicines) become contaminated with toxic metals during growth, development and processing (Ali *et al*, 2012). Most medicinal plants used in herbal medicines are not well researched and their formulations and sales need to be monitored (Oshikoya *et al*, 2008).

The use of herbal medicines is increasing recently in south west Nigeria, due to their low prices in the market. Heavy metals mostly occur as cations which interact with the soil matrix and can become mobile due to changing environmental conditions (Qishlaqi and Farid Moore, 2007). Due to the high prevalence of heavy metals in the environment, their residues also reach high levels and are assimilated into medicinal plants (Sarma *et al.*, 2012). There is now extensive interest in heavy metal transport by metal-tolerant plants (metallophytes) because of the repercussions for phytoremediation (Sharma, 2011). A copious number of plants have been explored for phytoremediation e.g *Chromolaena odorata*, *Solanum nigrum* etc (Sharma, 2011). However the accumulation of heavy metals in edible and medicinal plants need thorough investigation to prevent elevated concentrations from reaching the consumer (Sharma *et al*, 2006). Elevated levels of heavy metals in plants are reported in areas having; long-term use of treated/untreated wastewater (Sinha *et al.*, 2005., Sharma *et al.*, 2006), plants growing along heavy traffic ways (Liu *et al.*, 2007) and dumpsites (Nwachukwu *et al.*, 2010). Other anthropogenic sources of heavy metals include quarry activities, manures, fertilizers and pesticides (Hina *et al.*, 2011). Usually, uptake of heavy metals is mostly affected by changing the physico-chemical properties of the soil. The addition of chemicals such as fertilizers change the structure of the heavy metals and hence immobilize them. These may be deposited on soil and are absorbed by plants and/or deposited on leaves, barks and fruits.

MATERIALS AND METHODS

Study Area

The study was conducted in Onigambari forest reserve along old Lagos – Ibadan Express way in Oyo State. Onigambari forest reserve is located in Oluyole local government of Oyo State. Oluyole Local Government was established in 1976 and the Council occupies about 629 square kilometers. Based on 2006 population Census, its population is 202,725. The Agricultural products in the area include, cocoa, citrus, cassava, maize etc. The area is located between Latitude 7.2333° - 7° 14' north and Longitude 3.8667° - 3° 52' east. Maize, Cocoa-yam, plantain and cassava are the major food crops planted in the area. Major livestock reared in the zone are cattle, sheep and goats. The rainfall starts from May to July with a short dry spell in August and relative humidity of about 60 to 80%, which fluctuates during January and February.

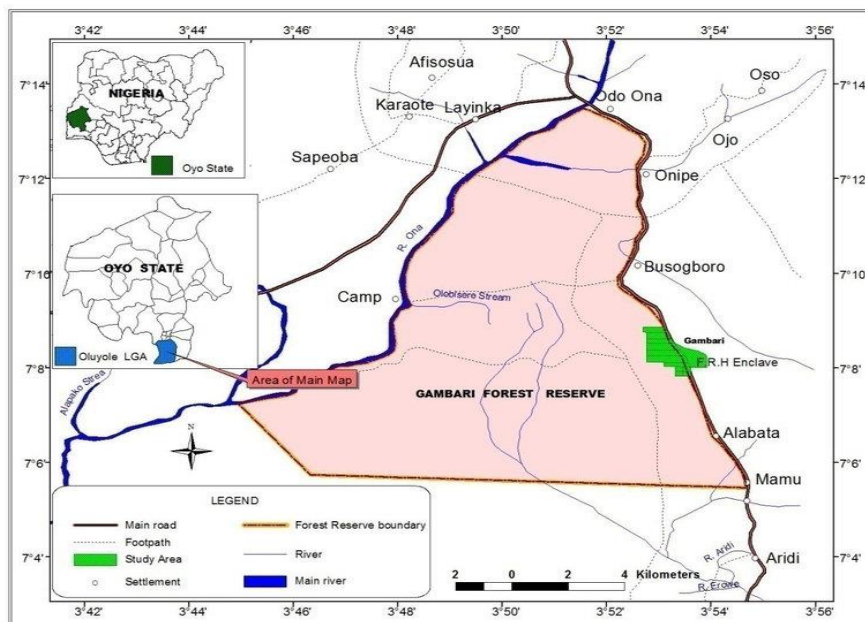


Figure 1: Map of Onigambari Forest Reserve

Sample collection

Six medicinal plant samples were collected from the Onigambari forest reserve in Ibadan. Samples were taken to the Nigeria Institute of Science Laboratory Technology Ibadan for heavy metal analyses.

Heavy metal analyses

Nitric acid (Laboratory grade reidel – de Haen) 65% was used for digestion of samples. Methods described by Henok and Ariaya (2013) and Idu *et al.*, (2014) were used in this study. Plant sample (0.2 g) was ashed at 550°C overnight in a muffle furnace. Ashed samples were then transferred quantitatively to 100 ml glass (Pyrex) beaker. Crucibles used for ashing were washed with 25 ml of 20% Nitric acid (HNO₃) solution as part of qualitative transferring. The washouts were added to the ashed samples in a beaker and then warmed in fume hood to boiling point. The volumetric flask solution was made to the mark with distilled water (AOAC, 1990). Samples were run on Atomic Absorption Spectrophotometer to obtain the absorbance values.

Statistical Analysis

The results are presented as Mean $\pm$ SEM (standard error of mean) and n represents the number of replicates used in each experiment. Data were analyzed with one-way ANOVA and multiple comparisons using Graph pad computer software version 6.0.

Results

Six medicinal plants were obtained from Onigambari forest reserve were analysed (Table 1). Heavy metals such as lead (Pb), zinc (Zn), cadmium (Cd), copper (Cu), Mercury (Hg), chromium (Cr) and

magnesium (Mg) assessed (Table 2). However, Pb, Cd, Hg and Cr were absent in the plants analyzed while concentrations of Zn ranged from 0.20 ppm in *Khaya grandifoliola* to 0.40 ppm in *Khaya ivorensis* and 0.30 ppm in *Mangifera indica*. Copper concentration ranged from 0.015 in *Khaya grandifoliola* to 0.23 ppm in *Garcinia kola*; while Mg was 0.55 ppm in *Kigelia africana*.

Table 1: Medicinal plants obtained from Onigambari forest reserve

S/N	Medicinal Plant samples	Disease cured
1.	<i>Zingiber officinale</i>	Malaria, typhoid.
2.	<i>Khaya ivorensis</i>	Energy booster
3.	<i>Garcinia kola</i>	Malaria, typhoid.
4.	<i>Mangifera indica</i>	Malaria
5.	<i>Khaya grandifoliola</i>	Pile, dysentery, constipation, diarrhea.
6.	<i>Kigelia africana</i>	Purifies the blood, Prevents oedema.

Table 2: Heavy metal evaluation in medicinal plants

Medicinal plants	Pb (ppm)	Zn (ppm)	Cd (ppm)	Cu (ppm)	Hg (ppm)	Cr (ppm)	Mg (ppm)
<i>Zingiber officinale</i>	ND	0.28±0.06	ND	0.22±0.20	ND	ND	ND
<i>Khaya ivorensis</i>	ND	0.40±0.05	ND	0.20±0.04	ND	ND	ND
<i>Garcinia kola</i>	ND	0.31±0.05	ND	0.23±0.02	ND	ND	ND
<i>Mangifera indica</i>	ND	0.30±0.03	ND	0.20±0.01	ND	ND	ND
<i>Khaya grandifoliola</i>	ND	0.20±0.06	ND	0.15±0.03	ND	ND	ND
<i>Kigelia africana</i>	ND	0.35±0.05	ND	ND	ND	ND	0.55±0.10

Key: Values are Mean±SEM; n=3, ND= Not Determined.

DISCUSSION

Environmental pollution with chemicals and heavy metals due to industrial and motorized activities along with extensive use of pesticides and fertilizers have become a major concern. These pollutants and heavy metal deposits get into the human food chain through plant parts. Continuous release of fertilizers, sewage sludge and fuel combustion are the major reasons for the increase in Pb pollution in the environment. The permissible limit of lead (Pb) is 10 ppm (WHO, 2007). However, lead which causes renal failure and liver damage in humans, was not detected in the plant samples. Cadmium (Cd) is another hazardous heavy metal which can reduce plant yield at concentrations ranging from 5–30 mg/kg. Cadmium is gaining more attention due to its occurrence in water, soil, herbal products and medicinal plants. Phosphate fertilizers, zinc mines and combustion of fossil fuels are some of the sources leading to accumulation of cadmium in soil and plants. However, the samples analyzed in this study had no Cadmium, whose permissible limit 0.03 ppm (WHO, 2007). Zinc (Zn) is a major component of proteins in plants. Zinc content ranged from 0.20 ppm in *Khaya grandifoliola* to 0.40 ppm in *Khaya ivorensis*. These values are low compared to the dietary limit of Zinc (100ppm). This result is in agreement with the research findings of Idu *et al.* (2014). Zinc provides protection against both cadmium and lead, and a deficiency of Zn is associated with loss of taste, hypogonadism, retarded growth, and fertility problems.

Concentration of copper ranges from 0.015 ppm in *Khaya grandifoliola* to 0.23 ppm in *Garcinia kola*. These concentrations are below the permissible limit of 2 ppm (WHO, 2007). Copper is an essential part of several enzymes and it is necessary for the synthesis of hemoglobin, deficiency can lead to anemia and hypo-proteinemia. Magnesium (Mg) detected was 0.55 ppm in *Kigelia Africana*, which was lower than the WHO permissible limit for Mg (10 ppm) (WHO, 2007). Magnesium deficiency is associated with leaching and low concentration of magnesium results in loss of chlorophyll in old leaves of plants. Chlorosis, or yellowing between leaf veins is the major symptoms of magnesium deficiency. The work of

Gajalakshmi *et al.* (2012) revealed a high deposition of heavy metals in vegetables in the Southern part of Nigeria. They reported the following concentrations (mg/kg) of metals: Cr (1.50-10.25), Mn (9.75-62.75), Ni (15.75-19.25), Co (1.75-3.00), Cu (7.75-11.00), Cd (1.25-1.50), Zn (79.75-186.95) and Pb (6.25-8.00).

CONCLUSION/RECOMMENDATION

Poisoning due to heavy metal contamination poses a threat to the public that consume medicinal plants for the treatment of disease conditions. Hence, adequate screening and monitoring of heavy metal contents in herbal remedies before consumption is recommended. Also, pharmaco-vigilance of medicinal plants is required to ensure permissible limits of heavy metals in herbal remedies. The absence of Pb, Cr and Cd in the medicinal plants analyzed in this study indicate that the plants from the area are safe for consumption.

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A Retrieval of Spatial-Temporal Surface Albedo from Landsat-8 Surface Reflectance and its Relationship with Land Surface Temperature

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Abstract

The surface energy budget is controlled by surface albedo, and the climate and environment are significantly impacted by albedo-induced radiative forcing. The algorithms and outcomes of surface albedo have been detailed in previous reviews. In this investigation, three satellite photos that had less than 10% land and scene cloud coverage were taken from the official website of the US Geological Survey (USGS). The satellite images used in this investigation were from the years 2013, 2017, and 2022. Using the conversion of digital numbers into thermal spectral radiance and subsequently to brightness temperature using the Planck radiation function, the land surface temperatures (LST) were retrieved from Landsat 8 data. Without adjusting for air conditions, albedo was calculated by linearly combining the reflectance of the OLI-Landsat 8 bands. With a Pearson's r value of -0.78473 , findings indicated a negative correlation between albedo and LST in 2013. Albedo and LST had a greater inverse association in 2017 and 2022, with Pearson's r equal to -0.92604 and -0.88849 , respectively. By increasing surface albedo, the study shows specific metropolitan areas to create UHI mitigation strategies. Satellites offer a useful tool for tracking the effects of the albedo urban pattern on cooling or heating.

Keywords: surface albedo; radiative forcing; urban; Landsat 8; land surface temperature.

INTRODUCTION

The amount of solar radiation reflected by the surface is commonly managed by land surface albedo, which in turn manages the Earth's energy budget (Liang *et al.*, 2010). An albedo is a number that quantitatively defines the absorption/reflection behaviour of a surface. It is the total hemispherical reflectance of a particular surface integrated over the solar spectrum, including specular and diffuse reflection. Albedo levels typically range from 0.10 to 0.50, with metallic surfaces having greater values. The past three decades have seen steady advancements in satellite remote sensing of land surface albedo, and several satellite products are now available for use in applications requiring coarse-resolution climate modelling (He *et al.*, 2014a; Liang *et al.*, 2013; Muller *et al.*, 2012; Riihela *et al.*, 2013; Wang *et al.*, 2013). Although there is a great demand for satellite albedo products with a fine spatial resolution that show the regional variability of land surface albedo and the fluctuations in albedo due to small-scale changes in land cover (Roman *et al.*, 2013; Shuai *et al.*, 2014). However, there are no products with such long-term, worldwide coverage available today. For example, scale discrepancies between coarse-resolution data and ground measurements have prevented a more accurate evaluation of current satellite data for research on climate modelling in the absence of fine-resolution data (Burakowski *et al.*, 2015). Due to the free availability of Landsat data, albedo data may be used in applications that require data at finer spatial resolutions, such as ecosystem functioning assessment and urban environmental assessment (Zhou *et al.*, 2012), agricultural monitoring (Gao *et al.*, 2014; Li and Fang, 2015), forestry management (Kuusinen *et al.*, 2014), and monitoring of agriculture (Gao *et al.*, 2014; Lagomasino *et al.*, 2015). It is difficult to apply such physically-based or semi-empirical methods to data from fine-resolution satellite sensors because of the inadequate angular samples from one sensor over a short period for collecting surface anisotropy caused by the lower return frequency (such as Landsat). Previous studies revealed that failure to remove the impacts of the surface bidirectional reflectance distribution function (BRDF) can lead to inaccuracies of up to 60% in fine-resolution data, which highlights the relevance of converting surface directional reflectance to albedo (e.g., Gao *et al.*, 2014). For research on the surface energy budget related to long-term climate change, there is a growing demand for accurate and trustworthy surface albedo products (e.g., Ghimire *et al.*, 2014). All of the approaches for determining surface albedo from Landsat data need surface reflectance produced from a precise atmospheric correction. It is unlikely to obtain an accurate surface reflectance when the landscape lacks dark, thick vegetation or when the

visible bands are saturated. Large urban surfaces like pavements and rooftops, for instance, are covered with materials like cement and bitumen. Buildings can be made of composite materials in addition to glass, steel, concrete, bricks, and wood. Other surfaces are covered with plants, grass, or water, as seen in gardens, parks, or open areas. One of the surface characteristics that connects urban climate to land use and the cover is albedo or the proportion of incoming solar radiation reflected by the surface. This is because both surface reflectivity and total hemisphere emissivity are material qualities involved in radiant heat exchanges. It is reasonable to suppose that the average albedo of present roofs does not exceed 0.25 and that, with targeted refurbishment or interventions, their albedo may be increased to around 0.55 to 0.65. (Silva *et al.*, 2005; Wang and Davison, 2007; Giongo *et al.*, 2010; Lopes *et al.*, 2013; Souza *et al.*, 2014).

Remote sensing images generated by spaceborne and airborne sensors may be very helpful to obtain a global perspective of the albedo distribution across an urban region and of the accompanying land surface temperature (LST) trend. The albedo-LST link has been traced in this study using several remote sensing instruments with various spatial resolutions. This study's main goal is to determine the relationship between land surface temperature and surface albedo using Landsat TOA reflectance data. Additionally, the outcomes may be utilised to look at the uncertainties in datasets with coarse resolution over varied landscapes. Retroreflective materials (RRMs), such as glazed facades, appear to be an efficient way to boost urban albedo and reduce human heat emissions in residential areas (Morini *et al.*, 2017). Additionally, there has been a lot of interest in roof albedo, and analytical findings indicate that the albedo varies depending on the materials (such as the membrane, asphalt shingle, roofing aggregate, and tile materials) (Levinson *et al.*, 2020). Additionally, pavement is a crucial component of urban areas, and road albedo changes depending on the kind of material used and how old it is (Chen *et al.*, 2019; Sen and Roesler, 2016). Understanding and limiting climate change depend heavily on surface albedo. Many surface albedo datasets, including those for land degradation (Liu *et al.*, 2017), fast surface dynamics (Wang *et al.*, 2018), and catastrophic catastrophe events, including forest fires, have been used to study slow climate change (Potter *et al.*, 2020). Many management techniques have been used to reduce greenhouse effects, such as afforestation (Kirschbaum *et al.*, 2011) and the use of high-albedo materials for pavement and roofs in urban areas, as these variations in surface albedo has a significant impact on the carbon trade-off (Lintunen and Rautiainen, 2021, Akbari *et al.*, 2009). Urban development is a significant human activity that causes a significantly slower rise in surface albedo as canopy coverings give way to darker impermeable covers (like roofs and pavement) (Trlica *et al.*, 2017; Tang *et al.*, 2018). Urban roof evaluation demonstrates that high-albedo materials can successfully reduce Urban Heat Islands (UHI) (Susca 2012). Along with materials, the LCA of pavement albedo also has a variety of effects on the carbon budget, with cement concrete pavement reducing CO²-equivalent emissions by 9.2 per cent and hot mixed asphalt pavement increasing emissions by 19.1per cent (Yu and Lu, 2021). The objective of this study is to examine the algorithmic principles behind the retrieval of albedo from Landsat 8 images in relation to the land surface temperature of the study area.

MATERIALS AND METHODS

Study Area

Ogbomoso is located between 4° 14' 28.2° and 4° 14' 56.9° North and 8° 06' 70° and 8° 06' 99° East of the Equator. It is a derived Savannah region and is situated 104 kilometres north of Ibadan, 58 km north of Osogbo, 57 km south of Ilorin, and 53 km north of Oyo (Ogunkan and Jelili, 2019). Ogbomoso's strong resistance led to the sheltering of more than 140 communities. The town's rapid expansion was further aided by the entrance of missionaries and the building of Ladoke Akintola University of Technology, established in 1991. According to Bowen (1957), the population expanded from 25,000 in 1885 to over 166,000 in 1991 and was expected to be at 299,535 in the 2006 census. Due to demographic fluctuations, Ogbomoso's built-up area has expanded. The town's built-up area rose from 2 km² in 1935 to 4.5 km² in 1963, and Opeloyeru (1983) estimated that it would reach 24.3 km² in 1995 (Popoola, 2007) in 2003, it increased to 27.5 km². (Abolade, 2004). The region's geology is composed of Precambrian rocks that are characteristic of Nigeria's basement complex (Rahaman, 1976). It frequently includes assemblages of rocks with lower metamorphic grades and notably higher proportions of mafic and ultramafic rocks (Ajayi and Adegoke, 1988). By nature, dendrites are the drainage kind. Locally, there are two different seasons in the Ogbomoso region: the rainy season, which normally lasts between March and October, and the dry season, which happens every year between November and February. The

majority of Nigeria's southwest is affected by this tropical rain. The research region experiences an annual rainfall of 1016 to 1524 millimetres, with the majority of it occurring during the rainy season (Sunmonu *et al.*, 2013).

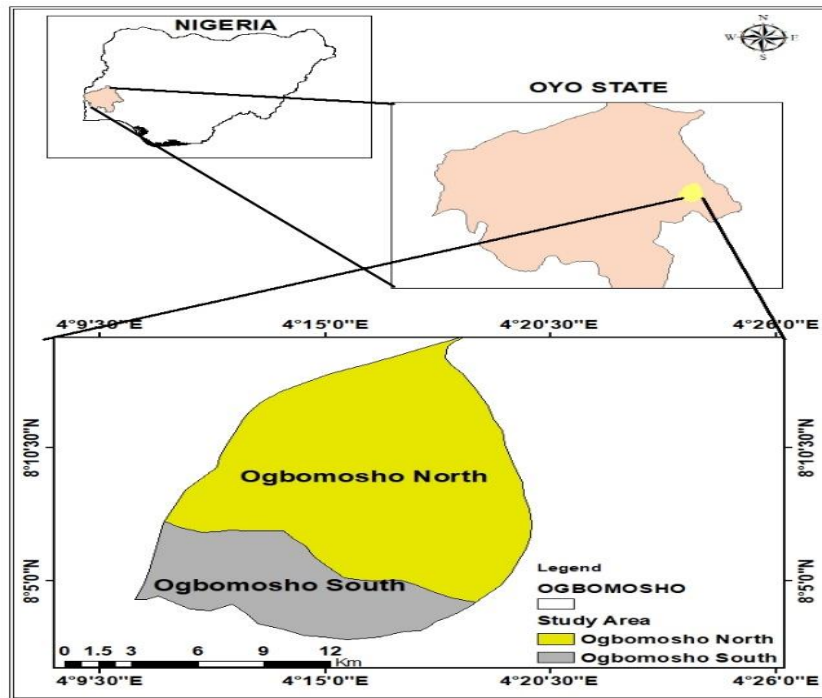


Figure 1: Map of Ogbomoso (inset: maps of Oyo state and Nigeria)

Dataset Preparation

Three satellite images with less than 10% land and scene cloud coverage, retrieved from the US Geological Survey's (USGS) official website (<http://earthexplorer.usgs.gov/>), were used in the study. The dataset utilised for this study consisted of satellite images from 2013, 2017, and 2022 (December, November, and January, respectively). The data months (dry season) were carefully chosen to prevent cloud cover issues and the influence of rainfall seasonality on the land surface temperature. Table 1 lists the satellite images that were used in the investigation.

Table 1. Satellite Specification

Satellite/ Sensor	Resolution	Path and Row	Date
Landsat 8 OLI	30m	191/054	18 th Dec. 2013
Landsat 8 OLI	30m	191/054	17 th Nov. 2017
Landsat 8 OLI	30m	191/054	27 th Jan. 2022

Land Surface Temperature (LST)

Landsat 8 OLI satellite images were used to determine the land surface temperature for the research region for the years 2013, 2017, and 2022. The three-year LST maps were then created, and over the research period, variations in LST were noted. LST estimation was done using Equations 1–5. (Tasumi *et al.*, 2008).

$$L_{\lambda} = A_{\lambda} + M_L * Q_{CAL} \quad (1)$$

Where: L_{λ} = TOA Spectral Radiance ($W / (m^2 \times sr \times \mu m)$); M_L = Radiance multiplicative scaling factor for the band; A_L = Radiance additive scaling factor for the band; Q_{CAL} = the quantized calibrated pixel value in Digital Numbers (DN)

The second stage included converting the TOA spectral radiance (L) measurements into another quantity known as the At-Satellite Brightness Temperature (TB)

$$TB = \frac{K_2}{\ln \frac{K_1}{L_{\lambda+1}}} \quad (2)$$

Where: TB = At-Satellite Brightness Temperature, in Kelvin (K); K1, K2 = Thermal conversion constants for the band

Equation 3 was used to translate the TOA Brightness Temperature into values for land surface temperature (LST).

$$LST = [TB / (1 + (\lambda * TB / \alpha)) * \ln \varepsilon] \quad (3)$$

Where: LST = Land Surface Temperature in Kelvin (K)

λ = the wavelength of emitted radiance

$\alpha = hc/k$ (1.438×10^{-2} mK)

h = Planck constant (6.626×10^{-34} J s-1), and

c = velocity of light (2.998×10^8 m s-1)

k = Boltzmann constant (1.38×10^{-23} J K-1)

ε = surface emissivity, calculated according to equation 4

$$\varepsilon = 0.004 * Pv + 0.986 \quad (4)$$

Where: Pv is the vegetation proportion calculated with equation 5

$$P_v = \left[\frac{NDVI - NDVI_{min}}{NDVI - NDVI_{max}} \right]^2 \quad (5)$$

273 was taken out of the basic numbers to get the land surface temperature readings in Celsius (°C) (K).

Vegetation Normalized Difference Index (NDVI)

The near-infrared and red spectral bands of Landsat's multispectral sensor are used to determine the NDVI. The idea behind measuring the NDVI is based on the highest radiation reflection in the near-infrared (NIR) spectral band and the absorption of light in the red (R) spectral band.

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (6)$$

The range of the NDVI is from -1 to +1, with values close to -1 indicating a lack of vegetation and values near to +1 indicating a thick canopy.

Surface Albedo Retrieval

Using coefficients calculated from several linear regressions and the reflection bands of the satellite sensors. From images captured by Landsat 8 (OLI) in the years 2013, 2017, and 2022, the albedo of the study area was estimated. The reflectance of the bands (from 2 to 7) of the OLI-Landsat 8 was combined linearly to determine albedo without atmospheric adjustment (toa). (Equation 7):

$$\alpha_{toa} = p_2 \times r_2 + p_3 \times r_3 + p_4 \times r_4 + p_5 \times r_5 + p_6 \times r_6 + p_7 \times r_7 \quad (7)$$

Where: Chander and Markham (2003) derived the reflectance for each of the bands (from 2 to 7).

RESULTS AND DISCUSSION

Spatial distribution of Land surface temperature

The investigation of surface temperature revealed the temperature dispersion throughout the research region. In 2013, the research area's average LST was 30.86°C. In 2017, it rose to 34.37°C, and in 2022, it dropped to 28.16°C (Figure 2). Microclimatic variability may have had a strong influence on variation in LST. The coverage area with the lowest LST in 2013 was 2672.46 ha. In 2017, it expanded to 4362.57 ha, and in 2022, it slightly decreased to 3805.29 ha. In 2013, 8355.60ha of the land was covered by mild temperatures; in 2017, 8296.11 ha; and in 2022, 1521.45 ha. Very high temperatures were recorded throughout (Table 4). According to the geographical distribution data, Ogbomoso North LGA had a higher prevalence of high LST than Ogbomoso South LGA.

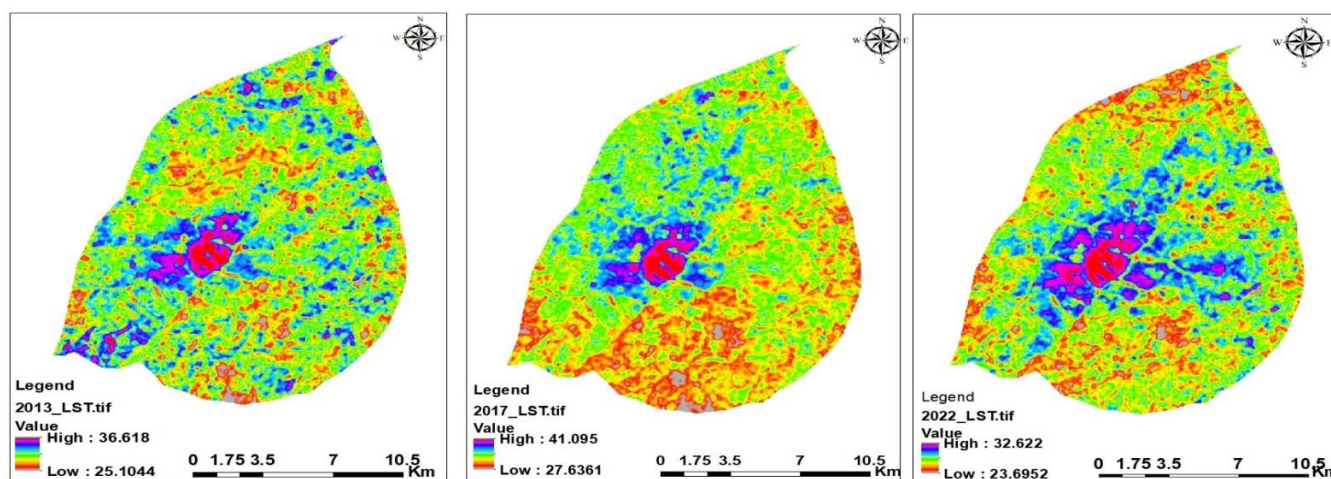


Figure 2: Land surface temperature maps of the study area in 2013, 2017 and 2022

Table 2: Observed spatial dynamics of LST in 2013, 2017 and 2022

Name	Area(ha)			Percentage (%)		
	2013	2017	2022	2013	2017	2022
Very Low	2672.46	4362.57	3805.29	10	16	14
Low	6565.68	8025.21	15024.24	26	30	56
Moderate	8355.60	8296.11	1521.45	30	31	6
High	6928.83	4891.14	3988.98	26	18	15
Very High	2260.44	1208.16	2443.23	8	5	9

Spatial distribution of surface albedo

In 2013, the research area's average albedo was 0.089, it rose to 0.114 in 2017, and by 2022, it had dropped to 0.085. (Figure 3). The region in 2013 with the greatest albedo was 1006.65 ha. It decreased to 613.89 ha in 2017 and increased to 1448.91 ha in 2022. In the years 2013, 2017, and 2022, it was high in areas covering 3757.05 ha, 2999.25 ha, and 4517.65 ha, respectively. In 2013, the study area's moderate albedo was 7117.56 ha. It reduced to 6304.14 ha in 2017 and 6063.75 ha in 2022. However, areas with the lowest albedo were 5885.46 ha, 7007.76 ha and 5962.22 ha in 2013, 2017 and 2022, respectively (Table 3).

Table 3: Spatial dynamics of Albedo in the years 2013, 2017 and 2022

Name	Area(ha)			Percentage (%)		
	2013	2017	2022	2013	2017	2022
Very Low	5885.46	7007.76	5962.22	22	26	22
Low	9016.47	9858.15	8789.67	33	37	33
Moderate	7117.56	6304.14	6063.75	27	23	23
High	3757.05	2999.25	4517.65	14	11	17
Very High	1006.65	613.89	1448.91	4	3	5

In 2013, 3.76% of the study area had very high albedo, though highly concentrated around the Kinnira area (Administrative Headquarters) of Ogbomosho North and the Arowomole area (Administrative Headquarters) of Ogbomosho South. There were dotted 'very high' surface albedo across the study area. In 2017 and 2022, the highest surface albedo values were 2.29 and 5.41%, respectively.

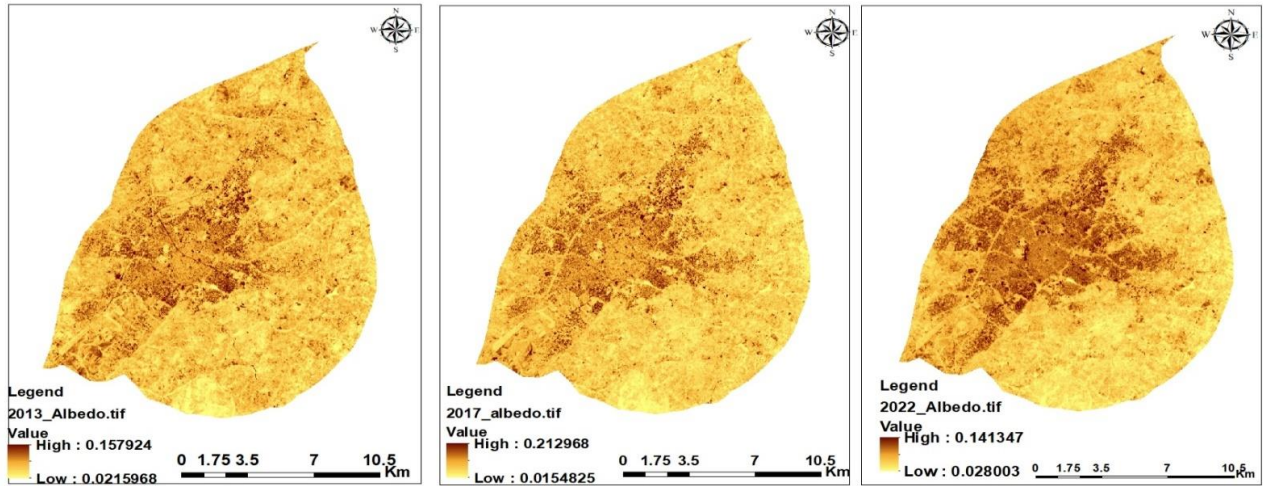


Figure 3: The spatial distribution of surface albedo in 2013, 2017 and 2022

Relationship between albedo and LST

There existed a negative association between albedo and LST in 2013 ($r = 0.78473$), which increased in 2017 ($r = -0.92604$) and 2022 ($r = -0.88849$) (Figures 4, 5 and 6). The hypothesis that high albedo levels imply lower LST values is supported by this association. Therefore, for the majority of pixels at 30 m, impervious percentage and canopy had the biggest effect in the simultaneous model, despite a few rare pixels with very high and extremely low albedo, showing a substantial influence on the modelled LST. These results were consistent with earlier remote-sensing studies that stated that impermeable cover had a beneficial impact on urban LST, whereas canopy cover had a negative impact and albedo had a negligible impact (Kong *et al.*, 2014; Haashemi *et al.*, 2016; Jenerette *et al.*, 2016; Zhang *et al.*, 2016).

For both natural and manmade surfaces (such as buildings, roads, and paved surfaces), the dynamics in the spectral interactions between surface albedo (SA) and LST often shift as a result of fluctuations in land cover type (Yoon *et al.*, 2019). Complex urban morphologies including block forms, plan density, facade density, building height, and layout orientation all contribute to the atmospheric interplay between urban surface albedo and LST (Groleau and Mestayer, 2013).

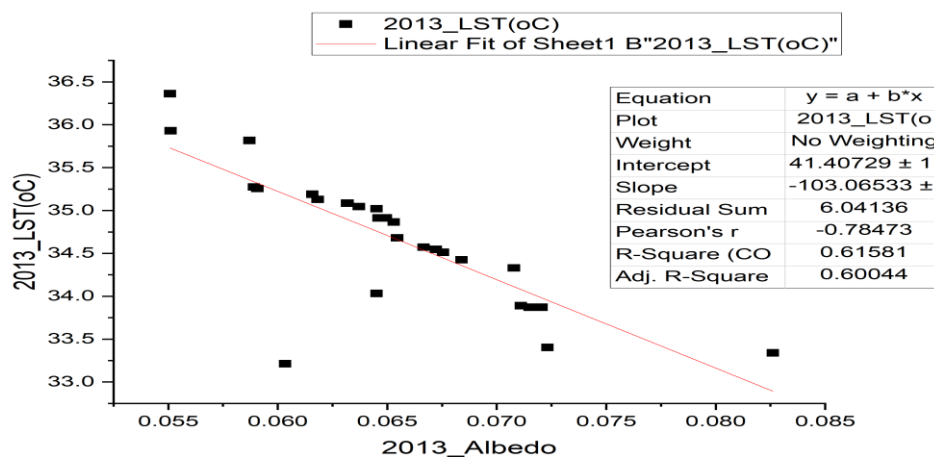


Figure 4. LST vs. Albedo scatterplot for the study area in 2013

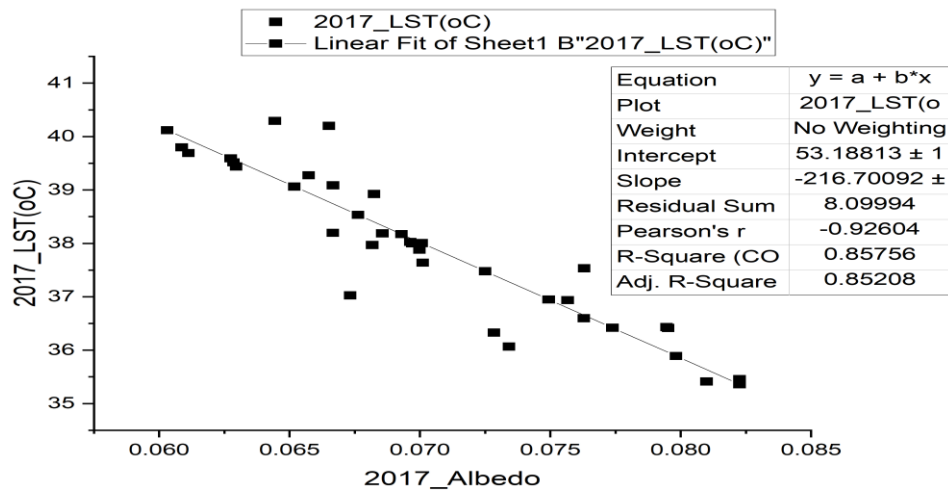


Figure 5. LST vs. Albedo scatterplot for the study area in 2017

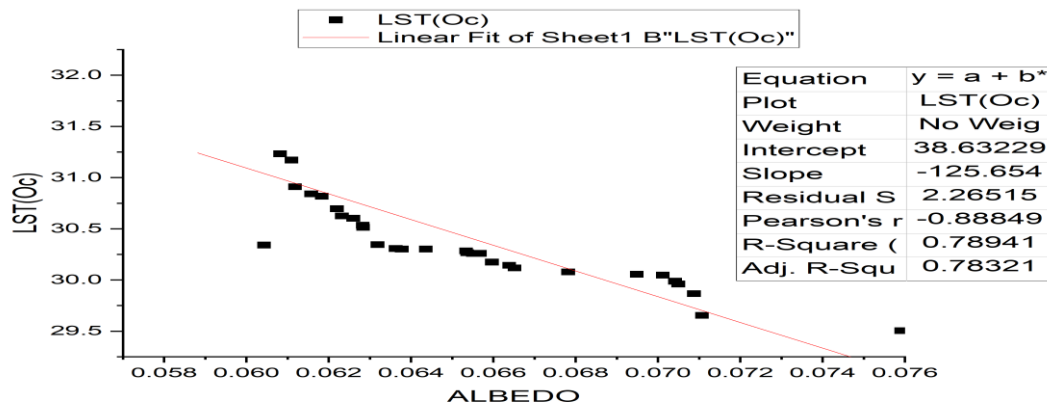


Figure 6: LST vs. Albedo scatterplot for the study area in 2022

CONCLUSION

Using data from Landsat 8, the study illustrates the existing "inverse" linear relationship between LST and albedo (OLI). The fluctuation and range of values of the LST and albedo relationship are confirmed by observing different years. Satellites are therefore an effective instrument for monitoring the impact of the albedo urban pattern on cooling or heating.

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Termiticidal Efficacy of Three Tropical Plant Oils on Epigeal Mound Builder Termite, *Macrotermes bellicosus* (Blattodea: Termitidae)



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Abstract

The use of botanical pesticides in pest management is considered to be environmentally safe compared to synthetic pesticides. The utilization of these botanical pesticides and their modes of application for effectiveness are of great importance to researchers and farmers. The focus of this study was to determine the anti-termite efficacy of Neem seed oil, *Jatropha* seed oil and Palm kernel oil using two methods of application. Five aqueous concentrations, 0, 2.5, 5.0, 7.5 and 10.0 percent of the oil were applied to soil and a food source in plastic cages. Thereafter, thirty adult worker castes of *Macrotermes bellicosus* were introduced. The treatments were replicated five times and arranged in a Completely Randomized Design in a dark cupboard. Termite mortality was assessed at 2, 6, 12, 24, 48 and 72 hours after treatment. Data were analysed using ANOVA, LSD at $p \leq 0.05$ and Probit analysis was carried out to determine the LC_{50} and LT_{50} of the different oil. The results showed that termite mortality in both soil and feeding experiments increased with increase in oil concentration and period of exposure to oil. The estimated values of LC_{50} and LT_{50} were lower in soil bioassay than in feeding bioassay. Application of the three plant oils as soil treatment gave a higher and faster termite mortality than when applied directly to food. Hence, soil application of neem seed oil, *Jatropha* seed oil or /and palm kernel oil could be included in Integrated Pest Management (IPM) component of termites.

Keywords: *Macrotermes bellicosus*, Modes of application, Termite mortality, Plant oil and IPM.

INTRODUCTION

Termites are considered as serious pests to crops, rangeland and forestry in tropical Africa. Some of the deleterious species belong to the family Termitidae, which comprises four subfamilies namely, Macrotermitinae, Nasutitermitinae, Termitinae, and Apictotermitinae (Murgerwa *et al.*, 2014). Over 90% of the termite damage in agriculture, forestry and urban settings in Africa has been attributed to members of the subfamily Macrotermitinae (Sileshi *et al.*, 2009; Abdurahman *et al.*, 2010). Members of this family which include species from the genera *Macrotermes*, *Odontotermes*, *Ancistrotermes* and *Microtermes* have been reported to be associated with *Eucalyptus* plantations in Nigeria (Alamu, 2017). Other reports have also shown that members of the genus *Macrotermes* cause complete damage to agricultural crops and domestic products (Umeh *et al.*, 1999; Joshi *et al.*, 2005; Nyeko *et al.*, 2010).

Different methods have been used by local farmers in Africa in the control of termites. These include destruction of termite mound (Mugerwa *et al.*, 2011a), application of wood ash (Nyeko and Olubayo, 2005; Mugerwa *et al.*, 2011b) and animal excreta (Mugerwa *et al.*, 2008). Synthetic pesticides remain the primary method use to prevent termite attack to wooden structures, agricultural crops and forest trees. They are applied directly to termite mound (Mugerwa *et al.*, 2011b), plant or wood materials and also directly to soil. However, the persistent use of synthetic termiticides is of environmental concern and has resulted in the need to search for plant-derived compounds as an alternative for termite control.

Many plants have been recognized to have anti-termite activities (Sakasagawa *et al.*, 2003; Supriadi and Ismanto, 2010) or repellent to the termites (Zhu *et al.*, 2001). The crude seed oil of *Piper guineense* at a 10% concentration significantly lowered damage by termites (Umeh and Ivbijaro, 1999). Neem seed oil has been reported to inhibit growth of termite surface-tunnels (Yashroy and Gupta, 2000). Soil treated with 2% solution of *Calotropis procera* L. and *Azadirachta indica* prevented damage by *Odontotermes obesus* (Rambur) to sugarcane setts (Deka and Singh, 2001). Extracts from leaves of *Tephrosia vogelii* have been reported to protect tree seedlings from termites' infestation in Malawi and Zambia (Nkunika

1998; Sileshi *et al.* 2008). Extract from *Lagenaria breviflora* fruit pulp has also been used as a wood protectant against termites (Emerhi *et al.*, 2015).

The indiscriminate use of pesticides for the management of termites has generated a number of biological and environmental hazards in air, water, soil and in food chains (Abdullah *et al.*, 2014). Insecticides from plant materials are very common, environmentally friendly and reservoir of chemical compounds with anti-termite properties. There is the need however, in addition to the identification of these plants to determine the effective rate and methods of applications. The objective of this study therefore was to assess the anti-termite efficacy of different concentrations and two methods of application of neem seed oil, Jatropha seed oil and palm kernel oil on adult worker caste of *Macrotermes bellicosus*.

MATERIALS AND METHODS

Sources of oils

Neem and *Jatropha* oil extracts were obtained from National Research Institute for Chemical Technology (NARICT), Zaria, Kaduna State and Palm kernel oil was obtained from local producers in Ekiti State, Nigeria.

Collection of termites for laboratory studies

Worker caste of *Macrotermes bellicosus* were collected from *Macrotermes* mounds in the experimental fields of Institute of Agricultural Research, Ahmadu Bello University, Zaria, Savanna Forestry Research Station office premises and Kurumi Bomo village, Zaria in Zaria North Local Government Area of Kaduna State, Nigeria. The termites were maintained in the laboratory on Sugar cane strips for 72 hours prior to use. The moribund termites were removed and only active ones were used for the experiments.

Mortality rate of termite on food source treated with different botanical oil extracts

Feeding deterrence bioassay was conducted to determine the effects of different concentrations such as (0%, 2.5%, 5%, 7.5%, and 10%) of Neem seed oil (NSO), Jatropha seed oil (JSO) and Palm kernel oil (PKO) on termite mortality rate. The experiment was carried out in plastic containers (15 cm in diameter and 10 cm high) using sugar cane strip as a source of food on sand substrate. River sand was collected and oven-dried at 100°C for 6 hours. After cooling, 30 g of sand was weighed into each plastic container and moistened with 6 ml of sterile distilled water using hypodermic syringe. The sand was stirred with a rod for uniform distribution of water in the soil. Sugar cane strips were cut to 6 x 2 x 1 cm in size and individually soaked in different concentrations of the oils for five minutes and placed in the plastic cages. Thirty adults worker caste of *M. bellicosus* were introduced into each plastic container and covered with a perforated lid. Each treatment was replicated five times and arranged in a dark cupboard in a Completely Randomized Design. Termite mortality was assessed at 12, 24, 48 and 72 hours. All dead termites were removed at each time of counting.

Mortality of termites on soil treated with different concentrations of plant oils

Thirty grammes (30 g) of oven-dried river sand was weighed into plastic cages and treated with 3 mls of different concentrations (0%, 2.5%, 5%, 7.5% and 10%) of Neem seed oil (NSO), Jatropha seed oil (JSO) and Palm kernel oil (PKO) using hypodermic syringe. The soil was stirred with a stirring rod for uniform distribution of oil in the sand medium. Thirty (30) worker caste of *M. bellicosus* were introduced into each plastic cage and sugar cane strip was added as food. Each treatment was replicated five times and arranged in a Completely Randomized Design in a dark cupboard. The number of dead termites was counted at 12, 24, 48 and 72 hours. Data on percentage termite mortality for the two experiments were corrected using Abbott's (1925) formula thus:

$$P_T = \frac{P_o - P_c \times 100}{100 - P_c}$$

Where P_T = Corrected mortality (%); P_o = Observed mortality (%); P_c = Control mortality (%)

Data on termite mortality was analyzed using ANOVA and means were separated using LSD at $p \leq 0.05$. Probit analysis of termite mortality was carried out to determine the LC_{50} and LT_{50} . Significant differences in LC_{50} and LT_{50} were determined by the overlapping and non-overlapping of the 95% confidence intervals (CI) (Appel *et al.*, 2001).

RESULTS

Mortality of Termite on Food Treated with Different Concentrations of Plant Oils

The highest mortality of termite (79.85% - 100.00%) recorded in 10% Neem seed oil at 24 and 48 hours after application was significantly higher than average mortality of termites in 0% - 5.0% Neem seed oil (Table 1). However, the mean mortalities of termites between 7.5% and 10.0% Neem seed oil were not significantly different at 24 and 48 hours after application. In addition, at 72 hours after termite exposure to Neem seed oil, termite mortalities at concentrations of 5% to 10.0% were not significant but significantly higher than mortalities at 0% and 2.5%. Sugarcane strips treated with 7.5% and 10.0% Jatropha seed oil caused more than 50% termite mortality at 24, 48 and 72 hours after application. Termite mortalities in 7.5% and 10.0% Jatropha seed oil were significantly higher ($p \leq 0.05$) than average mortalities in 0%, 2.5%, and 5% Jatropha seed oil. Similarly, Palm kernel oil concentrations of 5.0, 7.5 and 10% gave significantly higher ($p \leq 0.05$) termite mortalities than Palm kernel oil concentration of 2.5%. In all cases, higher termite mortality was recorded with increase in the period of termite exposure to treated food.

Mortality of Termite on Soil Treated with Different Concentrations of Neem, Jatropha and Palm Kernel Oils

Termite mortality recorded on sand treated with Neem seed oil at concentrations of 7.5% and 10% between 24 and 72 hours were not significant but significantly ($p \leq 0.05$) higher than termite mortality at 2.5% Neem seed oil concentration (Table 2). Across the three periods of termite exposure to sand treated with Jatropha seed oil, the mean mortality of termite at the concentration of 2.5% were significantly lower than mortality recorded at the concentrations of 5.0, 7.5 and 10.0%. Termite mortality on sand treated with different concentrations of Jatropha seed oil at 24 hours after application were significantly different. However, at 48 and 72 hours after application, the mean mortality of termite observed at the concentrations of 5.0 to 10.0% Jatropha seed oil was not significant. Termite mortality at 24, 48 and 72 hours in all the concentrations of Palm kernel oil were significantly different except at 48 hours where mean termite mortality of 71.51% and 71.53% recorded at Palm kernel oil concentrations of 5.0% and 7.5%, respectively were not significantly different.

DISCUSSION

The application of botanical pesticides in the management of termites and other insects in agriculture and forestry holds a promise for reducing threats posed to the environment by synthetic pesticides and also has prospects for increasing crop yield. From this study, application of Neem seed oil, Jatropha seed oil and Palm kernel oil to a food source and soil showed that mortality response of termite is dose and time dependent.

Mortality of termite increased with increase in oil concentration and with increase in the period of exposure to oil. The mortality response of *Odontotermes obesus* to leaf extract of *Cordia dichotoma* has been reported to be dose and time dependent (Pal *et al.*, 2013). The formation of thin oil layer on termite cuticle when in contact with oil may also be a contributory factor to termite mortality. The covering of respiratory opening on termite body with oil could prevent passage of oxygen into the insect respiratory organs and also prevent exit of carbon dioxide from the body. The accumulation of carbon dioxide in insect tissues and low supply of oxygen to internal tissues reduce insect metabolism and also lead to suffocation which could lead to eventual death. Insect mortality has been reported to be increased with lower oxygen concentrations (Hoback and Stanley, 2001).

Probit analysis of termite mortality in Neem seed oil, Jatropha seed oil and Palm kernel oil showed that the three oil sources were effective against termite as indicated by the low values of LC_{50} both in soil and feeding bioassays. However, the LC_{50} in Neem seed oil and Jatropha seed oil were lower than LC_{50} in Palm kernel oil indicating that Neem seed oil and Jatropha seed oil were more toxic than Palm kernel oil. The lower LT_{50} values observed in Neem seed oil indicates that the application of Neem seed oil caused termite mortality faster than Jatropha seed oil and Palm kernel oil in soil and feeding bioassays. The lower values of LC_{50} and LT_{50} in soil bioassay compared to feeding bioassay is an indication that the three oils are more potent when applied as soil termiticides than when applied directly to plant materials.

Table 1. Mortality of worker caste of *Macrotermes bellicosus* on food treated with different concentrations of Neem, *Jatropha* and Palm kernel oils

Oil concentration	Neem seed oil			<i>Jatropha</i> seed oil			Palm kernel oil		
	Period of exposure (hour)								
	24	48	72	24	48	72	24	48	72
0%	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
2.5%	16.81±3.00	40.43±3.05	52.94±3.75	13.47±5.18	32.11±2.73	48.87±2.55	13.80±4.50	36.12±2.93	50.00±2.53
5.0%	54.85±13.75	80.14±11.30	86.03±10.49	39.58±9.73	63.50±2.00	72.93±3.23	27.59±5.67	60.56±3.41	71.66±3.02
7.5%	61.81±8.14	92.91±3.17	99.26±0.74	53.47±6.64	71.53±2.92	89.47±1.41	53.11±4.31	66.20±3.95	86.59±1.50
10.0%	79.85±5.95	100.00±0.00	100.00±0.00	60.42±4.34	73.72±2.13	96.99±2.19	64.14±4.83	75.36±1.11	93.31±2.73
LSD(0.05)	23.08	16.00	14.73	17.92	6.53	6.43	12.80	8.03	6.62

Table 2. Mortality of worker caste of *Macrotermes bellicosus* on sand treated with different concentrations of Neem, *Jatropha* and Palm kernel oils

Oil concentration	Neem seed oil			<i>Jatropha</i> seed oil			Palm kernel oil		
	Period of exposure (hour)								
	24	48	72	24	48	72	24	48	72
0%	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00
2.5%	57.72±4.32	84.50±2.86	92.54±3.92	42.86±3.94	56.71±8.05	74.73±7.56	17.01±3.33	44.45±3.64	65.40±6.58
5.0%	79.20±4.16	97.89±2.11	100.00±0.00	62.58±1.52	93.28±2.94	100.00±0.00	38.77±2.40	71.51±2.31	83.06±2.59
7.5%	95.31±2.28	100.00±0.00	100.00±0.00	82.99±1.08	100.00±0.00	100.00±0.00	48.94±3.40	71.53±1.30	95.14±2.05
10.0%	97.32±0.67	100.00±0.00	100.00±0.00	90.48±2.72	100.00±0.00	100.00±0.00	60.54±2.31	82.64±3.80	100.00±0.00
LSD (0.05)	8.51	4.69	5.18	6.78	11.33	9.97	7.67	7.78	9.72

Table 3. Median lethal concentrations (LC₅₀) of three plant oils on adult worker caste of *M. bellicosus* in feeding and soil assays after 24 hours of exposure

Plant oil	Feeding bioassay		Soil bioassay	
	LC ₅₀ (%)	95% Confidence Interval	LC ₅₀ (%)	95% Confidence Interval
Neem seed oil	5.19a	4.09 – 6.36	2.22a	1.10 – 3.00
<i>Jatropha</i> seed oil	7.12a	5.59 – 10.21	3.17a	1.93 – 4.09
Palm kernel oil	7.38a	5.93 – 10.23	7.39b	5.64 – 10.85

Table 4. Median lethal time (LT₅₀) of three plant oils on adult worker caste of *M. bellicosus* in feeding and soil bioassays at 10% concentration

Plant oil	Feeding bioassay		Soil bioassay	
	LT ₅₀ (hour)	95% Confidence Interval	LT ₅₀ (hour)	95% Confidence Interval
Neem seed oil	18.37a	13.38 – 27.67	4.26a	2.97 – 5.55
<i>Jatropha</i> seed oil	26.19a	22.23 – 30.98	4.29a	2.94 – 5.65
Palm kernel oil	25.27a	21.33 – 30.10	18.68b	12.04 – 35.06

The presence of oil in the soil and the contacts made with termite body could have caused termite mortality and could also deter termites from constructing tunnels in the soil. It has been suggested that inhibition of tunneling may be exploited in agricultural ecosystem to prevent termites from access to seed and plant parts (Ahmed *et al.*, 2007). Similarly, the result of feeding bioassay suggested that NSO, JSO and PKO could serve as deterrent to feeding by termites on plant materials. The inability of termites to feed might lead to starvation and eventual death. The three oils tested were effective for the control of termite, but NSO was the most effective followed by JSO. It should however be noted that though, all the oils were toxic to termite; the degree of toxicity depends on the concentration applied and the period of exposure. Extracts of neem and *Jatropha* seeds have been reported to be effective as termiticides at concentrations of 10 - 35% (Adissu *et al.*, 2014).

The insecticidal activity of seed oil of *J. curcas* has been attributed to the presence of sterols and terpene alcohols in the seed (Adebawale and Adedire, 2006; Nisar *et al.*, 2012) and has been reported as contact and stomach poison insecticides (Jembere *et al.*, 2005). The main active ingredient of *Azadirachta indica*, azadirachtin has been reported as contact poison (Adissu *et al.*, 2014). Isman (2006) reported that azadirachtin has broad mode of activity and demonstrated feeding deterrence, insect growth regulator, repellent, sterilant and may also inhibit oviposition of insect pest. Other locally sourced plant materials such as African locust bean, *Parkia biglobosa* (Olugbemi, 2011), *Moringa oleifera* (Janfa *et al.*, 2015), *Curcuma longa* (Turmeric), *Nerium indicum* (Oleander) and *Melia azedarach* (Derek) (Manzoor *et al.*, 2011) have been reported to possess anti-termite properties in Nigeria. The application of Neem seed oil, *Jatropha* seed oil and palm kernel oil as soil termiticides could be utilized by poor resource farmers in the management of termites in agriculture and forestry in sub-Saharan Africa.

CONCLUSION AND RECOMMENDATIONS

The results of this study showed that Neem seed oil, *Jatropha* seed oil and Palm kernel oil caused termite mortalities at the concentration of 2.5% - 10% when applied to food substrate or as soil treatment. However, the oils were more potent as soil termiticides due to the observed low LC₅₀ and LT₅₀. It is therefore recommended that these three plant oils can be used by farmers in Sub-Saharan Africa as alternatives to synthetic termiticides.

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Development of Larvae and Adult Populations of *Dermestes maculatus* on Three Smoked Fish Species



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Abstract

Fish is one of the major sources of protein in Nigeria and world-wide. Great losses to fish in storage have been attributed to insect pests and some other pathogenic organisms. In this study, laboratory experiments were conducted to analyze the growth of *Dermestes maculatus* (Coleoptera: Dermestidae) and its influence on smoked *Clarias gariepinus* Burchell, *Tilapia niloticus* Linnaeus and *Synodontis nigrita* Cuvier, in storage under, ambient conditions. The experiment was laid using a Completely Randomized Design and replicated three times. The population of *D. maculatus* at different days after infestation and the respective damage on each fish species was analyzed using one way analysis of variance (ANOVA) and differences in means were separated using LSD at $p \leq 0.05$. The results revealed that the population of *D. maculatus* was significantly higher on *S. nigrita* than on *T. niloticus* and *C. gariepinus*. The population of *D. maculatus* and damage caused on each fish species increased with increase in the number of days after infestation. A significantly higher damage was recorded on *S. nigrita* while *T. niloticus* suffered the least damage. The population of *D. maculatus* significantly correlated positively with the damage recorded on the three fish species.

Key words: Population, Weight loss, Susceptibility, Smoked fish, *Dermestes maculatus*

INTRODUCTION

Fish is a valuable source of high quality protein (Barrie *et al.*, 2003; Widjaja *et al.*, 2009) comparing favourably with eggs, milk and meat in the nutritional value of its protein (FAO, 1998). It contains fats, minerals and it is a major source of protein in West Africa constituting about 40% of animal protein intake (Eyo, 2001). In Nigeria, it serves as an important source of animal protein (Akande, 1997) as well as a source of income (Amusan and Okorie, 2002).

In view of its importance as a source of food, the demand for fish has been on the increase. Fish farming in commercial quantities has been gradually appreciating in the recent past in Nigeria, in the quest for meeting the needs of fish consumers across the West African sub-region. Fish production, handling, processing and distribution provide means of livelihood for millions of people as well as foreign exchange earnings (Al-Jufaili and Opara, 2006).

The processing and preservation of fresh fish prevents economic losses and deterioration of fish (Okonta and Ekelemu, 2005). It has been reported that, 10% weight loss by fish is as a result of poor handling, processing, storage and distribution (Akande *et al.*, 1998, Madison *et al.*, 1998). The longer the processor leaves the fish in conditions favourable to spoilage, the greater the destruction. Most processed fish are susceptible to damage by insects such as blow fly larvae and beetles (Procter, 1972; Madison *et al.*, 1998).

Under ambient conditions, it is estimated that; between 25 -75% of the nutritional value of fish is lost due to insect attack (Johnson and Esser, 2000). Losses caused by insect infestation include, physical, economic and nutritional. These losses often lead to an increase in the retail cost of fish beyond the purchasing power of the poor (Moses, 1992). Fish farmers and or sellers began to develop various means of storing fish in order to preserve it for a longer period. Smoking is one of the commonest methods of preserving fish in Nigeria. However, the responses of different smoked fish species to pest infestation are not clearly understood. Therefore, the objectives of this study were to compare the population growth and the level of damage caused by *D. maculatus* to *T. niloticus*, *S. nigrita* and *C. gariepinus* in storage.

Materials and methods

Study area

Lagos State is located in southwestern part of Nigeria between longitude 6°35' (N) and latitude 3°45' (S). It shares its boundary with Ogun State in the north and east, and with the Republic of Benin in the west. Behind its southern borders lies the Atlantic Ocean which is 22% of its 3,577km land mass (Figure 1). The estimated population of the state is 17.552 Million (Lagos State Bureau of Statistics 2005). The major traditional occupation of the inhabitants of the state is fishing which is widely distributed across the entire state (Figure 2).

Source and identification of fish species

The smoked fish species, *T. niloticus*, *S. nigrita* and *C. gariepinus* were obtained from Oyingbo market in Lagos. They were wrapped tightly in polythene bags and transferred to the Entomology Laboratory, Nigeria Stored Products Research Institute (NSPRI) Yaba-Lagos where they were identified.

Establishment of *D. maculatus* culture

Adults of *D. maculatus* were removed from the infested fish obtained from Oyingbo market. About 120g of oven-sterilized cured fish were put in a series of 1-litre glass jar and infested with 80 unsexed adults of *D. maculatus*. All the glass jars were covered with brown muslin cloth and secured on top with rubber band to keep the insects and to allow aeration. Three such cultures of each fish species were prepared at a time and placed on inverted Petri dishes in paraffin oil on shallow trays to keep out mites and other parasites. The parent adult insects were sieved off after two weeks of oviposition. The jars were left undisturbed until adults emerged. The F1 progeny of the insects (0-7 days old) were used for the experiments.



Figure 1: Residential Area of Lagos State, Nigeria

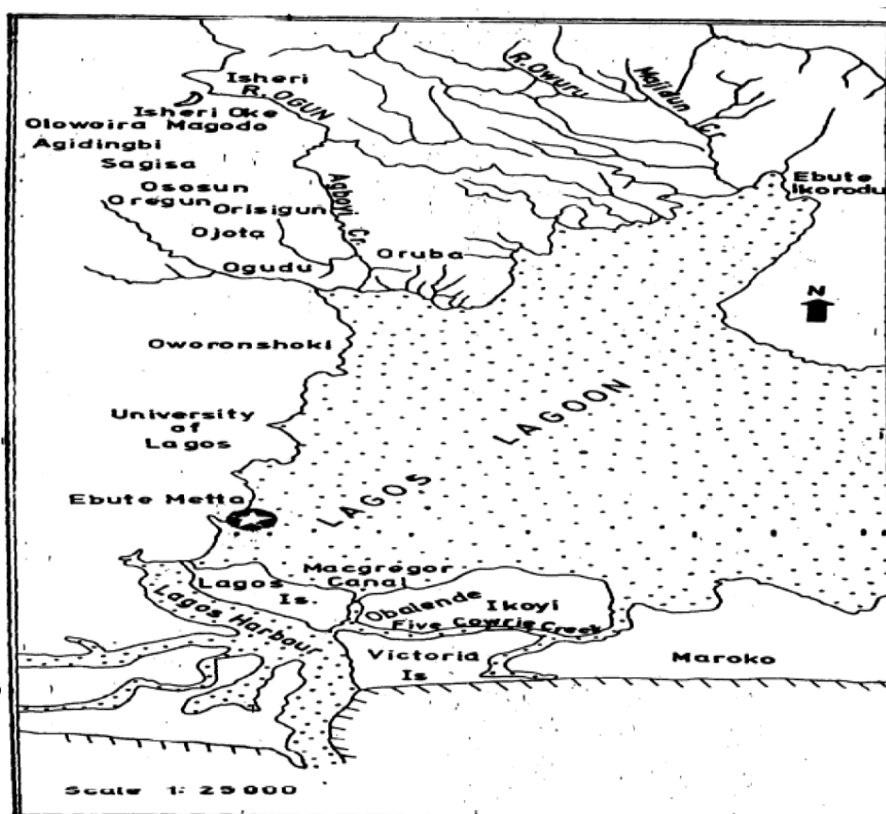


Figure 2: Fishing area in Lagos State

Population growth of *D. maculatus* on different smoked fish species

The three fish species were kept free of infestation at the commencement of the experiment by sterilizing the smoked fish thermally at 60°C for one hour in an air circulated oven to kill any pest present and to keep the moisture content constant. The glass jars used were also sterilized by scrubbing the inner with cotton wool dipped in Methylated spirit. A medium sized sterilized fish weighing 65g of each species were weighed and placed in separate glass jars.

The fish species were individually infested with three adult females and two males of *D. maculatus*. Each fish species was replicated eight times and arranged in a Completely Randomized Design (CRD) in the laboratory under ambient conditions. The experiment was left undisturbed and observed for adult emergence. The population growth of the pest (larvae and adult) was counted at two week intervals and recorded.

Damage assessment of fish species

Damage assessment of the different fish species was carried out after three months of storage. The different fish species were oven dried at 60°C for one hour after which the final weight was taken and recorded. The loss in weight of the fish was determined as the difference in weight of fish sample before the experiment and after the experiment and expressed as percentages using the formula:

$$\frac{W1 - W2 \times 100}{W1}$$

Where W1 = Initial weight of fish before the experiment, W2 = Final weight of residual fish after the experiment

Data analysis

The data obtained were analyzed using two way analysis of variance (ANOVA) and significant means were separated using Least Significant Difference at $p \leq 0.05$. A regression analysis was carried out to determine the relationship between the population of *D. maculatus* and the damage caused on each of the fish species.

RESULTS

The population of *D. maculatus* observed on *S. nigrita* at different periods after infestation was significantly higher than the numbers recorded on *T. niloticus* and *C. gariepinus* which were not significantly different from each other (Table 1). The differences in the populations of *D. maculatus* recorded on *S. nigrita* increased from 119 at 40 days after infestation to 155.45 at 100 days after infestation, but the differences in the populations between these periods were not significantly different from one another. On the contrary, the population of *D. maculatus* on *T. niloticus* and *C. gariepinus* increased significantly with increase in the number of days of infestation (Table 1).

Table 2 showed that the damage due to *D. maculatus* infestation recorded on the three fish species increased with increase in the days of infestation. The damage suffered by *S. nigrita* was significantly higher than the damage observed in *T. niloticus* and *C. gariepinus*. The differences in the percentage damage inflicted by *D. maculatus* on *S. nigrita* were significantly different from one another between 40 and 100 days after infestation. Similarly, *T. niloticus* and *C. gariepinus* were observed to suffer significantly higher damage with increase in days of infestation. The population of *D. maculatus* significantly correlated positively with the percentage damage on *T. niloticus* ($R^2 = 0.895$, $p = 0.004$), *S. nigrita* ($R^2 = 0.882$, $p = 0.005$) and *C. gariepinus* ($R^2 = 0.991$, $p < 0.00001$) (Figures 1, 2 and 3).

DISCUSSION

The results of this study indicated that a substantial loss in smoked fish occur due to infestation by *D. maculatus*, although, fish species differ in their susceptibility to *D. maculatus*. Loss in weight results from scarification and partial or complete consumption of the fish tissues. Damage and weight loss are mostly caused by the tunneling and feeding activities of the larvae and adults (FAO, 1998).

The lowest and highest weight loss were recorded in *T. niloticus* and *S. nigrita*. This is not unconnected with the higher density of *D. maculatus* on *S. nigrita* compared to the other two fish species. The weight loss in *S. nigrita* is at variance with the findings of Medugu and Kabir, (2013), who recorded highest weight loss in smoked *C. gariepinus*. Furthermore, it could be explained that higher weight loss recorded in *S. nigrita* was due to the multiplication of *D. maculatus* over a prolonged period of (100 days) of exposure. Awoyemi (1991) reported that fishes were reduced to frass and bones after 60 days of exposure to insect infestation. The study showed a significant positive correlation between the population of *D. maculatus* and the damage caused on the three fish species. The *S. nigrita* species was highly susceptible to infestation in comparison to *T. niloticus* and *C. gariepinus*. It provided a more suitable substrate for the culture, growth and development of *D. maculatus*. Nevertheless, the high infestation rate of *D. maculatus* in the three fish species was an indication that the insect constitutes a serious threat to stored fish product. The considerable loss of the three fish species substrates led to fragmentation and loss of quality. This is also attributable to extensive feeding habit of *D. maculatus* on fish substrates. Atijegbe (2004), evaluated quality loss during storage and noted that, damage severity may partly be a function of moisture content and lipid contents of the fish at the time of storage.

Similar findings were also reported in previous investigations by Osuji (1974) that different fish genera may vary in their susceptibility to attack by beetles. In some cases high lipid content may increase susceptibility to insect infestation. In addition to weight loss, infestation by insect can cause mould development, loss in nutritional and aesthetic values of fish (Osuji, 1974; Adedire and Lajide 2000).

CONCLUSION

This study has clearly shown that population and length of infestation are two important factors predisposing *T. niloticus*, *S. nigrita* and *C. gariepinus* to damage by *D. maculatus*. Efforts are required to reduce *D. maculatus* population on these fish species in order to limit damage.

Table 1. Population of *D. maculatus* (±S.E) on three fish species on different days after infestation

Fish species	Days after infestation						LSD (0.05)
	40	54	68	72	86	100	
<i>T. niloticus</i>	24.00±3.63 ^c	30.88±3.39 ^b	35.13±5.13 ^b	39.63±3.67 ^b	41.75±5.31 ^c	44.75±3.51 ^c	11.94 ^b
<i>S. nigrita</i>	119.50±15.75 ^a	122.50±19.73 ^a	135.25±21.01 ^a	129.25±24.45 ^a	146.13±26.91 ^a	155.25±18.96 ^a	61.76 ^a
<i>C. gariepinus</i>	22.88±1.53 ^b	28.25±1.92 ^c	33.00±2.50 ^c	38.13±1.85 ^b	43.00±3.04 ^b	46.88±2.22 ^b	6.36 ^c
LSD(0.05)	27.26	34.15	36.98	43.77	46.86	32.96	

Table 2. Mean damage (±SE) (%) of three fish species infested with *D. maculatus* at different days after infestation

Fish species	Days after infestation						LSD (0.05)
	40	54	68	72	86	100	
<i>T. niloticus</i>	6.54±1.04 ^c	9.68±1.22 ^c	11.79±1.16 ^c	13.73±1.06 ^c	15.66±1.11 ^c	18.91±1.17 ^c	3.22 ^b
<i>S. nigrita</i>	18.72±1.34 ^a	26.83±0.95 ^a	33.12±0.88 ^a	38.85±1.10 ^a	44.15±1.00 ^a	50.79±0.85 ^a	2.95 ^a
<i>C. gariepinus</i>	15.40±0.98 ^b	18.19±1.14 ^b	20.62±1.15 ^b	22.89±1.18 ^b	25.17±1.30 ^b	28.46±1.23 ^b	3.34 ^b
LSD(0.05)	3.32	3.27	3.16	3.28	3.37	3.22	

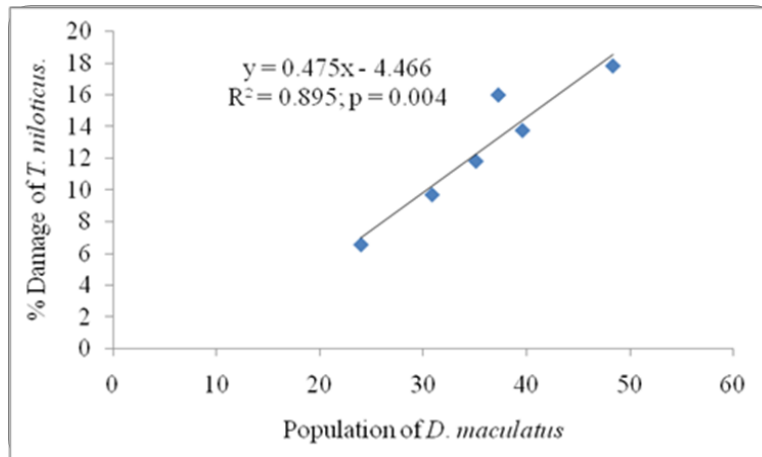


Figure 1. Relationship between population of *D. maculatus* and percentage damage of *T. niloticus*

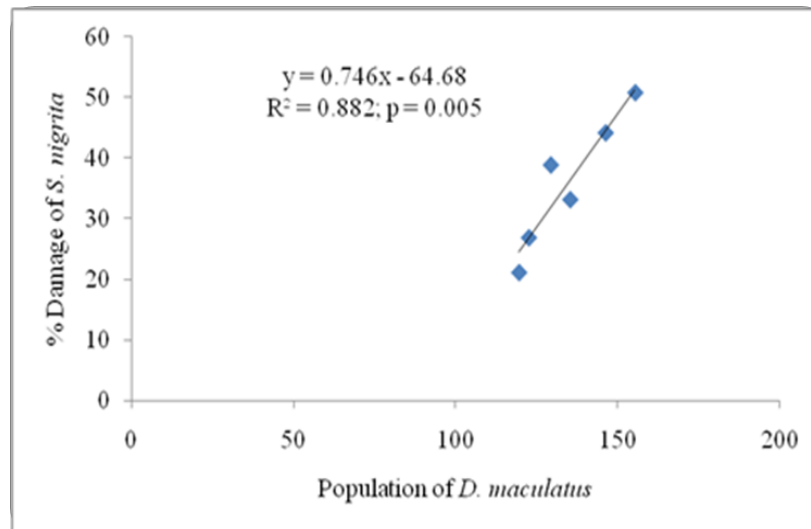


Figure 2. Relationship between population of *D. maculatus* and percentage damage of *S. nigrita*

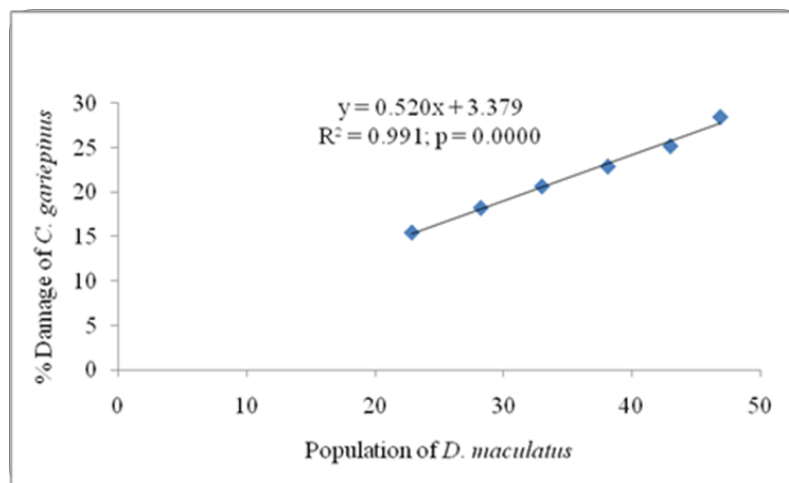


Figure 3. Relationship between population of *D. maculatus* and percentage damage of *C. gariepinus*

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Unsustainable Exploitation of Forest Resources: Sustainable Forest Management to the Rescue

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Abstract

Forests are important natural resources that enhance and improve the economic well-being of developing countries. However, continued exploitation of forest resources has created serious concerns for its sustainability. This calls for sustainable utilization strategies that will ensure that forests meet the needs of present and future generations. Existing natural forests should be conserved and well managed because they maintain and increase ecosystem health. They act as carbon reservoirs, protect people from sudden negative climatic events and reduce vulnerability to weather-induced problems. This paper reviews the factors responsible for unsustainable exploitation of forest resources, and its implications on sustainable forest management. In order to restore ecological balance, maintain biodiversity and avert the imminent problems of unsustainable exploitation, the paper recommends sustainable forest management as a viable tool in managing, conserving and sustaining Nigeria's forest ecosystems.

Keywords: forest resources, forest exploitation and sustainable forest management

INTRODUCTION

Nigeria as a country is blessed with rich vegetational zones and endowed with forest resources cutting across the entire nation (Aigbe and Oluku, 2012). Forests are important natural resources that enhance and improve the economic well-being of developing countries. According to Ojo *et al.* (2008), forests provide a wealth of important wood and non-wood forest products (such as edible nuts and fruits, medicinal plants, fibres, rattan, gum Arabic etc.) that people in the developed and developing world rely on. Research shows that healthy forests make substantial contributions to agricultural production, global carbon budgeting, aesthetics and local entrepreneurial opportunities like; tourism, and recreation for forest dependent communities (MEA, 2005; Busch *et al.*, 2017). Forests are tremendously endowed to sustain the health of the environment by regulating climate and creating a basis for more sustainable economic and social development (Gbadebo *et al.*, 2022). This natural resources are however, hampered by human-induced activities which disrupt the structure of forest ecosystems.

According to FAO (2015), Nigeria's forest estate was 7.7% of the country's land area which was below the country's target of a minimum requirement of 25% forest estate (FAO, 2010). Nigeria is one of the countries with the highest deforestation rate globally losing about 450,000-600,000 hectares of its forest cover as a result of anthropogenic activities (NCF, 2018). More than 70% of the world's population and over 2 million people in Nigeria depend on forest resources and earn income from forest-related enterprises such as fuel wood and charcoal sales, saw-milling, commercial hunting, handicraft production etc. (FAO, 2010). In spite of its importance, the natural tropical high forest is diminishing rapidly and constantly experiencing indiscriminate exploitation of its resources with little or no control measures of conservation to ensure its sustainability.

Over the years, sustainable management of forest resources has been a major concern due to its importance in enhancing global ecological functions and maintaining biological diversity. Forest resource management and conservation according to Adekunle *et al.*, (2010) is plagued with multiple challenges as guiding principles of managing forest sustainably are no longer in operation. Challenges like forest encroachment, legal and illegal felling, declining manpower and capacity in forestry department, inadequate forest patrol, outdated forestry laws and regulations, collection of fuel wood, industrialization, population pressure and the need to mitigate the effects of poverty, have led to loss of the Nigerian forest estate (Adetula, 2008; Gbadebo *et al.*, 2022).

Sustainable Forest Management (SFM) is the way through which forests are continually managed in order to achieve the stated goals and objectives of forest development without reduction of its inherent values and future productivity and without undesirable effects on the physical and social environment. SFM offers a holistic approach to ensure forest activities deliver social, environmental and economic benefits, balance competing needs, maintain and enhance forest functions at local, national, and global levels without jeopardizing the future (FAO, 2020). It therefore follows that SFM will enhance the status of the forest to meet the forest resource needs of the people (FAO, 2017). Considering the aforementioned, this paper reviewed the causes of unsustainable exploitation of tropical forest resources in Nigeria, its implication on SFM and the importance of sustainable conservation and effective management of forest resources.

AN OVERVIEW OF FORESTRY DEVELOPMENT IN NIGERIA

Forestry in Nigeria commenced in 1889 as a response to major concerns about forest reservation and lumber jacking (Geomatrics, 1997). Before independence, demand for forest products for export and local needs were adequately met. However, after Nigeria's political independence in 1960, demand for wood products, in particular became insatiable and pressure was exerted on our forests to generate revenue and meet the needs of the increasing populace. This led to unregulated encroachment and exploitation, which led to degradation of the forest resources in the country. Intervention programs such as Tropical Shelter Wood System, enrichment planting schemes and agroforestry were implemented at local government, state and federal levels without a holistic review of the forest sector. The problems plaguing the sector invariably persisted in spite of huge financial commitment to these forest development programs (Nwoboshi, 1986). The schemes and programs were not fruitful in promoting forest development in Nigeria. According to GFW (2021), Nigeria has lost 1.14 Million hectares (Mha) of forest cover from 2001 to 2021 which equates to an 11% decline in forest cover since 2000. The cause of this forest loss was ascribed to human induced activities, which accounts for about 80% of deforestation (Enabor and Popoola, 1994). This and many more led to the formulation of forest reservation policy which also had no holistic knowledge of ecology, biology and the silviculture of natural forest ecosystem (Osemeobo, 1998).

FACTORS RESPONSIBLE FOR UNSUSTAINABLE EXPLOITATION OF FOREST RESOURCES

Sustainable utilization of forest resources requires several elements which include legal and policy framework, sustained production of forest products and environmental protection. Absence of any of these elements results in negative influence on the availability and utilization of the forest resources (Eugene, 2004). This would further lead to the disruption of the forest ecosystem and the depletion of forest resources. Some of the causes of unsustainable exploitation of forest resources include:

Forest fire: One of the challenges recognized as a major reason behind forest exploitation in Nigeria is forest fire especially during dry season. Forest fire poses a serious threat to forest, its flora and fauna resulting in degradation and global warming

Agricultural practices/Shifting cultivation: Forest estates and vegetation cover are destroyed to provide land for cultivation of food crops or cattle grazing. Fire outbreaks from agricultural farms has a huge effect on the forest coverage as farmers intentionally set farmlands ablaze, in order to prepare it for the cultivation season. These practices cause environmental degradation and forest loss.

Urbanization and Industrialization: The advent of industrial revolution created the modern world with the establishment of global commerce, factories, large cities, construction of roads and markets, public and private buildings. Forest estates are infringed upon by industrial and residential development as population increases and cities extend outward. These factors force people to exploit forest resources and convert forested areas to meet the demand of the increasing population.

Exclusion of relevant professionals and stakeholders in forest policy formulation and implementation:

Policy makers in Nigeria are good at initiating policies to achieve sustainable forest management. The missing links between these established policies is the exclusion of relevant stakeholders within the sector. The non-participation of relevant professionals such as foresters, research scientists, environmentalists and more importantly the host communities, has led to prevalence of environmental challenges and partial accomplishment of forest policies. It is therefore necessary to involve them in the process to ensure effective participation and support for forest management activities.

Political inconsistency and somersault:

In Nigeria, political inconsistency has made various programs and policies aimed at sustainable forestry practice retarded and short lived. Whenever there is a change in political administration, the new administration is in the habit of discontinuing with the programs and policies put in place by the previous administration.

Implications of Unsustainable Exploitation of Forest Resources

The overall effect of continuous and unsustainable exploitation of forest resources without adequate regeneration strategies will lead to structurally and genetically degraded forests which are extremely difficult and expensive to rehabilitate. Exploitation of forest and its resources causes reduction in the capacity of a forest to produce multifunctional and diverse ecosystem services such as carbon sequestration; water and air purification; flood and erosion control; sustenance of biodiversity and genetic resources. This calls for the re-visitation and implementation of basic principles of SFM, which is the way out of the total collapse of forests. All stakeholders; forest managers, policy makers and the society at large should collaborate and manage Nigerian forest resources judiciously to avert the imminent problems of unsustainable exploitation.

STRATEGIES FOR SUSTAINABLE UTILIZATION OF FOREST RESOURCES

Forest is a very important gift of nature that should be properly utilized, maintained and protected for present and future use. The following strategies are proposed:

- Awareness campaigns should be organized to sensitize stakeholders on the consequences of depletion of forest resources and the need for sustainable forest management.
- Government and relevant stakeholders should embark on more sustainable afforestation and reforestation programs especially at the state and local government levels. Participation of private investors should also be sought, promoted and encouraged, while the cooperation of host communities courted. This will promote ecosystem balance, increase the forest cover, promote sustainable forest management and enhance the growth of a sustainable environment. For instance, in a bid to conserve forest resources and increase the biodiversity hub of the country, President Muhammadu Buhari at the 2019 Biodiversity Summit (United Nations General Assembly) in New York, America made a pledge that Nigeria would plant 25 million trees amounting to 23,000 hectares of tree cover (Nigerian Tribune, 2020). This made Forestry Research Institute of Nigeria (FRIN) acting on the mandate of Mr. President via the Federal Ministry of Environment to embark on a 25 million seedlings production project under the National Afforestation Program in 2019. This was aimed at ensuring that 25% of total land area of the country was forested. It is noteworthy that the Institute raised 13 million tree seedlings; the Great Green Wall Project raised about 7million; while other sister agencies raised 5 million with a view to actualizing the vision of Mr. President (Gbadebo, 2022). The import of the project is to mass produce tree seedlings for the National Afforestation Program whose objective is to ultimately increase the nation's forest cover,

address climate change mitigation and adaptation, provide ecosystem services, biodiversity conservation and reclamation of degraded lands.

- Preservation of living species or genetic materials via ex-situ conservation should be encouraged in order to protect biodiversity, ameliorate climate and achieve ecological balance. Such conservation entities include: gene banks, botanical gardens, plantations, arboretum and sites other than natural habitats.
- Existing natural forests should be conserved and well managed because they maintain and increase ecosystem health. They act as carbon reservoirs, protect people from sudden climate events and reduce their vulnerability to weather-induced problems such as floods and droughts. Such conservation units include, Man and Biosphere reserves, Strict Nature reserves, permanent sample plots, National Parks, forest reserves, fetish forests (sacred grooves) etc.
- Regulatory bodies with the support of the government and other stakeholders should work on implementing training and empowerment programs on green businesses for host communities around the forest to enhance sustainable livelihood and reduce pressure on the forest resources. Empowerment programs such as establishment of wood lot, bee keeping, locust bean and Shea butter production, snail farming, mushroom production, grasscutter farming, rabbit production etc.
- Involvement of host communities (forest-dependent communities) in communal forest management must be highly encouraged.
- Provision of enabling environment for forest laws and policies to effectively flourish without prejudice.

CONCLUSION AND RECOMMENDATIONS

Nigeria has suffered greatly from the consequences of continuous and unsustainable exploitation of forest resources. This situation is predicted to accelerate in the years ahead with significant impacts. This has great implications on forestry development. It is therefore imperative for relevant stakeholders to embark on more sustainable afforestation and reforestation programs to balance our ecosystem, increase the forest cover and enhance the growth of a sustainable environment. This study therefore recommends SFM as a veritable and viable tool in managing, conserving and sustaining Nigerian forests.

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Assessment of Indirect Drivers of Mangrove Destruction in the Niger Delta, Nigeria



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Abstract

The extent to which the mangrove ecosystem is overexploited and degraded, despite their productive and valuable attributes, raises concerns as to the sustainability of mangrove resources for rural communities. Hence, this study identified the indirect drivers inducing changes/destruction in the mangroves of the Imo River estuary. It assessed the impact of the mangrove on some socioeconomic variables of respondents. A multistage sampling procedure was employed, in which eight (8) communities were randomly selected at 10% sampling intensity. The second stage involved the random selection of twenty households from each community which formed the target respondents. A total of hundred and eighty (180) questionnaires were administered for the study while hundred and twenty-four (124) were retrieved. Questionnaire administration, Focus Group Discussion and Key informant Interviews (KIIs) were used to elicit information on the indirect drivers of mangrove change. Descriptive statistics (frequency distribution and chi-square) were used to analyse the data obtained. The use of improved tools (91.1%), migration (87.9%) and culture (54.8%) were the major indirect drivers of mangrove ecosystem change in the estuary. However, religion, an aspect of culture was observed to conserve the mangrove resources. In light of the above, environmental awareness on the effects of mangrove degradation and conservation education are recommended.

Keywords: Indirect drivers, mangroves, culture, conservation education

INTRODUCTION

Various reasons have been adduced as to why mangroves are regarded as valuable ecosystems in the world. These include protective, regulating and provisioning functions (Pendleton *et al.*, 2012; Wylie *et al.*, 2016). Its strategic location at the interface between land and sea enables mangroves to trap sediments that help in vertical land development while also shielding the coasts and communities from storms (Lee *et al.*, 2014; Doughty *et al.*, 2017). Equally, their biogeochemical relevance is evident in the interception of land-derived nutrients and sediments, provision of fish and shrimp nurseries, creation of habitat for crabs, oysters, and endangered species such as crocodiles and monkeys, and sequestering of carbon (Kelleway *et al.*, 2016; Yando *et al.*, 2016; Benzeev *et al.*, 2017; Kamel *et al.*, 2017). Even rural communities' livelihoods are sustained by the provisioning of timber, fuel wood, food, tannins and dye from mangrove environments (Palacios and Cantera, 2017).

The economic benefits derived from its goods and services contribute greatly to the improvement of human well-being (Aye *et al.*, 2019; Gideon and Onyema, 2020). For instance, the sales of mangrove wood for house construction and energy for cooking, and food condiments such as periwinkle, crabs, oysters, are livelihood sources for many in rural mangrove communities. Therefore, rural communities depend on the mangroves to meet their timber, fuelwood, food and medicinal needs. In the Niger Delta of Nigeria, for example, the products derived from the mangroves in most cases, are major sources of livelihood for the coastal communities in the region (James *et al.*, 2013). In view of the constant search

for improved well-being, humans, through their activities, overexploit, deforest, urbanize and convert mangrove land to other uses, including agriculture, aquaculture and even cause pollution to the mangrove ecosystem (Van Lavieren *et al.*, 2012). These myriads of anthropogenic activities occur at different spatial and temporal scales within the mangroves creating heterogeneity in resource availability, community structure and ecosystem process. Anthropogenic drivers have therefore, been incriminated as a major contributor to the declining trends in mangrove distribution (Feller, 2017).

Direct anthropogenic drivers in the mangroves are influenced by indirect drivers such as demographic, economic, sociopolitical, scientific and technological, cultural and religious forces. Globally, human population continues to increase and reached 8 billion in November 2022 (UN, 2022). It is expected that by 2030, coastal human population in the mangroves will increase to about 1.3 million (Neumann *et al.*, 2015; Feka, 2017). Such population increase has also been observed in the Niger Delta of Nigeria, with about 20 million people seeking improved livelihood in the region (IPPC, 2000). Population growth results in pressure on ecosystem for food, fuelwood, medicine, wood and other ecosystem services (Nautiyal and Kaechele, 2008). Thus, increase in population correlates with dependence on ecosystem goods and services, hence, the destruction of forest. In areas where these occur, low economic growth and limited income generation options are evident. Additionally, the extraction of natural resources is enhanced by the development or introduction of new technology to a locality or region for improved productivity.

Drivers which indirectly induce mangrove ecosystem changes are substantiated by anthropogenic activities (such as timber logging, and fuelwood harvesting) undertaken to improve human well-being. These indirect drivers are usually taken for granted and their overall contribution to the changes in the mangroves is given less attention, especially in the region. This study, therefore, seeks to identify the indirect drivers inducing changes/destruction in the mangroves of the Imo River estuary with a view to assessing the impact of the mangroves on respondents' socioeconomic variables.

MATERIALS AND METHODS

Study Area

The study was conducted in nine communities in the Imo River estuary which is situated between latitudes 4°32' and 5°53'N and longitudes 7°30' and 8°25' E, respectively. The area has a humid tropical climate which is influenced by the movement of the Inter-Tropical Front. The mean annual temperature of the study area is 27°C (Akwa Ibom State, 2014). The livelihood activities are heterogeneous such as fishing, timber and fuelwood harvesting, boat making, agriculture, trading of manufactured wares and mangrove resources, hunting, craft making and artisans (Gideon and Onyema, 2020). The vegetation is mainly that of tropical mangrove species. Deposits of recent alluvium and beach ridge sands occur along the coast, and estuaries of the Imo River and along the flood plains of the creeks (Fed. Min. of Power and Steel, 2000).

Research Design and Data Collection

A multistage sampling procedure was employed in which eight (8) communities (Iko, Atabrikang, Okoromboko, Agasi, Emeroeke, Utaewa, Opukuloma and Iwuoma) were randomly selected for the study at a 10% sampling intensity in the first stage. The second stage involved the random selection of twenty households from each community which formed the target respondents. A total of hundred and eighty (180) questionnaires were designed and administered but hundred and twenty-four (124) were retrieved. Target respondents were those with knowledge of the mangrove resources and had resided in the area for an extended period (>10 years). Additionally, the use of Focus Group Discussion (FGD) and Key Informant Interviews (KIIs) was adopted to elicit information on the indirect drivers of mangrove change. The indirect drivers inducing changes in the mangroves were analysed using descriptive statistics, and the results were presented in percentages and tables.

RESULTS AND DISCUSSION

Socioeconomic characteristics of respondents

The information in Table 1 served as explanatory variables for human activities that were induced by indirect drivers of mangrove change. Number of males (53.2%) was greater than females confirming a census report by NPC (2006). A higher population of males implies increased harvesting of mangrove resources to meet economic and food needs. The Chi-square revealed a relationship between gender and the harvesting of mangrove resources (Table 2). This is in contrast to the findings of Nchimbi, (2019) who found that gender did not influence mangrove resource exploitation in Zanzibar. The FGD revealed that logging of merchantable mangrove trees was done by men while women sometimes in the company of their children/husbands engaged in the harvesting of fuelwood from standing small-diameter trees using matchete. Men, on the other hand, make less frequent visits but target large-diameter trees. This is consistent with Feka *et al.* (2011). Also, the needs of the people involved in the extraction of mangrove resources determined the frequency of extraction. For instance, the need for daily cooking of family meals and drying of fish/crayfish required regular visits, at least once a week while the sale of fuelwood required between 2 to 4 times of visits per week, to the mangrove forest. Although this depended on the demand for their item of trade. This repeated visits affected the ecological structure and composition of the mangrove.

The population was dominated by young people (44.2%) implying an active age group who engaged in mangrove resource harvesting. This is consistent with previous findings that those in the active and productive ages got involved in activities that may cause depletion and degradation of mangrove resources (Branch *et al.*, 2002; Nchimbi, 2019). The intermediate residency period of between 31 and 40 years was more than other durations (between 10 and 20 years, 21 and 30 years, and >41 years). This duration exposed the respondents to valuing and utilizing of the resources. Long-term residents of mangrove communities have been able to adapt to mangrove environmental conditions and exploitation for subsistence and commercial uses (Kunstadter, 1984). The natural resource-dependent category, even though less than those in the service-oriented occupation, pointed to a higher dependency of the respondents on natural resources. The low-income category (40.9%) was higher than other categories of income earners. Low-income earners often resort to the utilization of natural resources, and rely on a wide range of ecosystem services provided by the mangroves (Orchard, 2015; Aye, 2019).

Indirect drivers inducing changes in the mangroves

In this study, migration (87.9%), use of improved tools (91.1%) and attitude/lifestyle (54.8%) were the major indirect drivers advanced for the continuous human activities in the Imo River estuary besides economic reasons (Table 3). The migration of people into mangrove communities directly influences the population of the area. Except for the Iwuoma community which migrated in the 20th century as reported by discussants during the FGD session, other communities migrated to their present location around the 17th century with few persons making up the population at that time. Migration was necessitated by the fishing occupation. Additionally, the extraction of mangrove resources was conservatively done with simple tools. A low human population and a subsistence-oriented economy encouraged the sustainable utilization of mangrove resources for the communities at that time. Over time, there has been an increase in the population of the area. The population of the area as of 2006 was 192,578 which comprised 98,035 males and 94,543 females (NPC, 2006). However, the population as of 2018 showed an increase to 271,150 comprising 138,033 males and 133,116 females. Again, the rural population of Akwa Ibom State for 2006 was 3,121,641 but the projected figure of 4,395,271 for 2018. Most households fell into the medium household-sized category (5-8 members), while others were in the broad category of >9 (Gideon and Onyema, 2020). Surprisingly, the Chi-square test showed a lack of relationship between respondents' household size and harvesting of mangrove resources (Table 3). This suggest that birth may not be the salient demographic factor responsible for the observed mangrove destruction. The findings of Aye *et al.* (2019) and Nchimbi (2019) confirm that population increase is one of the reasons for mangrove resource depletion. More so, the output from FGD revealed that people who engaged in timber/wood exploitation

from the mangrove appeared to be migrants (itinerant immigrants) given that such a venture is capital intensive and most local community members could not afford it. Granted that a few of the community members occasionally engaged in wood business at the secondary/intermediate level. They could not afford the purchase of improved equipment such as power chain saws and motorized boats, often used by these merchants in their extraction process. This is consistent with the findings of Nyangoko *et al.* (2022) in Tanzania.

Table 1. Socio economics characteristics of the respondents in the study area (N=124)

Variable	Category	Frequency	Percentage
Gender	Male	66	53.2
	Female	58	46.8
Age (years)	20-40	55	44.2
	41-60	48	38.6
	61 and Above	21	17.2
	Mean age	43.85	
Household size	1-4	35	30.2
	5-8	61	52.6
	9 and above	20	17.2
	Mean size	6	
Residency (years)	10- 20	18	15.5
	21-30	30	25.9
	31-40	36	31.0
	>41	32	27.6
	Mean	35.4	
Occupation	Non-natural Resources Dependent (e.g. teachers, preachers, paid wage workers, civil servants and retirees)	66	53.2
	Natural resources Dependent (e.g. fuelwood, stilt root and timber harvesting, crab and periwinkle harvesting)	58	46.8
Income(N)	<20,000	49	40.9
	20,000-32,000	40	33.2
	>32,000	31	25.9
	Mean	25,141	

Source: Field Study, 2020

Table 2. Effect of selected respondents' variables on extraction of mangrove resources

Variable	Df	x ²	Tab. Value	0.05	Remarks
Gender	4	20.34	20.339**	0.000	
Age	8	5.22	5.22*	0.74	
Household size	8	11.70	11.70*	0.17	
Residency	12	14.96	14.96*	0.24	

**Significant at $P < 0.05$, * Not significant at $P_{0.05}$

The Chi square showed a significant influence on gender in the harvesting of mangrove resources.

Table 3. Indirect drivers of change in the mangrove (N=124)

Item	Category	Freq	%
Respondents' acknowledgement rate about mangrove change	Yes	108	87.1
	No	16	12.9
Top three (3) perceived drivers of mangrove destruction	Migration (demographic)	109	87.9
	Availability of improved tools for harvesting	113	91.1
	Culture (Attitude and lifestyle)	68	54.8

Migration (emigration) may, therefore, be the major driver inducing mangrove resource utilization. The implication is that as wealthier migrants with intentions to extract wood resources in the estuary increase, the pressure on the mangrove for wood will increase causing more degradation. Migration affects the way natural resources are extracted and used. Migrants use extraction techniques that are not appropriate for a particular ecosystem. They have limited or no knowledge about the ecosystem and local utilization of the resources. They do not consider the long-term effect of resource extraction and use on the ecosystem (Begossi, 1998; Perz, 2003). Migration induces deforestation and resource depletion (Sierra, 1999; Cassels *et al.*, 2005), species extinction, soil degradation and erosion (Kirch, 2002) and reduced resilience of the ecosystem (Begossi, 1998).

The FGD revealed that before the 1980s, machetes were the only equipment available for felling wood, mainly at the subsistence level for fuelwood and house construction. This restricted community members from felling large-sized mangrove trees. The demand for more wood has witnessed an increase in the introduction of the power chain saw. Consequently, more stands of mature mangrove trees are felled leading to overexploitation. This in simple terms translates to more money earned in a shorter time invested in the activity. Additionally, ownership of motorized boats for the transportation of people and goods has increased in the area thereby facilitating the conveyance of more logs and other resources from the swamp. Men, unlike women, target large-diameter trees and use more sophisticated equipment than women (Feka *et al.*, 2011).

The culture (which was expressed in attitude and lifestyle) and religion influenced the way mangrove forest resources were exploited. The community members were socially, culturally and economically attached to their forest and therefore viewed the mangroves as an integral part of their existence. They had an attitude portrayed as '*our inherited endowment and unreplenishable resources*'. The FGD revealed that persuasion for detachment and reorientation from this attitude is usually met with resistance and violence, except there are alternative livelihood sources able to meet their energy and food needs.

Lifestyle is also expressed in the traditional pattern of land ownership and use. Land ownership in the study area is communal in nature. In the past, the traditional pattern of land ownership and land use in addition to low population sustained subsistence utilization of mangrove resources. A shift from a subsistence-oriented attitude to a commercial-oriented attitude put more pressure on mangrove resources. Nonetheless, the reclassification of most regions from rural to semi-rural and gradually into peri-urban locations further gave an indication of the likely trend of growth not purely based on population density but the rate of economic activities.

Consequently, the establishment of developmental projects by multinational oil companies or the government that offer compensation in monetary value and jobs/wages is enticing to the locals. For instance, the proposed Seaport in Akwa Ibom State that will virtually destroy the mangroves of Utaewa and other parts of the Imo River estuary was wholeheartedly welcomed by the community with excitement. In the long term, the ecological implications may outweigh the immediate gratifications which are in monetary "compensation". The impacts of the project could lead to further degradation and loss of part of the mangrove ecosystem in addition to regular confrontations ensuing from ignorance and greed on the part of the communities and insincerity on the part of the multinational oil companies and government. Religion was observed to play a key role in the utilization of the mangrove. In Opukuloma, a sacred forest of about 1 ha has been preserved for over fifty years. It is the only communally conserved mangrove forest in Akwa Ibom State. This has encouraged the conservation of the bio-resources of the

mangroves in this community. The findings of this study are consistent with the findings of Kathiresan and Bingham (2001), and James *et al.* (2013) that mangrove forest areas have been set aside as sacred grooves for religious rites in some communities. Furthermore, it was observed that the lack of environmental awareness affected the behaviour of communities towards the extraction of mangrove resources. Bohensky *et al.* (2006) observed that public awareness of environmental issues can help a community that is faced with environmental degradation to be more organized and committed to addressing restoration and sustainability issues.

CONCLUSION

The changes that have occurred in the Imo River estuary have far-reaching impacts on the biodiversity of the mangrove ecosystem and the communities surrounding the estuary. Many factors (anthropogenic and non-anthropogenic) observably caused changes within the mangrove resource area. It was evident that indirect drivers can also have significant impacts. In light of the above, no driver (cause of disturbances) ought to be played down because cumulatively, an insignificant driver, if unchecked, could cause adverse impacts on the ecosystem. This would disrupt the economic, social and even cultural balance on which a given community rest. Regular environmental awareness is therefore required to sensitize communities about the effects of mangrove degradation and the need for the conservation of mangrove resources.

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Phytoremediation of Spent Engine Oil Contaminated Soil using *Eucalyptus camadulensis* (Dehnh) Seedlings



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Abstract

The use of tropical trees for the natural clean-up of contaminated soils is a potentially cost-effective and environmentally friendly approach to the remediation of polluted land. Spent engine oil is a petroleum derivative that increases bulk density, decreases water holding capacity, and aeration propensity of soils, thereby creating toxic environments for plants and animals. This study determined the phytoremediation potentials of *Eucalyptus camadulensis* seedlings grown in spent engine oil contaminated soil. Topsoil (3 kg each) was contaminated with spent engine oil in order to obtain varying levels of pollution: 0 ml/kg, 25 ml/kg, 50 ml/kg, 75 ml/kg and 100 ml/kg. Seedlings were planted in polythene bags containing the contaminated soil and control treatments. The treatments were replicated 20 times, and the effects of varying levels of spent engine oil on the survival, growth, and heavy metal uptake of *Eucalyptus camadulensis* seedlings were assessed. The seedling height and collar diameter were measured while the number of leaves was counted fortnightly, for 16 weeks. Biomass accumulation was determined monthly using the destructive sampling method. At the end of the experiment, heavy metal analysis was conducted to determine Lead, Zinc, and Chromium concentration in the seedlings from the different treatments. Data were analysed using descriptive and inferential statistics at $P < 0.05$ level of significance. The survival rate was 59% for *Eucalyptus camadulensis* seedlings. There were significant differences in total height, number of leaves and collar diameter of seedlings in the different treatments. The highest height (104.43 cm), number of leaves (18) and collar diameter (4.52 mm) were observed for the control treatment. Seedlings growing in 50 ml/kg spent engine oil contamination had the least height (89.58 cm), and number of leaves (3) while seedlings exposed to 75 ml/kg spent engine oil contamination had the least collar diameter (2.80 mm). The heavy metal uptake varied across the treatments with Lead showing the highest level of uptake. The study indicated that *Eucalyptus camadulensis* had a high potential for phytoremediation of spent engine oil from contaminated soil.

Keywords: *Eucalyptus camadulensis*, spent engine oil, heavy metals

INTRODUCTION

Soil is an essential component of the environment but soil pollution has become a major problem worldwide, with many people suffering from health problems related to industrial and atmospheric pollutants. In recent years, significant attention has been paid to environmental contamination by chemical pollutants, particularly from hydrocarbon sources (El-Demerdash and Elagamy, 1999; Merkl *et al.*, 2004).

This indiscriminate disposal of spent engine oil into gutters, water drains, unoccupied land areas, and farms is a common environmental problem causing soil contamination in Nigeria. Spent engine oil, sometimes referred to as waste engine oil or spent lubricant, is obtained from automobile mechanic shops, and electrical engine repairers' shops, where servicing of various types of engines takes place. It has dark brown to black colour, and can increase soil toxicity .

Spent engine oil contains a mixture of chemicals, compounds, lubricants, additives, decomposition products, and heavy metals. These are unsafe substances that are dangerous to plants, animals and humans (Duffus, 2002). There are comparatively large amounts of hydrocarbons in the spent oil, including highly toxic polycyclic aromatic hydrocarbons (Wang *et al.*, 2000). Heavy metals such as Vanadium, Lead, Aluminium, Nickel, and Iron, which were below detection in unused lubricants, have been reported to be present in high amounts in spent engine oils (Whisman *et al.*, 1974). These heavy metals may be bound with organic matter in the soil and are retained in the form of oxides, hydroxides, carbonates, and exchangeable cations (Yong *et al.*, 1992). These contaminants alter soil biochemistry, destroy soil microbial communities, affect soil pH, inhibit oxygen diffusion and limit nutrient availability (Merkl *et al.*, 2004). It could lead to the accumulation of heavy metals in the biosphere with serious consequences on the health of flora and fauna.

Phytoremediation is a promising technology for the cleanup of petroleum-contaminated soils, especially in the tropics where financial resources can be limited, but climatic conditions favour plant growth and microbial activity. It involves growing plants in a contaminated matrix for a critical growth period to remove contaminants from the matrix or facilitate immobilisation (binding/containment) or degradation (detoxification) of the pollutants. The plants can be subsequently harvested, processed and disposed off. It is a low cost, solar energy driven cleanup technique, most useful on sites with shallow or low levels of contamination (Merkl *et al.*, 2004; Olajuyigbe *et al.*, 2019). Phytoremediation is effective for the cleanup of different kinds of pollutants such as heavy metals, radionuclides and a broad range of organic pollutants (Schroder *et al.*, 2002). Plants with high heavy metal uptake capacity and high biomass production are needed to extract pollutants from soils within a reasonable time frame (Ebbs and Kochian, 1997). Nevertheless, various studies have shown the efficacy of crops and grasses in remediating contaminated soils. Trees which exhibit low toxicity symptoms have also been suggested to have tolerance mechanisms that allow them to serve as efficient phytoremediators. For example, tree species such as *Hildegardia barteri*, *Azelia* spp., *Enterolobium* spp. and *Parkia* spp. have demonstrated remediating capabilities for crude oil contaminated soil (Olajuyigbe and Aruwajoye, 2014; Olajuyigbe *et al.*, 2019). Phytoremediation by tree species offer potential benefits ranging from aesthetically pleasing environments, lower risk of secondary pollution and a cost-effective approach. It is, therefore, imperative to identify potential tree species that can grow and remediate polluted soil. *Eucalyptus camadulensis* is a species that thrives well in tropical soils; hence, this study assessed the species potential in remediation of spent engine oil contaminated soil. The survival, growth and heavy metal absorption of the seedlings exposed to varying concentrations of the spent engine oil (SEO) were determined.

MATERIALS AND METHODS

Study area

This study was conducted at the nursery section of the Department of Forest Production and Products, University of Ibadan, Nigeria. The University is located in the southwestern part of Nigeria about 160 km from the Atlantic Ocean along latitude 7°26'45''- 7°27'31''N and longitude 3°53'31''- 3°54'14''E at an altitude of 277 m above sea level. The tropical climate is characterised by dry and rainy seasons. The dry season starts from November and ends in March with the characteristic dry cold wind of harmattan. The wet season usually starts from April to October with occasional strong winds and harmattan. The mean annual temperature is between 22°C and 34°C, while the annual rainfall is about 1300 mm (Olajuyigbe *et al.*, 2019).

Soil sample collection

Topsoil was collected from the nursery section and sieved with a 2 mm sieve to remove debris and large stones. Then, the physico-chemical properties of the topsoil were determined (Table 1). Spent engine oil was measured and systematically introduced to the topsoil to obtain homogeneous soil/pollutant mixtures at different ratios/levels: 25 ml, 50 ml, 75 ml, and 100 ml per kg of topsoil. After thoroughly mixing the

soil and contaminants, 3 kg of the mixture was placed in polythene pots, while soil without spent engine was used as the control treatment.

Table 1. Physico-chemical properties of the topsoil obtained from the nursery and used in the experiment

Parameter	Value
Phosphorus	6.45
Organic Carbon (%)	0.64
Total Nitrogen (%)	0.055
Availability Phosphorus (mg/kg)	6.825
Potassium (Cmol/kg)	0.023
Copper (mg/kg)	2.9
Zinc (mg/kg)	10.2
Magnessium (Cmol/kg)	1.579
Sodium (Cmol/kg)	0.626
Calcium (Cmol/kg)	2.994
Chromium (mg/kg)	10.06
Manganese (mg/kg)	200
Iron (mg/kg)	84
Sand %	86.5
Clay %	7
Silt %	6.5

Source: Department of Forest Production and Products, University of Ibadan, Nigeria

Seedling growth and development

In a completely randomised experiment, twenty 6-months old, uniformly growing *Eucalyptus camaldulensis* seedlings were introduced to each soil treatment. Daily watering of seedlings to field capacity of the soil was done. The seedling height, collar diameter were measured, and the number of leaves was counted fortnightly for 16 weeks. A vernier mini caliper was used to measure collar diameter, while a measuring tape was used to measure total height.

Biomass assessment

To determine biomass allocation and distribution, three replicates were randomly selected every month for biomass determination. The seedlings were uprooted, cleaned and separated into roots, stems, and leaves. Stem length was estimated using a meter rule. The seedling parts were oven-dried at 60°C until constant dry weight was achieved. Leaf, stem, root and total biomass were determined.

Heavy metal analysis

The Lead (Pb), Zinc (Zn) and Chromium (Cr) accumulation in the seedlings (roots, stem, and leaves) were determined after 16 weeks. The plant samples were milled, and homogenised and stored in plastic bags until acid digestion was carried out. The milled samples were placed in 250 ppm digestion tubes and 10 ml of Nitric acid (HNO₃) was added. The solution was heated for 45 minutes at 90°C, then the temperature was increased to 150°C. The sample was boiled for 8 hours until a clear solution was obtained. The solution was filtered, and the filtrate transferred quantitatively into a 25 ml volumetric flask. The Atomic Absorption Spectrophotometer (Buck Scientific Model 210/211 VGP) was used to determine the amounts of Pb, Cr, and Zn in seedlings grown in different treatments.

Data analysis

Data were subjected to two-way analysis of variance (ANOVA), and means found to differ significantly were subjected to follow-up test procedure using Holm-Sidak posthoc analysis. Data were analysed using the SigmaStat 11 Software.

RESULTS

Effect of spent engine oil on growth of *Eucalyptus camaldulensis* seedlings

There were significant differences in the effect of time of exposure ($p < 0.001$) and concentration of spent engine oil ($p < 0.001$) on height. However, there was no significant difference in the interaction effect ($p = 0.756$). After 16 weeks, the highest height was observed for seedlings in the control treatment (104.43 ± 16.64 cm) while seedlings growing in 50ml/kg spent engine oil contaminated soil performed the least (89.58 ± 20.28 cm) (Table 2).

Table 2. Height (cm) of *Eucalyptus camaldulensis* seedlings in topsoil contaminated with varying levels of spent engine oil

Weeks	25ml	50ml	75ml	100ml	Control
0	88.71 $\pm$ 13.68	83.50 $\pm$ 18.42	89.75 $\pm$ 13.64	89.15 $\pm$ 16.68	94.75 $\pm$ 13.83
2	88.88 $\pm$ 13.61 ^a	83.55 $\pm$ 18.34	89.79 $\pm$ 13.66	89.19 $\pm$ 16.71	95.54 $\pm$ 14.00
4	93.90 $\pm$ 13.97	85.53 $\pm$ 20.09	89.17 $\pm$ 15.95	93.77 $\pm$ 19.50	99.33 $\pm$ 15.17
6	94.00 $\pm$ 13.04	86.49 $\pm$ 19.60	89.16 $\pm$ 14.80	90.89 $\pm$ 15.65	101.10 $\pm$ 15.17
8	97.04 $\pm$ 12.83	89.12 $\pm$ 20.24	90.78 $\pm$ 14.44	91.67 $\pm$ 16.13	102.98 $\pm$ 15.50
10	97.32 $\pm$ 12.94	89.21 $\pm$ 20.25	90.99 $\pm$ 14.57	92.74 $\pm$ 16.64	102.99 $\pm$ 15.94
12	97.41 $\pm$ 12.90	89.28 $\pm$ 20.26	91.03 $\pm$ 14.55	92.76 $\pm$ 16.67	103.23 $\pm$ 16.02
14	97.48 $\pm$ 12.92	89.32 $\pm$ 20.27	91.06 $\pm$ 14.52	92.92 $\pm$ 16.61	103.50 $\pm$ 16.04
16	97.57 $\pm$ 12.93	89.58 $\pm$ 20.28	91.06 $\pm$ 14.52	92.92 $\pm$ 16.61 ^a	104.43 $\pm$ 16.64

There were significant differences in the effect of varying levels of spent engine oil on the number of leaves, with the highest (27.40 ± 23.58) recorded for seedlings in the control treatment (0ml/kg) after 16 weeks. The number of leaves reduced as the concentration of spent engine oil increased. Hence, a progressive decrease was observed for the number of leaves of seedlings in the 50ml/kg, 75ml/kg, and 100ml/kg of spent engine oil treatment (Table 3).

Table 3. Number of leaves of *Eucalyptus camaldulensis* seedlings growing in topsoil contaminated with varying levels of spent engine oil

Weeks	25ml	50ml	75ml	100ml	Control
0	13.75 $\pm$ 4.74 ^a	13.25 $\pm$ 4.39 ^a	16.50 $\pm$ 6.95 ^c	11.05 $\pm$ 3.03 ^b	17.20 $\pm$ 4.31 ^c
2	8.25 $\pm$ 6.32 ^a	4.95 $\pm$ 3.72 ^b	0.70 $\pm$ 2.05 ^c	3.55 $\pm$ 4.24 ^b	9.45 $\pm$ 5.61 ^a
4	15.00 $\pm$ 12.27 ^a	7.90 $\pm$ 8.83 ^b	4.10 $\pm$ 5.51 ^c	9.85 $\pm$ 9.28 ^b	18.80 $\pm$ 13.90 ^d
6	15.15 $\pm$ 14.56 ^a	6.55 $\pm$ 7.94 ^b	1.15 $\pm$ 2.91 ^c	5.60 $\pm$ 7.74 ^b	22.90 $\pm$ 20.91 ^d
8	15.75 $\pm$ 15.07 ^a	7.70 $\pm$ 9.04 ^b	1.35 $\pm$ 3.31 ^c	6.15 $\pm$ 8.04 ^b	26.40 $\pm$ 23.01 ^d
10	16.55 $\pm$ 13.37 ^a	8.15 $\pm$ 7.92 ^b	1.80 $\pm$ 4.58 ^c	7.75 $\pm$ 11.45 ^b	26.30 $\pm$ 23.84 ^d
12	16.35 $\pm$ 13.06 ^a	8.70 $\pm$ 8.70 ^b	1.45 $\pm$ 3.89 ^c	4.90 $\pm$ 7.14 ^b	26.85 $\pm$ 23.63 ^d
14	16.25 $\pm$ 13.05 ^a	8.90 $\pm$ 8.53 ^{ac}	1.55 $\pm$ 4.08 ^b	5.05 $\pm$ 7.19 ^{ac}	27.25 $\pm$ 23.59 ^d
16	16.05 $\pm$ 12.84 ^a	8.75 $\pm$ 8.26 ^{ac}	1.75 $\pm$ 4.35 ^b	5.05 $\pm$ 7.19 ^{ac}	27.40 $\pm$ 23.58 ^d

****Means of values with the same superscript along rows were not significantly different at $p < 0.05$**

There were significant differences in the effect of time of experiment on seedling collar diameter. The highest mean collar diameter was recorded for seedlings in the control treatment (4.52 ± 1.32 mm), while 75ml/kg treatment had the least (2.80 ± 0.87 mm). The mean values of collar diameter increased from 2.94 ± 1.19 to 4.52 ± 1.32 mm for the control, 2.74 ± 0.83 to 3.57 ± 0.69 mm, 2.48 ± 1.07 to 3.06 ± 1.22 mm, 2.42 ± 0.72 to 2.80 ± 0.87 mm, and 2.91 ± 1.21 to 3.71 ± 1.52 mm for 25ml/kg, 50ml/kg, 75ml/kg and 100ml/kg, respectively (Table 4).

Table 4: Collar diameter (mm) of *Eucalyptus camaldulensis* seedlings growing in topsoil contaminated with varying levels of spent engine oil

Weeks	25ml/kg	50ml/kg	75ml/kg	100ml/kg	Control
0	2.74±0.83	2.48±1.07	2.42±0.72	2.91±1.21	2.94±1.19
2	2.74±0.83	2.61±1.23	2.47±0.73	3.03±1.29	3.18±1.31
4	2.91±0.77	2.65±1.10	2.54±0.85	3.20±1.43	3.33±1.25
6	3.20±0.88	2.80±1.19	2.66±0.92	3.54±1.50	3.64±1.11
8	3.49±0.71	2.86±1.16	2.70±0.90	3.60±1.54	4.34±1.27
10	3.51±0.71	2.86±1.16	2.70±0.90	3.61±1.53	4.40±1.27
12	3.54±0.71	3.00±1.25	2.75±0.91	3.68±1.55	4.44±1.29
14	3.56±0.69 ^a	3.00±1.23 ^b	2.75±0.90 ^b	3.69±1.54 ^c	4.48±1.31 ^c
16	3.57±0.69 ^a	3.06±1.22 ^b	2.80±0.87 ^b	3.71±1.52 ^c	4.52±1.32 ^c

****Means of values with the same superscript along rows were not significantly different at $p < 0.05$**

Effect of spent engine oil contamination on the biomass of *Eucalyptus camaldulensis* seedlings

Leaf biomass was highest in the control treatment (0.99±0.25 g) and leaf production differed across treatments (Table 5). The highest stem biomass was obtained for seedlings grown under control treatment (6.61±3.01 g), followed by seedlings under 25ml/kg spent engine oil contaminated soil (6.49±3.95 g), while the least was for 75ml/kg spent engine oil contaminated soil (3.17±1.79 g). However, the spent engine oil contamination did not significantly affect stem biomass of the seedlings. There were no significant differences in the root biomass across treatments. The seedlings exposed to 25ml/kg of spent engine oil contaminated soil had the highest root biomass (2.60±1.55 g), while those in the control treatment had the least root biomass (1.36±0.93 g) (Table 5).

Table 5. Biomass (g) of *Eucalyptus camaldulensis* seedlings grown in soil contaminated with varying amounts of spent engine oil

Weeks	25ml/kg	50ml/kg	75ml/kg	100ml/kg	Control
Leaves					
4	0.40±0.37	0.47±0.32	0.00±0.00	0.05±0.01	1.90±0.48
8	0.53±0.30	0.30±0.01	0.00±0.00	0.08±0.01	0.11±0.01
12	1.41±0.06	0.08±0.00	0.00±0.00	0.00±0.00	0.99±0.25
Stem					
4	5.13±2.58	4.27±2.09	3.91±1.92	4.26±1.06	5.98±3.36
8	7.60±4.23	3.94±0.52	2.93±0.70	2.36±1.61	4.90±2.60
12	6.49±3.95	3.59±0.81	3.17±1.79	3.58±1.72	6.61±3.01
Roots					
4	1.87±0.78	1.76±0.92	1.60±0.72	1.50±0.74	1.80±0.26
8	2.53±1.07	1.32±0.98	1.45±0.79	0.98±0.83	2.19±0.01
12	2.60±1.55	1.82±0.65	2.21±0.98	2.03±1.02	1.36±0.93

Heavy metal uptake of *Eucalyptus camaldulensis* seedlings grown in varying levels of spent engine oil contamination

There were significant differences in the heavy metal uptake of the roots of the seedlings grown in different levels of spent engine oil. There was an accumulation and the concentration of heavy metals increased with increasing level of contamination. After 16 weeks, seedlings in 25ml/kg, 50ml/kg, 75ml/kg and 100ml/kg had Pb concentration of 77.50 ppm, 45.77 ppm, 88.00 ppm and 89.45 ppm, respectively, in their stem/leaves. Zinc concentration was 9.19 ppm, 5.31 ppm, 5.56 ppm, and 7.60 ppm in the stem/leaves of seedlings exposed to 25ml/kg, 50ml/kg, 75ml/kg and 100ml/kg spent engine oil

contamination. The Chromium concentration followed the same pattern, increasing with the level of contamination (Table 6).

Table 6. Lead, Zinc and Chromium concentrations in the *Eucalyptus camaldulensis* seedlings after 16 weeks of exposure to spent engine oil contaminated topsoil

Plant part	Treatment			
	25ml/kg	50ml/kg	75ml/kg	100ml/kg
Lead				
Roots	114.36±76.14	123.67±19.34	188.63±60.34	222.33±35.35
Stem/leaves	77.50±18.02	45.77±3.83	88.00±36.64	89.45±20.74
Zinc				
Roots	5.44±1.74	7.89±0.61	8.02±0.22	10.5±1.25
Stem/leaves	9.19±2.41	5.31±1.69	5.56±0.00	7.60±1.0.6
Chromium				
Roots	5.09±1.30	5.59±1.17	5.63±0.98	8.95±0.87
Stem/leaves	3.44±0.23	3.71±0.22	4.20±0.60	6.30±0.64

DISCUSSION

The introduction of *Eucalyptus camaldulensis* seedlings to the pollutant resulted in initial shock evidenced by the wilting of leaves. This could be a response to the toxic effect of pollutants. The oily substances around the root inhibit respiration. These extreme effects were clearly observed during the study. The survival of the seedlings was affected by the increasing concentration of spent engine oil (Olajuyigbe and Aruwajoye, 2014; Olajuyigbe and Sijuola, 2015; Olajuyigbe *et al.*, 2019).

The decline in seedling growth observed in this study has been earlier reported for tropical species such as *Phaseolus vulgaris*, *Terminalia ivorensis* and *Hildergardia barteri*, and grown in spent engine oil (Nwoko *et al.*, 2007; Olajuyigbe and Sijuola, 2015; Olajuyigbe *et al.*, 2019). The control treatment had the highest seedling height and collar diameter, indicating that height increase was inversely related to the increase in spent engine oil concentration. In addition, spent engine oil contamination had a negative influence on leaf production. This agrees with Odjegba and Sadiq (2002) and Olajuyigbe *et al.* (2019), who observed a significant reduction in the leaves of *Amaranthus hybridus* and *Hildergardia barteri* seedlings grown in spent engine oil. This loss of foliage suggest that photosynthetic efficiency might have been greatly hindered by the pollutant. The observed reduction in growth variables with increasing contamination could be attributed to a limiting of the flow of food resources to the roots and a decline in the supply of water and nutrients from the soil (Nwoko *et al.*, 2007).

The control treatment had the highest biomass accumulation, which reduced with increasing pollutant concentration. Leaf biomass reduced in all treatments due to leaf abscission resulting from changes in environmental conditions. The trend of reduction in biomass accumulation is similar to the result of Olajuyigbe and Aruwajoye (2014), who reported variations in the biomass of two hardwood species (*Terminalia superba* and *Khaya senegalensis*), exposed to diesel oil contamination. The *Eucalyptus camaldulensis* seedlings were able to accumulate Lead, Zinc and Chromium in their plant parts. The roots tended to accumulate more heavy metals (except Pb) than the other plant organs. Olajuyigbe and Aruwajoye (2014) stated that the roots of *Terminalia superba* and *Khaya senegalensis* could retain over 50% of heavy metals in most of the treatments in their study. Plants tend to exhibit some form of differentiation in heavy metal accumulation in actively growing tissues such as stem, roots and leaves. It was observed that the level of heavy metal accumulation increased with increasing level of spent engine oil contamination as 100ml/kg of soil recorded the highest amount of Pb, Zn and Cr in the roots, stem, and leaves.

CONCLUSION

This study has demonstrated that spent engine oil had a strong effect on the growth of *Eucalyptus camaldulensis* seedlings. There was a translocation of heavy metals from belowground to aboveground parts of the seedlings indicating some tolerance of the spent engine oil. Therefore, the species tolerance of the spent engine oil toxicity can be explored in phytoremediation. Therefore, further studies of heavy metal accumulation in the seedlings of the species over extended periods are required to ascertain the phytoextraction pathways and mechanisms of *Eucalyptus camaldulensis*.

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Perceptions on Availability and Variation of Hardwood Species in Iseyin Local Government of Oyo State Nigeria

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Abstract

The study, carried out in Iseyin Local Government Area of Oyo State, Nigeria, involved 64 respondents (Timber sellers- 30 at Abaletu sawmill and 34 at Koso sawmills) who were selected through purposive sampling techniques. Primary data of perceptions on availability and variation of hardwood species in the study area were collected through an interview guide. Results from the data analysis showed that 73.4% of the timber sellers were male, 51.6% of them married with a mean age of 38.7 years. 53.1% of them had between 6 and 10 persons household members, 40.6% with monthly income of ₦50,000 to ₦100,000 and more than half (54.7%) financed their businesses through personal source. 79.7% of the respondents affirmed that deforestation is very high due to constant demand for hardwood species in the study area. This compelled them to travel several kilometers into the forest during the dry season, as rainy season and bad road were major limitations. The study concluded that deforestation was high during dry seasons in an attempt to satisfy curiosity and demand for hardwood species. Therefore, conservation education, treatments for softwood species, raising of seedlings and afforestation programmes are intervention strategies that should be advocated.

Key Words: Perception, availability and hardwood species

INTRODUCTION

Timber, being a construction material, has been used for different purposes, including structural and ornamental purposes. It is used throughout the world for many tasks, from simple structural application to highly finished and ornate decoration and it is the dominant industrial material in Nigeria (Fuwape, 2000). There are approximately 200,000 hardwood species and 1000 softwood species in Nigeria, of the total number; only 2,300 tree species are commercially important (Oluyeye, 2007). In building and furniture industries, various species of timber are used for different purposes. The choice of wood species used varies, due to different features and characteristics of the wood, some of these features are wood strength, natural durability, colour (appearance), ease of machine and workability, cost, contraction, hardness and availability (Adekunle et al., 2014).

In recent years, the number of timber species harvested and marketed in production forests in Africa has grown, especially near seaports or major local markets, where prime species have been largely logged out. However, a handful of species still make up the bulk of production. In Central African Republic, for example, loggers harvest 15 to 18 timber species, and five species make up 90% of production; in Northern Congo, 18 to 20 species are harvested, but five species account for nearly 80% of production (ITTO, 2005). The major timber species exported from Nigeria and some other African countries include Mahogany (*Khaya senegalensis*), Obeche (*Triplochiton scleroxylon*), Afara (*Terminalia superba*), Abura (*Mitragyna ciliata*), Iroko (*Milicia excelsa*), and Teak (*Tectona grandis*) (ITTO, 2005). Timber can be described as wood in a form suitable for construction or carpentry, joinery or for reconversion to manufacturing purpose. Timber has been used as a building material for over 400, 000 years and it is a common and best known material for house construction including framing of floors, walls and roofs (RMRDC, 1998). Timber accounts for about half of worldwide wood consumption and this exceeds the use of steel and plastic combined (Cunningham et al., 2005). According to Lucas (2006), the preference

of timber may not be unconnected to its versatility, abundance, accessibility, renewability, less energy input required for processing and relative cheapness. However, it occurs in low density in most tropical forests, therefore, large areas tend to be exploited diffusely to extract a few prized logs. In the estimation of FAO (2010), Nigeria loses about 3.7 percent of its forest area yearly and this makes it to have the highest net loss from 2000 to 2010, mainly due to overexploitation of wood for timber production. Consequently, yield of the most valuable timber species declined as a result of initial overcutting and failure to leave sufficient seed trees (Kellman and Tackabery, 1993). This has led to a decline in the availability of tree species like Iroko (*Milicia excelsa*), Opepe (*Nauclea diderrichii*), Teak (*Tectona grandis*) and many other valuable timber species. The scarcity of these fine quality timber species has forced species such as *Pycnanthus angolensis*- Akomu, *Triplochiton scleroxylon*- Arere and *Albizia zygia*- Ayunre into the markets. Ten to twenty years ago, these species were considered only acceptable for low-end construction type uses (Awe *et al.*, 2019). Therefore this study determined perceptions on availability and variation of hardwood species in the study area with a view to promoting sustainable utilization and conservation.

MATERIALS AND METHODS

Study Area

The study was carried out in Iseyin Area of Oyo State. The area comprises Ifelodun I and II Local Government Areas. Oyo State is situated within the southwestern zone of Nigeria. It is the most centrally located of all the states of the federation, with a population of 1,232,789 (NPC, 2006). The state has two distinct seasons (the wet and dry seasons) and a humid tropical climate.



Figure 1. Map of Iseyin Local Government Area (Source: NPC, 2006).

Population of Study: The study population consisted of those involved in the sale of planks (Timber sellers) at the designated sawmills in Iseyin town.

Sampling Frame: A total number of 122 wood sellers were identified during the study. This was possible through the help of the wood sellers association at the sawmills.

Sampling Size and Sampling procedure: purposive sampling technique was used for selecting the study area since there are only two sawmills at Iseyin which are Abaletu and Koso sawmills. Thirty and 34 respondents were selected at Abaletu and Koso sawmills respectively to achieve an effective study population of 64 respondents, representing 53% of the sampling frame. The respondents were randomly selected based on their willingness to participate in the study.

Measurement of Variables

- i. Sex: This was measured at nominal levels by indication of either being a male or a female.
- ii. Age: This was measured at interval levels by obtaining the specific age of the respondents.
- iii. Marital status: This was measured at nominal level by an indication of either being married or single.
- iv. Educational Level: This was measured at ordinal level using indicators such as “no formal education”, “primary education”, secondary school education” and “tertiary education”.
- v. Household size: This was measured at interval level by asking the respondents to give specific number of people that make up their household.
- vi. Monthly Income: This is measured at interval level by asking the respondents to choose a range within which the income falls.
- vii. Years of Experience: This was measured at interval level by obtaining the specific number of years the respondent had spent in the business of wood selling.
- viii. Source of finance: This was measured at interval level by asking the respondents to give specific source of finance.
- ix. Association Membership: This was measured at nominal level by an indicator of either being a member of association or not.
- x. Perceptions on hardwood species: This was measured at ordinal level using indicator such as “strongly agreed”, “agreed”, “undecided”, disagreed” and “strongly disagreed” from series of perceptual statements.

Validity and reliability of research instrument: The interview guide was subjected to face and content validity with the help of a resource person in the field of forestry and extension services. This ensured that appropriate variables were measured and relevant information sought. The reliability test was done through a test-retest method in which the research instruments were administered to some selected respondents at an interval of two weeks (between first and second administration) in order to ascertain the consistency of result obtainable from several administered data-gathering instrument.

Data Collection: Primary data on availability of hardwood species in the sawmill and perceptions on hardwood were collected from respondents through the use of interview guide.

Methods of Data Analysis: Data obtained from the field were subjected to descriptive statistics, using SPSS (Statistical Package for Social Science). Descriptive statistic such as frequency and percentages were used for presentation of data obtained at nominal and ordinal levels of measurement. A five-point Likert scale was used to analyse respondents’ perceptions about hardwood species in the study area.

RESULTS

Demographic Characteristic of Respondents

Most of the respondents were male (73.4%) with 26.6% being females (Table 1). This notwithstanding, women were also active in wood selling due to their role in selecting and sorting of planks at the sawmills. Majority of the respondents’ fell within the age range of 31 and 40 years, with mean age of 38.7 years. This suggests that most of the wood sellers were relatively young and agile enough to manage the tediousness of the business. About 51.6% of the respondents were married, 3.1% of them had between 6 and 10 persons as household members. This means that more mouths would have to be fed or more people catered for by household heads. Most respondents (90.6%) had one form of education, with the

exception of 9.4 %, who had no formal education (Table 1). This is an indication that wood selling business is a convenient venture for both the educated and non-educated.

Table 1. Demographic characteristic of respondents (N = 64)

	Frequency	Percentage (%)	Mode/Mean
SEX			
Male	47	73.4	Male
Female	17	26.6	
AGE			
Less Than 20 years	7	10.9	38.7 years
21 -30 years	10	15.6	
31 – 40 years	30	46.9	
41 – 50 years	9	14.1	
51 – 60 years	5	7.8	
Above 60 years	3	4.7	
MARITAL STATUS			
Married	33	51.6	Married
Single	16	25.0	
Widow	15	23.4	
EDUCATIONAL LEVEL			
No Formal education			Primary Education
Primary Education	6	9.4	
Secondary Education	35	54.6	
Tertiary Education	17	26.6	
	6	9.4	
House Hold Size			
0 - 5			6 – 10 Person
6 – 10	16	25.0	
11 – 15	34	53.1	
Above 15	7	10.9	
	7	10.9	

Source: Field Work 2022

Socio-Economic Characteristic of Respondents

It was observed that 20.3% of the respondents had estimated monthly income less than ₦ 50, 000. Those with monthly income of ₦ 50, 000 – ₦ 100, 000 were the highest (40.6%). Those with monthly income of ₦ 100, 000 – ₦ 150, 000 represented 26.6% of the respondents (Table 2). This is an indication that the business is profitable because respondents could make some profit. Those with lesser profit were just starting the business and required more capital to expand their business. About 59.4% of respondents had been in the business for between 11 to 15 years, while 10.9% had spent above 15 years. A few (14.1%) had work experience that was less than five years. This implies that those with higher years of experience had mastered the business and made more profit. This is attested to by their ability to know and supply wood species that were in high demand. Majority of the respondents (54.7%) financed their business through personal sources, 6.6% got their financial source from cooperative societies, 14.1% of them relied

on family ties, while very few (4.7%) were able to access bank loans. The inability to access bank loans may be due to the fact that take up capital for the business was high with limited collateral. A good number (70.3%) of the respondents were members of association, while the rest (29.7%) were not.

Table 2: Socio-Economic Characteristic of Respondents (N = 64)

	Frequency	Percentage	Mode
Estimated Monthly Income			
Less than ₦ 50, 000	13	20.3	₦50, 000 – ₦ 100, 000
₦ 50, 000 – ₦ 100, 000	26	40.6	
₦ 100, 000 – ₦ 150, 000	17	26.6	
Above ₦ 150, 000	8	12.5	
Working Experience			
0 – 5 years	9	14.1	11 – 15 years
6 – 10 years	10	15.6	
11 – 15 years	38	59.4	
Above 15 years	7	10.9	
Source of Business Finance			
Personal Source	35	54.7	Personal Source
Cooperative	17	26.6	
Bank Loan	3	4.7	
Family Source	9	14.1	
Membership Of Association			
Yes	45	70.3	
No	19	29.7	

Source: Field Work 2022

Respondents' Perception on Deforestation of Hardwood in the Study Area

Majority (79.7%) of the respondents affirmed that the demand for hardwood species was high. Naturally, wood users demanded for hardwood because of its durability. Most (73.4%) respondents agreed that hard woods were durable and not readily affected by insects. Some wood sellers believed that other species could be made durable by treating them with chemicals. The durability of wood species depends on their ability to withstand wood destroying agents, either naturally or by the use of chemicals. Most respondents (71.8%) disagreed that hardwood species were readily available in the sawmills.

In terms of monetary value placed on wood species, 75.0% agreed that hardwood species were more expensive than other wood types. Also, 67.2% affirmed that they traveled several kilometers into the forest before felling trees. Distance covered to logging site is a function of the time/season of the year. It is easier to go deep into the forest, during the dry season. The wet and muddy conditions during the raining season affects the skid ways, a reason why many logs are abandoned in the forest after felling operations. Transportation of the felled logs to the sawmills is another challenge, with 15.6% strongly agreeing that high cost of transportation and maintenance were factors hindering the business. Most respondents (73.4%) agreed that tree species (especially hardwood) removal was very high.

Majority (79.7%) disagreed with the statement that re-afforestation programmes were ongoing in the study area. Re-afforestation which is the planting of seedlings to replace trees being cut down could safe guard a deforested area from environmental disaster. Meanwhile, many respondents (78.1%) were interested in afforestation, if seedlings were provided.

DISCUSSION

The preference and demand for hardwood species was constantly on the increase, due to their ability to withstand decaying agents (such as borers, termites e.t.c), their durability and longevity in service. Idumah and Awe (2011) reported that the choice of wood species by furniture makers in Ibadan metropolis was based, mainly on their hardness (strength) and durability. It has been discovered that hardwood species were not readily available in sawmills. Powertrac (2018) reported that logging equipment can be built to operate in all conditions; but heavy rains can reduce its functionality and the visibility of operators. Slippery roads can cause truck and other machines to drift uncontrollably. Loggers traveled several kilometers into the forest during the dry season in their quest for hardwood. This leads to decimation of the population of hardwood species in the study area. This corroborates the findings of Famuyide *et al.* (2012) who reported that species like *Milicia excelsa*, *Khaya spp.*, *Aziziana africana*, *Nauclea diderrichii*, *Triplochiton scleroxylon* and *Terminalia spp.* were now scarce in the market due to overexploitation in the forests in Nigeria. Lucas (1983) also observed that *Nauclea diderrichii* had been listed as threatened among other common economic wood species that were fast thinning out in forests of southwest Nigeria.

CONCLUSION AND RECOMMENDATION

The results revealed that deforestation was high during dry seasons, in an attempt to satisfy demand for hardwood species. Conservation education on wood preservation, treatment of softwood species, raising of seedlings and afforestation are hereby recommended.

Table 3. Perception of deforestation of hardwood species in the Study Area (N = 64)

	SA 5	A 4	U 3	D 2	SD 1	χ	$\pm\lambda$
Demand for Hardwood species are on the increase in Iseyin	33 (51.6%)	18 (28.1%)	5 (7.8%)	4 (6.3%) 6 (9.4%)	4 (6.3%)	0.88	1.189
Hardwood species are most durable and are not readily affected by insect in construction	21 (32.8%)	26 (40.6%)	7 (10.9%)	39 (60.9%)	7(10.9%)	1.16	1.171
Hardwood species are always readily available in the sawmill	-	8 (12.5%)	10 (15.6%)	1 (1.6%)	6 (9.4%)	2.70	0.830
Hardwood species are more expensive than other woods in the sawmills	29 (45.3%)	19 (29.7%)	9 (14.1%)	7 (10.9%)	4 (6.3%)	1.00	1.234
Several kilometers are covered into the forest before encountering hardwood	6 (9.4%)	37 (57.8%)	10 (15.6%)	3 (4.7%)	3 (4.7%)	1.47	1.023
The major problem encountered is that of bad road network and maintenance	10 (15.6%)	41 (64.1%)	7 (10.9%)	6 (9.4%)	23 (35.9%)	1.19	0.924
Deforestation purposely for Hardwood species is very high in Iseyin	21 (32.8%)	26 (40.6%)	7 (10.9%)	28 (43.8%)	3 (4.7%)	1.16	1.171
There is always re-afforestation program in Iseyin	4 (6.3%)	4 (6.3%)	5 (7.8%)	6 (9.4%)		2.97	1.126
We are interested in afforestation programmes if given seedlings of different wood species in Iseyin	32 (50.0%)	18 (28.1%)	5 (7.8%)			1.91	1.178

Respondents' Formats: SA= Strongly Agreed, A= Agreed, U= Undecided, D=Disagreed, SD= Strongly Disagreed, χ = Mean, λ = Standard Deviation. Figures in Parenthesis are in Percentage.

Source: Field Work 2022

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Ethnobotanical Survey of Selected Medicinal Plants Used in Treating Measles in Iseyin, Oyo State, Nigeria.

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Abstract

Plants have been used as primary sources of medicine since ancient times with about 80% of the world's population using herbal medicine to treat different ailments. The knowledge of plant medicine differs in location and time, thus requiring documentation to avoid its loss from one generation to another. This study surveyed, identified, documented and examined medicinal plants used by indigenes of Iseyin for the treatment of measles. Questionnaires and study guides were used to elicit information from the traditional medicine practitioners and herb sellers in the study area. The plant species frequently used by herb sellers were *Argemone mexicana*, *Ocimum gratissimum*, *Vernonia amygdalina* and *Nicotiana tabacum*. The most used plant part was the leaves (42%), while decoction was the main method of drug preparation (36%). These medicinal plants may be useful in drug discovery and may also be incorporated into the healthcare delivery system of the country.

Keywords: Ethnobotanical survey, medicinal plants, measles

INTRODUCTION

Medicinal plants are used by families, medicine men and practitioners of classical traditional systems of medicine in many countries (Buhler and Miranda, 2000). Medicinal plants play a vital role in the development of new drugs. According to the World Health Organization (WHO, 2006), over 80% of the world population rely on traditional plant-based systems of medicine to meet their primary health care needs (Trapti *et al.*, 2009). In recent times, there has been a renewed interest in complementary and alternative medicine with interest in drugs of plant origin growing steadily (Nuzzi, 2008). The need for primary, secondary and tertiary healthcare to complement one another cannot be overemphasized. The importance of traditional medicine and their practices being incorporated into primary healthcare delivery has been the subject of many studies (WHO, 2000). Although herbs had been prized for their medicinal, flavouring and aromatic qualities, the synthetic products of the modern age surpassed their importance, for a while (Senjottuvelve *et al.*, 2007). However, the blind dependence on synthesis is over and now people are returning to the natural products with hope of safety and security. Children who are under-nourished have lower resistance to infection and are more likely to die mainly due to malaria, acute respiratory infections, measles and diarrhoea (UNICEF, 2006). Measles is an acute, highly communicable viral disease which can be prevented by vaccination. Children do not die directly from measles, but from its complications when not properly managed (WHO, 2006). Hence, ethnomedicinal plants are utilized for the treatment of measles (Akwa *et al.*, 2007). Through a long process of trial and error, our forefathers were able to select hundreds of wild plants in their various localities for specific use. The information on plant use was handed down from one generation to another orally through word of mouth and with little or no published records. Hence, such knowledge is scarcely documented in developing countries and this may result in distortion or loss of the indigenous knowledge (Gupta *et al.*, 2003). It is therefore necessary

to document some ethnobotanicals used in the treatment of measles (infant disease) in south western Nigeria, for easy access by the healthcare providers and practitioners.

Study Area

The laboratory experiment was carried out at the Research Laboratory, Oyo State College of Agriculture and Technology, Igboora, Oyo state. Igboora lies on latitude 7°15N and longitude 3°30E of the equator with annual rainfall of 150 mm and temperature of 27°C Oyo State. The area falls within South West region of Oyo State and is noted for both hot and cold weather conditions (Akamigbo, 2014).

Ethnobotanical Survey

Thirty (30) herbal practitioners and herb sellers were contacted to obtain information on plant species and their medicinal uses with reference to measles, using structured questionnaire. Major information was gathered from these herbs sellers in form of plants used, and some details on the mode of preparation, methods of administration and dosage of medicinal plants for treating measles (Sofowora, 2002).

The questionnaire was administered directly to those who could read and write, while others were filled after oral interviews using an interpreter. The questionnaire was subdivided into three sections. The second section dealt with recipes used in treatment of measles, their arrangements, herbal preparations (dry or freshly collected), traditional solvent of choice (e.g. palm wine, alcohol, hot pap, fermented maize extract etc), traditional extraction methods e.g. grinding, boiling, infusion, strong heating etc. The third section included information on professional experience on the treatment of diseases.

Sample collection

Tobacco leaf, Scent leaf (*Ocimum gratissimum*) and Prickly poppy (*Argemone mexicana* L) were obtained from the herb sellers around Iseyin city, Oja-Oba, Iseyin Local Government, Oyo State, Nigeria.

Data analysis

Descriptive statistics was used to analyse the data.

RESULTS AND DISCUSSION

Three plants were identified in the treatment of measles (Argemone leaf, scent leaf, and tobacco leaf). These were used in the production of decoctions for treating measles disease. All tested phytochemical parameters were present in the plants, except chalcones (Table 1). Also, cardiac glycosides and Di-terpenes were absent in scent leaf. The quantitative phytochemical analysis of plant samples showed that for *Argemone* leaves, flavonoids had the highest percentage (30.09±0.15) (Table 2). The result showed that for Scent leaves and Tobacco leaves, total phenols content had the highest percentages, 11.00±0.052 and 22.11±0.05, respectively.

It was also revealed that 43.0% of the respondents' used leaves, 20% used seeds, 16.7% used fruits, and 10.0% used stem bark for preparation of decoctions (Table 3). Recipes were prepared from the combination of different parts of two or more plant species including leaves, seeds and stem (bark). Most (76.7%) respondents mentioned that the medicinal plants used were mostly common, while 23.3% agreed that it was scarcely common (Table 4). This implies that the plants were readily available and accessible for use. The most used method of application of medicinal plants for effectiveness was internal application (93.3%). In addition, 36.7% chose to use external application of ointment. The preferred method of herbal administration included; external application (bathing, ointment and lotion) and internal application (ingestion and chewing). Table 6 showed that the most used method of preparation of medicinal plants was crushing (56.7%). Others mentioned were decoction (26.7%), juicing (10%), powdering (3.3%) and use in the natural form (3.3%).

Table 1. Qualitative phytochemical analysis of different medicinal plants (Argemone, scent and tobacco leaves)

S/N	Phytochemical Parameters	Argemone leaves	Scent leaves	Tobacco leaves
1	Saponin	+	+	+
2	Tannin	+	+	+
3	Flavonoid	+	+	+
4	Steroid	+	+	+
5	Terpenoid	+	+	+
6	Coumarin	+	+	+
7	Chalcones	-	-	-
8	Quinone	+	+	+
09	Anthocyanins	+	+	+
10	Alkaloid	+	+	+
11	Cardiac Glycosides	+	-	+
12	Phenols	+	+	+
13	Di-terpenes	+	-	+

Keywords: + means present; – means absent

Table 2. Quantitative phytochemical analysis of medicinal plants

S/N	Phytochemical parameters	Concentration		
		Argemone leaves (<i>A. mexicana</i>)	Scent leaves (<i>O.gratissimum</i>)	Tobacco leaves (<i>N. tabacum</i>)
1	Total Phenolics (mg/g)	06.00±0.02	11.00±0.052	83.00±0.50
2	Tannin (mg/g)	4.11±0.09	8.05±0.30	22.11±0.05
3	Alkaloid (%)	1.70±0.03	4.80±0.09	6.320±0.04
4	Flavonoid (mg/g)	30.09±0.15	7.37±0.21	12.03±0.62
5	Saponin (%)	2.18±0.02	4.23±0.25	4.17±0.03

Table 3. Plant parts used in traditional treatment of measles

S/N	Plant part	Frequency	Percentage (%)
1	Root	3	10.00
2	Stem	0	0.00
3	Leaf	13	43.30
4	Flower	0	0.00
5	Fruit	5	16.70
6	Seed	6	20.00
7	Root bark	0	0.00
8	Stem bark	3	10.00
9	Latex	0	0.00
10	Gum	0	0.00
	Total	30	100.00

Table 4. Rate of availability of the medicinal plants

S/N	Rate of availability	Frequency	Percentage (%)
1	Mostly common	23	76.70
2	Scarcely Common	7	23.30
3	Rarely Common	0	0.00
	Total	30	100.00

Table 5. Mode of application of herbal recipes

S/N	Internal Application	Frequency	Percentage (%)
1	Chewing	2	6.70
2	Ingestion	28	93.30
3	Inhalation	0	0.00
4	Ticking	0	0.00
	Total	30	100.00
External Application			
5	Lotion	9	30.00
6	Bath	10	33.30
7	Ointment	11	36.70
8	Poultice	0	0.00
	Total	30	100.00

Table 6. Method of preparation of the selected medicinal plants

S/N	Method of Preparation	Frequency	Percentage (%)
1	Natural form	1	3.30
2	Crushed	17	56.70
3	Juice	3	10.00
4	Decoction	8	26.70
5	Poultice	0	0.00
6	Soft paste	0	0.00
7	Solid preparation	0	0.00
8	Powder	1	3.30
	Total	30	100.00

CONCLUSION

The study focused on ethnobotanical survey along with preliminary phytochemical screening of different extracts of the medicinal plants used for treating measles. Traditional knowledge on the use, preparation, and application of three medicinal plants (*Ocimum gratissimum*, *Argemone mexicana* and *Nicotiana tabacum*), common in the area. The presence of phytochemicals such as Alkaloids, Flavonoids, Tannins and Saponins indicated the high potentials for drug development. Herbal medicine has the potential to cure different kinds of skin diseases especially measles among rural communities in Iseyin local government area.

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Contributions of Private Plantation Forestry to Socio-Economic Development

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Abstract

Globally, forest plantations covered 187 million hectares in 2000, of which Asia accounted for 62%. Although, forest plantation area represents a significant increase from 1995 estimates (124 million hectares), human activities have greatly influence their existence through deforestation and degradation. Forests play an important role as an economic resource of great significance to the people and the nation. Forest plantation is established artificially by afforestation on land which did not previously carry forests. This artificial forest or man-made forest, sometimes comprises the same tree species with the same size and age. Forest plantations are established to supplement industrial wood supply from natural forests, thus providing sawnlogs, veneerlogs and pulpwood. Non industrial plantations provide fuel wood, non-timber forest products and environmental protection. Private plantation forestry plays a significant role in socio-economic development through the supply of wood and wood products, non-timber forest products; employment generation; contributions to infrastructural development, income generation, and land security; sociocultural benefits and environmental sustainability. It will be of greatest value to provide the local private sector with the opportunity to help bring investors to Nigeria to generate a multiplier effect to stimulate the economy. Comprehensive community-based development programmes, including a forest resource-based economic development plan, should immediately be introduced to stakeholders (central and local government, the private sector and the local community). These developmental programmes will improve the welfare of the community and encourage sustainable tropical forest management.

Keywords: Private plantation, forestry, socio-economic and development

INTRODUCTION

Definition and meaning of Forest Plantation

There are many difficulties associated with the definition of forest plantation (Evans *et al.*, 2009). It is somehow difficult to make a distinction between forest plantation and enrichment planting, rehabilitation of degraded forest ecosystem and sometimes from natural forest, especially where the natural forests are mostly dominated by a single species. Different authors have defined forest plantation in diverse ways, some of which are: Forest plantation is a forest stand established artificially by afforestation on land which did not previously carry forests or forest stand established artificially by afforestation on land which carried forest within the previous 50 years or living memory and involving the replacement of the previous by a new and essentially different crop (FAO, 1967).

Forest plantations are established by planting and/ or reseeding in the process of afforestation or reforestation. They are either introduced species or intensively managed stands of indigenous species which meet the following criteria: one or two species at planting, even age class and regular spacing (FAO, 1988). Forest plantations are artificial forest or man-made forest, which comprise the same tree

species with the same size and age, where silvicultural practices are taking place. Normally, forest plantations are relatively simple production systems, usually even-aged monocultures, mostly managed to optimize the yield of wood from a site, protect or recover an environment and provide benefits and/or amenities that are important to the community (Kanowski, 1997; Evans, 1998; Carle *et al.*, 2002). The main aim of forest plantation establishment is to supplement the supply of industrial wood from natural forests (Pandey and Ball, 1998; Carle *et al.*, 2002), although there has been a recurrent diversification of reasons. Industrial plantations are established totally or partly to provide wood for industrial uses (sawnlogs, veneerlogs, pulpwood) and account for 80% of total global forest plantation area. Non-industrial plantations are established mainly for non-industrial uses (provision of fuelwood, environmental protection, etc.) and account for the remaining 20% (Carle *et al.*, 2002).

Importance of Forest Plantation

Forest is an important economic resource of great significance to livelihood sustenance of people and nations (Eriboh, 2005). Forest plantations provide wood which is one of the major building materials and the main source of fuel in rural areas and some cities. They also supply poles, wood for housing, fencing, and furniture; sawn timber for construction and joinery; weaving fibers for baskets. Forest plantations provide pulpwood for newsprint, papers and boards, containers, textiles; veneer for ply wood, and residues (sawn dust) for particleboards (Stephens, 2004).

Apart from wood, forest plantation provide Non Timber Forest Products (NTFPs) such as tannins, gum, sponge, wrapping leaves, mushroom, rattan, medicinal herbs, spices, fruits, seeds/nuts, condiments, stimulants, and aromatic plants. Forest plantations offer ecosystem services such as watershed protection to control runoff, storage and soil nutrient maintenance; atmospheric regulation as in the case of absorption of solar radiation in evapotranspiration and sequestration of carbon. In erosion control, forest plantations serve as shelterbelts, sand dune fixation, rehabilitation of eroded terrain and degraded areas and soil nutrient and structure maintenance (Stephens, 2004).

To meet the growing demands for wood in developing nations, there will have to be intensification of management of industrial plantations, combined with substantial increase in their productivity, and a greater reliance on wood produced by rural populations for communal use and industry (Turnbull, 1999; Mead, 2005). Some other functions of forest plantations are listed below:

- shade and shelter for livestock
- windbreaks
- increased capital value of lands
- aesthetic improvements – the appearance of trees in the landscape, landscaping, screening
- water table and salinity reduction
- a long-term, low management-input land use
- conservation of native biodiversity and wildlife corridors
- long-term economic and environmental security

Extent of Forest Plantation in Nigeria

The global area of tropical forest plantations has witnessed extraordinary growth since the middle of the twentieth century, particularly within the past three decades (Onyekwelu *et al.*, 2011). For example, tropical forest plantations covered an area of 6.7 million ha in 1965 and 21 million ha in 1980, it tripled to about 62 million ha in 1990 and almost doubled to about 100.2 million ha by the year 2000 (Onyekwelu *et al.*, 2011). The total area of forest plantations in tropical countries was estimated at about 109 million hectares by the year 2005. Annual change in plantation area was higher between 1990 and 2000 (about 3.8 million hectares) than between 2000 and 2005 (about 890,000 ha) (Onyekwelu *et al.*, 2011). According to STCP (2009), tropical Asia has by far the largest area of tropical plantations and is planting greater areas than any other tropical region. For instance, over 85% of new plantings between 1990 and 2005 took place in Asia, with China and India accounting for a much greater part of the plantings (Evans and Turnbull, 2004; Carle *et al.*, 2009). In tropical South America, Brazil, Argentina and Chile are the leading plantation countries while South Africa, Sudan and Nigeria have the largest area of forest plantations in

tropical Africa. Between 1990 and 2000, Nigeria had the largest area of forest plantations in tropical Africa (Nwonwu, 2004).

Both indigenous and exotic tree species are used for plantation establishment in Nigeria, with exotic species dominating due principally to their fast growth rate and ability to suppress weed species, early. The dominant exotic plantation tree species in Nigeria is *Gmelina arborea*, while *Nauclea diderrichii* is the dominant indigenous plantation species (Onyekwelu, 2001). Forest plantation establishment, which began in Nigeria in the early 20th century, has grown to over 700,000 ha. The initial aim of plantation forestry in Nigeria was to stimulate natural forest through planting mixtures of indigenous species. However, the aim has since shifted to meeting the anticipated wood deficit, provide fuelwood and raw materials to feed the pulp and paper industries. Consequently, the choice of species changed from indigenous to fast growing exotic species. The good pulping characteristics of *Gmelina*, its fast growth rate and high productivity led to its adoption as the most favoured exotic species for pulp and paper production. This was followed by large-scale planting of *Gmelina* in many forest reserves in Nigeria. Today, *Gmelina* has become the most dominant plantation species, accounting for over 50% of total plantations in Nigeria (Onyekwelu and Fuwape, 2008).

Private Forest Plantation

Forest plantation development activities will definitely become more complex and fragile if private stakeholder participation is not integrated into plantation development. A new approach to forest development should be introduced by developing a model for future development of sustainable forest in the form of partnership between private companies and local communities, where the government acts as a facilitator to ensure investment security and maintain consistent policies to achieve forest sustainability and improve incomes of the local community (CIFOR, 2000).

Private forest plantation refers to the practice of growing trees or managing native forests on private land and includes: farm forestry and plantation forestry (CIFOR, 2000). Private forestry can be integrated into agricultural systems to provide forest products and to complement existing farming enterprises or it can be a stand alone use of land. The private sector includes individual, for-profit, and commercial enterprises or businesses; business associations and coalitions as well as corporate philanthropic foundations. Viewed through the lens of size, the private sector can range from the individual up to the largest multinational corporation employing millions of people. From the perspective of motivation, the private sector covers a wide spectrum, from those living subsistence lifestyle to high profit-focused enterprises. It includes formal and informal sectors, both foreign and domestic enterprises, and covers actors along the length of supply and value chains.

Global Extent of Private Forest Plantations

Private forest plantations covered 187 million hectares in 2000. The annual planting rate was 4.5 million hectares globally, with Asia and South America accounting for 89%. About 3 million hectares are estimated to be successful. Half of the forest plantation estate is for industrial end-use, one-quarter for non-industrial end-use and one-quarter not specified. Globally, the main fast-growing, short-rotation species are in the genera *Eucalyptus* and *Acacia*. Pines and other coniferous species are the main medium-rotation utility species, primarily in the temperate and boreal zones (FRA, 2000).

The potential for private forest plantations to partially meet demand from natural forests for wood and fibre for industrial use is increasing. In some countries private forest plantation production already contributes the majority of industrial wood supply. There is increasing interest in the development of forest plantations as carbon sinks; however, failure to resolve international debates on legal instruments, mechanisms and monitoring remains a serious constraint (Lungu, 2002).

Leaders in forest plantation development (top ten countries by area)

As detailed in Table 1, the ten countries with the largest forest plantation development account for 79% of the global forest plantation development area. Six of these countries, account for 56% of global forest plantations, and are in Asia. The top ten countries are China, 24%; India, 17%; the Russian Federation,

9%; United States, 9%; Japan, 6%; Indonesia, 5%; Brazil, 3%; Thailand, 3%; Ukraine, 2% and the Islamic Republic of Iran, 1%.

Within the top ten, an estimated 52% of forest plantations are grown for industrial purposes to supply raw materials to industries; 26% for non-industrial uses (fuel wood, soil and water protection, biodiversity conservation); and the purpose was not specified for 22%. The industrial forest estate in these top ten countries was owned publicly by 33%, 26% were private and 26%; while others or unspecified were 41%.

Table 1. Purpose and ownership of plantation for the ten largest plantation development countries

Country	Total area 000ha	Industrial Purpose 000ha					Non-industrial purpose 000ha					Unspecified purpose
		Public	Private	Other	Unspecified	Subtotal	public	private	other	Unspecified	Subtotal	
China	45083	10 182	-	26 994	-	37 176	102	-	7 805	-	7 907	-
India	32578	32 578	8 258	3 749	-	12 007	11 370	8 641	560	-	20 571	-
Russian federation	17340	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	17 340
United States	16238	1185	115053	-	-	16238	-	-	-	-	-	-
Japan	10682	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	10682
Indonesia	9871	4531	1228	-	-	5759	358	3754	-	-	4112	-
Brazil	4982	-	-	4802	-	4802	-	-	180	-	180	-
Thailand	4 920	850	314	-	-	1164	1219	2537	-	-	3756	-
Ukraine	4 425	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	4425
Islamic Republic of Iran	2 284	241	-	-	-	241	1938	105	-	-	2043	-
Top 10 Total	148403	25247	20344	31796	-	77387	14987	15037	8545	-	38569	32447
Top 10 %	79%					87%					80%	66%
World Total	187086	30226	25876	27202	5871	89175	19836	18161	9772	680	48449	49463

Source: FAO

Private Plantation Forestry in Nigeria

Onyekwelu (2001) observed that the participation of the private sector in forest plantation establishment in Nigeria has been very marginal, with the plantations established by the private sector probably less than 1.0% of the total plantations in the country. Although FORMECU (1999) identified a growing interest among the private sector in establishing forest plantations in Nigeria. This interest has not led to significant increase in the area of forest plantations established by the private sector. Recently, there has been increasing and active interest as well as great awareness in tree planting in Ekiti State by private investors, farmers, communities and civil society organizations. Though, these investments in forest plantations by the private sector in the state is currently small and medium-scale, there are indications that the contribution is valuable with growth potentials for future expansion.

It has been pointed out that the participation of the private sector in forest plantation establishment in Nigeria is being militated against by some government policies, which include: land tenure, charging of royalties for exploiting trees outside forest reserves and placing of moratorium on felling trees of certain species (Sayer *et al.*, 1992; Onyekwelu, 2001). To attract and/or increase private sector participation in plantation forestry in Nigeria, reformation of some of these policies and the provision of incentives are necessary and have been advocated (Umeh, 1991; Sayer *et al.*, 1992; FORMECU, 1999; Onyekwelu, 2001). Umeh (1991) has summarised some of the necessary reformations and incentives. Apart from government policies, the private sector is constrained by a number of economic factors, some of which are:

The high initial capital investment to establish the forest plantations;

- The long period between initial planting efforts and harvesting and thus the corresponding concern for the high capital cost or interest being carried until harvesting period;
- The high biological and economic risk involved in forest plantations; and
- Unattractive and inappropriate investment incentives provided by the government for forest plantation investments in the past.

Contribution of Private Plantation Forestry to Socio-Economic Development

The involvement of private sector in forest plantation development has potential in reducing deforestation and forest degradation, which could bring significant livelihood benefits and biodiversity conservation. Historically, public-sector agencies have dominated forest plantation development (Egunjobi *et al.*, 1993). This pattern has changed in many countries for three main reasons:

1. Decentralization of forest management has led to greater involvement of communities and the private sector in forest management.
2. The performance (financially and biologically) of public-sector plantations with few exceptions has been disappointing.
3. Shrinking government budgets make it impossible for most forest departments to devote as many resources to forest plantations as they had in the past.

Hence, governments are increasingly seeking the involvement of communities and the private sector in plantation development, and are using a variety of direct and indirect incentives to stimulate tree growing.

CONCLUSION

Private sector investments in forest plantation development in Nigeria are relatively low compared to USA, Chile, Brazil, New Zealand, Japan and China. Nevertheless, private sector participation has potential role in reducing deforestation and forest degradation. These forest plantations could bring significant benefit to livelihood sustainability and biodiversity conservation. Therefore, the government should formulate policies and provide incentives that will promote private forest plantation establishment. This will encourage long term security of wood and the growth of an expansive wood-based industry in the country.

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Morphological Response and Early Growth Characteristics of *Senegalia senegal* (Linn) Wild and *Balanites aegyptiaca* (Linn) as Influenced by Mychorriza and Salt Concentration



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Abstract

The nature of the soil in savannah requires restoration trial studies. Therefore, this study investigated the growth responses of two indigenous tree species to mychorriza and salt concentration in Dutse Jigawa State. Mychorriza at three different levels (0%, 50%, and 90%) and salt concentration at three different levels (control, 2.2 dsm^{-2} and 2.8 dsm^{-2}) were applied and the germination and early growth performance of *Senegalia senegal* and *Balanites aegyptiaca* were monitored. Treatments were replicated three times for early growth study. The morphological features such as shoot height and stem diameter were observed and recorded for the period of ten weeks. Analysis of variance (ANOVA) was carried out to test any differences among treatments. The results showed that salt concentration at 2.2 dsm^{-2} had the highest influence on germination count of 70% and 60% for *S. senegal* and *B. aegyptiaca*, respectively. Mychorriza at 90% also had the highest germination count of 82% and 69% for *S. senegal* and *B. aegyptiaca*, respectively. Hence, application of mychorriza and salt concentration at 90% and 2.2 dsm^{-2} had a stronger effect on early growth for both species. Therefore, more indigenous tree species and a wider range of salt concentration and mychorriza should be investigated to widen the scope of tree regeneration effort especially on marginal lands.

Keywords: Growth responses, indigenous tree species, mychorriza and salt stress

INTRODUCTION

Marginal lands sometimes called wastelands or idle lands can be defined as lands which are of low importance to biodiversity or carbon sequestration (Nándor and Gergely, 2023). They play limited role in food production and in guaranteeing people's livelihood (Shujian *et al.*, 2013). They have poor soils containing toxic levels of salt, are deficient in essential plant nutrients and generally unsuitable to crops. High concentration of salt particularly in the root zone could cause stress to a plant and eventually damage or kill it. Salt stress often coexists with other abiotic stresses such as drought. Tilman *et al.* (2006) estimated that developing countries have vast areas of marginal lands (at least 500 million hectares). Genetic analysis has shown that tolerance for abiotic stresses such as salinity could be attributed to germplasm hormones (Mackill, 2004).

Plant growth has been determined at different levels to involve different metabolic processes in cells and there is a link between the cells and external factors. Philipson, (1987) showed how flowering could be induced in potted grafts of Sitka spruce and hybrid larch species by stem injections of a mixture of mychorriza in combination with drought and high temperature treatments (external factors). Mycorrhiza represents symbiotic association between certain fungi and plant roots which enhances the uptake and nutrients; associated with the hyphae of either an ectotrophic or endotrophic fungus (Salami *et al.*, 2020). Differentiation processes are not controlled just by a single factor, but by a complex, balanced equilibrium of growth regulators and external factors like light, temperature, nutrients, moisture and soil (Jonathan *et al.*, 2002). Researchers have indicated that mychorriza mediate between an external factor

and physiological activities (Benjamins and Scheres, 2008). The process of tree breeding techniques has advanced and is currently at the phase where certain economic traits such as high wood density, good stem straightness and disease resistance could be induced using a combination of several factors.

Soil salinity has an adverse effect, by limiting the available land for cultivation of tree and other crops. It continues to affect agricultural productivity in many parts of the world. Soil salinity is well known as a soil condition characterized by a high concentration of soluble salts. Soils are classified as saline when the electrical conductivity of the saturated paste extract (ECe) is 4 dS/m⁻¹ or more, which is equivalent to approximately 40 mM NaCl and generates an osmotic pressure of approximately 0.2 MPa (USDA-ARS, 2008). According to FAO (2008), soil salinity is one of the major factors of soil degradation. More than 800 million hectares of land throughout the world are salt affected. This amount accounts for more than 6% of the world's total land area. Most of this salt-affected land emanated from natural causes; the accumulation of salts over long periods of time in arid and semi-arid zones (Rengasamy, 2002).

Weathering of parent rocks release soluble salts of various types, mainly chlorides of sodium, calcium, and magnesium, and to a large extent, sulphates and carbonates (Bahadur and Singh, 2015). Other causes of accumulation are the deposition of oceanic salts carried in wind and rain. Apart from natural salinity, a significant proportion of recently cultivated agricultural land has become saline owing to land clearing or irrigation, both of which cause water tables to rise and concentrate the salts in the root zone (Munns and Tester, 2008). Salinity effect is more conspicuous in the arid and semi-arid areas where 25% of the irrigated land is affected by salt. Salt-tolerant plants (halophytes) have evolved to grow on these soils. Halophytes and less tolerant plants show a wide range of adaptations. Attempts to improve the salt tolerance of plants have given limited success due to the complexity of their trait both genetically and physiologically (Zhu, 2016). Therefore, this study determined the germination and early growth characteristics of two native plants (Figures 1 and 2) to varying salt and mycorrhiza levels in the soil, in view of recommending better rate of dosage for the improvement of the species.



Figure 1. Typical stand of *Balanites aegyptiaca*



Figure 2: Typical stand of *Senegalia senegal*

MATERIALS AND METHODS

Study area

This study was carried out in the nursery of a semi-arid environment located at the Federal University Dutse, Jigawa state, Nigeria along latitude 11.00°N to 13.00°N and longitude 9°15'E to 9°36'E. The University's campus is located in the capital of Jigawa state, Dutse, an ancient town in the North western Nigeria (Figure 3). The University's host town and Dutse offer the charm of a small agricultural town (Jibo *et al.*, 2022; Salami *et al.*, 2019)

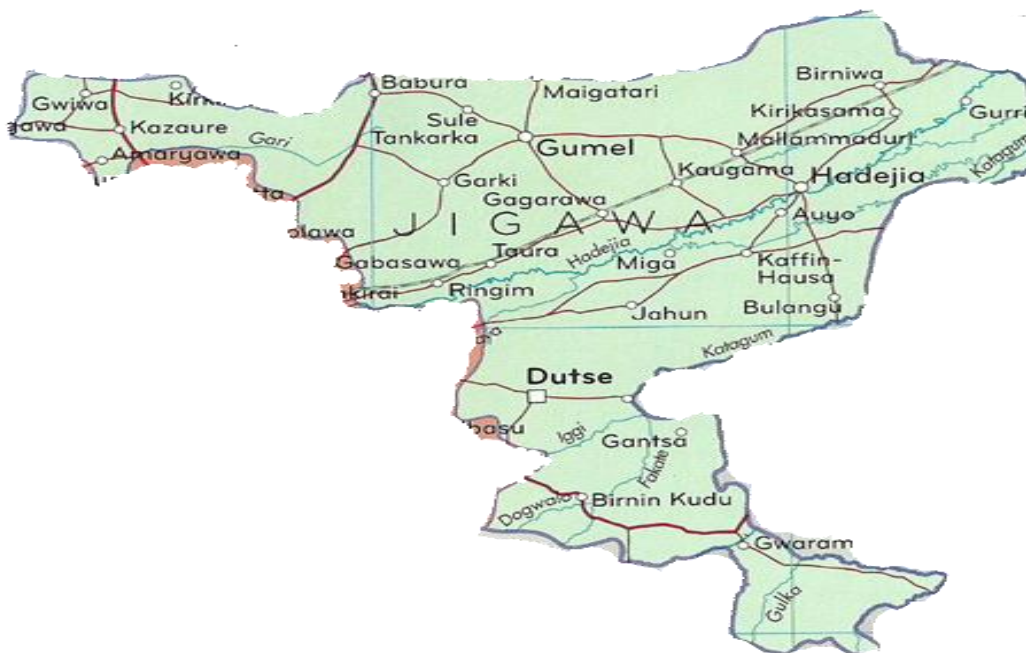


Figure 3. Map of Dutse, Jigawa State, Nigeria (Adapted from Garba *et al.* (2021)).

Seed collection and Germination

Top soil was collected from Federal University Dutse, nursery plantation site and used for the germination and growth trials. Seeds of *Senegalia senegal* and *Balanites aegyptiaca* were sourced from a mother tree within the study area. The seeds were sterilized for 15 minutes in 5% NaCl and rinsed for 10 minutes under running tap water to remove the effect of contaminants (Lyubun, 2009). The control experiment for seed germination was sown on germination trays and watered with distilled water to deionized the nutrient. Medium sized poly pots (3.5"× 7" ×7") were filled with soil samples from the nursery sites and used for the experiment. The seeds were sown and watered daily until complete germination observed.

Early growth characteristics

A total of 18 seedlings (3 seedlings for each treatment) were used for the experiment. The treatments were applied with salt at 2 levels (0, 2.2 and 2.8 dSm⁻¹) and it was replicated three (3) times. Seedlings in a poly pot were considered as an experimental unit. One kilogram of Urea fertilizer dissolved in 3.3 litres of water was applied in order to reduce growth defect due to nutrient deficiencies. The experiment was laid in a Completely Randomized Design.

Application of Treatments

The seedlings were watered daily throughout the period of the experiment. 0.5 dSm⁻¹ of Sodium Chloride (NaCl) solution was applied to soils in polypots under 2.2 dSm⁻¹ and 2.8 dSm⁻¹ salinity levels fortnightly to maintain soil salinity due to dilution and leaching. Also, Mycorrhiza was collected from the root of *Pinus caribaea* and mixed with the soil in a polythene bag before sowing the seed and used to water regularly.

Data collection

Growth parameters (shoot height and collar diameter) were recorded fortnightly for 12 weeks. Stem height was measured using meter rule, while collar diameter was measured using veneer caliper. At the end of 10 weeks, the seedlings were harvested for the determination of Relative Growth Rate (RGR).

Data analysis

Analysis of variance (ANOVA) was carried out to test for differences among treatments. Significance levels were taken at 5% level. Analysis of variance and Turkey's honestly significant difference were used to evaluate the effect of salinity on early growth. All analyses were performed using the statistical software MINITAB Release 16.12.

RESULTS

The results of different salinity level as shown in (Table 1) revealed significant differences among the germination rates of *S. senegal* and *B. aegyptiaca*. The highest germination rate was observed in 2.2 dSm⁻¹ salinity treatment of *S. senegal* (70%) and *B. aegyptiaca* (60%), respectively. This was followed by control treatment in both *S. senegal* (45%) and *B. aegyptiaca* (55%). The 2.8 dSm⁻¹ salinity treatment of *Senegalia senegal* and *B. aegyptiaca* recorded the lowest germination rate of 35% and 30%, respectively.

Table 1: Effect of salinity on seed germination

Plant species	<i>S. senegal</i>			<i>B. aegyptiaca</i>		
	Salt concentration			Salt concentration		
	Control	2.2dSm ⁻²	2.8dSm ⁻²	control	2.2dSm ⁻²	2.8dSm ⁻²
n=20	7	14	8	11	12	6
Percentage (%)	35	70	40	55	60	30

Effect of Mycorrhizal on Seed Germination

At 0% mycorrhizal treatment, the germination of *B. aegyptiaca* was 50%, but it was 69% at 90% level of mycorrhizal inclusion (Table 2). The *S. senegal* showed a better germination performance at 90% mycorrhiza level (82%) and but it was 60% germination at 0% level of mycorrhizal. It was observed that *S. senegal* showed an increasing trend in germination percentage with corresponding increase in the levels of mycorrhiza.

Table 2. Effect of mycorrhizal inclusion level on seed germination

Species	0% Mycorrhizal	50% Mycorrhizal	90% Mycorrhizal
	Percentage of germination (%)	Percentage of germination (%)	Percentage of germination (%)
<i>S. senegal</i>	60	50	82
<i>B. aegyptiaca</i>	50	40	69

Shoot height

There were significant differences in the shoot height of the treatments. *Senegalia senegal* at 2.2 dSm⁻¹ had the highest shoot height at the second (3.42 cm), fourth (10.0 cm) and tenth (15.9 cm) week. While *S. senegal* at 2.8 dSm⁻¹ had the highest height at weeks 6 and 8 (11.6 cm and 12.7 cm, respectively). The *B. aegyptiaca* at 2.8 dSm⁻¹ had the lowest shoot height at weeks 2 to 10 (Table 3). At 10th week of planting,

mycorrhiza at 90% had the highest effect on *S. senegal* (24.1 cm) followed by 0% (19.9 cm). However, 0% of mycorrhiza had *highest* height for *B aegyptiaca* (15.14 cm) (Table 4).

Stem Diameter

After 10 weeks, salt concentration at (2.2 dSm⁻¹) for *S. senegal* had the highest stem diameter (0.48 mm). Stem diameter observed in *B. aegyptiaca* (2.8 dSm⁻¹) for weeks 2, 4, 6, 8 and 10th were 0.09 mm, 0.1 mm, 0.12 mm, 0.18 mm and 0.35 mm (Table 5). There were significant differences in the stem diameter of the species. At the 10th week, mycorrhiza at 90% had the highest effect on stem diameter of *Senegalia senegal* (0.48 mm) followed by control (0.38 mm) (Table 6). However, control treatment (without mycorrhiza) had the highest for *B. aegyptiaca* (0.35 mm) followed by 90% inclusion (0.28 mm).

Table 3. Mean values of shoot height (cm) at different salt concentrations levels

Plant species	Salt concentration	2wk	4wk	6wk	8wk	10wk
<i>A Senegal</i>	2.2 dSm ⁻¹	3.42	10.0	11.3	12.8	15.9
<i>B aegyptiaca</i>	2.2 dSm ⁻¹	3.14	9.0	10.0	11.8	12.1
<i>A Senegal</i>	2.8 dSm ⁻¹	2.9	6.58	11.6	12.7	13.8
<i>B aegyptiaca</i>	2.8 dSm ⁻¹	1.98	5.88	7.13	8.13	9.15

Table 4. Mean values of shoot height (cm) at different mycorrhiza levels

Plant species	Mycorrhiza	2wk	4wk	6wk	8wk	10wk
<i>S. senegal</i>	0% mycorrhiza	5.00	8.30	9.74	14.1	19.9
<i>B aegyptiaca</i>	0% mycorrhiza	4.53	7.50	9.83	13.23	15.14
<i>S senegal</i>	50% mycorrhiza	5.10	9.40	12.60	19.50	21.40
<i>B aegyptiaca</i>	50% mycorrhiza	3.35	8.50	9.90	12.30	14.00
<i>S. senegal</i>	90% mycorrhiza	5.29	13.81	14.5	21.04	24.1
<i>B aegyptiaca</i>	90% mycorrhiza	2.90	9.58	10.6	12.7	13.8

Table 5. Mean values of Stem Diameter (mm) at different Salt concentration levels

Plant species	Salt Concentration	2wk	4wk	6wk	8wk	10wk
<i>S senegal</i>	2.2 dSm ⁻¹	0.13	0.22	0.28	0.3	0.48
<i>B aegyptiaca</i>	2.2 dSm ⁻¹	0.1	0.14	0.18	0.25	0.37
<i>A seegal</i>	2.8 dSm ⁻¹	0.1	0.15	0.19	0.27	0.41
<i>B aegyptiaca</i>	2.8 dSm ⁻¹	0.09	0.1	0.12	0.18	0.35

Table 6. Mean values of stem diameter (mm) at different mycorrhiza levels

Plant species	mycorrhiza	2wk	4wk	6wk	8wk	10wk
<i>S senegal</i>	0% mycorrhiza	0.1	0.14	0.18	0.25	0.38
<i>B aegyptiaca</i>	0% mycorrhiza	0.1	0.14	0.16	0.21	0.28
<i>S senegal</i>	50% mycorrhiza	0.1	0.17	0.19	0.26	0.40
<i>B aegyptiaca</i>	50% mycorrhiza	0.09	0.12	0.14	0.19	0.37
<i>S senegal</i>	90% mycorrhiza	0.13	0.2	0.22	0.28	0.48
<i>B aegyptiaca</i>	90% mycorrhiza	0.09	0.1	0.12	0.18	0.35

DISCUSSION

Higher amounts of mycorrhiza inclusion had a great influence on the growth of *S. senegal*. Mycorrhiza plays a very important role in the enhancement of plant growth and yield due to an increase in the supply of phosphorus. Mycorrhizal plants can absorb and accumulate several times more phosphate from the soil or solution than non-mycorrhizal plants (Salami *et al.*, 2020). The bacteria derived food, nutrients and water from the legume (Rafal *et al.*, 2016). Jonás *et al.* (2021) reported the highest growth performance of species on the effect of arbuscular mycorrhizal fungi (AMF) in the rainforest and savanna soils inoculated with AMF. This implies that AMF inoculation could be a valuable procedure in ecological restoration projects of tropical forests. Kanno *et al.* (2006) also observed the positive performance of the AMF on the shoot and root dry weights in plants of *Brachiaria brizantha*, *B. decumbens*, and *Panicum maximum* which were grown in a glasshouse for 70 days but no effect on the performance of *B. humidicola*. Attempts to introduce pines into regions, where the soil was not fertile and the proper symbiont was lacking have almost invariably ended in conspicuous failure (Daubenmire, 1959).

Moderate salinity, however, particularly if it tends to be uniform throughout the field, can often go undetected because it causes no apparent injuries, other than restricted growth. Leaves of plants growing in salt infested areas may be smaller and darker blue-green in colour than normal leaves (FAO, 2005). Increased succulence often results from salinity, particularly if the concentration of chloride ions in the soil solution is high. Plants in salt-affected soils often have the same appearance as plants growing under moisture stress (drought) conditions although the wilting of plants is far less prevalent because the osmotic potential of the soil solution usually changes gradually and plants adjust their internal salt content sufficiently to maintain turgor and avoid wilting. Apart from the effect on water availability to plants and the possible toxic effect of some constituents, excess neutral soluble salts in soils may also interfere with the normal nutrition of crops in saline soils. At a given level of salinity, growth and yield of crops are likely to be depressed more when nutrition is disturbed than when it is normal. At moderate salt concentrations in the soil solution, plants generally try to exclude unwanted ions, as far as possible, and promote the uptake of nutrients. With increasing salt concentration, the uptake of sodium and chloride ions increases sharply. This luxury consumption of ions is essential for the plants to compensate for the increased outside osmotic pressure but is responsible for growth retardation. Excessive uptake of certain ions, in turn, often results in reduced uptake of some essential plant nutrients causing nutrient imbalances and deficiencies (FAO, 2005). The distinguishing characteristic of saline soils from the agricultural standpoint is that they contain sufficient neutral soluble salts to adversely affect the growth of most crop plants. Soluble salts most commonly present are the chlorides and sulphates of sodium, calcium and magnesium (Richards, 1954). Nitrates may be present in appreciable quantities only rarely. Sodium and chloride are by far the most dominant ions, particularly in highly saline soils, although calcium and magnesium are usually present in sufficient quantities to meet the nutritional needs of crops. Many saline soils contain appreciable quantities of gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) in the profile. Soluble carbonates are always absent. The pH value of the saturated soil paste is always less than 8.2 and more often near neutrality (Abrol *et al.*, 1980).

CONCLUSION

Seeds of *Senegalia senegal* and *Balanites aegyptiaca* were used to investigate the germination and seedling growth as influenced by different salinity and mycorrhizal concentrations. Different levels of salt and mycorrhiza tested increased germination percentage, stem height and stem diameter of the tree species. *Balanites aegyptiaca* showed high seed germination percentage, stem height and stem diameter growth in comparison to other species at the salinity and mycorrhiza levels considered. Soil salinity stress is an abiotic factor responsible for a change in plant growth and when in excess could lead to death of plant. This was observed as the growth of the plant species used were influenced at varying salt levels. Land suitability classification is very important when the objective of management is the regeneration of tree species.

RECOMMENDATIONS

Indigenous tree species and a wider range of salt concentrations should be investigated to widen the scope of tree regeneration effort especially on marginal lands. Researches on seasonal mycorrhiza levels present in indigenous tree species both at early and mature growing stages should be conducted. *Balanites aegyptiaca* has proved to be highly tolerant and could be used in reclamation of marginal lands. This is very important to tree growers and it is hoped that this will help land users and managers in Nigeria when planning and allocating land for various uses.

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Morphological Variation of *Tamarindus indica* Linn in Benue State, Nigeria

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Abstract

This study investigated variations in the morphological characteristics of *Tamarindus indica* Linn. Trees, fruits, and seeds from three different locations were examined in Benue State, Nigeria. *Tamarindus indica* mother trees and plant parts were evaluated for their morphological traits. ANOVA was used to test the significant differences in morphological traits of the mother trees, fruits, and seeds. The relationship between fruit and seed traits was determined using Pearson Correlation Coefficient. There were significant variations ($P \leq 0.05$) among the height of *Tamarindus indicas* trees across the three locations, with the tallest from Buruku (41.48 m) while the shortest height was from Ukum (28.41 m). There was no significant difference in the tree dbh in the three locations, while crown diameter was significantly different (35.40 m, 24.60 m, and 8.49 m) in Ukum, Buruku, and Vandeikya, respectively. Similarly, significant ($P \leq 0.05$) variations existed among the *T. indica* fruits and seed traits. Ukum LGA recorded higher values for fruit morphological traits such as fruit length and weight, pulp and seed weights, while other variables show no significant differences. Linear correlations existed between the morphological traits of the species. Fruit breadth and number of seeds (0.99), seed and pulp weight and weight of seeds ($r = 0.99$), as well as fruit weight and seed weight ($r = 0.97$) were the most significant. These morphological parameters could be used to select plus trees for improved tree breeding. The observed variances are likely due to environmental factors, climate, land use types, and inherent genetic factors of the individual trees.

Keyword: Morphology, *Tamarindus indica*, trait, breeding, environment

INTRODUCTION

Tamarindus indica Linn is a fruit tree species in the Order Fabales, family Fabaceae syn. Leguminaceae, subfamily Caesalpinioideae, and genus *Tamarindus*. *Tamarindus* is a monotypic genus with only one species (El-Siddig *et al.*, 2006). *Tamarindus. indica* is found throughout the tropics and subtropics. It is native to many tropical African countries, including Nigeria, where it grows on wastelands, backyards, and roadsides in the Savannah region of the country (Adeola and Aworh, 2010). The species is naturally widespread on farms and wild habitats in the tropics and plays a crucial role in the ecological and economic services of many tropical countries (Okello *et al.*, 2018). *Tamarindus indica* has various socio-economic benefits, especially in the savanna region of Nigeria (Ajiboye, 2010). The tree is grown as a shade and fruit tree on farm lands, along the roadside, indoor yards and parks. Its wood is hard and durable, and its leaves, and bark have numerous applications in traditional medicine (Abubakar *et al.*, 2008). However, its main attraction lies in its fruit production. A mature tree, under favorable conditions, may annually yield 150-225 kg of fruits (Diallo *et al.*, 2008). It is used traditionally for daily food needs, culture, and medicine in most tropical countries (Fandohan *et al.*, 2010; Bhadoriya *et al.*, 2011). Research on the sugar and dietary fibre components of tamarind fruits suggests that consumption could improve

health in diabetes and heart patients (Adeola and Aworh, 2010). It has been a significant export commodity in some countries with Thailand becoming particularly prominent due to the availability of the sweet species (Cuyvers *et al.*, 2013). However, it is consumed locally in Nigeria, adding flavor to a local drink called "Kunu, and tsaamia, prepared from the pounded and boiled pods in most Southern and Northern Nigeria. These multiple benefits have made it known as a multipurpose tree species.

Tamarindus indica, despite its multiple benefits, exists mainly in the wild, is retained on farmland during land cultivation; or deliberately planted in homegardens. Anthropogenic activities such as charcoal burning, over-exploitation for food and timber purposes, firewood gathering, animal fodder, and increasing conversion to farmlands have led to severe species genetic erosion and threatened habitat (Masette *et al.*, 2015; Lakor *et al.*, 2016). Very little research attention has been paid to this native tree and legume species in Benue State, creating dearth of scientific information on the tree, its fruit and seed morphological traits. Morphological traits information would guide the selection of *Tamarindus indica* for various uses, such as domestication and breeding improvement. This study assessed the variations in the morphological traits of *T. indica* mother trees, fruits, and seeds in Benue State, Nigeria.

MATERIALS AND METHODS

This study was carried out in Benue State, Nigeria. The State is located in the central middle belt of Nigeria in the river Benue basin and trough. Benue State lies between latitudes 6° 25' - 8° 08' N and longitudes 7° 47' - 10° 00' E (Enwezor *et al.*, 2012). Climatically, the State belongs to the Koppen's aw climate group and experiences seasonal wet and dry seasons. The rain falls for about seven months, from April to October, with total annual rainfall between 1200 – 2000 mm, while the dry season sets in November and ends in March (Ogunoris and Tersoo, 2006). Temperatures are constantly high, averaging between 28° - 32°C and sometimes rising to 37°C, especially within Makurdi, the state capital. Benue state is located within the guinea savanna belt, the broadest vegetation zone in Nigeria, characterized by heterogeneous species of scattered trees and grasses (Hula and Ukpong, 2013). In the Southwestern part, mostly along stream courses, are *Tamarindus indica* and *Khaya senegalensis*, while *Daniella oliveri*, *Linnea sp.*, and *Isobrerlina doka* are found chiefly in the northeast and north-western parts of the state (Toungos, 2019). Other tree species such as *Parkia biglobosa* (Locust bean tree), *Prosopis africana* (Iron tree), *Vitellaria paradoxa* (Sheabutter tree), and *Burkea africana* (Oil bean tree) are also common (Ekhuemelo *et al.*, 2017).

Data Collection

Data was collected using multistage sampling technique. The first stage involved a purposeful selection of three Local Government Areas within Benue State with abundance of *Tamarindus indica* trees. Ukum, Buruku, and Vandeikya Local Government Areas were selected. Two forest communities were selected from each local government area, resulting in six communities with abundance of *Tamarindus indica* trees. Selected locations included; Kyado, Burya, Abuku, Ortese, Asoor, and Adikpo. Thirty (30) healthy and mature trees with sufficient fruits and with no visible insect damage or disease symptoms were used for the study. Tree growth characteristics such as tree height, crown diameter, and diameter at breast height (dbh at 1.3m above ground) were measured using Spiegel relaskope, metric tape, and girth tape. Fruit samples were collected from ten (10) matured mother trees of *T. indica* in each location. A minimum distance of 100 m was maintained between each selected tree to rule out the chances of sampling the same parental tree (sampling siblings). Fruits of *Tamarindus indica* were collected from the lower, middle, and upper parts of the trees. Two hundred and ten (210) fruits of *Tamarindus indica* were collected for morphological characterization. Linear measurements of the fruits and seeds were obtained using an electronic veneer caliper, while an electronic weighing balance was used to determine the weight of the fruits and seeds.

Method of Data Analysis

Statistical analyses were performed using Statistical Package for Social Scientists (SPSS 20.0). One-way analysis of variance was used to test for the significant differences in the morphological characteristics of *Tamarindus indica* trees, fruits, and seeds from the three locations. Duncan's multiple-range tests was conducted where significant difference existed.

RESULT AND DISCUSSION

There were significant variations in the morphological traits of *Tamarindus indica* from the three study locations in Benue State (Table 1). The mean height of *Tamarindus* trees ranged from 28.41 m to 41.48 m, with the tallest tree (41.48 m) from Buruku area. The tree diameter at breast height showed no significant variation ($P>0.05$) across the three locations (Table 1). The mean tree diameter ranged between 16.60 cm - 21.10 cm, and the largest diameter class was found in Vandeikya. The mean crown diameter (35.40 m) was recorded at Buruku, followed by Ukum (35.40 m), while the least was recorded in Vandeikya (8.48 m). Statistical analysis showed that crown diameter in Ukum and Buruku were significantly higher ($P<0.05$) than Vandeikya.

Table 1: Morphological characteristics of *Tamarindus indica* trees in the Study area.

Location	Height (m)	Tree Dbh (m)	Crown diameter (m)
Ukum	28.41±1.67 ^b	1.60±1.36 ^a	24.60±2.24 ^a
Buruku	41.48±5.31 ^a	2.01±5.30 ^a	35.40±5.90 ^a
Vandeikya	29.43±2.47 ^b	2.10±1.83 ^a	8.48±4.60 ^b

Mean values with the same superscript in a column were not significantly different ($P > 0.05$).

The morphological parameter of fruits of *Tamarindus indica* showed that fruit length from Ukum varied from 9.57 cm - 18.70 cm with a mean value of 13.45 cm, while those from Buruku varied from 6.64 cm - 11.45 cm with a mean value of 9.72 cm (Table 2). Fruit length in Vandeikya varied from 9.07 cm – 13.69 cm with a mean value of 7.59 cm. Statistical analysis showed significant differences ($P < 0.005$) among fruit lengths in the study area. However, there was no significant difference ($P < 0.005$) in the breadth of fruits in the three locations. Fruit breadth from Ukum ranged from 1.87 cm - 2.29 cm with a mean value of 2.02 cm; that of Buruku ranged from 1.72 cm - 1.84 cm with a mean value of 1.82 cm, while that of Vandeikya ranged from 2.15 cm - 3.73 cm. The fruit weight from Ukum ranged from 10.42 cm - 15.28 cm with a mean value of 12.74 cm, Buruku ranged from 4.71 cm - 9.43 cm with a mean value of 7.41 cm, and fruit weight from Vandeikya ranged from 7.57 cm - 13.42 cm with a mean value of 11.69 cm. Statistical analysis showed that there were no significant differences ($P>0.005$) in the fruit weight in Ukum and Vandeikya but they were significantly higher than that of Buruku location (Table 2).

Table 2. Morphology of fruits of *Tamarindus indica* in the study area

Location	Fruit Length (cm)			Fruit Breath (cm)			Fruit Weight (kg)		
	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Ukum	9.57	13.45±1.74 ^a	18.70	1.87	2.02±0.40 ^a	2.29	10.42	12.74±0.82 ^a	15.28
Buruku	6.64	9.72±0.05 ^c	11.45	1.72	1.82±0.24 ^a	1.84	4.71	7.41±0.67 ^b	9.43
Vandeikya	9.07	7.59±0.51 ^b	13.69	2.15	2.53±0.54 ^a	3.73	7.57	11.69±0.75 ^a	13.42

Mean values with the same superscript in a column were not significantly different ($P > 0.05$).

The pulp+seed of *Tamarindus indica* from Ukum varied from 2.10 g - 27.2 g, while samples from Buruku varied from 2.00 g - 13.3 g, and that of Vandeikya ranged between (3.2 - 16.7 g). The highest number of seeds/pods were obtained from Vandeikya, with a mean value of 6.5, while the lowest number of seeds/pods were from Buruku, with a mean value of 4.1. Statistically, samples from Vandeikya were

significantly higher ($P < 0.005$) in the number of seeds/pods. The mean weight of seeds was 2.75 g, 1.97 g, and 3.20 g in Ukum, Buruku, and Vandeikya, respectively. However, statistical analysis revealed no significant differences in the seed weight from Ukum and Vandeikya, but they were significantly higher than those in Buruku.

The average mean length (0.34 cm, 0.40 cm, and 0.37 cm) and breadth (0.04 cm, 0.10 cm, 0.20 cm) of *Tamarindus indica* seeds varied across Ukum, Buruku, and Vandeikya. However, there were no significant differences in the seed length and breadth across the three locations (Table 3).

There were strong, positive and significant correlations among the fruit and seed variables except for seed length and breadth (Table 4). The strongest, positive linear relationship was observed between fruit breadth and the number of seeds per pod ($r = 0.99$), while fruit breadth and length recorded the least ($r = 0.46$). Seed+pulp weight and seed weight ($r = 0.99$), fruit weight and seed weight ($r = 0.97$), fruit weight and fruit pulp weight ($r = 0.96$), the number of seeds per pod and weight of seeds ($r = 0.95$) were all positively correlated. However, the result showed that seed length and breadth were negatively correlated with all fruit parameters, while the strongest negative correlation was between fruit length and seed length ($r = -0.99$), the most negligible negative correlation was for the number of seed/pod and seed length ($r = -0.47$).

DISCUSSION

Variations in the morphological traits of the mother trees of *Tamarindus indica* in this study reflect the disparity in environmental and climatic factors across the three locations (Okello *et al.*, 2018). There were significant differences in the height and the crown diameter of the trees from the three locations. Sobola *et al.* (2019) stated that an environment's climatic condition significantly affects the morphology and productivity of individual trees. Similar studies (Fandohan *et al.*, 2011; Nyadoi *et al.*, 2014) have also reported high morphological diversity among tamarind populations in Kenya as a result of ecological differences. Buruku local government and Vandeikya had the tallest trees and largest crown diameters in this study, indicating more significant fruit production. Studies have shown significant correlations between seed production and tree diameter, as well as height and crown diameter (Etemad and Sefidi, 2017). Minor and Kobe (2019) observed that larger trees were likely to produce more fruits, possibly due to greater access to resources while larger crown diameters give room for more fruit production. However, findings in terms of the morphological traits of the fruits showed longer fruit lengths in Ukum and weightier fruits in Vandeikya. However, the smallest fruit lengths and weights were from Buruku. This observed variation could be as a result of difference in genetic and environmental factors in the various locations. Our studies also revealed heavier seeds and pulp in Vandeikya LGA than other locations. In some cases, *Tamarindus indica* is desirable for its pulp which is commonly used for flavoured drinks in northern Nigeria. Hence location with fruits with heavier pulp would be suitable for fruit collection. Many researchers have discovered a strong correlation between seed weight and environmental factors, particularly rainfall. According to Raddad (2007) seed plants that grow in areas with less rainfall tend to produce smaller and lighter fruits. The genetic makeup of each cultivar regulates the size of the fruits and seeds, and plant management also has an impact in the fruit traits. Since fruit size is used to grade produce, larger fruits will command higher prices than locations with larger and heavier fruits would be desirable. The number of seeds per pod recorded for Vandeikya was equally higher than the two other locations; this shows that there might be abundant production of the seeds in the seeding year. However, a slight variation in seed weight showed that seeds from Vandeikya and Ukum were not significantly different from each other but were significantly heavier than those from Buruku. However, there was no variation in the seed length and breadth of *Tamarindus indica* in this study. According to Chimdi and Jibrin, (2021) location is fundamental to adequate seed production in terms of quality and quantity as it determines the extent to which the seeds can express their genetic characteristics and optimum possible yield.

Table 3: Seed morphological characteristics of *Tamarindus indica* in the study area

Location	Pulp+seed (kg)			Number of seed/pod			Seed weight (kg)			Seed length (cm)			Seed breadth		
	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max	Min.	Mean	Max
Ukum	2.10	7.8 ±0.70b	27.20	1.00	4.90±0.38b	11.0	0.50	2.75±0.33a	11.80	0.01	0.34±.075a	1.40	0.01	0.21±0.06a	1.10
Buruku	2.00	5.3 ±0.41c	13.30	1.00	4.16 ± 0.29b	12.00	0.20	1.97±0.17b	6.50	0.01	0.43± 0.08a	1.20	0.01	0.28± 0.05a	0.90
Vandeikya	3.20	9.8±0.48a	16.70	1.00	6.57 ± 0.35a	12.00	0.50	3.29 ± 0.24a	11.80	0.01	0.37±0.07a	1.20	0.01	0.14±0.22a	1.00

Mean values with the same letters in a column were not significantly different ($P > 0.05$).

Table 4: Pearson coefficient (R) of correlation between morphological traits of *Tamarindus indica*

	Fruit Weight (Kg)	Fruit Length (cm)	Fruit Breadth (cm)	seed+pulp (kg)	No. of seed/pod	Weight of seeds (g)	Seed Length (cm)	Seed Breadth (cm)
Fruit Weight (Kg)	1							
Fruit Length(cm)	0.87	1						
Fruit Breadth(cm)	0.83	0.46	1					
seed+pulp	0.96	0.70	0.95	1				
No. of seed/pod	0.84	0.48	0.99	0.96	1			
weight of seeds	0.97	0.73	0.94	0.99	0.95	1		
Seed Length	-0.86	-0.99	-0.45	-0.69	-0.47	-0.72	1	
Seed Breadth	-0.93	-0.64	-0.97	-0.99	-0.98	-0.99	0.63	1

The strong positive and negative linear correlations revealed in the fruit and seed attributes are of importance to breeders in hybridization programmes. The correlated or dispersion relationships suggest that all the studied morphological traits can be used to select plus trees for tree breeding improvement. This study also suggests that it will be easier for the tree breeding improvement to simultaneously increase *T. indica* fruits and seed traits in the same breeding population and will not require separate ideotypes for the traits. The morphological traits variation should form the basis to guide the indirect selection of plus tree species for valuable nutritional requirements and the breeding program.

CONCLUSION AND RECOMMENDATION

There were significant differences in the morphological traits of *Tamarindus indica* trees in the various locations, with the tallest tree and larger crown diameter from Buruku, while the shortest was from Ukum. The best morphological trait was recorded in Ukum regarding fruit length and weight, pulp+seed weight, seed weight, seed length, and breadth. The strong significant positive linear correlations among morphological traits suggests that all the studied morphological traits can be used to select plus trees for tree breeding improvement. The observed variations in the morphology of the trees, fruits and seeds are probably attributed to variation in environment factors within the State. A reflection of *T. indica* species adaptation to different conditions showing genetic and phenotypic differences to be exploited. This study represents the first quantitative evaluation of *T. indica* morphological traits variation and should form the basis to guide the indirect selection of plus tree species for valuable nutritional requirements in both wild and on-farm land uses.

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Common Phytochemicals Found In Medicinal Plants

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Abstract

Plants remain the major source of valued secondary metabolites that endure pharmacognostic as well as pharmacological effects having the potentiality to appear as great medications in the future. Medicinal plants are low-cost substitute to conventional medicine. Medicinal plants contributed favorably to rural livelihoods and this has led to an increased need for herbal medicines globally leading to the comprehension of improved new drugs. In spite of the circumstance that herb plant use has been an ancient custom in most societies, the development of drug and multi drug resistant strains of microorganisms has opened a broader gap for continued investigation and findings on medicinal plants. Similarly most societies in emerging countries are profound into medicinal plant use owing to the disturbing rates of poverty. Consequently, this needs scientific support particularly in realizing their efficacies to management of diseases. Moreover in their pure compounds or as regular plant extracts, they offer infinite prospects for new drug information because of the incomparable readiness of chemical diversity. The bioactivity of natural products is in relation with the effects of several phytochemicals such as cardiac glycosides, alkaloids, saponins, phytosteroids and flavonoids among others.

Key words: Phytochemicals, bioactivity, medicinal plants, compounds, plant extract

INTRODUCTION

Plant-derived materials have newly become of profuse concern due to their versatile uses. Curative plants are the major bio-resource of medications for old systems of drug, contemporary medicines, nutraceuticals, diet complements, traditional remedies, pharmacological intermediates and biochemical units for synthetic drugs (Prashant *et al.*, 2011). Plants remain obviously exceptional at the synthesis of therapeutic compounds, whose classification has directed to finding of novel and low cost drugs with great therapeutic potential (Huie, 2002; Ukwuani *et al.*, 2013). Herbal based natural constituents can be obtained from diverse parts of plants such as seeds, bark, leaves and stems. Therefore, the regular selection of the plant with the aim of ascertaining novel bioactive combinations is a repetitive research by several scientists (Ukwuani *et al.*, 2013). Curative plants have remained acknowledged and used all over human antiquity. A comprehensive series of biochemical mixtures can be synthesized by plants in order to achieve significant biological roles and to safeguard them from attack by predators. In the human body, chemical composites in the plants facilitate their properties via a route similar to those previously well explained for the chemical compounds in conventional medications. Hence, traditional remedies do not vary significantly from conventional drugs in their performance and actions in the body. This means traditional herbs can be as active as conventional drugs, but also could possibly have detrimental side effects (Lay and Joy, 2004; Tapsell *et al.*, 2006).

Phytochemicals as anti-microbial remedies accidentally defend humans against pathogens. Certain phytochemicals are recognized to have beneficial and prophylactic properties, offer diet for usual cell wellbeing and maintenances, impede carcinogens and act as antioxidants (Ogunwemimo, 2007; Ngoci, 2011). Phytochemicals use their therapeutic properties by acting synergistically or additively and this eradicates the challenging side effects related to the prevalence of the sole xenobiotic complex, provide the medicinal plant with a wide range of action, as well as lessen the probabilities of the pathogens emerging confrontation or adaptive responses (Briskin, 2000; Olila, 2001). Therapeutic properties of plants usually depend on the presence of some phytochemical compounds like tannins, anthraquinones, saponins, alkaloids, polyphenols and cardiac glycosides that are bioactive sources responsible for the antimicrobial property (Ebana, 1993). The aim of this write up is to review the phytochemicals commonly found in medicinal plants.

Phytochemicals are extensive variety of nonnutritive chemical composites found in plant, which can have health benefits. (Ebana, 1993). Phytochemicals may have corresponding and/or overlying mechanisms of action in the body, including antioxidant effects, variation of enzyme actions, prompting the immune system, intonation of hormone breakdown, anti-bacterial and antiviral influence, meddling with DNA duplication and physical action in which some can bind substantially to cell walls thus inhibiting the linkage of pathogens to human cell walls (Ngoci, 2011). Some of the phytochemicals are as follows.

Alkaloids

Alkaloids remain among the secondary metabolites with healing properties. Alkaloid has heterocyclic ring structure containing basic nitrogen atom. Alkaloid has antibacterial, analgesic and antiplasmodic action which make them useful for therapeutic purpose (Pratibha *et al.*, 2021). Certain alkaloid like isopteropodine, pteropopine contains anti-microbial action which helps in promoting white blood cells to dispose destructive micro-organisms and cell debris (Ogunwemimo, 2007). Certain alkaloid such as harmaline, berberine and piperine perform their action by interpolating the DNA and cell wall (Cowan, 1999). Some alkaloids perform their action by simulating neurotransmitters like serotonin, acetylcholine and dopamine, hence affecting central nervous system at the synapses. They similarly performance their actions as antimalarial, rheumatism, topical anesthetic for ophthalmology; in management of high blood pressure, neuralgia, narcotics, motion illness, and similarly in prolonging the lifecycle of hormones (Ngoci, 2011). Alkaloid has analgesic action and therefore is used to ease pain, headaches, abdominal pains, septic wounds and eye problem. Indole alkaloid has antineoplastic action hence they can be used in the management of leukemia and Hodgkin's syndrome chemotherapy. They act via axing and de-polymerization of protein microtubules that produced the mitotic spindle in cell division. Yet, certain categories of alkaloids remain toxic, hallucinative and addictive, and therefore are used as shaft contagion for chasing wild game (Ngoci, 2011; Ogunwemimo, 2007). Alkaloids act on various metabolic pathways in humans and other wildlife; they nearly entreat unpleasant flavor (Müller, 1998).

Saponins

Saponins are a group of phytochemicals found in several classes of plants such as *Heliotropium indicum*, *Bryophyllum pinatum* and *Axonopus compressus* (Iatai, 2013). Saponins have soap-like properties and remain noticed via their capability to form bubbling and to haemolyze blood cells (Sospeter, 2013). Saponin has several biological activities such as improvement of respiratory system as cough syrup for management of cough. Saponins have anti-protozoa action that helps in order to react with cholesterol in the protozoal cell membranes triggering cell lysis. For instance, Yucca saponins are used against protozoan *Giardia lamblia*. Saponins acts as adjuvant, hence they can serve as vaccine promoters. Saponins contain antiviral, anti-inflammatory, molluscidal, antifungal, anti-bacterial emetics, insecticidal, and piscidal activities (Ngoci, 2011). Cardiac glycosides and saponins works in synergy in the management of heart failure and irregular heart beat. Certain saponins such as Radix Notoginseng have been described to raise the blood movement of the coronary arteries, avert platelet accumulation and to

reduce the intake of oxygen by heart muscles (Dong *et al.*, 2005). Saponins also have immune-regulatory, laxative, antitussive, and anti-oedema properties.

Flavonoids

Flavonoids are one of the obviously befalling phenolics in floras, described by the common existence of phenyl-benzo-pyrone ring system. They appear in free state or as glycosides with its various byproducts such as flavones, anthocyanidins, flavanone, chalcone, flavonol and isoflavone (Evans, 2009). Flavonoids appear in glycosylated or esterified system, and are produced via byproducts of amino acid phenylalanine and acetic acid via shikimic acid pathway. Almost 2000 different flavonoids have been identified in plants with cardio-protective, antimicrobial, anti-inflammatory, anti-aging, anti-cancer, anti-diabetic, antiviral and antibacterial activities. Therefore, flavonoids are measured to be a significant bioactive component of pharmacologically fabled therapeutic plants.

Flavonoid shows anti-cancer action via stimulation of programmed cell death, proteasome inhibition, initiation of cell phase arrest and by unfavorably relating with carcinogenic enzymes (Neuhouser, 2004). They act as regular anti-inflammatory compounds by acting as effective inhibitor of transcription factors which temper the appearance of gene that yields inflammation inducer such as eicosanoids, cytokines and chemokines. This leads to inflammatory response by augmenting beta cell role of quercetin-3-glucoside in ailments such as asthma, cardiovascular impairment, sepsis, leukemia, psoriasis, allergic rhinitis, ileitis, sclerosis, and rheumatoid arthritis (Choy *et al.*, 2019; Serafini *et al.*, 2010).

Cardiac glycoside

Cardiac glycosides are secondary compounds present in plants and are broadly dispersed in the environment with possible cardiovascular action. The mechanism of action of cardiac glycosides is based on the obstruction of the heart's sodium potassium ATPase, with affirmative inotropic outcome. The cardiac glycosides that are eminent include; oleandrin, digoxin, ouabain and bufalin among others (Ana, 2019). They appear as a compound combination in similar plant and some of them are lethal, though some has pharmacological action particularly to the heart (Harborne, 1999). Cardiac glycosides are applied in the management of congestive heart problem in which they impede Na⁺/K⁺-ATPase pump that causes affirmative inotropic effects and electro-physiological variations. Hence, it reinforces the heart muscle and the control of systolic meditation from congestive heart problem. Cardiac glycosides are similarly employed in management of atrial fibrillation, flutter, and they serve as emetics and also for diuretics (Awoyinka, 2007).

Phytosteroids

These are steroids of plants that can or cannot performance as weak hormones in the body. Phytosteroids share a mutual basic ring arrangement with animal steroids yet they are not alike because of changeable chemical groups bounded to the main ring in altered positions (Ngoci, 2011). Phytosteroids are primarily used to manage reproductive problems like management of venereal illnesses, to safeguard easy delivery during pregnancy, and also to stimulate libido and fertility in men and women, respectively. Phytosteroids also contains anti-inflammatory, anti-microbial, analgesic properties (Edeoga, 2005).

CONCLUSION AND RECOMMENDATIONS

Medicinal plants have remained and are still a main source of materials used for assisting the major health systems. The bio-activity of medicinal plants is generally linked with the secondary metabolites, often particularized for the plant protection. Certain phytochemicals unintentionally defend humans against pathogens and that is why they are a key target for medication searching programs. These phytochemicals are acknowledged to have numerous properties vital to cells including, therapeutic, nutritive, immune-modulative and prophylactic properties.

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Transforming Agrifood System in Nigeria through Agroforestry



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Abstract

The global food system is failing to deliver sufficient and nutritious food to all, while damaging the earth and unsustainably drawing down its resources. In addition, the global food system does not produce the diversity of foods needed for healthy diets. Only about 15 crops provide 90% of humanity's energy intake, such as rice, maize, and wheat which account to 48% of global average daily calories. Agrifood system refers to the business of producing food agriculturally, as opposed to through gathering, hunting, fishing, etc. Agrifood system provides an opportunity to address both food insecurity and malnutrition, but in order to do so; the food system needs to be re-shaped to become more nutrition-sensitive. Agroforestry is a form of land management system that combines agriculture with forestry for the production of abundant food crops, fertility of the soil, and for the ecosystem sustenance. Agroforestry has the potential to transform agrifood systems - especially in developing countries where agroforestry is being practiced the most.

Keywords: Food system, agrifood, agroforestry, food insecurity and malnutrition.

INTRODUCTION

Agriculture is an important source of livelihoods in developing countries, providing ways of life for billions of people, many of them poor. Out of the world's 6.5 billion inhabitants, 5.5 billion live in developing countries, 3 billion in the rural areas of these countries (World Bank, 2002). For producers with limited resources, diversification of agricultural practices is key to improving sustainability of farm resources. Indeed, diversification has been acknowledged for its role in enhancing sustainability compared to monocrop production systems in rural communities (Barghouti *et al.*, 2004) especially with regards to food security. Maxwell (2001) opined that a country and people are food secure when their food system operates in such a way that there is enough to eat. In particular, food security will be achieved when the poor and vulnerable, particularly women and children and those living in marginal areas have secure access to the food they want.

Agroforestry Systems

Agroforestry is a land use management practice that combines both forestry and agriculture, with the objective of improving crop productivity, increasing soil fertility, promoting biodiversity and controlling soil erosion (Adeola, 2015). Agroforestry has the potential to mitigate climate change and promote adaptation through carbon sequestration, greenhouse gases reduction, resilience enhancement, threat reduction, and rehabilitation of highly fragmented agricultural landscapes (Table 1). Furthermore, agroforestry techniques have the potential to increase soil porosity, reduce runoff, and increase soil cover, which can improve water infiltration and retention in the soil profile thereby reducing moisture stress in low rainfall years (Jose *et al.*, 2009). Other benefits of agroforestry system includes provision of food, fuel, timber and various agricultural products, in addition to restoring the equilibrium in the ecosystem and contributing to agricultural conservation (World Forestry Congress, 2005; Jose, 2009).

Table 1. Characteristics of Agroforestry Practices in Nigeria

Agroforestry practice	Characteristics	Examples of tree species used	Reference
Homegarden	This is the planting of trees along with vegetables and food crops in free spaces around the homes. They could be arranged to include many multipurpose trees in multistory association with animal, crops and small livestock. Home gardens are very well developed in the southern part of Nigeria especially in the East. The food crops are integrated with trees behind homesteads.	<i>Mangifera indica</i> , <i>Psidium guajava</i> , <i>Anacardium occidentale</i> etc.	Adeola (2015)
Taungya System	The cultivation of food crops in forest reserves. Lands under forests are known to be fertile and in communities with limited land where there are government forest reserves; forest lands are distributed to land hungry farmers to grow their food crops after forest exploitation. Such farmers will however plant seedlings of government preferred tree crops on such land along with their food crops.	<i>Tectona grandis</i> , <i>Gmelina arborea</i>	Adeola (2015) Adeyemi et al. (2020)
Improved Fallow	This agroforestry technology involves the planting of leguminous and other soil improving trees species on fallow land. It was developed especially to replenish soil nitrogen on farm lands.	<i>Gliricidia sepium</i> , <i>Leucaena leucocephalla</i> and <i>Enterolobium cyclocarpum</i>	Adeola (2015) Adeyemi et al. (2020)
Alley farming	Just like improved fallow, alley farming is an agroforestry based technology that can be used by small holder farmers in the humid tropics to control erosion. This system combines both mulching and hedgerow barriers in reducing run-off and creating soil stability. The hedgerow crops are pruned and scattered on the alleys. This is usually done to provide nutrients to the soil but it helps to reduce water run-off and sand drift.	<i>Gliricidia sepium</i> , <i>Leucaena leucocephalla</i> and <i>Enterolobium cyclocarpum</i>	Adeola (2015) Adeyemi et al. (2020)
Woodlots and Orchards	These are plots on farmer's lands where fuel-wood or fruit trees are planted by the farmers. This is mostly practiced in the northern/semi-arid zone of Nigeria.		Adeola (2015)
Fodder Tree Banks	Also referred to as protein bank, they are blocks of forage plants that are planted by farmers to serve as browse for their animals during off-season when there is fodder shortage e.g. during rainless months.	<i>Leucaena leucociphalla</i> and <i>Gliricidia sepium</i>	Adeola (2015) Adeyemi et al. (2020)

Agroforestry practice	Characteristics	Examples of tree species used	Reference
Live Fences	These are lines of trees/shrubs planted as boundary crops to delineate farm lands or pasture lands. It is made up of very dense hedges or thicket of trees (usually thorny) planted around a garden or farm to protect it from free ranging livestock. In most circumstances, they are planted around gardens within family compounds and buildings.	<i>Acacia nilotica</i> , <i>Acacia senegal</i> , <i>Prosopis juliflora</i> and <i>Zyziphus spp</i>	Adeola (2015)
Borderline Planting	In this practice, trees, shrubs and grasses are established to delineate individual farmlands. They are property markers even though they provide wood and other forest products for various purposes.	<i>Moringa oleifera</i> and <i>Terminalia indica</i>	Adeola (2015)
Scattered Trees on Cropland	This is also referred to as parkland agroforestry. In this practice, trees are retained or planted on farmer's cropland in a much dispersed sequence while the crops are grown in the understorey unhindered. They could also be scattered at random based on farmer's desire. Typical examples of this form of arrangement can be found in many parts of the semi-arid areas of Nigeria where trees, dispersed naturally on farm lands form an integral part of the cropping system.	<i>Vitellaria paradoxa</i> , <i>Parkia biglobosa</i> , <i>Adansonia digitata</i> , <i>Parkia biglobosa</i> , <i>Adansonia digitata</i> , <i>Vitellaria paradoxa</i>	Adeola (2015) Adeyemi et al. (2020)
Windbreaks	These are strips of trees/shrubs planted to protect fields, homes, canals or other areas from wind and blowing soil or sand. It is planted to reduce soil erosion, improve microclimate for growing crops as well as shelter people and livestock. It can also improve and sustain crop yield.	<i>Azadirachta indica</i> , <i>Eucalyptus camadulensis</i> and <i>Prosopis juliflora</i>	Adeola (2015) Adeyemi et al. (2020)
Roadside planting	This is amenity planting 1 - 3 rows of trees along roadsides and in public spaces. Apart from beautification, the trees have an effect on the microclimate of the area. They provide shade and protect the houses in the cities from storms which could otherwise be destructive.		Adeola (2015)

Agri-Food system

There is a global call to transform food systems so that they can deliver better diets for everyone. However, Agri-food systems need to be resilient or sustainable enough to supply countries with sufficient and nutritious food to meet the ever-increasing demand under changing climate or climate variability (Owusu *et al.*, 2023). Agri-food systems continue to play a major role in ensuring food security and economic development in many developing countries, particularly Africa and Asia (Tiwari, 2013; FAO, 2021; Norton *et al.*, 2022). Agrifood systems are therefore key pillars to achieving the Sustainable

Development Goals (SDG) of No poverty (Goal 1), No hunger (Goal 2), Good health and wellbeing (Goal 3) (Owusu *et al.*, 2023).

Agroforestry and Agri-Food System

Tree cover has been linked to greater dietary diversity (Ickowitz *et al.*, 2014), as all nuts and more than half of human-consumed cultivated fruits grow on trees (Powell *et al.*, 2013). Combining trees with crops, apart from providing important environmental services, help adapt and mitigate climate change, restore degraded lands, enrich biodiversity, while providing nutrient-dense crops. Agroforestry is one the few land use strategies that promises such synergies between food security and climate change mitigation (Mbow *et al.*, 2014). It supports provision of non-carbon ecosystem services, such as water cycle regulation (Smith and Olsen, 2010) or biodiversity conservation (Ravindranath, 2007), all of which are integral aspects of 'climate-smart agriculture. According to Amonum *et al.* (2012), agroforestry programme as a practice is very useful in sequestering carbon and could be used on sustainable landscape management principle to address the needs of the stakeholders for food, fibre, fodder and energy as well as other services while still serving as carbon sink (Figure 1).

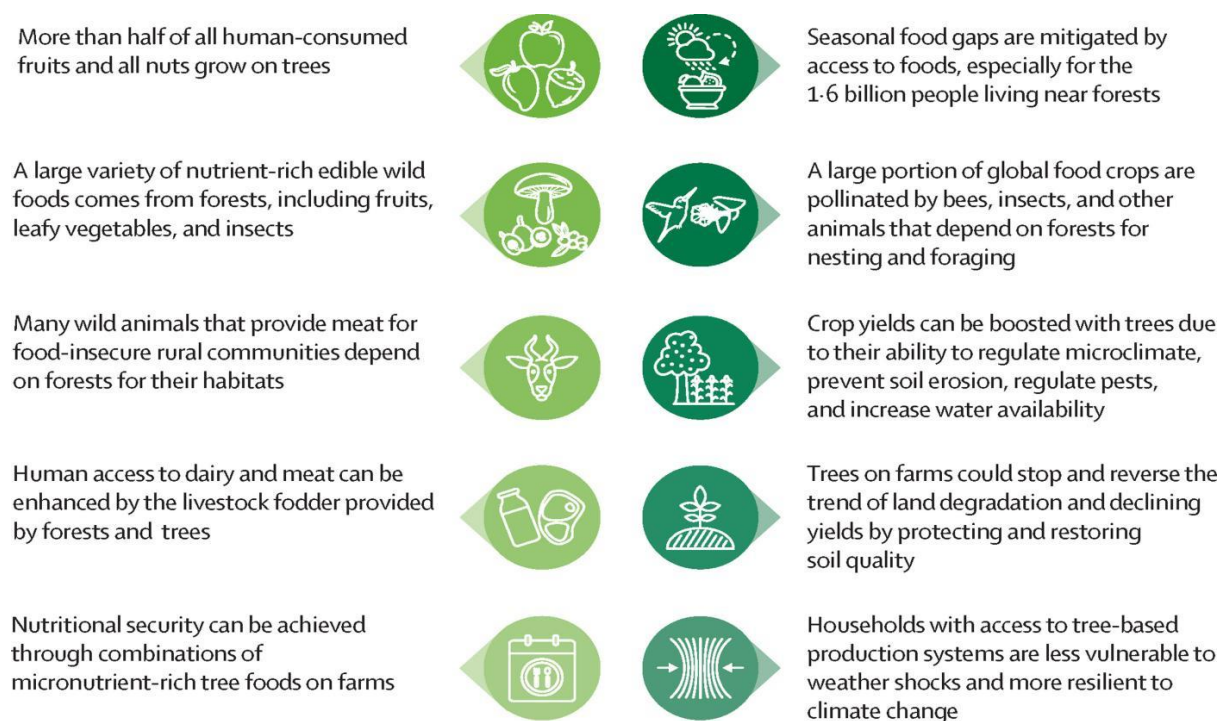


Fig.1. Reasons why trees and forests are crucial for food system transformation

Source: Ickowitz *et al.*, (2022)

CONCLUSION

The current global food system depend greatly on small set of staple crops produced in an unsustainable manner. This drives malnutrition, food insecurity, and environmental degradation. It is obvious the world needs a paradigm shift from the conventional to a more sustainable way. With the increasing price of fertilizer and other agricultural production inputs, coupled with scarcity of land associated with land degradation and rapid urbanization, Nigeria needs to transform its agrifood system urgently to ensure sustainable production of quality diets, and agroforestry can play a crucial role in this transformation. More research is however needed to determine how and under what circumstances agroforestry or related concepts, such as climate smart agriculture, can contribute to enhancing food security and livelihood

resilience in the face of climate change, especially for resource-poor rural populations in Africa (Thangataa and Hildebrand, 2012; Neufeldt *et al.*, 2013). Smallholder farmers who constitute a major component of agri-food sector in these countries are mostly rainfall-dependent in agricultural production. It is therefore important to build resilient and sustainable food systems by strategically strengthening the adaptive capacities of smallholder producers to sustainably increase farm productivity and food supply.

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Potentials of Non Timber Forest Products in Promoting Food and Nutrition Security in Nigeria



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Abstract

Forests contribute towards human livelihoods directly and indirectly. Forests support rural people through subsistence use of forest products such as wild fruits, medicinal plants and timber forest products. Non-timber forest products (NTFPs) are any product or service other than timber that is produced in forests. They include medicinal plants, resins, tree barks, bamboo, rattans, fruits and nuts, wild vegetables, wildlife, and a host of other biodiversity. NTFPs provide ecosystem service that supports human livelihoods in both developed and developing countries. Despite this vital role of NTFPs, their potential contribution to food security, nutrition, health, and sustainable livelihoods tends to be overlooked by policy-makers in Nigeria. It has not been accorded adequate attention in development planning and in nutrition-improvement programmes in the country. Indigenous knowledge on the sustainable use of NTFPs is also being lost due to non-transmission of knowledge between generations of indigenous people. It is against this backdrop that this paper gives an overview of the roles of NTFP in promoting food and nutrition security in Nigeria.

Keywords: Forest, NTFPs, food security, nutrition security, indigenous knowledge

INTRODUCTION

In agrarian parts of the developing world, communities depend significantly on local provisioning ecosystem services for their health and income. While agricultural production often provides the bulk of food and income in these areas, provisioning ecosystem services from forests, shrub lands and grasslands also make significant contributions to communities' livelihoods (Kar and Jacobson, 2012). Non Timber Forest Products (NTFPs) encompasses all biological materials other than timber which are extracted from forests, other wood lands, and trees outside forests and domesticated. These products are used as food and food additives (edible nuts, mushrooms, grass-cutters, snails, fruits, herbs, spices and condiments, aromatic plants, game), fibres (used in construction, furniture, clothing, or utensils), resins, gums, and plant and animal products used for medicinal, cosmetic or cultural purpose (Arnold and Ruiz, 2001).

NTFPs are plants or plant parts that have a perceived economic or consumption value sufficient to encourage their collection and removal from the forest. According to FAO (2005), it can also be referred to as all the resources or products that may be extracted from forest ecosystem and are utilized within the household or marketed, having social, cultural or religious significance. NTFPs which are harvested from within and on the edges of natural and disturbed forest, may be all or part of a living or dead plant, lichens, fungi, or other forest organisms. It therefore, represents a diversity of potential products sought after by a wide variety of people on a continuum of scales and intensities (FAO, 2005). Many households in rural and forested areas around the world depend heavily on NTFPs for survival. World Bank (2001) estimates that one out of four of the world's poor depend directly or indirectly on forests for their

livelihood. During the last decade, there has been a dramatic increase in interest and research on NTFPs (Shillington, 2002). This is due to the increasing recognition of the fact that NTFPs can provide important community needs for improved rural livelihood, contribute to household food security and nutrition, help to generate additional employment and income, offer opportunities for NTFP based enterprises, contribute to foreign exchange earnings, and support biodiversity and other conservation objectives (FAO, 2006). Many local people use varieties of wild plants in traditional ways for their daily requirements as well as primary health care. Some 80 percent of the population of the developing world use NTFPs for health and nutritional needs (WHO, 2000). They are particularly an important component of household subsistence, especially in terms of food consumption, nutrition, and health.

Economic Benefits of NTFP

According to Ahmed (2013), large proportion of rural people use NTFP worldwide. Forest-based activities in developing countries, which are mostly in NTFPs area, provide an equivalent of 17 million full-time jobs in the formal sector and another 30 million in the informal sector, as well as 13-35% of all rural non-farm employment (Duong, 2008). Researchers have identified NTFPs as key resources in a strategy to overcome difficulties in time of uncertainty that can be pursued by workers who find themselves without jobs, and by individuals whose employment opportunities are chronically limited by age, gender and disability. The independent nature of the activity is also suitable for people who do not fit comfortably within the demands of contemporary wage labour (Figure 1). The primary requirements to work with NTFPs are knowledge of products, their uses and locations, and the time, energy and mobility to access (Pierce *et al.*, 2002). Shillington (2002) also stated that many international development agenda promote NTFPs as tools for sustainable development. The promotion of gender equity materializes through NTFPs' ability to improve the economic situation of households by incorporating women as key actors, since they are recognized as the main extractors, processors, and marketers. So NTFPs are viewed as a potential means to better the livelihood strategies of rural populations while simultaneously sustaining the biodiversity of forested areas.

Categories of NTFPs

Food	Wild fruits, vegetables, nuts, edible roots, bush meat, edible insects, honey.
Food additives	Spices, flavourings, food colorants, fermentation agents.
Animal food	Fodder for livestock, straw, bait to catch animals, bee plants.
Animal products	Skins (leather and fur), living animals as pets, feathers, bones.
Construction	Palm leaves or grass for roof thatch, bamboo, wood (sticks and poles).
Materials	Fibres, baskets, furniture, bow and arrow, dye, paint, varnish, glue.
Fuel	Firewood, charcoal, petroleum substitutes, lighting resins.
Medicine	Medicinal plants, bark, resin, seeds.
Poisons	for fishing, to control insects, etc.
Social uses	Religious and magic plants, drugs, narcotics, intoxicants.
Environmental uses	Ornamental plants, shelter trees, plants for soil improvement.

Adapted from Gitz *et al.* (2021)

NTFPs were for long overshadowed by timber products and have received increased policy and research attention only in the last few decades. This policy and research attention was based on three propositions (Arnold and Ruiz-Perez, 2001). The first was that NTFPs contribute significantly to the livelihood and welfare for households living in and adjacent to forest. Secondly, exploitation of NTFPs is ecologically less destructive than timber harvesting and other forest uses, and the third point was that NTFP production and development could reduce tropical deforestation by giving a foundation for sustainable

economic development. These propositions encouraged researchers to put much effort on the determination of monetary values of NTFPs as well as their contribution to overall livelihoods of collectors (Ahmed, 2013). Collectors are frequently rural people who are often poor or landless. One of the difficulties for small-scale collectors who seek to commercialize NTFPs is that, often the markets for these products are relatively complex compared to those for timber and traditional agricultural goods. Prices for NTFPs vary across different locations as well as over time. In addition, buyers also impose different quality control standards.



Figure 1. Some NTFPs collected from tropical rainforest

Food and Nutrition Security through NTFPs

Food security is access by all people at all times to enough food for an active, healthy life. The essential elements are the availability of food and the ability to acquire it (World Bank, 2002). In particular, food security will be achieved when the poor and vulnerable, particularly women and children and those living in marginal areas have secure access to the food they want (Figure 2). FAO (2005) reported that ‘food security’ exists 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. While on the other hand, ‘food and nutrition security’ exists when all people at all times have physical, social and economic access to food, which is consumed in sufficient quantity and quality to meet their dietary needs and food preferences, and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life. Food and nutrition security (FNS) are interconnected and must be dealt with simultaneously (Ayala and Meier, 2017). Diet quality is an important factor of the FNS of a society. It is determined by food availability, access, utilization, and affordability at national, household, and individual level and by the nutritional quality of the available and accessible food. Within this dual context, it is understood that poor diet quality is often linked with compromised socioeconomic status (Akhter *et al.*, 2018).



The cost of malnutrition is devastating, impacting negatively and significantly on the most vulnerable in the developing world. Malnutrition in developing countries causes populations to suffer from deficiencies of one or more micronutrients. In addition to retarded and limited development, malnutrition can also lead to children death (Black *et al.*, 2008). This is in conformity with the assertion of Horton *et al.* (2010), that malnutrition is the main contributor of child morbidity and mortality worldwide. A person is considered food and nutrition secure only when the food consumed is nutritionally adequate and assimilated by the body for adequate nourishment for development, growth, resistance to diseases, and meet ordinary physiological demands of work and life. Interventions to prevent malnutrition and micronutrient deficiencies would best be addressed through food-based strategies such as dietary diversification through home-garden and collection of NTFPs. According to HLPE (2017), the multiple contributions of forests and trees to FSN, whether direct or indirect, short, medium or long term, can be grouped under four main categories viz: (i) direct provision of nutritious food, such as nuts, oils, vegetables (leaves, flowers, roots), fruits, bushmeat, fish, herbs, saps, mushrooms, tubers and insects; and feed for livestock; (ii) provision of

woodfuel for cooking food and boiling water, which is critical in developing countries for preparing many nutrient-rich foods (such as legumes and meats) facilitating nutrient assimilation, improving food safety and reducing the risks of diarrhoea; (iii) formal and informal employment and income generation in the forestry sector and through sales of wood and non-timber-forest products (NTFPs), with significant differences by gender and social groups; (iv) non-provisioning ecosystem services that sustain all food production and agriculture activities now and in the future.

CONCLUSION AND RECOMMENDATION

The contribution of NTFPs to improving livelihoods can best be assured through a process of gradual domestication of NTFPs in human-modified agroforest types. Intensive management and domestication of NTFPs may be an important means of improving livelihoods of the poor through higher yields, improved and more consistent quality and control over the timing of harvests and reduced pressure on wild and presumably endangered resources. The extraction of NTFPs is considered sustainable if it has no long-term deleterious effect on the regeneration of the harvested population, and when the yield remains more or less constant throughout the years. Hence NTFPs should be harvested in a sustainable manner. Furthermore, a vigorous promotion of NTFPs will constitute a very effective mechanism for popularizing the farming of NTFPs as an instrument for nutrition, health, and reduction of poverty. Creation of awareness about the nutritional, medicinal and environmental benefits of NTFPs by the Ministry of Agriculture, the Ministry of Health, the Ministry of Environment, and civil societies will significantly help promote the farming of NTFPs in Nigeria. The potential contribution of NTFPs to nutrition, health, and reduction of poverty has to be adequately promoted.

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Perceived Effects of Deforestation in Odeda Local Government, Ogun State, Nigeria



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Abstract

The study examined the perceived effect of deforestation in Odeda Local Government Area of Ogun State. A total of one hundred and twenty (120) respondents were randomly selected for the study and interviewed through a structured interview schedule. Descriptive statistics such as frequency distribution and percentages were used in analyzing the data while chi-square statistical tool was used in testing the study hypotheses. The result showed that age 31 – 40 years had the highest percentage of 65.6%. Males were 52.2% of the respondents, while females were 47.8%. Most (96.7%) household heads were married while 91.1% of the respondents had primary education. Trading (53.3%) was the highest primary occupation while 45.6% had their source of livelihood through farming. About 95.6% of the respondents had 5-10 years' experience in forest resources exploitation and utilization. Annual income on the sales of forest resources revealed that 50.0% derived income of ₦50, 000 - ₦100, 000, 44.4% derived the least annual income of less than ₦50, 000, while 5.6% derived income above ₦100, 000. The major forest products included forage for livestock (100 %), medicinal herbs (100.0%), palm tree products (100 %), timber (100 %), plant fibers (100%), snail (100 %), fruits (100.0%) and nuts (100.0%). The constraints to forest conservation in the study area were insufficient finance, instability of government policy, inadequate involvement of local people in decision making on conservation and lack of storage facilities for forest products. The study recommended that appropriate forestry policies should be implemented to encourage conservation of forest resources.

Keywords: Deforestation, effect, forest, conservation

INTRODUCTION

Deforestation is defined as clearing of any area of its natural vegetation cover, which normally leads to decrease in plant population and loss of biodiversity (Aliyu *et al.*, 2014). Deforestation could be characterised as forest decline, forest fragmentation and degradation, loss of forest cover or indiscriminate felling of trees without their replacement (Mustapha *et al.*, 2012). According to Becek and Odihi (2008), human activities are globally recognized as the principal cause of deforestation. Energy shortages are the greatest challenge, particularly, in rural areas of Nigeria. For instance, grid electricity and other conventional sources of energy are not reliable or in short supply. Nigeria has a population of over 170 million people with an average population growth rate of 2.8% (Food and Agriculture Organization, 2009). Fifty-two percent (52%) of the population live in the rural areas with 70.8% in absolute poverty and living on less than US \$1.25 per day and do not have enough to pay for fuel (World Bank, 2006). With this population growth and without concomitance of economic growth or technological advancement the high rate of deforestation is unavoidable. According to the United Nation's Framework Convention on Climate Change (UNFCCC, 2010), the overwhelming direct cause of deforestation is agriculture; with subsistence farming responsible for 32%, logging causing 14% and fire wood removal

resulting in 5% (Mustapha *et al.*, 2012). Nigeria has the worst deforestation rate in the world, which can be attributed to increase in population with high poverty level; and most of this population depend on forests for their energy needs (International Institute of Tropical Agriculture, 2011). Report from a study conducted between 2010 and 2014 in Benue State, Nigeria, shows that Nigeria lost an average of 409,700 hectares of forest every year, at an average annual deforestation rate of 2.38% (Ekhuemelo, and Akeh, 2015). Saliu, and Alao (2010) observed that extensive deforestation reduced 65 million hectares of intact forest cover in 1897 in Nigeria to 4 million hectares in 2010. The consequences of this according to the report are environmental degradation and accelerated wind and water erosion of fertile land, which has left Nigerian soil too poor for sustainable agricultural production.

MATERIALS AND METHODS

The study was carried out in Odeda Local Government Area, Ogun State, Nigeria. The Area is located in the moderately hot, humid tropical climatic zone of southwestern Nigeria. There are two distinct seasons in the State, namely, the rainy season, which lasts from March/April to October/November, and the dry season, from December to February. The temperature is relatively high during the dry season with the mean around 30°C. The harmattan, brought in by the northeasterly winds from December - February, has ameliorating effects on the dry season's high temperatures. Low temperatures are experienced during the rains, especially between July and August when the temperatures could be as low as 24°C. The distribution of rainfall varies from about 1000 mm to 2000 mm (NPC, 2009).

The state has two main types of vegetation, namely, tropical rainforest and guinea savanna. The natural resource endowment of the area includes land, water, mineral, forest and agricultural resources, through which a wide range of agricultural and forest products are obtained. Important cash crops such as cocoa, kola nut, citrus fruits, and palm produce are also available in these Local Government Area.

RESULTS AND DISCUSSION

Socio-economic Characteristics of respondents

The socio-economic characteristics of respondents (Table 1) revealed that the ages 31 – 40 years was highest (65.6%), while ages below 30 years was 31.1%. Majority were in their active and productive age with the capability of carrying out forest resource exploitation and use in the study area. Marla (2011) observed that the younger the household member, the more active he or she participates in forest resource exploitation and utilization, while older household members were less likely to participate in forest resource exploitation and utilization, especially activities that require application of hard labour. Wunder (2013) argued that older people in the rural households, who no longer had the strength to exploit forest resources employed youth for labour, so as to remain in the business.

The gender status indicated that 52.2% of the respondents were males, while 47.8% were females. This implies that males in the study area participate in forest resource exploitation/ utilization more than their female counterparts. This is because they have more responsibility to shoulder than the females. Wunder (2013) revealed that generally, females have less access to credit and other necessary technologies required for forest resource exploitation/utilization. Thankur (2013) opined that some technologies used for forest resources exploitation required intensive labour which could not be handled by women. Labour intensive activities such as cutting of big trees, breaking of wood into fuel wood, burning of big trees into charcoal, sawing of timber and loading/off-loading of logs are mostly carried out by men, while women and children carryout complementary activities which are less labour intensive. Arnold and Ruiz-Perez (2014) reported that less labour intensive complementary activities such as fruit picking, fruit gathering, fuel wood collection, charcoal gathering, timber packing to accessible points, roasting of animals, smoking of meat, harvesting of lower fauna and flora products as well as sale of products exploited are carried out by women and children in the rural areas.

Most (96.7%) respondents were married indicating that more work force is needed. The household heads have the responsibility of feeding the family and need to diversify their activities to forest resources exploitation to increase income from agriculture. Thankur (2013) stated that most members of a household get married not only to get helping hands from their wives but for agricultural and non-agricultural activities to boost households' income but also project an increase in labour force because of the children that will be produced in the family. The irony to this effect as noted by Wunder (2013) is that the more wives the members of rural households have, the more the household income is diverted to other needs rather than investing in agriculture or income diversifying opportunities like forest resources exploitation.

The educational level of the household heads (91.1%) was mostly primary education, while 8.9% acquired secondary education (Table 6). Excessive exploitation of forest resources is greatly attributed to the high level of illiteracy prevalent in rural communities (Townson, 2012). Kumar (2012) stressed that low literacy among rural population tends to limit their ability to understand the dangers of excessive forest resources exploitation, with focus only on economic gains to improve household income.

Majority (53.3%) had trading as their primary occupation while 45.6% had their source of livelihood through farming (Table 1). Only 1.1% were processing forest timber products as their main occupation. This implies that most household head take farming as their main income activity and complement it with other income diversifying activities. Household heads partake in non-farm and off-farm activities during their spare time to avoid being distracted from farming activities. Manza (2014) stated that off-farm activities were beneficial to rural households, who earned extra-income, which could be used to pay hired hands for farm operations and also off-set some household financial needs. Despite the major economic role played by off-farm activities, rural household heads were careful in selecting the most gainful ones and allotted time for such activities to avoid being distracted from farm operations.

Year of forest resources exploitation and utilization experience

Majority (95.6%) had 5-10 years of experience on forest resources exploitation and utilization (Table 1). Most of them had a preference for the non-farm activity to complement income from the farm for a long time. This result is supported by Rogerson and Sithole (2010) who stressed that experience on forest resources exploitation and utilization is an important factor of productivity. They posited that the effect of experience on productivity becomes positive or negative. Manza (2014) observed that it would appear that up to certain number of years, forest resources exploitation experience would have a positive effect. After that, the effect may become negative due to aging or reluctance to change from old and familiar practices and techniques to those that are modern and improved. Hames and Vickers (2011) opined that years of experience had a great influence on forest resources exploitation, marketing knowledge and social group formation of forest users. Average number of years of experience in this study, was fourteen years as presented (Table 8).

Annual income of households

Half of the respondents (50.0%) derived income of ₦50, 000 - ₦100, 000 from the sale of forest resources and 44.4% deriving the least annual income of less than ₦50, 000. The rural households found the off-farm activity to have contributed to their income and paid attention to it apart from farming. It was a good source of income to promote agricultural production as well as ease other household financial burdens. Similarly, Inoni (2009) revealed that common pool resources are always found to contribute substantial parts of the income of rural households. He noted that rural households collect forest products to meet their daily consumption needs and the surplus is sold in local and urban markets to boost household income.

Table 1. Socio-economic characteristics of the respondents

Socio-economic characteristics	Frequency	Percentage
Age		

Below 30 years	28	31.1
31-40 years	59	65.6
41-50 years	3	3.3
Sex		
Female	43	47.8
Male	47	52.2
Religion		
Christian	50	55.6
Muslim	40	44.4
Marital status		
Single	3	3.3
Married	87	96.7
Educational attainment		
Primary education	82	91.1
Secondary education	8	8.9
Main occupation		
Trading	48	53.3
Farming	41	45.6
Processing of forest timber products	1	1.1
Income from main occupation		
Below N50,000	40	44.4
N50,000-N100,000	45	50.0
Above N100,000	5	5.6
Other source of income		
Trading	50	55.6
Palm production	40	44.4
Income from other source		
Below N50,000	47	52.2
N50,000-N100,000	43	47.8
Years of experience		
5-10 years	86	95.6
11-15 years	4	4.4
Total	90	100.0

Source: Field survey, 2021

Existing Forest Resources in the Study Area

The major forest products existing were forage for livestock (100%), medicinal herbs (100%), palm tree products (100%), timber (100%), plant fibres (100.0%), snail (100%), local fruits (pears, orange, guava, e.t.c) (92.2%) and cashew nut (92.2%) (Table 2). According to Cunningham *et al.* (2005), timber accounts for about half of worldwide wood consumption. This finding is in line with the report of Ihenyen *et al.* (2009) who stated that timber tree species occur in most tropical forests and large areas tend to be exploited diffusely to extract a few prized logs.

Table 2. Distribution of the respondents based on forest resources available

Resources	Available	Not available
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	Freq	%	Freq	%
Star apple (<i>Chrysophyllum albidum</i>)	3	3.3	87	96.7
Forage for livestock	90	100.0	0	0.0
Medicinal herbs	90	100.0	0	0.0
Palm tree products	90	100.0	0	0.0
Timber	90	100.0	0	0.0
Plant fibers	90	100.0	0	0.0
Spices	90	100.0	0	0.0
Snail	90	100.0	0	0.0
Local fruits (pear, orange, guava, eta)	83	92.2	7	7.8
Breadfruit (<i>Treculia africana</i>)	4	4.4	86	95.6
Gum	1	1.9	89	98.1
Cashew nut	83	92.2	7	7.8

Source: Field survey, 2021.

Implications of Exploiting Forest Resources

Among the positive implications of forest exploitation are its contribution to income (92.2%); associated reduction of poverty (100.0%) and hunger (100.0%) as well as creation of employment (100.0%) (Table 3). On the other hand, the negative implications of forest resources exploitation were depletion of the resource base (92.2%), erosion (88.9%), contribution to climate change (93.3%) and the extinction of indigenous forest species (77.8%).

Table 3. Implications of Forest Resources Exploitation

Effect/Implications	Yes		No	
	Freq	%	Freq	%
Positive implications				
Increase in household income	90	100.0	0	0.0
Poverty alleviation	90	100.0	0	0.0
Alleviation of hunger	90	100.0	0	0.0
Employment	90	100.0	0	0.0
Negative implications				
Forest resource depletion	83	92.2	7	7.8
Erosion	80	88.9	10	11.1
Climate change	84	93.3	6	6.7
Extinction of indigenous forest and wildlife species	70	77.8	20	22.2

Source: Field survey, 2021

Methods of Forest Conservation in the Study Area

The prevention of clearing of forest area for agricultural purpose (100.0%) was rated as one of the methods of forest conservation (Table 4). The others are provision of forest guards for forest preservation, imposition of fines/sanctions on illegal exploiters, making laws against indiscriminate felling of trees and involvement of local people in the conservation movement (100.0%). Other preservation methods included prevention of illegal hunting or poaching (95.6%). Prevention of grazing in the forest area (98.9%), investing in forest conservation, not seeing the forest as only source of generating revenue and educating the people on the benefit of conserving forest resources (100.0%).

Table 4. Methods of Forest Conservation

Contributions	Yes	No
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	Freq	%	Freq	%
Prevention of clearing of forest area for agricultural purpose	90	100.0	0	0.0
Provision of forest guards for forest preservation	90	100.0	0	0.0
Imposition of fines/sanctions on illegal exploiters	90	100.0	0	0.0
Making laws against indiscriminate felling of trees	90	100.0	0	0.0
Involvement of local people in the conservation movement	90	100.0	0	0.0
Making laws against clearing of forest area for settlement	83	92.2	7	7.8
Prevention of illegal hunting or poaching	86	95.6	4	4.4
Prevention of grazing in the forest area	89	98.9	1	1.1
Making source trees sacred	2	2.2	88	97.8
Investing in forest conservation not seeing the forest as only source of generating revenue	90	100.0	0	0.0
Educating the people on the benefit of conserving forest resources	90	100.0	0	0.0
Encouragement of alternative sources of energy use other than wood	14	15.6	76	84.4
Making some animals sacred	2	2.2	88	97.8

Source: Field survey, 2021

Constraints to Forest Conservation in the Study Area.

The constraints to forest conservation was mainly insufficient finance (Table 5). This was followed by instability of government policies (100.0%). This showed that a change in government which brings about change in policy in Nigeria is a major constraint in forest conservation. Limited inadequate involvement of local people in conservation decision (100.0%) and high incidence of pest and diseases (76.7%) were perceived as other constraints. Ignorance about conservation technique due to low level of education (92.2%) was also regarded as a problem. Other constraints included ignorance of conservation technique, low level of education, deforestation without afforestation and

Table 5. Constraints to Forest Conservation in the Study Area

Contributions	Major		Minor		Not a constraint	
	Freq	%	Freq	%	Freq	%
Inadequate finance to conserve forest resource	90	100.0	90	100	0	0.0
Instability in government policies	90	100.0	90	100	0	0.0
Inadequate local people's involvement in conservation decisions	90	100.0	0	0.0	0	0.0
High incidence of pest and diseases infestation	13	14.4	69	76.7	8	8.9
Ignorance of conservation technique due to low level of education	83	92.2	7	7.8	0	0.0
Deforestation without afforestation	86	95.6	4	4.4	0	0.0
Deforestation and over grazing/ Damage by grazing animals	89	98.9	1	1.1	0	0.0
Inadequate material for reforestation	83	92.2	7	7.8	2	1.7
Ineffective regulations on the part of farmers' unions	86	95.6	4	4.4	0	0.0
Scarcity of resources due to irrational exploitation of resources	83	92.2	7	7.8	0	0.0
Lack of storage facilities for forest resources	80	88.9	10	11.1	0	0.0
Grand mean						

Source: Field survey, 2021

Table 6. Chi-square analysis of relationship between selected socio-economic characteristics of respondents and their perception on the effect of deforestation

Variables	Df	$\chi^2_{\text{cal}}(0.05)$	p value	Decision
Sex	1	5.292 ^a	0.021	Significant
Marital status	3	2.588 ^a	0.460	Not Significant
Education	3	1.392 ^a	0.707	Not Significant
Occupation	3	2.292 ^a	0.514	Not Significant
Religion	2	5.353 ^a	0.069	Not Significant
Variables		r-value		
Age		-0.033	0.705	Not significant
Household size		0.079	0.358	Not significant
Years of experience		-0.100	0.247	Not significant
Income		-0.033	0.700	Not significant

Source: Field survey, 2021

It was observed that no significant relationship existed between the effect/implications of deforestation and the constraints to conservation of the forest resources (Table 7).

Table 7: Correlation analysis of effect/implications of deforestation and constraints to conservation of forest resources

Variables	r-value	p-value	Decision
Effect/implications of deforestation and the constraints to conservation of the forest resources	0.096	0.323	NS

Source: Field survey data 2021

CONCLUSION

Forests provide varieties of food, fibre and medicine for humans. However, these benefits are endangered by human exploitation and activities. The study revealed the forest resources in the study area, which included: timber, palm tree products, herbs and fruits. It also explained the conservation practices in the area and the constraints faced by respondents in forest conservation.

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Bioremediation of Crude Oil Polluted Mangrove Sediment Using Cassava Peels and Sawdust



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Abstract

*This study evaluated the effect of organic matter (cassava peels and sawdust) in the remediation of crude oil polluted mangrove sediments. Sediment soil samples were collected, using the systematic random sampling technique, with a soil auger from a polluted site in the mangrove forest around Bille Community in Degema Local Government Area, Rivers State. Data were collected on microbial population, three weeks after organic matter were applied. The growth and survival of *Rhizophora racemosa* in the remediated sediment was also determined. A Complete Randomized Design was used in the study. The experiment was laid out in the nursery session of the Forestry Arboretum of the Rivers State University. Two kilograms (2kg) each of the prepared organic materials were properly mixed with 2kg of the polluted soil and was allowed to integrate for a period of three (3) weeks and samples were collected for laboratory analyses to determine Total heterotrophic bacteria count (THBC), Total heterotrophic fungi (THFC), Hydrocarbon utilizing bacteria (HUB) and Hydrocarbon utilizing fungi (HUF). Mangrove sediments remediated with cassava peels recorded significantly ($p \leq 0.05$) higher THBC ($500 \times 10^6 \text{cfu/g}$), Total heterotrophic fungi (THF) ($80 \times 10^6 \text{cfu/g}$) and Hydrocarbon utilizing bacteria (HUB) ($120 \times 10^6 \text{cfu/g}$). However, significantly lower counts were recorded in sediments without organic materials; Hydrocarbon utilizing bacteria (HUB) ($40 \times 10^6 \text{cfu/g}$) and hydrocarbon utilizing fungi (HUF) ($4 \times 10^6 \text{cfu/g}$). *Rhizophora racemosa* propagules measuring 17m in height were collected for the experiment. It was observed that the mean number of leaves (6) produced in sediments remediated with cassava peels and sawdusts were significantly higher at the eight week. The number of leaves produced in the sediments without organic material was significantly lower at week eight. It was also observed that the mean height of propagules in sediments remediated with cassava peels was (27 m) and sawdust (25 m), These were significantly higher than the mean height observed in the sediments without organic material (17 m). The findings from this study have shown that cassava peels are good bio-remediating materials for crude oil mangrove polluted soils. Hence, further studies should be conducted to determine the effectiveness of the cassava peels in the field.*

Keywords: Bioremediation, crude oil, mangrove sediment, organic matter

INTRODUCTION

The Nigerian mangrove which forms the vegetation band of 15 to 45 km in width, covers an area of about 10,000 km² and is found within the coastal regions of the Niger Delta in Nigeria (Abere and Ekeke, 2011). The morphological and physiological characteristics of the mangrove are distinct (Along, 2002). The mangrove trees are well adapted to the environmental conditions of the coastal region possessing salt filtering and complex root systems to survive the saline and low oxygen status of the waterlogged sediments. Globally, mangrove forests cover approximately 160,000 km², in which the largest forest areas are found in Malaysia, India, Bangladesh, Brazil, Venezuela, Nigeria and Senegal (Giri and Muhlhausen, 2008). Mangrove forests play a very important role in coastal ecosystems located at the interface between land and sea in tropical and subtropical areas of the world. Mangrove plants may grow in different types of soil; therefore, their vegetation, species composition and structure may vary considerably at the global,

regional and local scales (Sherman *et al.*, 2003). Mangrove soils are of marine alluvium origin, transported as sediment and deposited by rivers and seas. Soils are made up of sand, silt and clay in different combinations and mud actually refers to mixture of silt and clay, both of which are rich in organic matter. Topsoil is loosely formed as sandy or clayey types. The lighter-coloured top soils are porous and facilitate water percolation and aeration during low tide. The darker-colored clayey topsoils are less aerated. Soils below the surface i.e., sub-soils are typically waterlogged having little aeration facility, though they contain a lot of organic matter. The dark grey or black soil found in mangrove forest produces a strong odor due to the presence of hydrogen sulphide resulting from the anaerobic sulphur-reducing bacteria (e.g *Desulfotomaculum* spp.) which thrive under the anoxic conditions (Peter and Sivasothi, 2002). The soils in mangrove forest are characterized by the combination of various physical, chemical and biological factors, which may vary considerably among different forest sites (Ferreira *et al.*, 2007a and b). The soils in mangrove forests are complex systems resulting from various intricate interactions between abiotic (tides and physiography) and biotic (activities of plants and invertebrates) factors, that vary within short distances. Soil attributes such as salinity, iron sulfide concentrations, soil redox potential, nutrients, organic matter and physiographical position are the key factors in determining mangrove species composition and structure (Otero *et al.*, 2009). The accumulation and degradation of toxic compounds (Ke *et al.*, 2002) and the mobilization and availability of trace elements also significantly influence the zonation of mangroves (Machado *et al.*, 2004). Research results revealed significant variation in the composition of mangrove soils at different depths, clay mineralogy, total organic carbon content and carbon stock (UNESCO, 1998; Ferreira *et al.*, 2010). Different studies between forest structure and soil conditions suggest a wide variation in tree height and productivity in response to temporal and spatial variation of soil factors, such as soil salinity, nutrient availability and soil fertility (Feller *et al.*, 2003; Ukpog, 1991). Forest structure and vegetation is also varied depending on the carbon stocks and organic matter of the mangrove soil (Chmura *et al.*, 2003). The soil of the mangrove forest acts as a reservoir of carbon that is in interaction with the atmosphere, storing about three times the biomass that makes up the vegetation and structure of mangroves (Sah *et al.*, 2001). Studies on mangrove soil revealed that soil surface is mainly composed of new sediment particles. The soils have less than 35, 40 and 45% of sand, silt and clay particles, respectively in different mangrove forests (Ukpog, 1997). From the study of Moreno and Calderon (2011), it was observed that the soil texture was sandy clay loam with 53.17% sand particles. Sah *et al.* (1989) reported 48% sand particle with silt loam soil texture. However, lower sand particles and higher silt and clay particles having silty clay loam soil texture have also been reported (Khan *et al.*, 1993). Variable values of bulk density are found in the mangrove forests of the world ranging from 0.73 g cm⁻³ (Ukpog, 1997) to 1.42 g cm⁻³ (Sah *et al.*, 1989). Mangrove forests are usually enclosed and protected environments with low-energy waters, which is favourable for the sedimentation of clay particles (Wolanski *et al.*, 1998).

Mangrove is commercially and traditionally used worldwide, serving both ecological and economic functions for communities in the coastal areas, who depend on the mangrove for their livelihoods (Kathirensan and Bingham, 2001). Several studies have revealed that the mangrove forest have suffered a steady degradation over the years as a result of oil exploration activities in the Niger Delta. Heavy metals such as lead and chromium, associated with crude oil, contaminate the soil through underground deposits (Enujiughha and Nwanna, 2004). Simbi-Wellington *et al.* (2022) observed higher concentrations of Copper, Chromium and Lead in the mangrove sediments around a gas flaring location within a mangrove ecosystem in the Niger Delta, Nigeria. Ite and Semple (2012) reported that soils and sediments were sinks for pollutants arising from petroleum activities. Several remediation methods such as the physicochemical and biological treatment have been carried for the cleanup of hydrocarbon contamination. However, these methods have been linked with some disadvantages and are also considered to be expensive (Jain *et al.*, 2011). Bioremediation are considered to be more cost-effective and environmentally suitable for the remediation of hydrocarbon contaminated soil (Borah and Yadav, 2016). This study is aimed at investigating the effect of cassava peels and sawdust in the remediation of a crude oil polluted soil by

determining its effect on microbial population, as well as the growth and development of *Rhizophora racemosa*.

MATERIALS AND METHODS

Study Area

This study was conducted in the nursery of the Teaching and Research Farm of the Forestry and Environment Arboretum of Rivers State University, Nkpolu-Oroworukwo, Rivers State, Nigeria. It is situated at Latitude 4.51°N and Longitude 7.01°E at an altitude of 223 above sea level (Tariah *et al.*, 1991).

Sample Collection/Preparation

Sediment samples for this research were collected from a crude oil polluted site in the mangrove forest around Bille Community in Degema Local Government Area of Rivers State, Nigeria. Sediment samples were collected randomly from six different locations within the area, with the use of soil auger at a uniform depth of 0-15 cm and carefully place in polythene bags. The organic materials used for the study were cassava peels (CP) and sawdust (SD). The sawdust was sourced from Illoabuchi sawmill, Port Harcourt while the cassava peels were collected from the local garri millers in Imeogu, Omuagwa in Ikwerre Local Government Area of Rivers State.

Plant Materials

Propagules of *Rhizophora racemosa* were collected randomly from Kegbara Dere mangrove forest in Gokana Local Government Area of Rivers State. Sea water was also taken at this same location for the watering of the propagules. A total of eighteen (18) sampling units were used for this study. A total of 27 *Rhizophora racemosa* propagules were collected and used for the investigation. Three (3) propagules were planted each in the three (3) replications of each of the 3 treatments to determine the effect of the remediated mangrove sediment on the growth of *Rhizophora racemosa*. Data were collected on sprout, height and the number of leaves produced.

Organic Materials

Collected cassava peels were air-dried for three weeks and milled to obtain fine particles. Collected sawdust were also air-dried for three weeks. Two (2) kg of sediments were mixed properly with 2kg of sawdust (Treatment SSD) and 2kg of cassava peels (Treatment SCP). Collected sediments were used as control (NA). The potted mixtures were allowed to integrate properly for a period of three weeks before samples were taken for laboratory analysis.

Sediment Analysis

Sediment samples were collected to ascertain total heterotrophic fungi count (THFC), total heterotrophic bacteria count (THBC), hydrocarbon utilizing bacteria (HUB) and Hydrocarbon utilizing fungi (HUF). Samples were also collected to determine some physicochemical parameters; such as pH, Exchangeable cations (K^+ , Na^+ , Ca^{2+} and Mg), Total Nitrogen (TN), available phosphate and Organic Carbon (OC).

Ten fold serial dilution with sterile physiological saline as diluent was carried out with each sediment sample collected and inoculated on nutrient agar for total heterotrophic bacterial count (THBC). Mineral salt agar (MSA) was used for the determination of the hydrocarbon utilizing bacterial count (HUBC) using vapour-phase transfer technique as described by Okpokwasili and Amanchukwu (1988).

Microbial species observed were sub-cultured to obtain pure isolates which were further subjected to macroscopic and biochemical tests for characterization and identification according to Cowan and Steel (1965).

Sediment pH Determination

Sediment pH was determined in a 1:1 sediment to water ratio using a Glass Electrode pH Meter. Samples were air dried and passed through a 2 mm sieve. Then, 20ml of distilled water was added to 20 g of

sieved samples in a 50 ml beaker, stirred and allowed to stand for 30 minutes. The pH meter was inserted into the suspension and measurement was taken.

Cation Exchange Capacity (CEC)

Cation exchange capacity was calculated by adding the sum of exchangeable bases (Ca, Mg, K and Na) and exchangeable acidity and was expressed in meq/100g. Exchangeable bases were determined using standard methods involving EDTA titration, while the exchangeable acidity was determined by using 5 drops of phenolphthalein indicator titrated with 0.05 M NaOH solution.

Total Organic Nitrogen Determination

Total Organic Nitrogen was determined using the regular Macro-Kjeldahl digestion method. Samples were air dried and grinded to pass through a 0.5 mm sieve. Then, 20 ml of distilled water was added to 10 g of samples in a Macro-Kjeldahl Flask. The flask was swirled for few minutes and allowed to stand for 30 mins. One tablet of mercury catalyst, 10 g of K_2SO_4 and 30 ml of concentrated H_2SO_4 were added. The flask was heated at low temperature on the digestion stand. The temperature was increased steadily until the digest was clear and the H_2SO_4 condensed. Cooled digest was carefully transferred into another Macro-Kjeldahl flask. Distillation apparatus was attached to the Macro-Kjeldahl flask to commence distillation. Total Organic Nitrogen content was then calculated in percentage.

Total Organic Carbon Determination

Total Organic Carbon was determined using the Walkley and Black method. Grinded samples were passed through a 0.5 mm sieve. Sieved samples were weighed in duplicates into 250 ml Erlenmeyer flask. Then, 10 ml of $K_2Cr_2O_7$ solution were accurately added into each flask and swirled gently. Afterwards, 20 ml of concentrated H_2SO_4 was added to the solution and allowed to stand on sheets of asbestos for 30 mins and 100 ml of distilled water was added, thereafter. 3-4 drops of indicator were added and titrated with 0.5 N ferrous sulphate solution. Total Organic Carbon was then calculated in percentage.

Statistical Analysis

The Complete Randomized Design (CRD) was used to analyze data collected for this study. Differences between mean were determined using the Duncan Multiple Range Test (DMRT) at a probability level $P \leq 0.05$.

RESULTS

Soil Microbial Count

Results revealed that the mean counts of THB (500×10^3 cfu/g), THF (80×10^3 cfu/g), HUB 120×10^3 cfu/g) were significantly higher in sediments remediated with cassava peels (SCP). The HUF was significantly higher in sediments remediated with cassava peels (6×10^3 cfu/g) than sediments remediated with sawdust (SCP) (4×10^3 cfu/g). Microbial counts were lower in sediments with no amendment materials (NA) (Table 1).

Sediment Physiochemical Parameters

Soil pH for SSD (4.2) was significantly higher than NA (3.5) and SCP (3.3), at $p \leq 0.05$. Total nitrogen was significantly higher in SCP (0.357 mg/kg) and lowest in NA (0.131 mg/kg) (Figure 1). Total organic carbon was highest in SCP (4.134%) while SSD (2.574%) and NA (1.521%) were not significantly different. Treatment NA had the highest concentrations of phosphorus (0.12 mg/kg), sodium (197.20 mg/kg) and potassium (197.20 mg/kg) but recorded the lowest for calcium (38.18 mg/kg) and magnesium (170.32 mg/kg) (Table 3).

Effect of Treatments on Propagule Growth Parameters

The highest mean height (27 cm) was recorded in SCP and was significantly different from the control (NA) which had the lowest (17 cm) at the end of eight (8) weeks. Though the mean height (25 cm) recorded in SD was lower than that recorded for (CP), there was no significant difference (Table 4). There was no significant difference in the mean height (17 cm) of propagules in the control (NA) from week one to the end of the experiment. The number of leaves increased in treatment SCP and SSD (Table 5). The mean number of leaves produced in SCP and SSD at week 7 and 8, after the application of organic materials (6 leaves) were significantly higher than the leaves at week one and two (2).

Table 1. Isolated and identified organisms in the mangrove sediment

Microbes	SCP	SSD	NA
THB	<i>Bacillus subtilis</i> <i>Rhizopus</i> sp	<i>Stremococcus</i> sp <i>Bacillus</i> sp	<i>Pseudomonas</i> sp <i>Staphylococcus</i> sp
THF	<i>Staphylococcus aureus</i> <i>Aspergillus</i> sp	<i>Fusarium</i> sp <i>Mucor</i> sp	<i>Rhizopus</i> sp <i>Aspergillus</i> sp
HUB	<i>Acromonas</i> sp <i>Bacillus</i> sp	<i>Corynebacterium</i> <i>Bacillus subtilis</i>	<i>Staphylococcus</i> sp <i>Bacillus</i> sp
HUF	<i>Aspergillus</i> sp <i>Fusarium</i> sp	<i>Rhizopus</i> sp <i>Aspergillus</i> sp	<i>Rhizopus</i> sp <i>Fusarium</i> sp

Table 2. Mean microbial counts (cfu/g) in the treatments

Treatments	THB	THF	HUB	HUF
NA	70x10 ^{3b}	12x10 ^{3b}	40x10 ^{3c}	2x10 ^{3b}
SSD	120x10 ^{3b}	17x10 ^{3b}	70x10 ^{3b}	4x10 ^{3a}
SCP	500x10 ^{3a}	80x10 ^{3a}	120x10 ^{3a}	6x10 ^{3a}

Means in columns with different superscripts were significantly different at P≤0.05 using the Duncan Multiple Range Test

Table 3. Physicochemical properties (mg/kg) of sediments

Treatment	P	Na	K	Ca	Mg
NA	0.12 ^a	197.20 ^a	197.20 ^a	38.18 ^c	170.32 ^c
SSD	0.10 ^b	128.35 ^c	128.35 ^c	57.04 ^b	201.99 ^a
SCP	0.08 ^c	151.16 ^b	151.16 ^b	94.93 ^a	199.70 ^b

Means in columns with different superscripts were significantly different at P≤0.05 using the Duncan Multiple Range Test

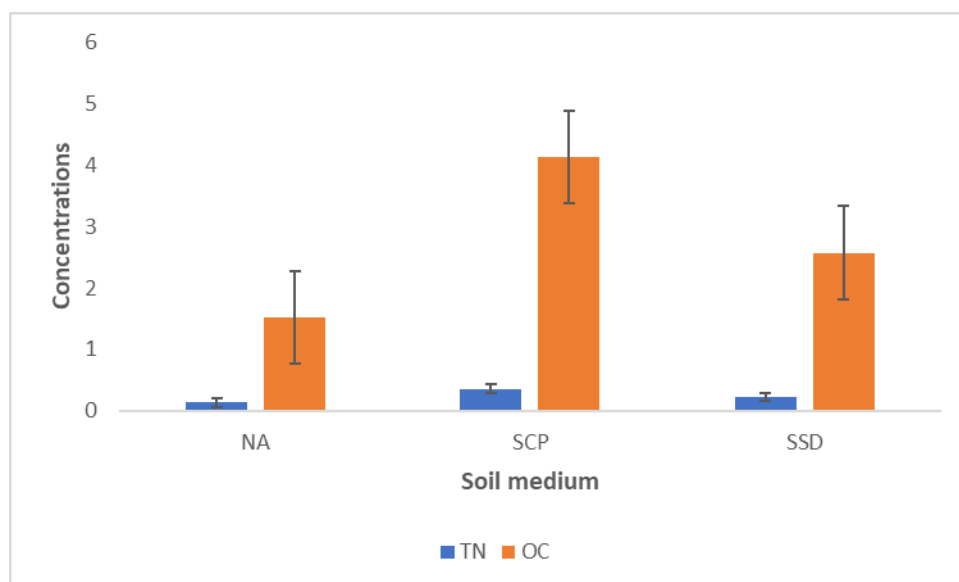


Figure 1. Effect of treatments on total nitrogen and organic carbon of sediments

Table 4. Mean height (m) of propagules grown in treated sediments

Weeks	CT	SD	CP
1 – 2	17.00 ^b	18.33 ^{a, b}	19.67 ^a
3 – 4	17.00 ^c	22.33 ^b	25.00 ^a
5 – 6	17.00 ^b	24.00 ^a	26.00 ^a
7 – 8	17.00 ^b	25.00 ^a	27.00 ^a

Mean with different superscripts within rows were significantly different at $p \leq 0.05$ using Duncan's Multiple Range

Table 5. Mean number of leaves of propagules grown in different treatments

Weeks	CT	SD	CP
1 – 2	2 ^a	2 ^b	2 ^b
3 – 4	2 ^a	4 ^{a, b}	4 ^{a, b}
5 – 6	0 ^b	6 ^a	6 ^a
7 – 8	0 ^b	6 ^a	6 ^a

Mean with different superscripts within columns were significantly different at $p \leq 0.05$ using Duncan's Multiple Range

CT – Control, SD – Sawdust, CP – Cassava peels

DISCUSSION

The crude oil polluted mangrove sediments remediated with cassava peels recorded higher microbial population and counts of THF, THB, HUF and HUB. This finding is in agreement with the report by Obialalaji *et al.* (2015) who stated that organic materials stimulate and increase microbial populations. Some microbial organisms identified in the mangrove sediments were *Bacillus* spp., *Pseudomocus* spp, *Rhizopus* spp, *Staphylococcus* spp, *Fusarium* spp, *Aspergillus* spp, and *Rhizopus* spp. This result in agreement with the report of Simbi-Wellington and Chukunda (2019) and Ukoima *et al.* (2021).

The pH values in the collected mangrove sediments were generally low ranging from 3.3 to 4.2. This is in agreement with the report by Simbi-Wellington *et al.*, (2022), where pH ranged from 3.2 to 4.1 in studies conducted within the Niger Delta mangrove forest. The acidic nature of the sediments can be attributed to the high level of air pollution resulting in acid rain and deposition in the region (Simbi-Wellington and Ideriah, 2020). Soil acidification is the resultant effect of acid deposition from the atmosphere which greatly decreases the pH of soil (Scheren *et al.*, 2002; Obiakalaije *et al.*, 2015). The results showed no increase in plant height as observed in the control treatment. It was also observed that the leaves on the propagules wilted at week 5 in the control medium. Omena and Olubukola (2017) stated that metals were essential for the biological function of plants and animals. However, at elevated levels they interfere with metabolic reactions in the systems of organisms. Toxic heavy metals which are not useful to plants are capable of reducing plant growth due to reduced photosynthetic activities, reduced plant mineral nutrient, and reduced activity of essential enzymes. Crude oil pollution impacts negatively on soil fertility, growth of plant and up take of nutrients (Leo and Iruka, 2007). Ekundayo *et al.* (2001) and Ukoima *et al.* (2016) also confirmed that the grain yield in crude oil polluted soil was significantly reduced by 95%.

CONCLUSION

The result reveals a significant increase in growth parameter of *Rhizophora racemosa* in the bio-remediated medium. The organic materials can be used to stimulate the indigenous microbial population, causing an increase in microbial counts, which in turn would help increase the mineral content and fertility of the soil.

RECOMMENDATIONS

Cassava peels and sawdust should be considered as good remediating organic materials that could improve fertility in oil polluted mangrove sediments. Disposal of cassava peels in the environment by local farmers should be discouraged, while considering its potential use in improving the mangrove ecosystem.

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Sustainable Forest Management and Poverty Alleviation

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Abstract

This paper examined the potential of sustainable forest management in poverty alleviation. It argued that sustainable management of forest is a vital component of providing means of livelihood and environmental sustainability, as it contributes to various infrastructural needs of society. Lack of proper management of the forestry sector will therefore, continue to lead to negative consequences on human survival. The paper highlights the importance of sustainable forest management in poverty alleviation; these include, conversion of forest to agriculture, timber extraction, non-timber forest product collection, environmental services, employment and indirect benefits. It discusses some of the challenges with possible solutions.

Keywords: Sustainable, poverty, alleviation, environmental management

INTRODUCTION

Sustainable forest management is defined as a dynamic and evolving concept aimed at maintaining and enhancing the economic, social and environmental value of all types of forests, for the benefit of present and future generation (FAO, 2010). Poverty can be defined as a pronounced deprivation of well-being related to lack of material income or consumption, low levels of education and health, vulnerability and exposure to risk, no opportunity to be heard and powerlessness (World Bank 2001). Poverty alleviation aims to successfully lessen deprivation of well-being. In this regard, Forest-Based Poverty Alleviation (FBPA) is an encompassing term, where forest resources are used either to avoid or to mitigate poverty, or to eliminate poverty, or both. The role forests and trees play in alleviating poverty tends to be linked with other land uses, in particular agriculture and grazing, mixed systems of crop and tree growing and utilization. There are three principal ways to achieve FBPA: to prevent forest resources from shrinking if they are necessary for maintaining well-being (protecting the pie); to make forests accessible and redistribute resources and rents (dividing the pie differently); and to increase the value of forest production (enlarging the pie). All are vital but are applied differently, depending on forest uses and strategies adopted.

Opportunities and Obstacles in Forest-Based and Poverty Alleviation

The fact that natural forests and poverty are found in the same place in some areas of the world is no accident. Natural forests are home to human evolution and human populations that have lived there for millennia are at a relatively low level of socio-economic development. Moreover, migrant rural populations that colonize forested areas and seek new agricultural lands are often relatively poor. Forests often serve as an employer of last resort for economically marginalized people, for example, due to skewed land distributions in the lowlands. In the course of history, forests have often served as a refuge for less powerful people fleeing oppression, conflict and war. Hundreds of millions of people depend on forests and forest resources for their livelihood (Byron and Arnold 1999; Calibre Consultants and SSC 2000). Byron and Arnold (1999) identified three categories: forest dwellers, including hunter-gatherers

and swidden cultivators; farmers living adjacent to forests, including smallholders and the landless; and commercial users, including artisans, traders, small entrepreneurs, and employees in forest industries. An additional category is consumers of forest products among the urban poor. Forests serve as a vital safety net for millions of people around the world. Their role in eliminating poverty is not as well documented, though probably applies to a smaller number of people (Wunder, 2001). Little is known on the extent to which forests can alleviate poverty in developing countries. Much research must be done to shed light on this question. This section summarizes basic information on the opportunities and obstacles for FBPA as regards to five categories of forest use: conversion of natural forests to agriculture; timber; non-timber forest products (NTFPs); payment for environmental services; and employment and indirect benefits. It also notes that the destruction and removal of forest cover, on the one hand, and its maintenance and sustained use, on the other, can support poverty alleviation. A critical role for science is to better understand where forest conservation and poverty alleviation converge, and where they diverge as policy goals.

Conversion of Forests to Agriculture

Between 1700 and 1980, the world's forest cover decreased by 19 percent and the area of agricultural land increased four and half times (Richards, 1990). The driving forces of this conversion have been forest rent capture (use of unexploited economic opportunities), commercial interests behind the establishment of agricultural trade, and conversion of forest land to agriculture. Rural smallholders have also benefited from this process. Conversion of natural forests to agriculture, that is to say, exploitation of the soil nutrient-building function of forests, is probably the main contribution to poverty alleviation in terms of numbers in that hundreds of millions of people likely benefited throughout history. Where smallholders are concerned, the conversion of natural forests can be either temporary, as in swidden systems, or permanent, in the case of sedentary agriculture. Population increases in developing countries and increasing demand for land are among the forces propelling forest conversion. According to Alexandratos (1995), the area of agricultural land in developing countries, excluding China, will have to increase from 760 million ha to 850 million ha by 2010 to meet demand for food. Dyson (1996) and Evans (1998) claim that potentially cultivable land is abundant and is not constraint in terms of supply. However, as Evans (1998) explained that: "Much of the presently uncultivated area is already used for grazing livestock or is of poorer quality, too remote or subdivided to be economic, vulnerable to erosion, or cherished in its present state." There are potentially disastrous consequences from clearing all available cultivable land to meet demand.

Timber

Timber is by far the largest source of wealth in most forests. In 1998, the value of international forest products exports from developing countries, considering industrial round wood, sawnwood, and wood panels alone, was \$10.4 billion (FAO 2001). With so much wealth stored in developing country forests, the question arises as to why little has gone toward alleviating the poverty of people living in their midst. There are two reasons. First, both extraction of timber from natural forests and tree growing have certain anti-poor characteristics. Although some production and processing of timber is small-scale and for local markets, high amounts of capital, technology, and skills, tend to increase the economies of scale of timber industries, which aim at specialized consumer markets. Tree growing for timber requires secure land tenure and the poor are often landless or only have informal control over the land they use. High-value timber for extraction tends to be in inaccessible humid forests, whereas the poorest of the poor are more numerous in dry forests. Tree growing requires a long-term, high risk investment whereas the poor require income in the near-term and strive to minimize risks. Nevertheless, many poor rural families that own land in established agricultural areas plant some trees. In addition, some poor are excluded from access to timber wealth precisely because the value of timber is so high and they lack power to invest in their production. In many countries, forest tenure, laws and regulations were designed to assure the state and holders of timber concessions were granted privileged access and to avert interference and counter-appropriation by the rural poor. Only in recent years has this begun to change. Two models of timber

production can possibly alleviate poverty but significant obstacles are attached to both. First, local management of natural forests is hampered by weak and slow-changing institutions, rent capture by local elites, inconsistent laws and regulations and cumbersome bureaucracy. In addition, communities lack control of downstream activities and much of the forest rent is captured by those involved in processing and marketing. Second, use of trees for subsistence, for example for fuelwood and fodder, is important yet over exploitation is common (Rathore *et al.*, 1995; Schulte-Bisping *et al.*, 1999).

Non-timber Forest Products (NTFP)

NTFPs provide a wide range of goods for domestic use and for the markets, among which are charcoal, fuelwood, game, fruits, nuts, medicinal herbs, forage, and thatch for roofs (FAO, 2010). In contrast to timber, NTFPs tend to have little or no capital requirements and tend to be available in open-access or semi-open access settings. The poor generally use various types of NTFPs so are able to spread risk among different activities. There is strong evidence that the poorest of the poor around the world are those most engaged in extracting NTFPs (Neumann and Hirsch, 2000). This then raises the question of whether or not NTFPs contribute positively to the livelihoods of the poor. NTFPs are safety nets, and a source of emergency sustenance in times of hardship, i.e., when crops fail, when economic crisis hits, in times of conflict or war, or when floods wash away homes. NTFPs tend to be seasonal and to perform a gap-filling function. Rarely are they the primary source of household income (Byron and Arnold 1999, Arnold 2001), and sometimes are a form of savings. But NTFPs can also be a poverty trap. Rural people rely on NTFPs because they are poor, but it is also possible they are poor because they rely on NTFPs and activities for which remuneration is low. Some characteristics of the forest environment and of the NTFP economy make it difficult or impossible for those who depend on them to rise out of poverty. Natural forests are often inferior production environments with little infrastructure, high transport costs due to remoteness, few buyers, and exploitative marketing chains. The net benefits of NTFPs are often too low to justify articulating property rights which, in turn, limits incentives to invest and increase yields. In the few cases where NTFPs have high value, the poor are often excluded from accessing them (Dove, 1993). Finally, sustained increase in demand for NTFPs can lead to collapse of the resource base, to intensive production on plantations outside forests, or to production of synthetics that out-compete NTFPs (Homma, 1992).

Environmental Services

The ecological services of forests are relevant to poverty alleviation in two ways: direct use for people living in or near forests and transfer payments on local services provided by those living in or near forests that they own or manage. Forest dwellers can benefit directly from maintaining healthy forest ecosystems. For example healthy forests can protect the quantity and quality of water supplies (WRI, 2000). They can maintain or enhance agricultural production by restoring soil fertility in agroforestry systems (Sanchez *et al.*, 1997). Also, forest biodiversity provides various ecological benefits, including germplasm for crop improvement. The direct use value of forest environmental services is related to the poverty avoidance/mitigation function of forests. Transfer payments involve situations where off-site users pay forest dwellers to maintain the ecological services of particular forests. These payments could potentially improve the livelihoods of these forest dwellers and help eliminate poverty. However, while the potential benefits are immense, the challenges to implementing such schemes continue to be daunting.

Employment and Indirect Benefits

Very little is known about alleviating poverty through formal or informal forest sector employment and through indirect benefits such as local multiplier effects or trickle-down effects. Angelsen and Wunder (2002) discussed these effects in greater detail, although limited empirical evidence is available. This section is limited to listing basic information about these aspects.

A. Employment

In the late 1990s, there were 17.4 million employees worldwide in the formal forestry sector and about 47 million altogether, including formal and informal employment (ILO 2001). In six developing countries, forest based enterprises accounted for 13-35 percent of all small scale rural enterprise employment (FAO 1987).

B. Local multiplier effects

It is possible that forestry activities alleviate poverty through local multiplier effects. For example, opening a forest concession and bringing in a logging workforce creates demand for food, goods and services and creates employment opportunities. Likewise, creation of a logging road not only enables transport of logs but opens access to markets for other goods, potentially increasing local incomes. It can also enable local people to access external health and schooling services. However, negative effects must also be considered.

C. Trickle-down effects

Not enough is known about the extent to which forestry contributes to poverty reduction through its impact on overall economic growth or whether cheaper forest products from increased market supplies make urban consumers better off. The contribution of the forestry sector to Gross Domestic Product (GDP) tends to be a small fraction of the total in most developing countries. It should be noted that the value-added figure for the forestry sector significantly underestimates the total value since a large share of forest products are not registered because they are used for subsistence and trade in local markets. Moreover, low GDP contributions can also reflect the simple fact that, in many cases, forest products are not scarce and therefore are cheap (Simpson 1999). Timber resources are often liquidated and the capital used to establish economic activities outside the forest sector.

CHALLENGES OF SUSTAINABLE FOREST MANAGEMENT

The emergence of sustainable forest management require some elements such as legal and policy framework, sustained and optimal production of forest products. Sustainable forest management requires protection of the environment, and wellbeing of people to be put in place. If any of these elements are lagging behind it could have a far reaching effect on the availability and utilization of forest resources.

This paper identifies some challenges facing sustainable forest management

- Weaknesses in implementation of forest management plan and enforcement of forestry legislation
- Inadequate land use planning
- Inadequate information about the forest resources base
- Inadequate protected area network
- Denial of indigenous peoples right
- Deforestation

Possible solution to the challenges

The following strategies have been proposed enhancing sustainable forest management:

- There is need for urgent policy reforms and technical innovations aimed at poverty alleviation.
- The government should make agricultural credit facilities available to farmers especially in the rural areas aimed at increasing forest productivity.
- Rural communities should be involved in the management of the forest. Their roles and responsibilities in the management, conservation and use of the forest resources should be recognized and appreciated, since local communities are often highly dependent on these resources.
- The federal and state forestry department should undertake comprehensive environmental education campaigns that reach all levels of the society, including state forestry staff and policy makers.

CONCLUSION

Sustainable forest management no doubt has a critical role to play in poverty alleviation. However, for forestry to contribute optimally in its potential for poverty alleviation, adequate attention must be given to its sustainable management.

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Effects of Feeding Diets Containing Graded Levels of Fermented African Locust Bean (*Parkia biglobosa*) Seed Meal on Internal and External Egg Quality Traits of Bovan's Brown Layers



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Abstract

An experiment was conducted to test the effects of replacing groundnut cake with fermented African locust bean (*Parkia biglobosa*) seed meal (FALBM) on egg quality traits of Bovan Brown layers. A total of 180 Bovan's Brown layers (30 weeks old) were allotted into five dietary treatments in a completely randomized design comprising 3 replicates per treatment. FALBM was incorporated at 0, 25, 50, 75 and 100% (as diets A, B, C, D and E respectively) replacement levels as alternative sources of protein to groundnut cake. The birds were housed in battery cages measuring 40 cm length, 35 cm width and 40 cm height and fed the experimental diets for 42 days. The data generated from the experiment were subjected to analysis of variance (ANOVA) and significantly ($P < 0.05$) different treatments were compared using Duncan's multiple range test. The results of egg quality parameters revealed that diets had no significant ($P > 0.05$) effect on all the parameters measured, except for egg weight (67.6 g for birds fed diet A and 65.83g for birds fed diet E) and yolk weight (18.41 g for birds fed diet A and 16.71 g for birds fed diet C) which were significantly different across the treatments. The values obtained for egg weight ranged from 67.61 to 65.83 g. Birds on control diet (A) had significantly higher values when compared with other treatments. Similarly, the values obtained for yolk weight showed that birds fed diet A (control) had the highest while birds fed diet D presented the least. It is therefore recommended that experiment with different processing methods be done in order to ascertain the effects of processing on the nutritional value of African Locust Bean.

INTRODUCTION

Poultry eggs are one of the most attractive targets for nutrition manipulation, owing to the extraordinary sensitivity of most of its traits to dietary factors. Varied and special nutritional approaches are developed targeting the specific properties of eggs (Jing *et al.*, 2017). The quality traits of an egg are parameters that affect its acceptability to the consumers (Duman *et al.*, 2016). The first concern of egg quality modulation is to reduce the defects of eggs, either on appearance or on flavor/taste (Jing *et al.*, 2017). Evaluation of egg quality parameters is essential both for table eggs and for the production of hatching eggs (Alkan *et al.*, 2013; Rotimi *et al.*, 2022). For example, there are studies on the relationship between egg weight and egg quality parameters (Olawumi and Ogunlade, 2008; Sarica *et al.*, 2012).

In the poultry industry, egg production is hampered by the shortage of feed ingredients (Jing *et al.*, 2017). To meet the severe challenge, the egg industry should develop sustainable ways of production at the lowest cost and slightest environmental impacts (Godfray *et al.*, 2010). The high cost of animal protein has directed interest towards several leguminous seed protein sources as vegetable protein for human food and livestock feed. Grain legumes are considered as major sources of dietary proteins and are consumed worldwide, especially in developing and under developed countries where consumption of animal protein may be limited as a result of economic, social, cultural or religious factors (Esenwah and Ikenebomeh, 2008).

Conventional feed ingredients are more expensive and not readily available to all producers at all locations due to competing demand for the commodity between man and livestock, adverse climatic conditions and the use of these ingredient in the biofuel industry (Iji *et al.*, 2011). This stimulated the search for alternative feed ingredients particularly protein sources for poultry. Among these alternatives is African locust bean seed which is rich in protein and is used as a flavor intensifier for soups and stews. According to Omafuvbe *et al.* (2004), its crude protein content is similar to other beans like cowpea, jack beans, lima beans and pigeon pea. It is a rich source of essential amino acids, minerals and vitamins. Improved performance traits, nitrogen retention and feed utilization of broilers fed fermented African locust beans as a replacement of groundnut cake have been reported by Kolo (2000); Ayanwale and Ari (2002) and Dawodu (2009). It is therefore on this positive attribute that this study was carried out to assess the egg quality of laying chickens fed fermented African locust beans as a substitute for groundnut cake. The aim of this experiment was to evaluate the possibility of composing a diet with a replacement of groundnut cake with FALBM in the diets feed ingredients as a major source of protein. The egg quality was analysed and cost benefit of using FALBM in the formulation of the experimental diet was determined.

MATERIALS AND METHODS

Experimental Site and Location

The study was conducted at Sensor farm between June 2019 and May 2020. The farm is located at Danladi Nasidi housing estate in Kumbotso Local Government Area of Kano state. The area is located within latitudes 11° 53' - 11° 88' 'N and longitudes 8° 30' - 8° 50', E. Kano is bordered with Kaduna state on the South west, Bauchi state in south east, Katsina state in the north west and Jigawa state in the north east (Dakata and Yelwa, 2012). The area is characterized with tropical wet (May - September) and dry seasons (October - April) (Olofin, 1987). The annual rainfall and temperature ranges between 886 mm and 960 mm and 21°C and 46°C, respectively, while humidity ranges between 20 - 40% (dry season) and 60 - 80% (wet season) (KNARDA, 2006).

Source of Experimental Feed Ingredients and Formulation of the Diet

Ingredient for the formulation which included maize, groundnut cake, limestone, wheat offal, fish meal and bone-meal were purchased from a feed raw materials market at Tafawa Balewa Road, Kano. African locust bean was purchased from Makole market along, Maiduguri Road, while lysine, methionine and Vitamin/ mineral premix were purchased from Animal Care Services Consult Limited, Kano.

The ingredients were milled by local feed millers using hammer mill and mixer. The experimental diets were formulated to contain different levels of fermented African locust as an alternative protein source to groundnut cake (Table 1).

Processing and Fermentation of Locust Bean Seed

Eighty kilograms (80 kg) of locust bean seed was cleaned, washed and poured into a container containing 200 liters of boiled water. It was allowed to soak for 24 hours, excess water was later removed. The seeds were allowed to ferment for 3 days in an air tight polythene bag. Fermented seeds were then removed after 3 days and spread on a polythene bags to be sundried for 3 days.

Experimental Birds and their Management

A total of one hundred and eighty Bovan's Brown layer chickens purchased from Sovet International Limited, Tarauni, Kano, at 30 weeks, were used in the experiment for a period of six weeks. The birds were housed in battery cages (40 cm length, 35 cm width and 40 cm height). The cages were well ventilated, in an east-west orientation. The birds were fed commercial layer mash prior to the commencement of the experiment. They were vaccinated against common poultry diseases such as Newcastle, infectious bursal disease, coccidiosis, fowl pox, infectious bronchitis and egg drop syndrome. A known quantity of feed and water was provided *ad libitum* throughout the experimental period.

Treatments and Experimental Design

The experiment was laid in a completely randomized design as outlined by Steel and Torrie (1980). The birds were allotted to 5 groups of different levels of inclusion of fermented African locust beans and each group was replicated three times with 12 birds per replicate. FALBM was incorporated at 0, 25, 50, 75 and 100% as an alternative source of protein to groundnut cake.

Table 1: Composition of the Experimental Diets

Ingredients	Diet (FALBM %)				
	A (0)	B (25)	C (50)	D (75)	E (100)
Maize	43.00	42.00	43.00	41.00	42.00
Groundnut cake	16.00	12.00	8.00	4.00	0.00
Maize bran	7.00	8.00	7.00	8.00	7.00
Wheat offal	17.00	17.00	17.00	18.00	18.00
FALBM	0.00	4.00	8.00	12.00	16.00
Fish meal	5.00	5.00	5.00	5.00	5.00
Bone meal	3.50	3.50	3.50	3.50	3.50
Limestone	8.00	8.00	8.00	8.00	8.00
Salt	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
Lysine	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100
Calculated Analysis (%) - Unless otherwise stated					
ME (kcal/kg)	2534.90	2527.90	2539.70	2517.14	2528.90
Crude protein	17.19	17.20	17.80	17.27	17.26
Crude fibre	4.10	4.26	4.20	4.45	4.40
Ether extract	3.70	3.60	3.50	3.40	3.30
Calcium	3.65	3.65	3.65	3.65	3.65
Phosphorus	0.47	0.45	0.48	0.44	0.46

ME=Metabolizable Energy.

FALBM= Fermented African Locust Bean Meal

Premix=Vitamin Mineral Mixture.

**2.5kg of premix supplied vitamin A 12500 I. U. Vit-D3 2500 I. U. Vit E-500mgL- Vit K3. 2.5mg; Vit B1, -3.0mg; Vit B2 6.0MG; Vit B6 6.0mg; Niacin 40.0mg; calcium pantothenate 10.0mg; Biotin 0.80mg; Vit B12 0.25mg; Folic acid 1.0mg; Choline Chloride 300mg; manganese 100mg; Iron 50mg; Zinc 45; Copper 2.0mg; cobalt 0.25mg; iodine 1.55mg, selenium 120mg.

Data Collection

Data were collected after seven days adaptation period. Feed intake, egg production, minimum and maximum temperature, humidity and mortality were monitored, daily, while egg quality and cost of feed per egg were monitored, weekly.

Egg Quality Assessment

After four weeks of the experiment, two fresh eggs were randomly selected from each replicate for external and internal quality assessment, for 3 consecutive days. Each egg was weighed and broken into a Petri-dish with a knife and the yolk was separated from the albumen using a yolk separator. Albumen and

yolk weights were measured using a sensitive electronic scale (to the nearest 0.01 g). Shell thickness was measured with the aid of micro meter screw gauge (Panda *et al.*, 2003). Egg shell weight was determined after emptying the egg contents. The shell interior was cleaned and allowed to dry, thereafter the weight was taken using a sensitive scale. The colour of yolk was scored visually with the aid of the Roche Colour fan (numbered from 1-15, indicating very light to orange colouration), the colour fan was placed near the yolk to determine the colour that matches the yolk and colour number was noted. The length of the egg was measured using veneer caliper, between the pointed end and the broad end. Similarly, width of the egg was taken at the widest point.

Chemical analysis

The samples of the experimental diets, raw and fermented African locust bean were properly ground and labeled at the Animal Science laboratory, Bayero University Kano. They were then subjected to proximate analysis to determine the nutrients (CP, CF, EE, Ca and P) compositions, following procedures outlined by AOAC (1990). The Concentrations of trypsin inhibitor, tannin and phytate were determined using the procedural methods outlined by Liener (1979), Dawra *et al.* (1988) and Maga (1983) respectively.

Feed Cost

Costs of experimental feed ingredients were taken in accordance with prevailing prices during the formulation of the experimental diets. The cost of each experimental diet, the average cost of actual feed consumed (₦/kg) and the cost of the feed/egg (₦/egg) were calculated by using the cost of each ingredient (₦) in the diet formulation.

Statistical Analysis

The data generated from the experiment were subjected to analysis of variance (ANOVA) using SAS (1999) statistical package. Significant differences between the means were determined using Duncan's multiple Range Test (Duncan, 1955).

RESULTS

Proximate Composition of the Experimental Diets Fed Graded Levels of FALBM

The dry matter ranged from 89.86 – 95.30%, Diet A had the highest value while diet E had the lowest (Table 1). The trend indicated that dry matter decreased with increasing inclusion levels of FALBM. Crude protein ranged from 15.66 – 16.38 %, ether extract ranged from 2.33-3.16%, crude fiber ranged from 4.43-4.56%, while the ash content ranged from 4.25-5.47%. The trend for the above proximate components decreased with increasing levels of FALBM for dry matter, crude protein, ether extract and nitrogen free extract. Meanwhile, the value increased with increasing levels of FALBM for crude fiber and ash contents.

Effect of feeding graded levels of FALBM on egg quality parameters of layer chickens.

There was no significant different in all the parameters measured, except for egg weight and yolk weight which were significantly ($P>0.05$) different across treatments (Table 2). Values for egg weight showed that birds fed diet A had significantly highest value compared to other treatment means. The values for birds fed diet A were statistically similar with birds fed diet B, which was not different from birds fed diet C and D. Yolk weight showed that birds fed diet A the significantly highest value compared to other treatments (Table 3).

Table 2. Proximate Composition of Experimental Diets

Parameter	Diets (FALBM %)				
	A (0)	B (25)	C (50)	D (75)	E (100)
DM	95.30	94.06	92.93	92.06	89.86
CP	16.38	16.23	16.13	16.05	15.66
CF	4.43	4.53	4.53	4.56	4.56
EE	3.16	2.81	2.56	2.41	2.33
NFE	67.30	65.28	64.50	63.65	63.04
Ash	4.25	4.80	5.18	5.18	5.47

DM: dry matter, CP: crude protein, CF: crude fiber, EE: ether Extract, NFE: nitrogen free extract
FALBM: Fermented African locust bean meal

Table 3. Effects of graded levels of FALBM on egg quality parameter

Parameters	Diets (FALBM %)					SEM	P value
	A (0)	B (25)	C (50)	D (75)	E (100)		
Egg weight(g)	67.61 ^a	66.89 ^{ab}	65.94 ^{bc}	65.94 ^{bc}	65.83 ^c	0.47	0.000
Yolk weight(g)	18.41 ^a	17.96 ^{ab}	16.72 ^b	16.69 ^b	16.71 ^b	0.45	0.001
Albumen weight(g)	27.21	27.19	26.56	25.90	25.57	0.63	0.061
Egg length(mm)	54.30	54.13	48.90	55.18	54.39	3.69	0.474
Egg diameter(mm)	42.81	42.85	42.23	42.99	42.99	0.34	0.234
Shell thickness(mm)	1.07	1.03	1.03	1.06	1.08	0.14	0.659
Yolk colour	2.89	2.78	2.89	2.11	2.89	0.34	0.234

^{a,b,c,d} Means in the same row with different superscript were significantly different ($P < 0.05$), FALBM: Fermented African locust bean meal, SEM: standard error of mean.

Cost of Diets Formulated

The cost of 100 kg of each of the experimental diet revealed a constant decrease from ₦9 635 in diet A to ₦9 235 in diet E. The cost of maize is higher in diet A and C (₦4300) followed by ₦4200 for B and E. diet D has the least cost of maize (₦4100). The cost of groundnut cake in 100 kg of the experimental diets was constantly decreasing from ₦2080 in diet A to ₦520 in diet D. On the other hand, the cost FALBM was increasing from ₦440 in diet B to ₦1760 in diet E. Other ingredients like fish meal, bone meal, lime stone, salt, premix, lysine and methionine were constant from diets A to E.

Table 4. Cost analysis of layer chickens fed graded levels of fermented African locust bean meal

Parameter	Diets (FALBM %)				
	A (0)	B (25)	C (50)	D (75)	E (100)
CED(₦)	9632	9485	9465	9250	9235
CF/kg(₦)	96.32	94.85	94.65	92.50	92.35

CED: Cost of experimental diet; CF/kg: cost of feed/kilogram

DISCUSSION

The dry matter, crude protein, ether extract and nitrogen free extract decreased as the levels of FALBM increased in the diets. The decrease in dry matter, ether extract and nitrogen free extract and increase in ash and crude fiber content of the diet could be due inclusion levels of FALBM. Akanji *et al.* (2015) found similar trends in the evaluation of egg laying performance and blood chemistry of birds fed fermented and unfermented African locust beans diets. The results obtained for crude protein however, contradict the findings of Akanji *et al.* (2015) who reported increase in crude protein content of FALBM.

The difference in crude protein content could be due to period of boiling and sources of African locust bean meal. The egg quality parameters were not different, except for egg and yolk weights. This is an indication that FALBM has no detrimental effect on egg shell formation. The observation is in agreement with the report of Babangida *et al.* (2011) who observed no differences in the egg shape index of Japanese quails fed graded levels of dietary protein.

The lower egg and yolk weights obtained for birds in diet 5 could be due to the increased level of FALBM. This could be due to lower levels of crude protein and nitrogen free extract. Novak *et al.* (2008) revealed that lowering CP in laying hen diets reduced egg weight through the period of 18 - 60 weeks. Summers *et al.* (1991) and Lopez and Leeson (1995) also reported that layer egg weight is strongly related to the CP in the diet.

The lower cost of FALBM based diets, when compared with the control was due to the relatively lower cost of FALBM to groundnut cake at the period when the ingredients were purchased. The lowest cost (₦92.35) per kg of diet was higher than (₦72.86) per kg diet obtained by Tamburawa *et al.* (2017) who evaluated the effect of soaked and fermented African locust bean seeds meal on the performance, organs and carcass characteristics of broiler chickens. This could be due to the seasonal variation in the price of ingredient.

CONCLUSION AND RECOMMENDATIONS

The inclusion of FALBM had positive influence on the total cost of the experimental diet, from A (25%) to E (100%) FALBM replacement levels. Based on this research it is recommended that fermented African locust bean meal can be incorporated up to 25% in the diet of layer chickens without any deleterious effect. Meanwhile, further research should be conducted in which another method of processing African locust bean would be used in order to better enhance its utilization by layer chicken.

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Socio-economic Determinants of Adoption of Agroforestry Practices in Akinyele Local Government Area of Oyo State, Nigeria



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Abstract

The study examined the socio-economic determinants of adoption of agroforestry practices among farmers in Akinyele Local Government Area of Oyo State. Ninety questionnaires were administered using five villages which are: Ijaye, Ajibade, Akinyele, Olorisaoko, and Iroko for the study. The data collected were analyzed using frequency table, percentage, mean and inferential statistics. The results revealed that 80% of the respondents were male while 18.9% were female. Only 29.9% were between 41 and 50 years with mean age of 49.9 years. Only 8% had no formal education, while 67.8% were married and 46.7% of the farmers had family size of 1-5. The mean household size was 6.4 persons and majority of the farmers adopted more than one type of agroforestry practices. Multipurpose trees on crop land (73.3%) was the most adopted practice while the least was apiculture with trees (6.7%). It was observed that 41.1% had between 2-10 years of farming experience, while 6.7% engaged in agroforestry for more than 40 years. Agroforestry practices had improved the standard of living of about 60% of the farmers and 48.9% agreed that agroforestry was complex to understand and costly to adopt. One of the major constraints faced by the farmers was transportation (48.9%), and 46.7% of the farmers confirmed that constraints led to deterioration of the produce harvested. The inferential statistics revealed that farmers' age, source of land, farm size, educational status and household size were the major socioeconomic determinants of agroforestry adoption in the study area.

Keywords: Agroforestry, socio-economic, determinants, practices, Oyo

INTRODUCTION

Agroforestry is the incorporation of agriculture and forestry. Agriculture is the knowhow, exercise and operation of farming, including cultivation of the soil for the growing of crops and the rearing of animals to provide food, wool, and other products, all for environmental and human benefits. Forestry is the knowhow, exercise and operation of creating, managing, using, conserving and repairing forests, woodlands, and associated resources for human and environmental benefits (Isaac *et al.*, 2005). Agroforestry is the interaction of agriculture and trees, including the agricultural use of trees. This comprises trees on farms and in agricultural landscapes, farming in forests and along forest margins and tree-crop production, including cocoa, coffee, rubber and oil palm (World Agroforestry, 2021). Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence (FAO, 2015).

Some Nigeria farmers have ventured into the concept of adopting agroforestry. The country is blessed with a large area of land and diverse vegetation. Unfortunately, the use of this important resource has been abused, not sustainably used or managed. Onovugbe (2012) pointed out that the forest has been

treated in the past by many rural dwellers as inexhaustible. Most of the timber rich zones of Africa are faced with diminishing forest resources due to forest degradation, human and animal population increase, mismanagement of the forest and other forms of forest exploitation (Ezebilo, 2004; Ladipo, 2010; Oyewo *et al.*, 2020). Over the past two decades, a number of studies have been carried out to analyse the viability of agroforestry (Akinwalere, 2017). The combined research has highlighted that agroforestry can reap substantial benefits both economically and environmentally, producing more output and proving to be more sustainable than forestry or agricultural monocultures (Ajayi *et al.*, 2007). Different incentives, institutional mechanisms and policies could be implemented to facilitate agroforestry adoption in some areas and countries, Nigeria inclusive. Information on the influence of policy factors on the adoptability and performance of agroforestry practices is scarce and this makes it difficult for policy-makers to implement proper interventions (Bugayong *et al.*, 2003).

This study therefore examined the socio-economic determinants of adoption of agroforestry practices by farmers in Akinyele Local Government Area. The following objectives were discussed: examine the socio-economic characteristics of the agroforestry farmers, identifying the agroforestry practiced and analyse the socio-economic determinants of the adoption of agroforestry practices by the farmers in the study area.

MATERIALS AND METHODS

Study Area

The study was carried out in Akinyele Local Government Area in Oyo State, Nigeria. It is one of the eleven local governments that make up Ibadan metropolis. Its headquarters is situated in Moniya. Akinyele Local Government Area was created in 1976 and shares its boundaries with Afijio Local Government to the north, Lagelu Local Government Area to the east, Ido Local Government Area to the west and Ibadan North Local Government Area to the south. It comprises of 12 wards which are: Ikereku, Olanla/Oboda/Labode, Arulogun/Eniosa/Aroro, Olode/Amosun/Onidundu, Ojo-Emo/Moniya, Akinyele/Isabiyi/Irepodun, Iwokoto/Talonta/Idi oro, Ojoo/Ajibode/Laniba, Ijaye/Ojedeji, Ajibade/Alabata/Elekuru, Olorisa Oko/Okegbemki/Mele and Iroko. Akinyele Local Government area occupies a land area of 464.892 square kilometers with a population density of 516 persons per square kilometer (NPC, 2006). Using 3.2% growth rate from 2006 census figures, the 2010 estimated population for the Local Government is 239,745 of which the inhabitants are Yoruba's. Ibadan has a tropical wet and dry climate, with a lengthy wet season and relatively constant temperatures throughout the course of the year. This good weather condition will enhance the adoption of agroforestry practices among farmers in the area.

Sampling Procedure and Data Collection

Data for this study was primarily sourced with the aid of a structured questionnaire; purposive sampling was used to select respondents from five villages which are: Ijaye, Ajibade, Akinyele, Olorisa oko, and Iroko, twenty (20) farmers were selected from each of the selected villages except Iroko where ten (10) farmers were selected, making a total of ninety (90) respondents. The selection was proportionate to the population of the farmers in each village.

Data Analysis

The data collected was analysed using frequency tables and percentages. Mean was used to analyze the socio-economic characteristics of the respondents and assess the agroforestry practices. Inferential statistics was used to analyze the socio-economic determinants of adoption of agroforestry practices by the farmers in the study area.

Model Specification

$$Y=f(x)$$

$$(b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + b_6 x_6 + x)$$

Where Y= adoption of agroforestry practices

X₁= gender (dummy)

X₂= age (years)

X₃= educational level (dummy)

X₄= family size (actual)

X₅= farm size (hectare)

X₆= source of land (dummy)

b₀= parameter estimated

X= error term

RESULTS AND DISCUSSION

Most respondents (80%) who adopted agroforestry practices were male, while 18.9% were female (Table 1). This showed that agroforestry farming practices were dominated by men. It was observed that 29.9% were between ages 41-50, 25.4% are 61 year and above, 18.9% were between the ages of 51-60 years, while 15.4% were between the ages of 31-40 years. This mean age of farmers was 49.9 years, which indicated that majority of them are youth, but not interested in agriculture due to negative perceptions of low social status (Phongsiri *et al.*, 2017). Hence the farming population was becoming an aging workforce (Szabo *et al.*, 2021). In the villages, 37.8% had secondary education, 27% had primary school education, 17% had tertiary school education, 8% had no formal education while 4% had adult education. This implies that most of them had some form of formal education, which could enhance their level of adoption of agroforestry practices. 46.7% of the respondents had family size of 1-5, while mean household size was 6.4 persons. The members of the household could be used as family labour. 56.7% of the farmers had farm size between 1-5 hectares, 24.5% had between 6-10 hectares while 18.9% had more than 10 hectares of farm land. This indicated that majority of the farmers were operating a small scale farming system. This corroborates the findings of Oyewo *et al.* (2020) that farmers in Ido local government operate small scale farming systems on farm land ranging from 0.10 ad 4.99 acres. Majority (63.3%) of the farmers engaged in full time agroforestry practices while only 36.7% farmers involved in agroforestry practices on a part time basis. However, 41.1% had been practicing agroforestry for 2 to 10 years, while 25.6% had farming year experience ranging from 21 and 30 years. Only 60% of the farmers attested that agroforestry practices had improved their standard of living, 25.6% improve their self-dependency, 11.1% were gainfully employed and 3.3% obtained social profit from agroforestry practices. This is an indication that agroforestry practices are a sustainable means of increasing the livelihood of the farmers and a good source of agribusiness.

Majority (73.3%) of the farmers adopted multipurpose trees on cropland, 60.0% adopted shelter belt and wind break systems, 50% adopted alley cropping practices, 47.8% taungya system and fuel wood production, 37.8% used trees on range land or pastures, while 36.7% adopted improved fallow practices and protein banks (Table 2). In addition, 28.9% had home gardens, 26.7% adopted home gardens involving animals, and 22.2% used agroforestry for the benefit of multipurpose woody hedgerows. A few of them used multipurpose woodlot (13.3%), aquaforestry (8.9%) and apiculture with trees (6.7%). Multipurpose trees on crop land where farmers intentionally leave few trees on their farms when clearing for farming activities was predominant. The trees commonly left were of economic importance and this practice could be adapted with other farming practices. Nevertheless, two or more agroforestry practices can be adopted on the same piece of land, to increase farmer's income and standard of living. Leakey (2017) stated that the dynamics of agroforestry which involves the integration of trees in farm and rangeland, diversifies and sustained smallholder production for increased social, economic and environmental benefits.

Table 1. Socio-economic characteristics of respondents

Variable	n=90	Frequency	Percentage (%)	Mean
Gender				
Male		72	80.0	
Female		18	18.9	
Age				
22-30		9	9.9	
31-40		14	15.4	
41-50		27	29.9	
51-60		17	18.9	
60 and above		22	25.4	49.9
Educational level				
No formal educational		8	8.9	
Primary		27	30.0	
Secondary		34	37.8	
Tertiary		17	18.9	
Adult education		4	4.4	
Marital status				
Single		5	5.6	
Married		61	67.8	
Divorce		11	12.2	
Widowed		9	10.0	
Separated		4	4.0	
Household size				
1-5		42	46.7	
6-10		42	46.7	
11 and above		6	6.59	6.4
Farm size (hectare)				
1-5		51	56.7	
6-10		22	24.5	
10 and above		17	18.9	7.9
Level of involvement				
Full time		57	63.3	
Part time		33	36.7	
Years of Agroforestry practices				
2-10		37	41.1	
11-20		19	21.1	
21-30		23	25.6	
31-40		5	5.6	
40 and above		6	6.7	
Benefits derived from business				
Self-dependency		23	25.6	
Employment		10	11.1	
Improved standard of living		54	60.0	
Social profit		3	3.3	

Table 2. Identified agroforestry practices adopted by the farmers

Variable	Frequency	Percentage (%)
Tree on range land or Pasture	34	37.8
Taungya System	43	47.8
Alley cropping	45	50.0
Home garden	26	28.9
Shelter break and wind break	54	60.0
Multipurpose on cropland	66	73.3
Improved fallow practice	33	36.7
Fuel wood production	43	47.8
Protein banks	33	36.7
Home garden involving animals	24	26.7
Multipurpose woody hedge rows	20	22.2
Apiculture with trees	6	6.7
Multipurpose wood lot	12	13.3
Aquaforestry	8	8.9
Multiple responses		

The multiple regression analysis of the socio-economic determinants of the adoption of agroforestry revealed that farmers' age, source of land and farm size were positively significant at 1% to the agroforestry adoption. This agrees with the findings of Akinwumi *et al.* (2002). Household size was significant at 5%, and had a positive relationship with the adoption of agroforestry, while educational level was negatively significant at 1%. This showed that farmer's age, farm size, source of land and household size increased, there was a proportionate and positive increment in the level of adoption of agroforestry practices. This is in line with the findings of Adebayo and Oluronke (2014) while the negative coefficient of educational status will bring about a decrease in the level of agroforestry adoption. This could be due to the level of education and awareness of adoption of agroforestry by the farmers in the study area.

Table 3 Socio-economic determinants of adoption of agroforestry practices

Variables	Beta	Std. Error	T-Values	Significance
Constant	-19.909	8.228	-2.420	0.819
Gender (X ₁)	1.880	2.397	0.784	0.435
Age (X ₂)	0.430***	0.071	6.059	0.000
Educational status (X ₃)	-2.832***	1.015	-2.791	0.007
Household Size (X ₄)	0.463**	0.249	1.858	0.067
Farm size (X ₅)	0.385***	0.096	4.008	0.000
Land source (X ₆)	4.920***	1.221	4.028	0.000

Author Analysis, Note: (***) and (**) mean significant at 1% and 5%, respectively

CONCLUSION AND RECOMMENDATIONS

The adoption of agroforestry in Akinyele Local Government Area is dominated by male farmers who had one form of formal education or the other. Multipurpose trees on cropland was the most widely adopted practice by the farmers. The farmer's age, educational status, household size, farm size, and source of land were the major determinants of adoption of agroforestry. It was recommended that rapid awareness and sensitization on the benefit and usefulness of agroforestry be created among the farmers. More youth should be encouraged to embrace agroforestry since it served as a source of livelihood. Farmers should build more resilience by adapting to changes in climatic conditions.

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Nursery Seedling Diseases of *Irvingia gabonensis* (Aubry-Lecomte ex O' Rorke) Baill at Rivers State University Forest Arboretum



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Abstract

Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) is an economically important tree, valued for health, medicinal, nutritional and economic benefits. A systematic study of the diseases of the young leaves, soil-borne diseases and nutrient status was carried out. The continued presence of disease symptoms in leaves and rhizosphere were investigated. Results showed that *Irvingia gabonensis* seedling was affected by nutrient deficiency and some microorganisms that were present in the soil. Disease symptoms were characterized by the appearance of brownish-black rot, and the severity of the disease increased with number of days at the nursery arboretum. Four genera of fungi; *Penicillium*, *Botrytis* spp, *Aspergillus*, spp and *Mucor* spp were isolated from the infected seedlings of *I. gabonensis*. The results showed the presence of soil pH (6.08 ± 0.1), nitrogen (1.02 ± 0.01), phosphorus (0.73 ± 0.1), potassium (0.82 ± 0.02), calcium (23.08 ± 0.26), magnesium (7.29 ± 0.02) and sodium (2.39 ± 0.08). Findings from this work avail us the prerequisite information on the nursery of seedling diseases of *I. gabonensis* and required soil nutrients, when planting *Irvingia gabonensis*.

Keywords: Nursery, seedling diseases, *Irvingia gabonensis*, forest arboretum

INTRODUCTION

Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) is a genus of African and South-East Asian trees in the family Irvingiaceae. Other names commonly attributed to it are Wild Mango or Bush Mango (Matos *et al.*, 2009). In Nigeria, there are two varieties identified *I. gabonensis* and *I. wombolu* where both the seeds are consumed, it is commonly called Ugiri or Ogbono by Igbo (Nosiri *et al.*, 2011). The genus, *Irvingia* comprises seven species which include *Irvingia gabonensis*, *Irvingia excelsa*, *Irvingia gradifolia*, *Irvingia malayaria*, *Irvingia giorobur*, *Irvingia smithii* and *Irvingia wombolu* (Ladipo *et al.*, 1996). The plant *Irvingia gabonensis* bears edible mango-like fruits, and is especially valued for its fat and protein rich nut (Ayuk *et al.*, 1999). Ethno medicine utilize the bark, kernels, leaves, or roots for a variety of ailments (Lowe *et al.*, 2000). The bark is mixed with palm oil for treating diarrhoea and for reducing the breastfeeding period. The shavings of the stem bark are consumed by mouth to treat hernias, yellow fever, and dysentery, and the boiled bark relieves tooth pain. In certain parts of Africa, the bark extract is ingested to produce an analgesic effect (Okolo *et al.*, 1995). The seed have been found to reduce fasting blood glucose levels in obese subjects (Ngondi *et al.*, 2005). The powdered kernels act as an astringent and is applied to burns (Nosiri *et al.*, 2011). The stems of the tree have been used as chewing sticks to help clean teeth (Fajimi *et al.*, 2007). In Nigeria and Cameroun, the seeds of *Irvingia gabonensis* are used as a condiment in soup (Ndjounekeu *et al.*, 1996). The purpose of this study is to isolate pathogenic bacteria and fungi from infected leaves of *Irvingia gabonensis*, and soil borne pathogens from the *Irvingia gabonensis* under nursery establishment. Antimicrobial susceptibility test was conducted on the pathogens isolated from leaves and soil using plant extracts.

MATERIALS AND METHODS

Study Area

The research was carried out in the laboratory of the Department of Forestry and Environment, Forest Pathology and Mycology Unit, Faculty of Agriculture, Rivers State University, Nkpulu-Oroworukwo, Port Harcourt, Rivers State, Nigeria, located at Latitude 4.5°N and Longitude 7.0°E, on an elevation of 18 m above sea level, a mean annual temperature of 27°C and rainfall of 2000-2467 mm (Ayolagha and Onuegbu, 2003).

Soil and Leaf samples Collection

Three replicates of soil and leaves of *Irvingia gabonensis* samples were collected from the affected seedlings of *I. gabonensis*, at Rivers State University Forest Nursery (Figure 1). The sample bags were labeled according to the samples collected and then transported in an ice chest to the Laboratory.

Enrichment of samples

The soil sample was enriched in mineral salt media (Bushnell Haas media) using glycerol as carbon source. About Ninety milliliter (90 ml) of BHM was distributed in 250 ml conical flask, supplemented with 10 ml of glycerol and sterilization was monitored at 121°C for 15 minutes at 15 psi. The setup was aerated and agitated using an orbital shaker incubator (Stuart, Germany S150) at 170 r.p.m at 37°C (Effiong *et al.*, 2019).



Figure 1. Infected seedling of *Irvingia gabonensis*

Determination of total heterotrophic bacterial and fungal count

The culture medium for the total heterotrophic bacterial count was determined by suspending twenty-eight grams of nutrient agar in de-ionized water. The suspension was heated over a Bunsen burner to dissolve the media completely and placed in an autoclave 121°C for 15 minutes at 15 psi. After cooling to room temperature, the medium was dispensing into Petri dishes. The media was allowed to cool and solidify at room temperature. One milliliter of the enrichment samples was drawn from the setup and diluted using pre-sterilized normal saline and using spread plate technique. Colony count within 30-300 CFU/ml was used to determine microbial load. Similarly, the total fungal count was determined by dissolving 0.1 ml of the enrichment broth and diluting in a 10-fold serial dilution. It was then plated on

Potato dextrose agar fortified with 0.1% lactic acid to inhibit bacterial contaminants. The inoculated plates was incubated at 25°C for 3-7 days (Abu and Ogiji, 1996).

Experimental Design and Statistical Analysis

The experiment was laid out in a Complete Randomized Design. The treatments were replicated five times. Data obtained were subjected to one way analysis of variance (ANOVA). The mean separation was done using Duncan Multiple Range Test (DMRT) at 5% probability.

RESULTS

The soil was slightly acidic (6.08 ± 0.1) with poor nitrogen (1.02 ± 0.01), phosphorus (0.73 ± 0.1) and potassium (0.82 ± 0.02) contents (Table 1). Tables 2 and 3 revealed the total heterotrophic bacteria count and total fungal count in the *Irvingia gabonensis* leaves and soil, respectively. The soil samples had microbial titre of 1.16×10^5 to 1.04×10^5 cfu/ml for bacterial and 4.2×10^4 cfu/ml to 3.2×10^4 cfu/ml for fungal. The characterization of fungal isolates revealed the presence of *Penicillium* species, with colonial nature with a green aerial mycelium, and dense conidiophores with branched cells (Table 4). Another fungal growth with a whitish-grey mycelia was observed. When viewed under the microscopy, it had a sporangiophore and a fused sporangium. Hence, it was characterized as *Mucor* spp. The conspicuous one was the black isolate that was sueded with venation, a conidia and an extensive conidiophore. This was identified as *Aspergillus* sp (Table 5).

Table 1: Physicochemical properties of soil of potted *Irvingia gabonensis*

Parameter	Mean $\pm$ SE
pH	6.08 ± 0.01
Nitrogen (mg/kg)	1.02 ± 0.01
Phosphorus ((mg/kg)	0.73 ± 0.1
Potassium (mg/kg)	0.82 ± 0.02
Calcium (mg/kg)	23.08 ± 0.26
Magnesium (mg/kg)	7.29 ± 0.02
Sodium (mg/kg)	2.39 ± 0.08

Data represents duplicate mean $\pm$ standard error

Table 2. Total heterotrophic bacteria count and total fungal count from soil of potted *Irvingia gabonensis*

Soil Sample	THBC (cfu/ml)	TFC(cfu/ml)
AS	1.16×10^5	4.2×10^4
BS	1.06×10^5	3.8×10^4
CS	1.12×10^5	4.0×10^4
DS	1.10×10^5	3.6×10^4
ES	1.04×10^5	3.2×10^4

Key: cfu/ml - colony forming unit per mill, THBC – Total heterotrophic bacteria count, TFC – Total fungal count

Table 3. Total heterotrophic bacteria count and total fungal count on infected leaves of *Irvingia gabonensis*

Leave Sample	THBC (cfu/ml)	TFC(cfu/ml)
A	1.02 x10 ⁵	3.4 x10 ⁴
B	9.8x10 ⁵	3.1x10 ⁴
C	1.06x10 ⁵	3.0x10 ⁴
D	1.08x10 ⁵	3.6x10 ⁴
E	1.04x10 ⁵	3.2X10 ⁴

Key: cfu/ml - colony forming unit per mill, THBC – Total heterotrophic bacteria count, TFC – Total fungal count

Table 4. Fungal isolates from leaves of *Irvingia gabonensis*

Probable isolate	Macroscopy
<i>Penicillium</i> spp	Smooth green surface fungi
<i>Aspergillus flavus</i>	Green rough surface, brown reverse side
<i>Aspergillus niger</i>	White mycelia with black tips covering at the centre
<i>Fusarium</i> spp	Fluffy-white with a ring and raised centre with salt crystals
<i>Mucor</i> spp	White fluffy, no colour at the reverse side

Table 5. Fungal isolates from soil of potted *Irvingia gabonensis* seedlings

Probable isolate	Macroscopy
<i>Penicillium</i> sp.	Smooth green surface fungi
<i>Candida</i> sp.	Creamy smooth fungi
<i>Aspergillus flavus</i>	Green sough surface, brown reverse side
<i>Aspergillus falvous</i>	White mycelia with black tips covering at the centre
<i>Aspergillus niger</i>	Tiny brown-raised mycelia with a cream rough reverse side

DISCUSSION

Physicochemical soil composition of potted *Irvingia gabonensis*

Pollution of soils is one challenge that has remained uncontrolled in Nigeria, due to increased industrialization and human activities. This has necessitated the need for soil amendment. Enitan *et al.* (2015) reported that the physicochemical composition of soil can be harnessed as good sources for availability of nutrient in the soil. Agwa *et al.* (2017) mentioned the importance of soil on farm land for cultivation of agricultural crops. In this study, the pH of the soil sample range from 6.08 ± to 6.23. This agrees with the findings of Benit and Roselin (2015) who reported pH of soil to range from 6.3-7.3. The slightly acidic nature of the soil allows for proliferation of a wide array of microorganisms (Sunny and Mathai, 2013). Kirkham (2006) opined that pH affects the bioavailability of trace minerals which could support growth of fastidious microbes. The pH of soil can be correlated with the presence of nutrient availability and other components that interact with the cations (Patil *et al.*, 2008). The nitrogen and phosphorus contents enhance the usefulness of the soils and are correlated with high conductivity. (Wolfgraber *et al.*, (2012). Heterotrophic bacteria and total fungal counts serve as proxies of microbial

quality. In this study, the counts were observed to be similar to the findings of Hamaidi *et al.* (2013) and Chukunda *et al.* (2020).

CONCLUSION

This study revealed that the pathogens that could cause nursery seedling diseases of *Irvingia gabonensis* included *Penicillium spp*, *Aspergillus flavus*, *Aspergillus niger*, *Fusarium spp*, *Mucor spp*. Their presence in the soil and leaves have implications on nutrient load and growth of *I. gabonensis*.

RECOMMENDATIONS

Foresters, soil scientists and silviculturists are required to carry out soil test to identify nutrient constituents available in the soil and required for seedlings growth and development. In addition, the identification of pathogens in seedlings and soil are essential for disease management in the nursery.

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Heavy Metal Contaminated Soil Remediation Using Selected Woody Tree Species

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Abstract

This study assessed potentials of selected tree species for phytoremediation of heavy metal contaminated soil. The experiment was a 3×5 factorial experiment laid out in Completely Randomized Design. The factors comprised three levels of contamination (control, double permissible level and triple permissible limit) and five tree species (*Gmelina arborea*, *Tectona grandis*, *Terminalia superba*, *Shorea roxborghi* and *Terminalia ivorensis*). Data collected included physico-chemical properties of the soil and metal concentration in the tree species. Data were subjected to Analysis of Variance (ANOVA) and significant means were compared using Duncan Multiple Range Test (DMRT) ($P < 0.05$). Result of the study showed that at 16 months after planting, *S. roxborghi* at the control level significantly ($P < 0.01$) accumulated more Manganese (76.38 mgkg^{-1}) in its stem compared to other species. Also, *T. ivorensis* at triple contamination level had the highest accumulation of Copper (7.65 mgkg^{-1}). *Terminalia ivorensis* significantly accumulated Lead in the leaves (0.006 mgkg^{-1}) at the triple contamination level. *Gmelina arborea* accumulated highest concentrations at the control (7.55 mgkg^{-1}) in the stem compared to other species. Meanwhile, there was no significant difference in Zinc and Cadmium accumulation in the leaves, stem and roots of the tree species. Conclusively, *T. ivorensis*, was found to possess a high metal accumulation potential especially at adverse contamination levels compared to the other tree species.

Keywords: Remediation, heavy metals, accumulation, contamination, species

INTRODUCTION

Part of the essential metabolites useful for plant optimum growth are heavy metals, required in minute amounts. Recently, anthropogenic activities have resulted in an increase in both type and concentration of heavy metals in the soil (Mahmood and Malik, 2014). Discharges of contaminated industrial effluents and atmospheric deposition have been posing a greater threat to ecological integrity of developing countries. Certain heavy metals are toxic even at low concentrations and can affect crop production (Yi *et al.*, 2011). Various physical and chemical remediation methods may be useful in the restoration of polluted soils of limited areas, but are usually very expensive (Sarma, 2011). Most of these methods have adverse effects on the properties of the soils, and render the soil useless for plant growth (Danh *et al.*, 2009). Phytoextraction is an emerging technology that has received significant scientific and commercial attention because of its elegance and the vast extent of contaminated areas they can treat (McGrath and Zhao, 2003). However, few available hyper accumulators are suitable for use (Baker *et al.*, 2000). As an alternative to herbaceous hyper accumulators, fast-growing, metal-accumulating woody plants have been considered as potential candidates for the development of feasible phytoextraction (Puschenreiter *et al.*, 2010). Trees are perennial, long-living plants having a large surface area compared to other groups of plants. Because of their large size and longer persistence, they have unique adaptability and large accumulation potential to environmental xenobiotics. Much to their advantage, trees have large canopy

area and extensive root and shoot systems that allow them to accumulate and store a significant amount of xenobiotics. Compared to other life forms, accumulation potential of tree species for heavy metals is less studied. The objective of this study was therefore to evaluate the heavy metal accumulation potentials selected tree species.

MATERIALS AND METHODS

Study Area and Collection of Plant and Soil Samples

The study was carried out at the screen house of the Sustainable Forest Management (SFM) Department, FRIN, Jericho Hill Ibadan, Oyo State, Nigeria. The institute is located on Longitude 07° 23'18" N to 07° 23'43"N and Latitude 03° 51'20"E to 03° 23'43"E). The climate is West African monsoon which is characterized by wet and dry season (bimodal rainfall distribution). The wet season begins in April and continues through October with the mean annual rainfall of 1548.9 mm, falling in approximately 90 days. The mean maximum temperature is 31.11°C, minimum 22.76°C and the relative humidity is 71.8% (FRIN, 2018). Heavy metals used for the experiment were obtained from the Soil Laboratory, Bioscience Department, FRIN, Ibadan, Oyo State. The heavy metals are lead (Pb), zinc (Zn), copper (Cu), cadmium (Cd) and manganese (Mn). The metals were added to the soil as water soluble salts in aqueous solutions. Thus, Cd was added as Cd (NO₃)₂.4 H₂O, Pb as Pb (CH₃COO)₂.2H₂O, Cu as CuSO₄.5 H₂O, Zn as Zn (NO₃)₂.6H₂O and Mn as MnO₄. Seedlings of *Tectona grandis*, *Gmelina arborea*, *Shorea roxburghii*, *Terminalia ivorensis* and *Terminalia superba* of uniform height (30 cm) were obtained from the Central Nursery of the Department of SFM, FRIN, Ibadan.

Soil Sampling and Physico-Chemical Analysis

Top soil was collected from uncultivated site of the Arboretum at FRIN, Ibadan. The soil sample was air-dried at room temperature and sieved with a 2mm sieve then physical and chemical properties of the soil were determined. The particle size distribution was determined using the hydrometer method (Bouyoucos, 1951). Soil pH was determined using a glass electrode pH meter (Rent Model 720) in distilled water according to Thomas (1996), at 1:2 soil /water ratio. Organic carbon was measured by the wet combustion method (Walkley and Black, 1934). Total Nitrogen concentration was determined by Macro-kjeldahl method (Bremner, 1996). Exchangeable Ca, Mg, K and Na were extracted with neutral normal ammonium acetate buffer according to Helmke and Sparks (1996). Potassium and sodium were determined using Flame Photometer (Gallenkamp Model FH 500) as well as exchangeable calcium and magnesium. Heavy metal contents (Cd, Pb, Cu, Mn and Zn) were determined using Atomic Absorption Spectrophotometer (BUCK SCIENTIFIC MODEL 210 VGP).

Experimental Design and Treatments

Top soil (10 kg) was weighed into 12 cm × 18 cm polythene bags and contaminated with the five heavy metals and left to equilibrate for one week. Then, three months old seedlings, of the selected tree species of equal height, were transplanted into the pots and watered to field capacity. The experiment was a 3 × 5 factorial experiments laid out in Completely Randomized Design. The factors comprised three levels of contamination (control, double permissible level and triple permissible limit) and five tree species (*Gmelina arborea*, *Tectona grandis*, *Terminalia superba*, *Shorea roxborghi* and *Terminalia ivorensis*). The treatments were replicated three times with 8 pots per replicate giving a total of 360 experimental units for each of the soils from the two different locations making a total of 720 units. The levels of contamination were: Level 1= Control, Level 2 = Cd = 0.006 g/kg, Cu = 0.2 g/kg, Pb = 0.4 g/kg, Zn = 0.6 g/kg, Mn = 6 g/kg of heavy metal, Level 3= Cd = 0.009 g/kg, Cu = 0.3g/kg, Pb = 0.6 g/kg, Zn = 0.9 g/kg, Mn = 9 g/kg of heavy metals (WHO 1996).

Statistical Analysis

Data obtained were subjected to analysis of Variance (ANOVA) and significant means were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

RESULTS AND DISCUSSION

The physicochemical properties of soils revealed the textural class as sandy loam (sand: 82.2%, silt: 3.7 and clay: 14.1) (Ditzler *et al.*, 2017) (Table 1). The soil pH was 6.38 which could be classified as slightly acid. The organic carbon and the Total Nitrogen were 1.92 % and 0.17% which were within the critical limits for the soils (Njoku *et al.*, 2009). The exchangeable K and Ca were 0.07 cmol/kg and 4.41 cmol/kg. Magnesium was 0.44 cmol/kg. These are still under the critical limit according to Epstein (1972). Manganese, Iron, Cadmium and Lead were 223 mg/kg, 159.14 mg/kg, 0.62 and 75 mg/kg, respectively, while zinc and copper were 82 mg/kg and 3mg/kg. The available phosphorus was 2.60 mg/kg. This is very low compared to the recommended 20-40 mg/kg (Olsen *et al.*, 1954).

Table 2 showed that there was no significant difference in the accumulation of Manganese in different part of the various species considered at 4 MAT. However, at 8 MAT, there were interaction effect $s(P < 0.05)$ for the roots of *T. superba* with the control having the highest concentration of Mn (4.145 mgkg⁻¹). This was also observed at 8, 12 and 16 MAT. Furthermore at 16 MAT, *S. roxborghi* significantly ($P < 0.01$) accumulated Mn (76.38 mgkg⁻¹) in its stem compared to the other tree species at the control level. This revealed that the increase in concentration of the Manganese, has led to a decline in the accumulation potential of the tree species.

Table 1: Physico-chemical properties of the soil before planting

Properties	FRIN
Sand (%)	82.20
Silt (%)	3.70
Clay (%)	14.10
Texture	Sandy loam
pH	6.38
Organic carbon (%)	1.92
Nitrogen (%)	0.17
Available P (mg/kg)	2.60
Exchangeable K (cmol/kg)	0.07
Ca (cmol/kg)	4.41
Mg (cmol/kg)	0.44
Zn (mg/kg)	82.00
Cu (mg/kg)	3.00
Mn (mg/kg)	223.00
Fe (mg/kg)	159.14
Cd (mg/kg)	0.62
Pb (mg/kg)	75.00

The stem accumulated higher amounts of Mn than the roots and this is in agreement with the assertion of Page and Feller, (2005) who believed Manganese generally tends to accumulate predominantly in the plant shoots than in the roots. Manganese content remarkably varied across plant species, growth stage and different organs and ecosystems. Normally, Manganese content in plants varies from 10 to 100 mg/kg. Hence, below 10 and above 200 mg/kg, Manganese deficiency/toxicity occurs and plant physiological processes are compromised (Zhao *et al.*, 2012). Metal accumulation in plants in most instances, are those capable of having bio concentration levels of the pollutants in their tissues above that of the contaminated media (Erakhrumen, 2014).

Copper is an essential element for plant growth, it occurs in many enzymes of oxidation–reduction reactions (Kabata-Pendias and Pendias, 1993). There was no significant difference in the accumulation of copper in the leaves, stem and roots of the tree species across different levels of contamination at 4, 8 and 12 MAT (Table 3). However, there was an interaction effect between stem and the roots at 16 MAT with *G. arborea* having significantly higher accumulation of Cu (13.14 mgkg^{-1}) at control. There was also a significant difference ($p < 0.05$) in the roots at triple contamination level with the *T. ivorensis* having the highest accumulation of Cu (7.65 mgkg^{-1}). This is an indicative of the fact that *T. ivorensis* has a very high accumulation of Cu high contamination level compared with the other tree species considered. This could be as a result of the ability of the roots to uptake the Cu^{2+} ions which is the bioavailable form of Cu in the soil which is facilitated by reduction reaction. This is in line with Das and Maiti (2007) who conducted a field studies in an abandoned copper mine tailings (Rakha mine, Jharkhand, India), to find out accumulation of metal levels. Copper accumulation in the root parts was found to be more than 1000 mgkg^{-1} dry weight (DW). This suggests an exclusion strategy for metal tolerance in the species. Thus, establishment of this species on heavy metal contaminated soil can be a safe method to stabilize the Cu metal. This also corroborated the assertion that there were differences in heavy metal accumulation and storage in actively growing tissues of plants (Majid *et al.*, 2011). For instance, Majid *et al.*, (2011) reported higher Cu absorption in roots than stems of various plants. In fact, Cu accumulation ability depends on many other factors. For example, Cu accumulation increased with seedling age; and the optimum growth stage of the plants enhanced the maximum Cu uptake on account of a much higher transpiration rate, which enhances metal uptake (Mleczek *et al.*, 2010).

Zinc is an essential element to plants and studies have shown that total zinc concentration in plant tissues increases as zinc supply increases in both tolerant and non-tolerant plants (Murray *et al.*, 2000). Table 4 revealed the there was no significant difference in the accumulation of Zn in the leaves and roots of the tree species. However, there were significant differences ($p < 0.01$) in main effect on the stem at 12 and 16 MAT. *S. roxborghi* at triple contamination at 12 MAT accumulated the highest Zn, while *G. arborea* had the highest Zn accumulation at control level among the different tree species considered at the 16 MAT.

According to Table 5, Cadmium was found to be particularly different in that there was no significant difference in the accumulation of Cd in the leaves, stem and the roots of the different tree species. However, all the species demonstrated a similar response in accumulation of Cd in their stems which was progressive in nature across the contamination levels throughout the period of observation. Cadmium is potentially toxic to plants and animals and has no essential biological function (Nabulo *et al.*, 2011). The uptake and distribution of trace metal especially cadmium varies from species to species, this may be associated with the differences in ability of plants to control the movement of trace metals from xylem to phloem and via the phloem to other parts of the plant (Singh *et al.*, 2011). Studies have shown that increased cadmium application to zinc deficient plant tends to decrease zinc concentration but in plant with adequate zinc supply, zinc concentration were either not affected or increased by cadmium (McBride, 2007).

Lead has a long soil retention time and can stay in the soil for about 150 to 5000 years (Shaw, 1990). Therefore, the probability for this metal to be absorbed is high. It does not naturally occur in the plants and can be very toxic if being consumed in high dose (Tuzen, 2003). Table 6 however showed that the accumulation of Lead was not significant at 4, 8 and 12 MAT. But at 16 MAT, there was a significant difference in accumulation of Pb in the leaves at the contamination ($p < 0.05$) and species ($p < 0.01$) main effects levels, while there was interaction effect ($p < 0.05$) in the Pb accumulated in the stem. *Terminalia. vorensis* significantly accumulated Pb in the leaves (0.006 mgkg^{-1}) at the triple contamination level, while *G. arborea* accumulated highest concentrations at the control level (7.55 mgkg^{-1}) in the stem compared to other species. This is in contrast with findings of Das and Maiti (2007) who stated that accumulated metals were mostly retained in root tissue indicating that an exclusion mechanism for metal tolerance widely existed in them. Retention of some metals at more than toxic levels in the above ground tissues of

some plants suggests the presence of internal metal detoxification and tolerance mechanisms. This also showed that *T. grandis* was a very potent phytoremediation species because it accumulates the metal from the soil in to the plant tissues in accordance with the study conducted by Blaylock et al. (1999) at a lead-contaminated site in Trenton, New Jersey.

CONCLUSION AND RECOMMENDATION

This study showed that *Tectona grandis* demonstrated high potential for accumulation of Mn, Cu and Pb in the stem portion of the plant tissues, while *Terminalia ivorensis* had the highest phytoremediation potential for Cu because of its ability to accumulate this metal especially in the root portion at a very high contamination level. Therefore, both *Tectona grandis* and *Terminalia ivorensis* are recommended as choice species for phytoremediation of heavy metal contaminated soils.

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Table 2. Mean concentration of Manganese (Mn) in Leaf, Stem and Root (mgkg⁻¹)

Treatment	4 MAT			8 MAT			12 MAT			16 MAT		
	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root
Control												
<i>T. grandis</i>	0.051	0.100	0.077	0.088	0.730	0.385	0.072	0.740	1.155	0.252	8.850	2.079
<i>G. arborea</i>	0.035	0.400	0.393	0.070	1.150	1.625	0.205	4.430	2.797	0.242	4.990	5.034
<i>T. superba</i>	0.071	1.000	0.891	0.156	1.160	4.145	0.294	3.730	12.436	0.041	23.800	22.385
<i>S.roxborghi</i>	0.205	0.250	0.190	0.098	2.530	1.193	0.063	6.370	3.580	0.095	76.380	6.444
<i>T. ivorensis</i>	0.048	0.250	0.698	0.006	2.540	3.488	0.030	3.380	10.463	0.468	21.310	18.833
Conta 2												
<i>T. grandis</i>	0.037	0.090	0.310	0.071	0.930	0.369	0.256	1.150	1.106	0.041	0.140	1.991
<i>G. arborea</i>	0.051	0.150	0.770	0.205	1.500	0.420	0.008	1.620	1.260	0.280	0.190	2.268
<i>T. superba</i>	0.008	0.250	0.260	0.048	2.500	0.754	0.056	0.850	2.263	0.070	0.100	4.073
<i>S.roxborghi</i>	0.061	0.020	0.015	0.045	0.190	0.293	0.269	1.920	0.880	0.239	12.950	1.584
<i>T. ivorensis</i>	0.092	0.190	0.193	0.083	1.900	0.905	0.005	1.70	2.715	0.399	10.450	4.887
Conta 3												
<i>T. grandis</i>	0.053	0.320	0.435	0.098	3.200	2.177	0.156	4.340	6.530	0.101	5.400	11.754
<i>G. arborea</i>	0.070	0.110	0.272	0.037	1.140	0.385	0.077	1.170	1.155	0.259	2.680	2.079
<i>T. superba</i>	0.167	0.020	0.025	0.031	0.220	0.197	0.040	2.240	0.590	0.002	2.880	1.062
<i>S.roxborghi</i>	0.073	0.110	0.146	0.006	1.140	0.272	0.253	2.800	0.815	0.140	3.670	1.467
<i>T. ivorensis</i>	0.248	0.400	0.783	0.050	4.030	3.188	0.273	3.720	9.565	0.167	12.450	17.217
F sig. (Conta)	ns	Ns	Ns	ns	Ns	*	Ns	**	*	Ns	**	*
F sig. (Species)	ns	Ns	Ns	ns	Ns	Ns	Ns	**	Ns	Ns	**	ns
F sig.(Interaction)	ns	Ns	**	ns	Ns	*	Ns	Ns	*	Ns	**	*

*= p<0.05, ** = p<0.01, ns = not significant. **Conta 1**= Control, **Conta2** = Cd = 6.0 mg/kg, Cu = 200 mg/kg, Pb = 400 mg/kg, Zn = 600 mg/kg, Mn = 6,000 mg/kg, **Conta 3** = Cd = 9.0 mg/kg, Cu = 300 mg/kg, Pb=600 mg/kg, Zn=900 mg/kg, Mn=9,000 mg/kg

Table 3. Mean concentration of Copper (Cu) in Leaf, Stem and Root (mgkg⁻¹)

Treatment	4 MAT			8 MAT			12 MAT			16 MAT		
	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root
Control												
<i>T. grandis</i>	0.005	0.020	0.015	0.027	0.110	0.076	0.003	1.090	0.226	0.006	13.140	0.406
<i>G. arborea</i>	0.004	0.090	0.101	0.001	0.900	0.503	0.008	1.270	1.510	0.017	0.520	2.718
<i>T. superba</i>	0.002	0.090	0.073	0.003	0.780	0.365	0.299	1.590	1.095	0.006	0.190	1.971
<i>S.roxborghi</i>	0.003	0.010	0.012	0.007	0.120	0.058	0.025	1.240	0.175	0.004	0.150	0.315
<i>T. ivorensis</i>	0.002	0.010	0.014	0.001	0.090	0.072	0.003	0.900	0.215	0.034	7.170	0.387
Conta 2												
<i>T. grandis</i>	0.006	0.240	0.012	0.002	2.370	0.058	0.006	2.760	0.175	0.006	0.330	0.315
<i>G. arborea</i>	0.005	0.010	0.014	0.003	0.110	0.070	0.001	1.130	0.208	0.021	0.140	0.374
<i>T. superba</i>	0.001	0.010	0.014	0.002	0.070	0.070	0.005	0.750	0.210	0.002	0.090	0.378
<i>S.roxborghi</i>	0.001	0.010	0.010	0.001	0.100	0.143	0.023	1.050	0.428	0.018	0.130	0.770
<i>T. ivorensis</i>	0.026	0.010	0.010	0.003	0.080	0.050	0.001	0.840	0.150	0.047	5.150	0.270
Conta 3												
<i>T. grandis</i>	0.040	0.010	0.023	0.001	0.150	0.113	0.003	1.480	0.340	0.004	1.920	0.612
<i>G. arborea</i>	0.002	0.010	0.021	0.003	0.080	0.376	0.032	0.770	1.129	0.019	3.770	2.032
<i>T. superba</i>	0.031	0.010	0.009	0.001	0.100	0.126	1.241	1.000	0.378	0.023	01.000	0.680
<i>S.roxborghi</i>	0.004	0.090	0.043	0.001	0.890	0.328	0.020	1.800	0.985	0.002	2.200	1.773
<i>T. ivorensis</i>	0.021	0.070	0.283	0.008	0.730	1.416	0.023	1.630	4.248	0.031	4.700	7.646
F sig. (Conta)	Ns	Ns	ns	ns	Ns	Ns	ns	ns	*	Ns	ns	*
F sig. (Species)	Ns	Ns	ns	ns	Ns	*	ns	ns	Ns	Ns	**	ns
F sig.(Interaction)	Ns	Ns	**	ns	Ns	Ns	ns	ns	Ns	Ns	*	*

*= p<0.05, ** = p<0.01, ns = not significant. **Conta 1**= Control, **Conta2** = Cd = 6.0 mg/kg, Cu = 200 mg/kg, Pb = 400 mg/kg, Zn = 600 mg/kg, Mn = 6,000 mg/kg, **Conta 3** = Cd = 9.0 mg/kg, Cu = 300 mg/kg, Pb=600 mg/kg, Zn=900 mg/kg, Mn=9,000 mg/kg

Table 4. Mean concentration of Zinc (Zn) in Leaf, Stem and Root (mgkg⁻¹)

Treatment	4 MAT			8 MAT			12 MAT			16 MAT		
	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root
Control												
<i>T. grandis</i>	0.621	0.450	0.357	1.282	1.390	3.565	0.913	1.550	3.365	0.035	18.610	1.143
<i>G. arborea</i>	0.584	0.240	0.380	0.599	2.350	3.803	0.049	2.680	3.087	1.457	3.630	0.031
<i>T. superba</i>	0.649	0.240	0.283	0.640	0.950	2.832	0.962	2.040	0.944	1.249	0.250	0.016
<i>S.roxborghi</i>	0.016	0.160	0.506	0.018	1.590	5.060	0.054	1.720	1.687	0.661	0.210	0.012
<i>T. ivorensis</i>	0.025	0.150	0.579	0.556	1.450	5.791	1.263	1.590	1.930	0.683	11.700	0.013
Conta 2												
<i>T. grandis</i>	0.361	1.000	0.349	0.649	2.080	3.490	0.272	2.320	1.163	1.594	0.280	1.033
<i>G. arborea</i>	2.100	1.410	0.080	0.016	1.630	0.802	1.160	3.170	1.427	1.520	0.380	2.264
<i>T. superba</i>	0.260	0.720	0.593	0.025	1.880	5.930	0.603	2.050	1.977	1.305	0.250	0.343
<i>S.roxborghi</i>	1.152	0.610	0.426	0.359	1.100	4.260	0.681	1.380	1.420	1.403	0.170	0.446
<i>T. ivorensis</i>	1.517	0.520	0.343	0.032	2.070	3.430	0.703	2.890	1.143	1.812	11.330	0.516
Conta 3												
<i>T. grandis</i>	1.847	1.370	3.595	0.260	2.450	35.945	0.683	4.180	11.982	0.630	5.130	0.632
<i>G. arborea</i>	0.661	0.090	0.174	1.150	0.900	1.738	0.044	1.090	0.579	1.257	6.610	0.015
<i>T. superba</i>	1.143	0.360	0.423	0.328	4.340	4.233	0.035	4.200	1.411	0.029	4.890	1.269
<i>S.roxborghi</i>	0.023	0.100	0.348	0.651	1.040	3.475	0.058	4.580	1.158	0.705	5.530	0.010
<i>T. ivorensis</i>	0.381	0.280	0.830	0.033	2.800	8.300	0.286	3.040	2.767	0.013	11.140	0.028
F sig. (Conta)	Ns	Ns	ns	Ns	ns	Ns	ns	**	ns	ns	**	ns
F sig. (Species)	Ns	Ns	ns	Ns	ns	Ns	ns	Ns	ns	ns	ns	ns
F sig.(Interaction)	Ns	Ns	ns	Ns	ns	Ns	ns	Ns	ns	ns	ns	ns

*= p<0.05, ** = p<0.01, ns = not significant. **Conta 1**= Control, **Conta2** = Cd = 6.0 mg/kg, Cu = 200 mg/kg, Pb = 400 mg/kg, Zn = 600 mg/kg, Mn = 6,000 mg/kg, **Conta 3** = Cd = 9.0 mg/kg, Cu = 300 mg/kg, Pb=600 mg/kg, Zn=900 mg/kg, Mn=9,000 mg/kg

Table 5. Mean concentration of Cadmium (Cd) in Leaf, Stem and Root (mgkg⁻¹)

Treatment	4 MAT			8 MAT			12 MAT			16 MAT		
	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root
Control												
<i>T. grandis</i>	0.001	0.100	0.003	0.039	0.730	0.013	0.032	0.740	0.181	0.005	8.850	0.326
<i>G. arborea</i>	0.007	0.400	0.001	0.008	1.150	0.005	0.001	4.430	0.015	0.002	4.990	0.027
<i>T. superba</i>	0.007	1.000	0.001	0.003	1.160	0.005	0.003	3.730	0.016	0.003	23.800	0.028
<i>S.roxborghi</i>	0.007	0.250	0.001	0.001	2.530	0.004	0.003	6.370	0.012	0.006	76.380	0.021
<i>T. ivorensis</i>	0.007	0.250	0.002	0.002	2.540	0.008	0.002	3.380	0.024	0.001	21.310	0.043
Conta 2												
<i>T. grandis</i>	0.007	0.090	0.001	0.006	0.930	0.002	0.004	1.15	0.006	0.003	0.140	0.011
<i>G. arborea</i>	0.007	0.150	0.001	0.001	1.500	0.004	0.002	1.620	0.013	0.020	0.190	0.023
<i>T. superba</i>	0.007	0.250	0.002	0.006	2.500	0.009	0.025	0.850	0.028	0.008	0.100	0.050
<i>S.roxborghi</i>	0.007	0.020	0.001	0.004	0.190	0.002	0.003	1.920	0.006	0.004	12.950	0.011
<i>T. ivorensis</i>	0.007	0.190	0.001	0.001	1.900	0.004	0.008	1.780	0.012	0.028	10.450	0.023
Conta 3												
<i>T. grandis</i>	0.007	0.320	0.001	0.004	3.200	0.005	0.003	4.340	0.016	0.008	5.400	0.028
<i>G. arborea</i>	0.008	0.110	0.001	0.002	1.140	0.007	0.006	1.170	0.021	0.023	2.680	0.038
<i>T. superba</i>	0.000	0.020	0.002	0.008	0.220	0.008	0.010	2.240	0.025	0.155	2.880	0.045
<i>S.roxborghi</i>	0.002	0.110	0.001	0.006	1.140	0.005	0.006	2.800	0.016	0.008	3.670	0.029
<i>T. ivorensis</i>	0.004	0.400	0.002	0.003	4.030	0.008	0.002	3.720	0.025	0.001	12.450	0.045
F sig. (Conta)	**	ns	ns	ns	Ns	Ns	ns	ns	Ns	Ns	ns	ns
F sig. (Species)	**	ns	ns	ns	Ns	Ns	ns	ns	Ns	Ns	ns	ns
F sig.(Interaction)	**	ns	ns	ns	Ns	Ns	ns	ns	Ns	Ns	ns	ns

*= p<0.05, ** = p<0.01, ns = not significant. **Conta 1**= Control, **Conta2** = Cd = 6.0 mg/kg, Cu = 200 mg/kg, Pb = 400 mg/kg, Zn = 600 mg/kg, Mn = 6,000 mg/kg, **Conta 3** = Cd = 9.0 mg/kg, Cu = 300 mg/kg, Pb=600 mg/kg, Zn=900 mg/kg, Mn=9,000 mg/kg

Table 6. Mean concentration of Lead (Pb) in Leaf, Stem and Root (mgkg⁻¹)

Treatment	4 MAT			8 MAT			12 MAT			16 MAT		
	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root
Control												
<i>T. grandis</i>	0.005	0.030	0.023	0.058	0.340	0.116	0.047	0.630	0.348	0.001	7.550	0.626
<i>G. arborea</i>	0.003	0.030	0.026	0.001	0.260	0.130	0.008	0.930	0.391	0.004	2.660	0.703
<i>T. superba</i>	0.003	0.040	0.006	0.005	0.370	0.032	0.091	3.740	0.095	0.001	0.450	0.171
<i>S.roxborghi</i>	0.006	0.050	0.035	0.004	0.480	0.173	0.012	4.860	0.518	0.002	0.580	0.932
<i>T. ivorensis</i>	0.003	0.000	0.011	0.002	0.050	0.053	0.001	0.460	0.158	0.002	4.300	0.284
Conta 2												
<i>T. grandis</i>	0.004	0.010	0.003	0.003	0.020	0.010	0.001	0.240	0.031	0.001	0.030	0.056
<i>G. arborea</i>	0.001	0.020	0.005	0.006	0.040	0.023	0.001	0.370	0.068	0.001	0.050	0.122
<i>T. superba</i>	0.004	0.020	0.007	0.003	0.050	0.034	0.005	0.480	0.103	0.002	0.060	0.185
<i>S.roxborghi</i>	0.003	0.040	0.036	0.001	0.410	0.182	0.002	4.200	0.545	0.003	0.500	0.981
<i>T. ivorensis</i>	0.027	0.010	0.024	0.001	0.090	0.154	0.004	0.920	0.463	0.005	2.470	0.833
Conta 3												
<i>T. grandis</i>	0.008	0.020	0.024	0.004	0.200	0.119	0.005	2.010	0.358	0.003	5.560	0.644
<i>G. arborea</i>	0.002	0.020	0.020	0.002	0.200	0.102	0.058	2.060	0.305	0.003	2.770	0.549
<i>T. superba</i>	0.006	0.020	0.005	0.004	0.170	0.026	0.077	1.700	0.078	0.001	3.250	0.140
<i>S.roxborghi</i>	0.004	0.040	0.032	0.002	0.350	0.159	0.056	3.570	0.478	0.002	5.950	0.860
<i>T. ivorensis</i>	0.001	0.010	0.008	0.006	0.080	0.212	0.001	0.780	0.635	0.006	3.920	1.143
F sig. (Conta)	Ns	Ns	ns	Ns	ns	Ns	ns	Ns	ns	*	**	ns
F sig. (Species)	Ns	Ns	ns	Ns	ns	Ns	ns	*	ns	**	*	ns
F sig.(Interaction)	Ns	Ns	ns	ns	ns	Ns	ns	Ns	ns	ns	*	ns

*= p<0.05, ** = p<0.01, ns = not significant. **Conta 1**= Control, **Conta2** = Cd = 6.0 mg/kg, Cu = 200 mg/kg, Pb = 400 mg/kg, Zn = 600 mg/kg, Mn = 6,000 mg/kg, **Conta 3** = Cd = 9.0 mg/kg, Cu = 300 mg/kg, Pb=600 mg/kg, Zn=900 mg/kg, Mn=9,000 mg/kg

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Selected Non-Timber Forest Products as Source of Livelihood for Rural Households in Communities in Omo Forest Reserve, Ogun State

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Abstract

Forest products provide sources of livelihood for rural households because of their proximity to natural resources. It has been a valuable contribution to the economy of developing world, especially Nigeria. This study was conducted in rural communities around Omo forest reserve. Primary data was obtained through structured questionnaire and oral interviews. Fifteen villages were randomly selected, base on proximity to the forest reserve and household heads were randomly selected proportionate to population found in the villages. Out of the 300 questionnaire administered, 276 were valid and used for the analysis. Descriptive statistics tools such as mean, median, frequency and percentage were used to analyse the data. The study revealed that most of the household heads were male (92.8%), and 87.3% were married. The mean age of the household heads 45.65 ± 11.55 years and the average number of years in school of household head was 8.08 ± 4.5 year. Average year of residence in the area was 18.92 ± 14.64 years. Farming was the major occupation of the household heads (51.6%). Also 36% of the respondents earned between ₦21000 - ₦40000 from fuel wood, 32.8% earned ₦40000 while 31.2% earned ₦1000-₦20000, annually. Most (97.2%) of the respondents engaged in mushroom and snail picking, herb collection and other enterprise, and earned income because of easy accessibility. This study concludes that revenue generated from selected products contribute to household income and source of livelihoods. It is therefore recommended that these selected forest products be domesticated so that the forest resources will not be endangered.

Keywords: Forest products, livelihood, rural households

INTRODUCTION

The role of forest products in the rural communities and the economy vary from one geographical location to another depending on the economic and cultural contexts. In the developed countries, for instance, forest products are usually used for cultural and recreational purposes, biodiversity conservation, and rural economic development (Yakubu *et al.*, 2018). In the developing countries, especially in Africa and Asia, they are mostly utilized for subsistence and income generation (Endamana *et al.*, 2016). Forests provides products for different uses at household and industrial levels (Appiah, 2009). In many parts of Nigeria, forest products account for substantial shares of cash and subsistence incomes (Duchelle *et al.*, 2014; Hajjar *et al.*, 2021). At the rural household level, forests are a source of various products ranging from fuel, food, fodder, construction materials, medicine, wild spinaches, charcoal, wooden utensils, thatching material, bark, roots, tubers, leaves, flowers, seeds, resins, honey, and mushrooms (Angelsen *et al.*, 2011; Onuche, 2011). They have demonstrated to economically disadvantaged households that they can satisfy everyday necessities such as energy, shelter, medicine, cash incomes, and employment. Access to forest resources helps rural households to diversify their daily needs. Millions of people generate parts of their income from selling forest products. Forest provides sources of varieties of food that supplement and complement what is obtained from agriculture (Yakubu *et al.*, 2018). In the recent decades, there have been growing interest in the contribution of forest products to livelihoods, development and poverty

alleviation among the rural populace. This has been prompted by the fact that communities living adjacent to the forest reserves rely to a great extent on the forest products for their livelihoods, and therefore any effort to conserve such resources should as a prerequisite understand how the host communities interact with them. Especially in the case of natural forest, resources are most accessible sources of services, products and incomes for many adjacent rural communities. Globally, it is estimated that more than 350 million people around the world depend on forests for their livelihoods (Mulenga *et al.*, 2015). The majority of these are rural people who live within or adjacent to dense forests on which they depend for their subsistence and income (Ojea *et al.*, 2016). According to Carney (1998) and Ellis (2000), the definition of livelihood is the capabilities, assets (natural, physical, human, financial, and social), and activities essential for a means of living and considered to be sustainable. It can serve and recover from stress and shocks and maintain or boost its capabilities and assets both now and in the future, while not undermining the natural resources base. A livelihood also include having access to and reaping the reward of state-provided social and public services including those in the areas of education, health, transportation, and water (Babulo *et al.*, 2008). In addition, Zaku *et al.* (2013) reported that over 70% of the Nigerian households depend directly on fuelwood as their main source of energy, with daily consumption estimated at 27.5 million kg/day. Thus, harvesting and processing of forest products in many areas in the country has shifted from subsistence exploitation and sales at the local markets to international cross-boundary trade. For example, in the high forest zone of Eastern and Western Nigeria, harvesting of game meat and snails for sales are now major income generating activities almost all year round (Onuche, 2011; Jimoh *et al.*, 2013).

MATERIALS AND METHODS

Study Area

Omo Biosphere Reserve, which derives its name from River Omo, is located north of Sunmoge and lies between latitudes 6° 35' to 7° 05' N and longitude 4° 19' to 4° 40' E in the Ijebu area of Ogun State, southwestern Nigeria (Figure 1). The reserve was constituted in 1925 as part of a larger Shasha forest reserve. Shasha was later split into Omo, Oluwa and Shasha forest reserves, the last two lying to the east and northeast of the present Omo. To the north and north-west of the reserve are Ife and Ago-Owu, and Oshun forest reserves, respectively. Omo covers about 130, 500 hectares, which includes a 460 ha Strict Nature Reserve (Okali and Ola-Adams, 1987), plus about 6 500 ha of enclaves and cut out areas with a total of about 20,000 inhabitants. It is roughly triangular in shape, and tapers southwards with its southernmost tip about 20 km from the Atlantic coast. River Oni forms its eastern boundary while the western boundary at the southern tip is, for about the first 50 km, formed by river Omo, before the Reserve broadens out such that river Omo is centrally located for the rest of the length of the Reserve.

Sampling Procedure

Primary data was used for this research work through structured questionnaire and oral interview. Fifteen villages were randomly selected base on proximity and nearness to the forest reserve. The random selection of household heads was proportionate to population found in the villages. Out of the 300 questionnaire administered, 276 were valid and used for the analysis.

Data Analysis

Descriptive statistics tools were such as mean, median, frequency and percentages were used for analyzing the data.

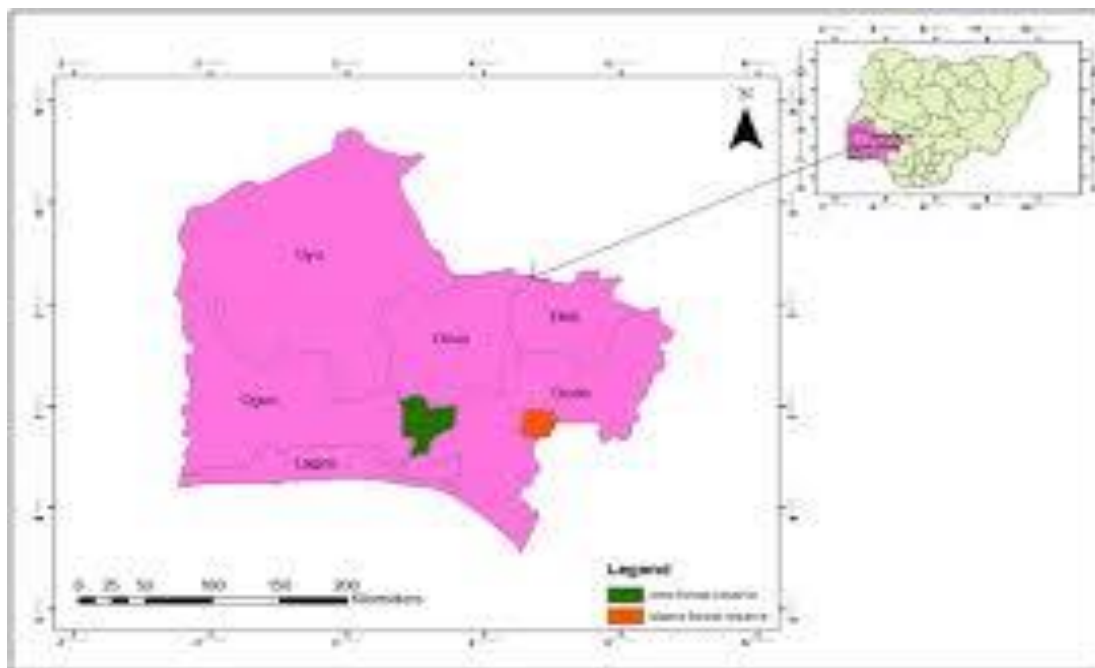


Figure 1: Map showing the location of Omo forest reserve (inset: Map of Nigeria)

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Study Area

The gender distribution revealed that male headed households were higher than female headed households. The male headed households constituted 92.8% while female headed household were 7.2% (Table 1). This is in line with Fonta *et al.* (2010) who reported that male household heads (86%) were more than females (14%) in Omo enclaves. This signifies a typical Nigeria rural area setting especially in southwestern region where men are predominantly farmers. Majority of the household heads were married (87.3%), 8.3% were single, 3.3% were widowed and 1.1% were divorced (Table 1.). This is in agreement with Bwalya (2011) who reported that 77% were married, while 23% were singled, widowed and divorced in rural Zambia. The age of household heads is expected to capture the extent to which household labour allocation changes over the life-cycle of the head of the household (Adhikari, 2010). The mean of the household head age was 45.65 ± 11.55 years and the median was 45 years. Hence, household heads were in the economically active age and could perform forest activities. Yakubu *et al.* (2018) mentioned that the average household head was 46.6 year in Bale forest area in Ethiopia. The average number of years in school of household head was 8.08 ± 4.5 years. This implies that majority of the household heads had higher education. Fonta *et al.* (2010) found similar results in River state, Nigeria. About 46.6% had household size between 1 and 5, 40.1% had between 6 and 10 household members while 13.4% had 11 and above household size. The mean household size of 2.5 was lower than 6.2 reported by Nwera (2014). The average year of residence in the area was 18.92 ± 14.64 years which was in line with Bwalya (2013). About 70.3% of the household heads (Table 2) had no access to formal credit facility while 53.7% were involved in informal ways of sourcing credit such as daily, fortnightly or monthly contribution. The major occupation was farming (51.6%), with households specializing in planting cocoa, kolanut, yam, cassava, palm trees, bitter kola, plantain and bananas.

Table 1. Socioeconomic characteristics of the household heads

Variable	Percentage	Frequency	Mean	Median
Sex				
Female	20	7.2		
Male	256	92.8		
Total	276	100.0		
Marital Status				
Married	241	87.3		
Singled	23	8.3		
Widow	9	3.3		
Divorced	3	1.1		
Total	276	100.0		
Age in Year			45.65±11.55	45
20-30	28	10.1		
31-40	63	22.8		
41-50	106	38.5		
51-60	44	15.9		
60 and above	35	12.7		
Total	276	100.0		
Education status			8+-4.5	8
No School	47	17.0		
Primary	82	29.7		
Secondary	108	39.2		
Tertiary	36	13.0		
Others	3	1.1		
Total	276	100.0		
Household size			2.5±1.0	3
1-5	129	46.6		
6-10	111	40.1		
11 and above	37	13.4		
Total	277	100.0		
Family Type				
NO	58	21.0		
YES	218	79.0		
Total	276	100.0		
Settlement years			18.92±16.64	15
1-10	63	22.7		
11-20	103	37.2		
21 and above	111	40.1		
Total	277	100.0		

Source: Field Survey, 2020

About 21.9% of forest dwellers went into extracting forest resources as their primary occupation, 6.7% were artisan, 6.0% were only wage/salary earners, while 9.2% were traders. A large number of people took forest activities as their secondary occupation (48.5%). This confirms the fact that forest resources serve as economic safety nets, during periods of economic hardship, drought, seasonal food shortfalls, and off farming seasons (Kabubo-Mariara and Gachoki, 2008; Nwera, 2014). About 21.7% practice agriculture as their secondary occupation, 17.39% were into trading of agricultural products and non-agricultural house needs, while artisanal activity (10.8%) and wage/salary (2.8%) were very few (Table 2.)

Table 2. Socioeconomic characteristics of the household heads

Variables	Percentage	Frequency
Formal Credit Accessibility		
NO	194	70.3
YES	82	29.7
Total	276	100.0
Informal Credit		
NO	148	53.7
YES	128	46.4
Total	276	100.0
Primary Occupation		
Farming	134	51.6
Forest Extract	84	21.9
Artisan	16	6.7
Wage/Salary	14	6.0
Trading	28	9.2
Total	276	100.0

Source: Field Survey, 2020

Distribution of Income from Selected Forest Products

All the respondents were involved in fuel wood trading (Table 3). Some (36%) of the respondents earned annually, between ₦21000-₦40000 from the sale of fuel wood, 32.8% earned above ₦40000, while 31.2% earned between ₦1000-₦20000. The income is added to the household livelihood and they also use fuel energy for their daily needs (Odeyale and Olawuyi, 2018). Most (64.12%) of the respondents were not involved in charcoal production. This is an indication that the forest reserve is not encroached and abused for such activity. Most (92.6%) of the respondents did not have any income from honey production. Also, since the reserve is protected and not disturbed, there are favourable conditions for mushrooms to grow. As a result of this, most (97.2%) of the respondents engaged in mushroom enterprise because of easy accessibility. They made between ₦100-₦10000, while 2.7% realized between ₦11000-₦20000 but 0.7% earned above ₦21000. Hunting is prohibited in the forest reserve, so most (72.8%) of the respondents earned just between ₦1000- ₦10000 from bush meat (Table 3). The income for households depend on the quality and quantity of the forest game and market location (Dokken and Angelsen, 2015). The income realized from forest fruits ranged ₦5000-₦10000 for 87.3% of the households, ₦11000-₦20000 for about 7.4 % and about 5.44% earned ₦21000 and above from picking forest fruits. This corroborates Mulenga, *et al.* (2015) who stated that cash income generated from selling forest fruits and other non-edible forest products form a huge part of livelihoods. The study discovered that respondents made as little as ₦100-₦10000 income from forest products such as leaves and herbs collected in the reserve area. These served as alternative incomes and sources of livelihoods (Sunderlin *et al.*, 2005; Jumbe *et al.*, 2008).

Table 3. Income derived from selected forest products by household heads

Products income (₦)	Frequency	Percentage	Product Income(₦)	Frequency	Percentage
Fuel wood			Bushmeat		
1000-20000	86	31.2	1000-10000	200	72.8
21000-40000	99	36.0	11000-20000	25	9.0
41000 and above	91	32.8	21000-30000	22	7.9
Total	276	100.0	31000-40000	10	3.5
			41000 above	19	6.7
			Total	276	100.0
Charcoal			Leaves		
None	263	64.12	500-10000	241	87.5
1000-10000	2	5.52	11000-20000	17	6.0
11000-20000	2	5.52	21000-30000	10	3.5
21000-30000	2	5.52	31000 above	8.0	3.0
31000-40000	2	5.52	Total	276	100.0
41000 and above	5	13.8			
Total	276	100	Fruits		
Honey			500-10000	241	87.3
None	256	92.6	11000-20000	20	7.4
Less 20000	11	4.0	21000-30000	7	2.6
21000 -40000	2	0.8	31000 above	8	2.8
41000 and above	7	2.6	Total	276	100.0
Total	276	100.0			
Mushroom			Herbs and medicine		
100-10000	269	97.2	100-10000	395	93.1
11000-20000	5	2.1	11000-20000	19	4.5
21000 and above	2	0.7	21000-30000	5	1.2
Total	276	100.0	31000 above	5	1.2
			Total	430	100.0
Snail					
100-10000	234	85.1			
11000-20000	17	6.3			
21000-30000	4	1.6			
31000-40000	6	2.3			
41000 and above	13	4.7			
Total	276	100.0			

CONCLUSION AND RECOMMENDATION

This study concludes that revenue generated from products contribute to household income. This findings showed that forests play a key role in maintaining and/or creating sources of livelihoods. It is therefore recommended that these selected forest products be domesticated so that the forest resources will not be endangered. Capacity building of farmers through trainings could increase their abilities to add value to the forest products.

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Effects of Ginger as Feed Addictive on the Microflora of African Giant Land Snail (*Archachatina marginata*)



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Abstract

Microbial diversity and inhibition of microflora in the various parts of African giant land snail (*A. marginata*) fed with different concentrations of ginger was investigated. The snail was dissected and the various parts; head, gut, foot, shell and fluid were used for the analysis of microbial diversity. Results revealed that feed additive such as ginger showed significant effect ($P < 0.05$) on microbial load on the various parts of the snail. It also revealed that the highest bacterial count of $82 \times 10^3 \text{cfu/g}$ was recorded from the gut of the control (i.e the snail that were not fed with ginger), while the lowest count of $6 \times 10^3 \text{cfu/g}$ was recorded in the shell of snail fed with 1.0g of ginger. The *Escherichia coli* count which indicates human faecal contamination was highest ($115 \times 10^3 \text{cfu/g}$) in the gut of the control snail, while the lowest count of $4 \times 10^3 \text{cfu/g}$ was recorded on the shell of the snail at 0.5 and 1.0g of ginger. The head region also recorded a considerably high number of fungal counts. Despite the feeding of the snail with ginger, some microorganism were isolated from various parts of the snail, such as *Proteus vulgaris*, *Enterobacter* spp, *Serratia marcescens*, *Klebsiella mobilis*, *Citrobacter* spp, *Salmonella* spp and *Escherichia coli* were the bacteria strains while *Saccharomycetes* spp, *Rhizopus stolonifer*, *Candida* spp, *Aspergillus flavus*, *Penicillium chrysogenum* and *Mucor* spp were fungi strains isolated. It was concluded that ginger as a feed additive will affect the diversity of microflora found on African Giant land Snail.

Keywords: Ginger, Feed additive, Microflora, Land snail and Diversity

INTRODUCTION

Snails are invertebrates, shell bearing animal belonging to the phylum Mollusca and class Gastropods. Habitually, they preferred very cool environment (Imran *et al.*, 2009). In southern Nigeria, where consumption of snails is very popular, *Archachatina marginata* is mostly common. These breeds (*Archachatina marginata*, *Archatina archatina*, *Limnocolaria* spp) vary in their adaptability to environment, size at day old, size at maturity, egg size and growth rate. Snail meat is high in protein, low in fat and a source of iron (Osawuyi, 1989). It constitutes an important component of the food of numerous rural dwellers, especially in the rainforest belt as well as other areas of the country where snail eating is not a taboo. Snails are predominantly vegetarians and can utilise a number of feeds for growth. In captivity, leaf and fruit of plants form a major constituent of snail rations and various species of natural feed stuffs have been utilized by various workers. (Ademolu *et al.*, 2004) have utilized pawpaw fruit, waterleaf and banana fruit while (Hamzat *et al.*, 2002) has used Kola-nut testa to feed snails. The success of any captive snail rearing programme however, depend on the availability and abundance of natural feed stuff. Most of the plants being eaten by snails are seasonal and also have multiple uses. Some of these plants harbour microorganisms. Thereby, allowing the snails to carry these microorganisms. However, efforts should therefore be geared towards sourcing for the effect of

these microorganisms or microflora on the body of the snails. The indigenous microflora of snail has previously been studied for many purposes. This include description of microbial spoilage (Joseph *et al.*, 1988) relationship between environment and snail microflora, the monitoring of changes in snail farms, the nutritional role of the intestinal flora (Moriarty, 1990) and the antibiotic resistance profile of the indigenous flora (Spanggard *et al.*, 1993). However, during the past years, the microflora of reared snail has also been studied with the purpose of finding disease – preventive bacterial strains (known as probiotics). It is generally recognized that the intestinal flora of endothermic animal serve both as a digestive function and protection barrier against disease (Sissons, 1989). The intestinal flora of snail has consequently received most attention by several authors, although the significance of the intestinal microflora with regard to disease protection still remains uncertain. Assuming that the non-pathogenic microflora has a disease preventing effect, the protection is likely to be mediated by microorganisms that are present in high number and characteristics of the dominant microflora are therefore a crucial part in probiotic snail research.

This study was carried out to determine the effect of different concentrations of ginger as feed additive on microbial diversity and load of the various parts of African giant land snail *Archachatina marginata*.

MATERIALS AND METHODS

Study Area

The study was carried out in the Snailery farm of the Department of Environmental Biology and Fisheries, Adekunle Ajasin University Akungba-Akoko, Ondo State, Nigeria premises.

Experimental Design

Twelve (12) plastic baskets each of 43x22x22cm was used for the experiment. The plastics were perforated and they were filled with sterilised humus soil. The baskets were filled to depth of 5cm with their bottom covered with sac and the humus soil was spread on the sac. A total of one hundred and fifty (150) growing snails *Archachatina marginata* were cultured under a humid condition. Each of snails were cultured under three different treatments of ginger concentrations and one control.

Table 1. Snail Feed Formulation with different concentration of ginger

Ingredient	Control (g)	Treatment 1 (g)	Treatment 2(g)	Treatment 3(g)
Fish meal	18.0	18.0	18.0	18.0
Groundnut cake	11.0	11.0	11.0	11.0
Yellow maize	42.5	42.5	42.5	42.5
Brewer's dry waste	10.0	10.0	10.0	10.0
Oyster shell	10.0	10.0	10.0	10.0
Red palm oil	5.0	5.0	5.0	5.0
Vitamin premix	3.0	3.0	3.0	3.0
Ginger	0.0	0.25	0.50	1.0

Sample Collection

A total of eight (8) snails were collected from the different treatments and control for microbial analysis at the Department of Microbiology Laboratory. Each of the snails was taken to the laboratory in a sterile plastic container.

Sterilisation of plates

All glass wares used were sterilised in the oven for 170°C for 2hours and subsequently allowed to cool before using. All media used were sterilised at 121°C for 15 minutes

Dissection of Gut of Snail after feeding experiments

The snails were dissected under aseptic conditions at room temperature of about 25-27°C in the laboratory. The entire gut from stomach to anus was removed and each gut was stripped out with sterile forceps into 69ml of sterile distilled bottles. The head, fluid, foot and the shell were also collected using sterile swap stick.

Preparation of the culture medium

Different culture media were used for isolation of different bacteria. Eosin Methylene Blue (EMB) was used to isolate *Escherichia coli*, Plate Count Agar (PCA) was used to isolate bacteria generally and Nutrient Agar (N.A) was used for stock culture preparation, while Sabouraud Dextrose Agar (SDA) was used to isolate fungi generally and also used for the slant preparation. The media were then autoclaved at 121°C for 15 minutes and allowed to cool before use. Each sample in 9ml of sterile distilled water was carried out by using pour plate method of isolation (Harrigan and MacLance, 1976). 1ml of the sample was pipetted and serially diluted to obtain a 10^{-1} dilution, serial dilution up to 10^{-6} was carried out. A drop equivalent to 0.01ml each of 10^{-6} dilutions of the various samples was pipetted into Petri dishes. The Plate Count Agar (PCA), Eosin Methylene Blue (EMB) Agar, Sabouraud Dextrose Agar (SDA) media were sterilized at 121°C for 15 minutes and allowed to cooled for about 45°C, were poured aseptically into sterile Petri dishes containing the samples. The PCA and EMB were then incubated at a temperature of 35°C for 24 to 48 hours while SDA were incubated at room temperature for 48-72 hours. After incubation, the colonies of each plate were counted and then sub-cultured to get pure cultures. The stock culture was kept in the refrigerator of 40°C pending further use.

Characterization and Identification of Isolates.

Microscopic observation, physiological and biochemical test and morphological characteristics of isolate were carried out.

Gram's Staining Techniques.

The staining of pure isolates was carried out by preparing a thin smear from an 18-24 hours old culture of each isolate on a clean glass slide. This was air-dried and then heat fixed by flaming the slide. The smear was flooded with crystal violet solution for 1-2 minutes and the solution was then pour off and the slide was then rinsed off with grams iodine solution and allowed to react for 1 minute and the iodine was pour off and the slide was washed with 95% alcohol until no more violet colour runs from the slide. This will last only between 5-15 seconds if a well thin smear is prepared. The slide was rinsed under gentle-running tap water after which the slide was then counter stained with Safranin reagent for 1-2 minutes, the slide was rinsed with tap water and blot dried using filter paper.

Catalase Test

In other way, this is used to determine whether the bacteria produce the enzyme catalase, which breaks down hydrogen peroxide to free oxygen and water. A glass rod was used to remove a good growth of a test organism and immerse in a freshly prepared 3% hydrogen peroxide solution.

Indole Test

This test was carried out to demonstrate the ability of certain bacteria to decompose the amino acid (tryptophan) to indole, which accumulates the medium. This test is also important in the identification of *Enterobacteria*. Most strain of *E. coli*, *Pseudomonas vulgaris*, *Pseudomonas rettgori*, *M. moryanii* and *Pseudomonas species* break down the amino acid tryptophan with the release of indole. About 5-6 drops of Kovac's reagent were added to the culture of isolates, which has been inoculated into peptone water and incubated for 48 hours at 37°C a red ring or

rose pink coloration develop at the tip layer which indicates a positive result of indole production while no colour change indicates a negative reaction.

Starch Hydrolysis

This test was used for the detection of those organisms that are capable of hydrolysing starch. Prepared nutrient agar was added to 1g soluble starch, 10ml of molten starch agar at 48°C was poured into a sterile Petri dish and allowed to cool and gel. The surfaces of the plate were streaked with the test organisms. The plates were incubated at optimum temperature for 3 days. After which plates were flooded with some quantity of gram's iodine solution. Hydrolysed starch formed a clear zone around the cultured cell, while the other parts of the plate medium that is unhydrolysed turns blue black of starch iodine complex reaction. The entire surface of negative culture turns blue black.

Casein Hydrolysis Test

This was prepared by weighing 2.8g of nutrient agar and 10g of skimmed milk in a conical flask. 100ml of distilled water was added. The mixture was homogenized and sterilized at 121°C for 15minutes. After sterilization, the media was poured into already sterilized plates, 10ml each. The plates were allowed to set and the organism were streaked once across the surface of the plates. Inoculated plates were incubated at optimum temperature for 5-7 days. After incubation, the plates were flooded with the test reagent (Mercury chloride solution). Clear zones on the plates indicated the hydrolysis of casein, while unhydrolysed casein formed opaque precipitation on the plates.

Carbohydrate Test (Sugar Fermentation)

One percent of fermentation sugars used for the carbohydrate test include glucose, maltose, lactose, mannitol and sucrose. They were constituted into the basal medium to test for the ability of the organisms to ferment them. The basal mediums that constitute peptone with phenol red indicator were prepared with nutrient broth. The mixture was agitated to dissolve. The preparation was then decanted into different test tubes with Durham tubes inverted inside each test tubes. The test tubes were covered with cotton wool and aluminium foil and were sterilized by autoclaving at 121°C for 15minutes. The test tubes were then inoculated by using sterile inoculating wire loop. The test tubes were incubated for 7 days. Change in colour from red to yellow indicated the production of acid while production of gas was detected with displacement of Durham tubes which is an evidence of positive reaction. Negative results do not bring about any change.

Motility Test

This was done to determine the motility of the isolates. The organism were grown in Mann Rogosa Sharpe (MRS) broth for 24 hours at 37°C. After incubation, a few drops of both organism and broth were put on a dry glass slide and covered with cover slip. This was examined under x100 (oil immersion) lens of the microscope.

Statistical Analysis

The result obtained were analysed using one-way analysis of variance (ANOVA). Duncan multiple range test (Steel and Torries, 1980) was also used to separate significant difference among means.

RESULTS AND DISCUSSION

Table 2 shows microbial load in the head, foot, fluid, gut and shell of Africa giant land snail (*Archachatina marginata*) fed with different concentrations of ginger. It shows that the highest bacterial count of 82×10^3 cfu/g was recorded from the gut of the control (i.e the snail that were not fed with ginger), while the lowest count of 6×10^3 cfu/g was recorded in the shell of snails fed with 1.0g of Ginger. Among the treatments, 0.25g of ginger had the highest bacterial

load in the gut of the giant land snail, while the lowest count was in the shell when 1.0g of ginger was fed to the snails. At 0.25g, 0.50g and 1.0g of ginger, the gut of the snail recorded the highest bacterial load of 70×10^3 cfu/g, 45×10^3 cfu/g and 23×10^3 cfu/g respectively. The total bacterial count in the head decreases from control to treatment (CTRL>T1>T2>T3), while the count in the body fluid decreased from T1>T2>T3>CTRL, the foot had this trend T1>T2>T3>CTRL, gut had CTRL>T1>T2>T3 and the shell CTRL>T1>T2>T3.

The count (E.C.C) which indicates human faecal contamination was highest (115×10^3 cfu/g) in the gut of the control snail, while the lowest count of 4×10^3 cfu/g was recorded on the shell of the snail at 0.5 and 1.0g of ginger fed to the snails. Across all treatments, the highest *E. coli* count was recorded in the gut, with values of 115×10^3 , 100×10^3 , 35×10^3 and 15×10^3 cfu/g respectively for the control, T1, T2 and T3 respectively. For the head, the *E. coli* count increased from CTRL>T1>T2>T3, while the body fluid decreased from T2>T1>CTRL>T3, the foot had this trend CTRL>T1>T2>T3, the gut followed with CTRL>T1>T2>T3 and shell T1>CTRL>T2>T3.

The fungal count on the various parts of the giant land snail fed with ginger showed that the shell of the control snail had the highest fungal count of 48×10^3 cfu/g while the lowest count of 3×10^3 cfu/g was in the gut. The head region also recorded a considerably high number of fungal count.

Table 3 shows the characterisation and identification of fungal isolates. The fungi isolated were; *Rhizopus stolonifer*, *Fusarium spp*, *Aspergillus flavus*, *Penicilium chrysogenum*, *Candida spp*, *Aspergillus fumigatus*, *Sacchromyces spp* and *Mucor spp* Biochemical characteristics of bacterial isolates from *Archachatina marginata* (Table 4). The bacterial isolated were, *Proteus vulgaris*, *Enterobacter spp*, *Serratia marcescens*, *Klebsiella mobilis*, *Micrococci varians*, *Citrobacter spp*, *Salmonella spp* and *Escherichia coli*.

Table 2. Microbial Load of African Giant Land Snail (*A. marginata*) fed with different Concentrations of Ginger

Total Bacterial Count (x10 ³ cfu/g)				<i>E. coli</i> Count (x10 ³ cfu/g)				Total Fungal Count (x10 ³ cfu/g)				KEYS- <i>T-Treatments</i> <i>CTRL-Control</i>	
Parts	T1	T2	T3	CTRL	T1	T2	T3	CTRL	T1	T 2	T 3		CTR
	(0.25g)	(0.50g)	(1.0g)		(0.25g)	(0.50g)	(1.0g)		(0.25g)	(0.50g)	(1.0g)		L
Head	47	23	19	55	9	6	5	25	31	43	40	34	
Fluid	60	41	15	8.0	20	23	11	15	20	6	11	12	
Foot	69	43	22	13	35	20	7	37	22	6	6	12	
Gut	70	45	23	82	100	35	15	115	13	13	3	20	
Shell	31	11	6	41	10	4	4	5	42	35	6	48	

Table 3. Characterisation and identification of Fungal Isolates from *A. marginata*

S/N	Source	Cultural Characteristics	Spore And Conidia Arrangement Under Microscope	Probable Fungi Isolates
1	Shell	White cotton-like mycelium with black base	Spore have well developed columela, spore are of different shapes	<i>Fusarium spp</i>
2	Shell	White cotton-like mycelium with black base	Spores have well developed columella spore of different shapes	<i>Fusarium spp</i>
3	Head	White cotton-like mycelium with black base	Spores have well developed columella spore of different shapes	<i>Fusarium spp</i>
4	Head	Black	Conidia heads are black and phialides are borne on metula conidiospore are very long	<i>Mucor spp</i>
5	Gut	White base with black colour in appearance	Conidia head radiates. Surface containing many flask shape phialides and chains of conidia. Non septate and no columela	<i>Saccharomycetes spp</i>
6	Gut	Green mould growth	Septate mycelium bearing single conidiospores which are branched near the cipex	<i>Penicillium chrysogenum</i>
7	Gut	White cotton-like mycelium	Conidia are rough and the conidiospores have large glubose vesicle and phailides are narrow	<i>Rhizopus stolonifer</i>
8	Gut	White base with brown colour	Brown conidiospore which make organism appear brown in colour. An upright conidiospore are one celled. Non septate	<i>Aspergillus fumigatus</i>
9	Foot	White base with black colour in appearance	Conidia head radiate surface containing many flask shape phialides and chains of conidia. Non septate and no columella	<i>Aspergillus flavus</i>
10	Foot	Green mould growth	Septate mycelium bearing single conidiospores which are branched near the cipex	<i>Penicillium chrysogenum</i>
11	Foot	Greenish spore	Mycelium are not extensive, conidia, forming short chains by budding which are produced on mycelium laterally	<i>Candida spp</i>
12	Fluid	White base with brown colour	An upright conidiospore are one called and vesicle glucose. Non septate	<i>Aspergillus fumigatus</i>
13	Fluid	White base with black colour in appearance	Conidia head radiates. Surface containing many flask shape phailides and chains of conidia. Non septate and no columella	<i>Aspergillus flavus</i>

Table 4. Biochemical Characteristics of Bacteria isolates

S/N	Source	Gram Rxn	Catalase	Coagulase	Indole	Ornithine	Casein	Starch hydrolyses	Motility	Glucose	Fructose	Manitol	lactose	Maltose	Probable bacterium
1	SH	-	+	-	-	-	-	+	+	AG	AG	AG	A	AG	<i>Serratia marcescens</i>
2	SH	-	+	+	-	+	+	+	+	AG	AG	A	A	AG	<i>Proteus vulgaris</i>
3	HD	+	+	-	+	-	+	+	-	AG	AG	AG	AG	AG	<i>Micrococci varians</i>
4	HD	-	-	-	+	-	+	+	+	AG	AG	A	AG	A	<i>Klebsiella mobilis</i>
5	GT	-	+	+	-	-	+	+	+	AG	AG	A	A	AG	<i>Proteus vulgaris</i>
6	GT	-	+	-	-	+	+	-	+	AG	AG	AG	AG	AG	<i>Escherichia coli</i>
7	GT	-	+	+	+	+	+	+	+	AG	AG	A	A	AG	<i>Proteus vulgaris</i>
8	GT	-	+	-	-	-	-	+	+	AG	AG	AG	AG	AG	<i>Salmonella spp</i>
9	FT	-	+	-	-	+	-	+	+	AG	AG	AG	A	AG	<i>Citrobacter spp</i>
10	FT	-	+	+	+	-	-	+	+	AG	AG	A	A	AG	<i>Proteus vulgaris</i>
11	FT	-	+	+	+	+	+	+	+	AG	AG	A	A	AG	<i>Enterobacter spp</i>
12	FD	-	+	-	+	-	+	-	-	A	A	A	AG	A	<i>Klebsiella mobilis</i>
13	FD	-	-	-	+	-	+	-	+	AG	AG	A	AG	A	<i>Klebsiella mobilis</i>

KEYS-

+ - Positive SH- Shell, HD- Head, GT- Gut, FT- Foot, FD- Fluid
 -- Negative
 AG Acid and Gas Production A Acid

DISCUSSION

Bacteria were found in the environment in which snail live and it is therefore rather impossible to avoid them being a component of their diet (Harnsen *et al*, 1992). Osungemiro (2005) observed that quantitatively the microbial flora in snail appears to be a function of the environment. The lowest bacterial count of 6×10^3 cfu/g on the shell of the giant land snail may be as a result of the fact that the shell is made up of calcareous (CaCO_3) materials that may not support the proliferation of bacteria. The highest bacterial load recorded in the gut of the giant land snail is consistent with the earlier work of Mondal *et al.*, 2008. Also, since snails feed on grasses, leaves, vegetables, fruits, soil among others (Ademolu *et al.*, 2004). These materials are very close to the soil hence the preponderance or huge bacterial count in their gut. The highest bacterial load in the gut of the control snails compare to the treatment may suggest that ginger has antimicrobial properties that hindered the growth of the bacteria on the snails after consuming it. The reduction in the bacteria load on the head, fluid, foot, gut and shell of the snail with increase in ginger concentration may suggest that ginger has antimicrobial property which eventually got to all parts of the snail's body through the haemolymph. The high fungal count recorded in the shell of had been reported by some workers (Idowu *et al.*, 2005). This may be due to the fact that the shell is dry with a low water activity and also the abundance of CaCO_3 which is known to support the growth of fungi. Hence the proliferation of moulds. Also, due to the peristaltic movement of food in the gut of the snail, fungi may not be able to establish in large number, hence they will be excreted.

CONCLUSION

It was concluded that ginger as a feed additive will affect the load and diversity of microflora found on African Giant Land Snail.

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Farmers' Perception of Climatic Variability in Ogbomoso Agricultural Zone of Oyo State



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Abstract

This study examined the farmers' perception of varying climate in Ogbomosho zone of Oyo State ADP. The study identified the perceived causes of climate change in the study area and determined the effect of climate change on crop yield in the study area. Primary data was used for this study with the aid of structured questionnaire. Three- stage sampling techniques was used for this study. The first stage, three blocks were randomly selected from five agricultural blocks in the area. In the second stage, two cells were randomly selected from each of the three blocks. Finally, 20 farmers were randomly selected from each of the six cells. Descriptive statistics was used to analyze the data collected. The results revealed that 52.5 percent, 54.2 percent, 28.3 percent and 36.7 percent of the farmers strongly agreed that bush burning, continuous cropping; burning of fossil fuel by industries and sin causes climate change. Also, 53.3 percent, 42.5 percent and 50.8 percent of the respondents agreed that overgrazing, excessive use of fertilizers and chemicals and deforestation causes climate change. Moreover, 27.5 percent of the farmers strongly disagreed that high use of irrigation water causes climate change; 20.8 percent disagreed that burning of firewood for cooking causes climate change and 35.8 percent of the respondents neither agreed nor disagreed that burning of crops and household wastes causes climate change. The effects of climate change on output in the study area showed that 60 percent of the respondents believed that the effect of climate change in the study area 5-10 years ago is mild, 55 percent said that the effect of climate change last cropping season was severe and 66.7 percent noted that the effect in the future will be very severe if nothing is done about the perceived causes of climate change.

Keyword: Climate; farmers; perception; change and variability

INTRODUCTION

Climate is the mean state of the atmosphere of a location or an area over a period of 30 years. (Ayoade, 2004). Climate plays vital roles in crop production in many countries especially in Nigeria where most farmers depend solely on climatic elements such as rainfall and temperature among others. (Onyeneke, 2010). The United Nations Framework Convention on Climate Change (UNFCC, 1994) defines climate change as a change which is directly or indirectly caused by human activities that alters the composition of the global atmosphere and an addition to natural climate variability observed over comparable time periods.

Climate change is attributable to human activities while climatic variability to natural sources. (UNFCC, 1994). From various studies by IPCC, Africa is one of the most continents experiencing and suffering from the effects of climatic change and variability. (IPCC, 2014). Climate change has affected agricultural production in Africa in several ways thereby leading to loss in GDP and reduction in productivity. (Enete and Amusa, 2010). The agricultural sector still remains one of the key sectors that are highly susceptible to climate change. This is due to the fact that agriculture depends on climatic variables such as precipitation, temperature, sunshine and wind. (IPCC, 2020). Africa

agricultural production is suffering from the effects of climate change such as the reduction in agricultural production, yields and definitely the income of small holder's famers. Output's reduction slows down the growth of countries in Africa especially Nigeria since most of the nation's revenue comes from Agriculture. (Enete and Amusa, 2010). According to the estimation by FAO (2013) that by year 2100, Nigeria and other West African countries are likely to have agricultural losses of up to 4% due to climate change. Climate change has been a relevant and important issue for over century now and most countries has been actively involved in its mitigation as the first generation solution followed by adaptation measure.

Several factors that directly connect climate change and agricultural productivity include, average temperature increase; change in rainfall amount and patterns; rising concentrations of CO₂ pollution levels such as tropospheric ozone and climate change associated with extreme events such as droughts and flooding. (Ziervogel, *et al.*, 2008; Semonov, 2009; Butterworth *et al.*, 2009). The arid zone of Nigeria is currently facing heat stress and rainfall shortage while the Sahel zone experiences less than 10 rainfall inches annually while some other regions in the south are faced with higher temperature and drought; irregular and unpredictable rainfall and torrential rainfall leading to erosion, wind storms etc. (Sayne, 2011).

Perception is defined as the process by which information or stimulus is being received and or transmitted to create a psychological awareness. Stimulus is perceived in different ways based on the differences in cultures and farming experiences. (RECOFTC, 2001; cited in Banjade, 2003). Farmers have different and diverse experiences in crop production, animal husbandry, agro forestry practices etc. These experiences coupled with their traditional and cultural beliefs, values, attitudes and interests make them see things, new idea or information about farming differently. It also helps them to understand climate, its elements, changes in climate and its effect on farming activities. (Wolf *et al.*, 2013). Trends of climatic variables are perceived based on the assessment of the frequency and intensity of the highs and lows of climatic data. (Weatherhead *et al.*, 2010). Today, the two major twins causing severe problems, hindering socio economic development and sustainable food availability are climatic variability and food security (Oyewole *et al.*, 2022). This study therefore examines the climatic elements distribution in the study area, the perceived causes of climate change and the perceived effects of climate change on crop yield in the study area.

MATERIALS AND METHODS

Study area

The study was conducted in Ogbomoso agricultural zones of Oyo state. The area lies between latitude 8°29' North of the equator and between 4°30' North of the Greenwich Meridian. It has a projected population of 1008214, using a population growth rate of 3.2% from 2006 population census (NPC, 2006). Ogbomoso has an area land mass covering about 37,984 square kilometers and located in the northern part of Oyo state. The area ranged from swamp forest to wetland uplands. In- between are rain forests and deciduous forest/ savannah. The rainfall patterns bimodal with the peaks in June, early July and September, while November to February is characterized by harmattan brought about by the effect of the north-eastern trade winds from the Sahara desert. The agricultural sector forms the base of the overall development thrust of the area with farming as the main occupation of the people. Crops usually grown include maize, yam, cocoyam, melon, cowpea and vegetables under mixed cropping practices. The livestock reared include poultry, sheep and goats.

Sampling Procedure

Three- stage sampling technique was used for this study. In the first stage, three blocks were randomly selected from five agricultural blocks in the area. In the second stage, two cells were selected from each of the three blocks. Finally, since information on the sample frame was not known, 20 farmers in each of the six cells were selected randomly.

Table 1. Distribution of Respondents in the Study Area

Agric. Blocks	Agric Cells	Number of farmers selected
1. Surulere	Iresaadu	20
	Oko	20
2. Oriire	Ikoyi-ile	20

3. Ogo- Oluwa	Oolo	20
	Ajaawa	20
	Otamokun	20
Total		120

Data Collection and Data Analysis

Primary and secondary data was used for this study. These were collected with the aid of structured questionnaires and the information collected was on the distribution of the climatic elements, perceived causes of climate change and the effect of climate change on the yield of selected crops in the study area. Descriptive statistics such as frequency, counts means and percentages were used to achieve the objectives of the study.

RESULTS AND DISCUSSIONS

Climatic elements distribution

Some climatic elements were selected and their distributions were examined for 5-10 years ago and last cropping season. The comparison of distributions of the selected climatic elements such as rainfall, sunshine, flooding, drought, wind and erosion in the study area are shown in table 2. Rainfall distribution showed that 65.8 percent of the respondents believed that rainfall is low while 34.2 percent said that it was high 5-10 years ago. Moreover, 27.5 percent of the respondents said that rainfall is low while 72.5 percent said it was high during the last cropping season. This clearly shows that rainfall was high 5-10 years ago compared to last cropping season. Sunshine distribution is also shows that 63.3 percent of the respondents believed sunshine was low and 36.7 percent said it was high 5-10 years ago. During the last cropping season, 61.7 percent concluded that sunshine was high while the remaining 38.3 percent said it was low. This shows that sunshine was high 5-10 years ago and it was low during the last cropping season. The distribution on the table 2 also shows that flooding was low 5-10 years ago but high in the last cropping season.

A large number of the respondents believed that (92.5 percent) believed that drought occurrences were low while only 7.5 percent said it was high 5-10 years ago. 40 percent and 60 percent of the farmers noted that drought was low and high respectively in the last cropping season. Flood and drought are two extreme negative situations caused by water imbalances. Drought can be simply defined as an extended lack of rainfall. While flood is a situation in which water temporarily covers a land where it normally doesn't. (Jackie Pedroso, 2016). Flood and Drought can have different meaning to different people depending on how water deficiency affects them. (Jackie Pedroso, 2016). Also, 65.8 percent perceived that wind was low and 34.2 percent that it was high 5-10 years ago. 42.5 percent said it was low and 57.5 percent that it was high last cropping. The distribution of respondents on erosion revealed that 73.3 percent perceived erosion as low and 26.7 percent as high 5-10 years ago. It was vice-versa in the last cropping season. This supports the findings of Babalola et al, 2003 that the soils of the south-western Nigeria becomes eroded with water due to the high intensity of rainfall in the zone.

Table 2. Distribution of respondents based on climatic elements in the study area 5-10 years ago and last cropping season

	5-10 years ago	Last cropping season
Climatic elements	Frequency (Percentage)	Frequency (Percentage)
Rainfall		
Low	87(72.50)	41(34.20)
High	33(27.50)	79(65.80)
Total	120(100)	120(100)
Average	1.64	1.26
Sunshine		
Low	74(61.70)	44(36.7)
High	46(38.30)	76(63.30)
Total	120(100)	120(100)

Average	1.63	1.38
Flooding		
Low	82(68.30)	31(25.80)
High	38(31.70)	89(74.20)
Total	120(100)	120(100)
Average	1.32	1.74
Drought		
Low	111(92.5)	48(40)
High	9(7.50)	72(60)
Total	120(100)	120(100)
Average	1.08	1.74
Wind		
Low	79(65.80)	51(42.50)
High	41(34.20)	69(57.5)
Total	120(100)	120(100)
Average	1.34	1.58
Erosion		
Low	88(73.30)	32(26.70)
High	32(26.70)	88(73.30)
Total	120(100)	120(100)
Average	1.27	1.73

Note: Figures in parenthesis represent the percentage

Perceived Causes of Climate Change

Table 3 shows the distribution of respondents on the perceived causes of climate change in the study area. 52.5 percent, 54.2 percent, 28.3 percent and 36.7 percent of the farmers strongly agreed that bush burning, continuous cropping, burning of fossil fuel by industries and sin causes climate change. Also, 53.3 percent, 42.5 percent and 50.8 percent of the respondents agreed that overgrazing, excessive use of fertilizers and chemicals and deforestation causes climate change. Forests are called the” lungs of the earth” and it works against climate change, the relationship between forests and climate change is that forest can mitigate climate change by absorbing carbon. The enemy of forest is deforestation as forests provide significant economic, social and ecological benefits for the citizenry.(FRIN, 2015)Moreover, 27.5 percent of the farmers strongly disagreed that high use of irrigation water causes climate change; 20.8 percent disagreed that burning of firewood for cooking causes climate change and this is against Borisade, 2020 who noted that cooking activities account for the high energy consumption in household which is a potential source of indoor air pollutants and global warming. 35.8 percent of the respondents neither agreed nor disagreed that burning of crops and household wastes causes climate change. All the aforementioned results are in line with (<http://www.news.dailytrust.com>) that climate variability are caused by buildup of green house gases such as carbon dioxide, nitrous oxide, Chlorofluorocarbons (CFCs) and methane in the atmosphere as a result of human activities such as burning of fossil fuels, bush burning, cooking using woodfuels, use of machines that produces smoke, deforestation, excessive use of fertilizers and herbicides among others.

Table 3. Distribution of respondents based on the perceived causes of climate change

Perceived causes	Strongly agree	Agree	Strongly disagree	Disagree	Indeterminate
Bush burning	63(52.5)	39(32.5)	11(9.2)	6(5.0)	1(0.8)
Continuous cropping	65(54.2)	46(38.3)	6(5.0)	3(2.5)	NIL
Overgrazing of farmland	36(30)	64(53.3)	4(3.3)	14(11.7)	2(1.7)
Burning of crops and	9(7.5)	21(17.5)	11(9.2)	36(30)	43(35.8)

household wastes

Burning of fossil fuels	34(28.3)	29(24.2)	13(10.8)	12(10)	32(26.7)
Excessive use of fertilizers and chemicals	40(33.3)	51(42.5)	4(3.3)	14(11.7)	11(9.2)
Deforestation	51(42.5)	61(50.8)	3(2.5)	3(2.5)	2(1.7)
High use of irrigation water	25(20.8)	21(17.5)	33(27.5)	25(20.8)	16(13.3)
Burning of firewood for cooking	21(17.5)	21(17.5)	22(18.3)	25(20.8)	31(25.8)

Note: Figures in parenthesis represent the percentage

Perceived Effects of Climate Change on Crop Yield

The distribution of respondents based on the perceived effects of climate change on output in the study area, table 4 revealed that 60 percent of the respondents believed that the effect of climate change in the study area 5-10 years ago is mild, 55 percent said that the effect of climate change last cropping season was severe and 66.7 percent the effect in the future will be very severe if nothing is done about the perceived causes of climate change. This supports the assertion of Zhu, 2005 that there could be a more negative influence of climate change on the long run on agricultural productivity which may lead to food insecurity if necessary actions are not urgently taken.

Table 4. The distribution of respondents based on the effects of climate change on output in the study area

Effects	5-10 years ago		Last cropping season		Future	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Very severe	3	2.50	52	43.30	80	66.70
Severe	11	9.20	66	55.00	1	0.80
Mild	72	60.00	2	1.70	0	0
Negligible	34	28.30	0	0	10	8.30
Indeterminate	0	0	0	0	29	24.20
Total	120	100	120	100	120	100
Average	3.14		1.58		1.02	

CONCLUSION AND RECOMMENDATIONS

The results of the finding shows that the perceived causes of climate change in the study area include bush burning, continuous cropping, burning of fossil fuels by industries, high use of irrigation water, overgrazing, excessive use of fertilizers and chemicals and deforestation. Also, respondents indicated that the climate change impact on crop output was very severe and the trend in the severity may likely to increase in the future. It is therefore recommended that farmers should be educated on the benefits of bush fallowing in replenishing lost nutrients from their farmland. Government should enforce that the existing law and policy against deforestation are strictly adhered to and there should be a working relationship between farmers and meteorologists for better agricultural productions.

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Cereals Production and Intra-Food Trade in Sub Sahara Africa: Implication on Agricultural growth



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Abstract

The supply-demand balance of cereals in sub-Saharan Africa countries left a gap that needs to be bridged by agricultural production that is growth-inclusive. Agricultural growth failed to keep to pace of the population growth as a result of low technology adoption, mechanization, reduced yield, food loss/waste, trade barrier and distortion, low investment and tenure security. This study however contributes to understanding the implication of cereals production and intra-food trade on agricultural growth in sub-Sahara Africa. The trend of cereals production and intra-food trade was studied using a cross sectional panel data of 48 countries in Africa. The result shows that cereal production has positive effect on agricultural growth, while intra-food trade and population growth negates the hypothesis of trade-led agricultural growth. The study suggests that increasing cereals production is vital to validate growth in the agricultural sector of many African countries.

Keywords: Agricultural land, Supply, Technology, Trend, Production and Population growth

INTRODUCTION

Africa is naturally blessed with adequate resources that allow timely and good growth of either crops and/or livestock. Yet, the region spends huge amount on importation of food to meet up with her local demand. According to African Progress Panel (2014), it cost the continent about US\$35 billion annually to import food. Among the top imported food products are cereals. Cereal grains including wheat, maize, and paddy are considered primary crops as they are staple foods to most of the population across the globe (Wang *et al*, 2018). Sustainable food production that will meet the demand of growing human population is one of the major problems most countries in 21st century battled. The challenge is mostly accelerated by increasing urbanization, climate change, environmental degradation, soil nutrient depletion and sometimes availability of human resources. The resultant effect poses great threat on feeding the world's growing human population projected to exceed nine billion by 2050 (Lobell *et al.*, 2008; Godfray *et al.*, 2010). Another major constraint to self-sufficiency in food is regional imbalance in agricultural production. This widen the demand-supply gap and increase the deprivation of the vulnerable and food insecure. Agriculture occupies a pivotal role in the improvement of sub-Saharan countries economy and her citizens' social security. This is the case as the sector provides primary means of employment and contributes at least 15% on average to the total GDP (OECD-FAO, 2016). Traditionally, agricultural produce has been a major and important product of trade in SSA. It has been a major economic importance in the region due to number of citizen involve in agriculture. However, agricultural productivity in SSA failed to commensurate with the demands due to increasing population in the region (Bjornlund *et al.*, 2020). The slow rate of agricultural productivity could be attributed to climate change factors, low technological adoption and practice, lack of productive inputs and weak institutions (FAO, 2019). SSA has unpretentious growth in agricultural production per capita between 1960s to the 1970s (FAO, 2009). However, the trend declines and consequently food security problem surfaced with more than 30% of SSA's population faced hunger (Pfister *et al.*, 2011; FAO *et al.*, 2021). Smallholder farmers are the most vulnerable in SSA, despite they are primarily food producer. Climate change pound more

effect on the existing precarious situation. Changes in growing season and rainfall pattern together with the extreme weather events such as flood and drought has increasingly undermine food production and thereby disrupt lives. Leveraging potential of SSA countries has been the giant step taken by its leaders. They believed that the prosperity of Africa lies in integration. With integration issues, the challenges with ease of doing business in the region will reduce. Malabo 2014 declaration commit African leaders to increase agricultural commodity trade to fast track the establishment of a continental free trade area (African Union, 2014). But despite all these efforts, intra-African food trade has remain low and disappointing when compare with what is obtainable in other region of the world. According to (IFPRI *et al.*, 2017), the share of trade of agricultural product within African countries still revolves between 13 to 20% over the period of 2000 to 2013. On this account, this study the implication of cereal production and intra-food trade on agricultural growth in SSA.

MATERIALS AND METHODS

The survey examines cereals production and intra-food trade in Sub Sahara Africa countries. The study adopts a multi-country secondary analysis using cross sectional panel dataset for the period of 1986 -2021. The data was sourced from the World Bank Development Indicators (WDI) and Food and Agriculture Organization (FAO) database. In the study, agricultural GDP (i.e. Agriculture % of GDP) was used as proxy for agricultural growth, land under cereal production (hectares), Population growth (annual %), Inflation and Labor force (total). Food trade was obtained from dividing the sum of both net food export and food import by growth. The study tested for stationary of the data using Im-Pesaran-Shin (IPS) unit-root test and Fisher-type unit root; this will prevent having spurious regression. Like the renowned Dicky-Fuller (DF) unit root test, IPS test entail testing for the existence of unit roots in panel data (IPS, 2003). The test of IPS unit-root relies on accepting alternative hypothesis of stationary of the panels as against the null hypothesis of unit (non-stationary) root of the panels. The IPS test for unit roots was performed.

Analytical technique

$$Y_{it} = \alpha_i + x'_{it}\beta + \varepsilon_{it} \dots \dots \dots (i)$$

α_i is usually random unrelated to x_{it} ; x_{it} are regressors and all the estimators are consistence for β . ε_{it} is idiosyncratic error.

There are two basic models for α_i ; these are fixed and random effect models. In fixed effect model (FE), allowing the α_i to be correlated with the regressors x_{it} will permit limited form of endogeneity. The error is $\mu_i = \alpha_i + \varepsilon_{it}$, so allowing the regressors to correlated with the time-variant component of the error and we continue to assume that the regressors in uncorrelated with the idiosyncratic error. It is possible to estimate β , for time-varying regressors by appropriate differencing transformations applied that could annual α . The model implied that $E(y_{it} | \alpha_i, x_{it}) = \alpha_i + x'_{it}\beta$, assuming $E(\varepsilon_{it} | \alpha_i + x'_{it}) = 0$,

RESULTS AND DISCUSSION

Table 1 presents the summary statistics of the variables used for the study. This include agricultural growth, food trade, cereal output, cultivated area under cereals production, labour force (total), population growth, inflation, consumer price index and tax on international trade. The table revealed the average agricultural growth as 1.347. Food trade was 6.209; the average cereal output was put to 2504738 metric tons; meanwhile the area under cereal cultivation was 4.024 hectares on the average, the average labour force (total) stood at 44.88, and the population growth was 2.464. The inflation rate was about 46% and the tax on international trade (% of revenue) was 28.160

Table 1: Summary statistics

Variables	Observation	Mean	Std.dev
AgricGDP_growth	1,536	1.347	6.940
Food Trade	1,536	6.209	28.160
Cereal_output	1,536	2504738	4744234
Cultivated_area	1,536	4.024	2.515
Labour_force	1,536	44.886	7.082
Population growth	1,536	2.464	6.124

Consumer price index	1,536	2.464	1.097
Inflation	1,536	45.773	691.737
Tax on international trade	1,536	28.160	0.901

Source: Author computation, 2023

Unit root test was conducted on the variables of choice with or without trend. Fisher-type (Fisher) unit root test and Im-Pesaran-Shin (IPS) unit-root test entail testing for the existence of unit roots in panel data (IPS, 2003). The test of IPS unit-root relies on accepting alternative hypothesis of stationarity of the panels as against the null hypothesis of unit (non-stationary) root of the panels. In this survey, IPS test for unit roots was performed. Lag difference of 1 was used. As presented on Table 2, the t-statistics of all the series except cereal output and the cultivated area under cereal production have p-value < 0.05; indicating that the series were statistically significant and does not contain unit root at their level form. The two variables (cereal output and cultivation area) were significant at differencing level. The result implied that all the series were generated by similar stochastic processes and also exhibits the possibility of moving together in the long run. Since the variable failed stationarity test at level, it is therefore imperative to establish the relationship between the variables (Seok and Moon 2021).

Table 2: Im-Pesaran-Shin Unit root test

Variables	t statistics	p-value	lag	Stage	Decision
AgricGDP_growth	-12.9569	0.0000	1	Level	Stationary
Food Trade	-8.7195	0.0000	1	Level	Stationary
Cereal_output	-2.9708	0.0015	1	1 st difference	Stationary
Cultivated_area	-4.0378	0.0000	1	1 st difference	Stationary
Labour_force	-1.9850	0.0236	1	Level	Stationary
Population growth	-28.5274	0.0000	1	Level	Stationary
Consumer price index	-7.0268	0.0000	1	Level	Stationary
Inflation	-13.2433	0.0000	1	Level	Stationary
Tax on international trade	-6.7973	0.0000	1	Level	Stationary

Source: Author computation, 2023

In Table 3, the pairwise correlation result was presented. The test was carried to test the collinearity of the explanatory variables, that is, if the variables were collinear. From the result it was observed that the coefficient of the estimates is less than unity. This simply implied absence of perfect collinearity among the variable of interest, however, the condition satisfy the establishment of the relationship between the dependent and the explanatory variables. We also perform test for multicollinearity. The variance inflation factor (VIF) mean value was 1.73; with this value it was deduced that there is no multicollinearity since mean vif was less than 10 (rule of thumb). Also, Breusch–Pagan/Cook–Weisberg test for heteroskedasticity was carried out to confirm if the model maintained constant variance of the error term, however, the result was below the significance level of 5%, thereby indicated absence of heteroskedasticity.

Table 3: Pairwise correlations of the explanatory variables indicated

Variables	Agric GDP_growth	Food Trade	Cereal_output	Cultivated_area	Labour_force	Population growth	C_price index	Inflation	Tax on int. trade
AgricGDP_growth	1.0000								
Food Trade	-0.0153	1.0000							
Inflation	-0.0573	0.005	1.0000						

		0							
Cereal_output	0.0741	0.010	0.0141	1.0000					
Cultivated_area	0.0426	0.080	0.0030	0.8789	1.000				
Labour force	-0.0203	0.016	0.0444	0.0715	0.052	1.0000			
Pop_growth	0.0429	0.041	0.0518	0.0780	0.169	0.0073	1.0000		
C_price index	0.0069	0.110	0.0632	0.0513	0.015	0.0905	0.0785	1.0000	
Tax on international trade	0.0406	0.057	0.0434	0.0199	0.064	0.0417	0.0138	0.4830	1.0000

Source: Author computation, 2023

In panel data estimation, the choice of the most appropriate model might be of concern. So, some test to guide the choice of the model was performed. To ascertain the model performance, firstly, Ordinary Least Square regression (OLS) model was run to establish the relationship between the dependent and the explanatory variables; and the variables were also regressed against the residual of the OLS. Secondly, Hausman test to decide on the best and most appropriate model between fixed effect model and random effect model was carried out. The result of the test pinpoints failure to accept the null hypothesis, since the p-value was higher than 5% and hence, random effect model was appropriate for the study. Table 4 showed about seven different models, the first model showed the relationship between agricultural growth and food trade. The coefficient of food trade on this model was insignificant though the coefficient showed existence of positive relationship. When cereal output was added to the model the coefficient of both food trade and cereal output were positive significant. This indicated that both variables contributed to agricultural growth in sub-Sahara Africa. Food trade was significant at 1 percent level and cereal output was significant at 5 percent level of confidence. The coefficient of food trade also showed significant relationship with agricultural growth on 5th and 7th model. The result here indicated that an increase in food trade in sub-Sahara Africa will increase agricultural growth. Mwangi (2021) had suggested that agricultural trade is one of the turbines that powered economic growth of many developing nation.

Furthermore, the coefficient of inflation is another major variable of concern as showed on the table. The coefficient was negative and significant on model 3-7; the result here is an indication reverse of agricultural growth with an increase in inflation. Inflation has been a one important factor militating against growth and development in most countries in sub-Sahara Africa. With hike in food and product prices, most agricultural producers face challenges in production as a result of high input cost and some other operational cost. Also, to ensure free flow of food in sub-Sahara Africa, restrictions by the countries affect free trade which invariably retards growth most often. For instance, total border closure in Nigeria affect commodity trade, other countries have one or more policy that restrict free flow of commodities within their borders. Expansion of market within and outside sub-Sahara Africa and permission of free trade will aid food security and sufficiency within African borders (Asiru and Fanifosi 2023), The coefficient of tax on international trade justify the claim as the coefficient showed negative sign and it was significant. The implication of this is that increase in tax placed on international trade will reduce agricultural growth by 0.00115.

Table 4: Regression results from cereal production and Food Trade to Agricultural Growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Food Trade	0.000108 (0.05)	0.000187*** (3.11)	0.000310 (0.20)	0.000305 (0.19)	0.000312*** (4.20)	0.000610 (0.38)	-0.000645* (2.40)
Cereal_output		0.000000129* (2.23)	0.000000123* (2.17)	0.000000162 (1.80)	0.000000158 (1.72)	0.000000160 (1.76)	0.000000170 (1.87)

Inflation	-0.000398*	-0.000399*	-0.000400*	0.000393*	-0.000401*
	(-2.05)	(-2.05)	(-2.05)	(2.02)	(-2.06)
Cultivated_area		8.37e-08***	-7.36e-08	-7.75e-08	-
		(3.53)	(-0.46)	(-0.49)	0.000000103
Labour_force			0.0186	0.0173	(-0.65)
			(0.31)	(0.30)	0.0187
Population growth				0.0241	(0.32)
Consumer price index				(1.57)	-0.0268*
Tax on international trade					(-2.60)
					0.275
					(1.32)
Constant	1.348***	0.650***	0.748	0.822***	-0.00115***
	(7.64)	(3.64)	(1.78)	(4.85)	(-4.17)
N	1452	1360	1191	1185	-1.007
					(-0.37)

Source: Author computation, 2023

t statistics in parentheses

* p<0.05, ** p<0.01, *** p<0.001

CONCLUSION

This study examines the effect cereal production on intra-food trade and agricultural growth in sub-Saharan Africa. The survey covers 48 countries in sub-Saharan Africa and cross sectional panel dataset for the period of 1990 – 2021 was used. The study tested for the stationarity of the variables used using the Im-Pesaran-Shin unit-root. Also tested was correlation between the explanatory variables; multicollinearity, and heteroscedascity problem. Hausman test was also computed for the choice of the best and appropriate model (fixed or random effect model) for the study. The study showed the significance of cereal production in food intra-trade and agricultural growth in sub-Saharan Africa. Food intra-trade influences agricultural growth, observing that trade is the main engine of economic growth and development especially in sub-Saharan Africa, since agricultural sector is one of the dominating sector of the economies of these countries. The result suggests increasing food intra-trade will open opportunities for agricultural development, foster food security and food sufficiency in sub-Saharan Africa. To achieve this, trade barrier need to be lifted and develop ties through trade-driven policies within the region. At the same time, trade-led agricultural growth would be achieved by encouraging agricultural export and expansion of free trade agreements within the region.

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Exploring how Socio-cultural Networks are related to Land Access and Utilization of Farming Households in Oriire Local Government Area, Oyo State, Nigeria



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Abstract

A secure land access is the basis for agricultural food system. In most rural areas of African countries, where agriculture is a predominant livelihood activity, a large hectare of cropland is transiting from relative to relative. This paper explores how socio-cultural networks relate to farmland access and utilization in Oriire Local Government Area, Oyo State, Nigeria. A sample of 120 farming households was drawn from the existing population frame by multi-stage sampling. Primary data were collected with structured questionnaire and analyzed using descriptive statistics, Tobit and Logit regression analyses. Based on the findings, most (61.67%) of the farmers were males, their mean age was about 46years, farm size was around 5 hectares on the average and farmers were members of 3 different social groups at most. In terms of access to farmland and use, 60.83% of the farming households have free access while agricultural land use was heavily intensified on arable crops. Logit regression showed that native (10%), membership (1%), number of associations (10%), members belonging to the same lineage (1%), collective work participation (1%) and number of time participated (5%) are indices of socio-cultural ethics and statistically influenced land access. The analysis of Tobit regression further identified that membership (1%), number of associations belonged to (1%) and members belonging to the same lineage (5%) driven land use in the study area. The study observed that most elements of socio-cultural networks which determined land access and use are linked to organizational and/or family-ties, and it was further affirmed that mode of land acquisition is often by inheritance, which denotes ownership.

Keywords: Socio-cultural networks, land access, land utilization, farming households, Logit and Tobit regression models.

INTRODUCTION

Brush and Turner II (1987) proposed that demand for agricultural land-use intensity should be expanded to include biological, social, and market forces. Social variables such as kinship, culture, and taxes were thus posited as potential demands over and above population pressure (Brush and Turner II 1987). Social capital, though non-monetary asset may be a veritable tool in addressing farm problematic issues, either in the aspect of sharing or redistribution of farm physical assets like land and capital resources in the rural areas (Ganiyu and Olawuyi, 2018). This is because the familiarity developed through social cohesion among individuals or groups is noticeable and measureable, either qualitatively or quantitatively. Also, when farm households get themselves involve in a mutual relationship, the link, bond and bridge established through this medium are viewed as promising ways to optimize production outcomes in our societies.

The initiation of socio- cultural networks into the system of agricultural resources management has in past and present contributed to improvement of farm set-up. For example, past studies in developed world on social capital advocate its significant role in enhancing the use of modern agricultural practices and as well its capacity to improve the well-being among the populace (Adepoju and Oni, 2012; Willy and Holm-Muller, 2013; Ganiyu and Olawuyi, 2018). Recently, social relationship and neighborhood ties have taken over the position of Governments in the distribution of land resource

particularly in the local communities. In other words, access to farm resources including land is not based on official allocation to people by Governments, but the available plots of land are shared on basis of whom you know which by extension, termed as social capital. According to reviewed literatures social capital is not interpreted in the same way as different author defines it as being related to the studies at hand. One clear definition of social capital conceived it as networks plus resources such as trust, belief, norm credit, information. Moreover, social capital unlike other reproducible capitals is assumed to be not homogeneous variable due to racism's differences and complexity of societies. The theory of social capital is particularly rooted on the notion of trusts, norms, reciprocity and other informal networks such as membership, attendance at meeting, belonging to the same lineage/clan, neighborhood ties, collective activities which are said to be valuable resources for economic development (Adepoju and Oni, 2012; Ifabiyi and Komolafe, 2016). Social capital is broadly defined as multi-dimensional phenomenon comprising a stock of social norms, values, beliefs, trusts, obligations, relationships, networks, friends, memberships, civic engagement, information flows and institution that fosters cooperation and collective actions of mutual benefits and contributions to economic and social development. Thus, scaling up of accessibility to farmland could be facilitated through kinship ties, peer influence, and some other social networks that govern mutual interactions among individuals.

Naturally, land is a free gift of nature to mankind but due to its huge economic values it becomes a lucrative asset and even scarce in recent decades (Federal Ministry of Housing and Urban Development (FMHUD), 2006; United States Agency for International Development (USAID), 2012; Tsue, 2015). Titilola and Jeje (2008) consistently affirmed that land is a strategic socio-economic asset especially in poor communities where wealth and survival are measured by control of and access to land. These benefits and some other factors like agricultural land-use change, land conservation and land markets are responsible for in alienation on land by whoever claimed to be the owners. Besides, the demand for land is a derived demand, for land is more than asset or input in the production process, as it has economic, historical and cultural values (Alabi, *et al.*, 2020). The major concern of most African countries, including Nigeria, in recent times is how to increase access to land which plays an important role in food production because of food insecurity issues, which by extension, is a major contributing factor to the prevalence of poverty.

Agricultural activities are mostly determined by access to farmland, most especially a fertile cropland for productive farm works (Odoemelam *et al.*, 2013). Land access is referred to as the opportunity to acquire and use land or the state of having acquired holding over farmland (Bruce and Holt, 2011). A lot of empirical studies identified the potential of land on agriculture, as being the single most important factor of farm production. Therefore, proper land ownership, accessibility, and the sustainability of this access are very crucial for any meaningful agricultural development planning. Furthermore, the vital role of land in production of food is linked to social, political and economic life of most African nations, where agriculture, natural resources and other related land-based activities are critical to livelihoods, food security, incomes and employment. So, this study is motivated based on the pillar that socio-cultural networks guarantee accessibility to farm incentives particularly farmland across the local domains of Nigeria. Consistently, land-use pattern is comprehended as the function(s) that human apply to land available to them. For example, the farmland may be used for arable cropping, cash crop farming, tree/forest plantations, horticultural crop farming, pasture growing or grazing land and raising livestock, whereas land use intensity has been defined as the number of continuous cropping cycles before putting land into fallow. In the rural areas, land-use is governed mainly by the requirement of the agricultural industry which is important for the livelihood of the people (Oyekale, 2007), although the land tenure system or property right has huge implication on land use. To continue this discussion with respect to socio-cultural dimensions, Polain de Waroux *et al.*, (2021) study is worthy to be mentioned here because he contemplates on the important role of culture on land-use in myriad ways. Culture can be understood as a symbolic system that is shared and passed on among groups and is used to interpret the world and guide behavior (Geertz, 1973; Kroeber and Parsons, 1958). For the purposes of LSS, it can be useful to think of culture as beliefs, knowledge, norms, and values organized into shared mental models that allow members of a group to 'interpret observations, generate novel inferences, and solve problems' (Kempton *et al.*, 1996). Cultural features are often expressed through informal institutions, rather than formally codified

(Ostrom, 1990). These aspects can be largely invisible to outsiders, but nevertheless guide the ways that people interact with and manage the local environment (Colding and Folke, 2001).

A handful of researches had considered the outcome effect of social relationship inform of social capital networks on different fields of specialization. This paper noticed that significant traces exist between social relationship and culture, or social interaction is embedded in cultural behaviour among people especially in the rural community. In view of this, its main objective is to investigate the effect of socio-cultural networks on land access and land utilization and the specific objectives were to describe the socio-economic characteristics of farming households, know the various modes of land access and land utilization, identify the existing socio-cultural networks, and examine their influences on land access and land utilization in the study area.

EMPIRICAL LITERATURE REVIEWS

Alawode *et al.*, (2020) examined the effect of land access and land use conflict on crop commercialization of smallholder farmers in Southwest Nigeria. A multistage sampling technique was used in selecting 300 respondents and primary data were collected using structured questionnaire. Data were analyzed using descriptive statistics, Land Market Index (LMI), Land Use Conflict Index (LUCI), Crop Commercialization Index (CCI) and Tobit regression model. Majority (95.3%) of the farmers were male, natives (81.3%), and married (97.3%) with an average household size of 9 persons. Also, 69.3% had formal education and an average of 24 years of farming experience. Majority (78.0%) of the farmers had their total landholding through non-market means (inheritance, borrowed and gift), 14.0% acquired their total landholding through market means (purchase, rent and lease), and the mean LMI was 0.16(± 0.35), showing farmers had access to 16% of farmlands through market participation. Farmers were coping with conflict on majority (90.4%) of their landholdings and 95.2% of conflicts could be attributed to competition for natural resources, especially farmer-herder clashes (94.2%). The mean LUCI was 0.91(± 0.27), implying farmers experienced conflicts on 91% of farmlands. Mean commercialization of maize, cassava and yam were 84.19% (± 16.0), 84.01%(± 16.67) and 61.42%(± 24.83), respectively, indicating that the crops driving commercialization were maize and cassava. Tobit regression results indicated that farm size, presence of local market and LMI significantly ($P < 0.01$) increase commercialization. In conclusion, extent of land market participation significantly increases commercialization while land use conflict reduces crop commercialization, although not significantly. Policy efforts should be intensified with a view to facilitating land access by farming households through market participation, and also reducing or resolving all arable land use

Alabi *et al.*, (2020) analyzed the determinants of land access and utilization for agricultural activities among farming households in Surulere Local Government Area, Oyo State, Nigeria. Population under the present study comprises of all peasant farmers in Surulere Local Government Area of Oyo State. The sampling procedure employed was multistage random sampling technique leading to the selection of 90 farmers. Data were obtained through the use of structured questionnaire while the data were analyzed using descriptive statistics and inferential statistical tool such as logistic regression model. Most (85.6%) of the respondents were males, had a mean age of 43 years, were married (74.4%) and have an average household size of 8 members. Most (86.7%) engaged primarily in farming with an average experience of 19 years and cultivated an average farm size of 2.4ha. Family inheritance (61.1%) was the major mode of land access. Majority (63.3%) of the respondents used their land for agricultural purposes alone. The average land size was between 1.80-10.50ha with an average distance of 1.11km-5.0km from homestead. Result of probit regression model showed that income level ($Z = 2.71$) and farming experience ($Z = 1.80$) were significantly related to land access. Also, household size ($Z = 2.39$), farm right ($Z = 2.10$) and scale of production ($Z = 4.06$) were significantly related to land utilization. Income level and farming experience influenced land access for agricultural activities while household size, farm land right and scale of production are determinants of land utilization. Ifabiyi and Komolafe (2016) in their study focused on the contributions of social networking in accessing resource for irrigation farming among farming households in north central Nigeria. Systematic random sampling was used to select 194 respondents from Oke-oyi and shonga (Kwara State) and Ejiba (Kogi State). Data were obtained using structured questionnaire. The data were analyzed using descriptive statistics and Pearson Product Moment Correlations. The findings

indicated that market information with the mean score of 2.75, was the most important contribution of social networking in accessing resource for irrigation farming while lack of input with mean score of 2.27 was the highest ranked constraint faced by the farmers using irrigation for crop production. The result of correlation analysis revealed that there was no significant relationship between the contributions of social networking in accessing resources for irrigation and the constraints faced by the farmers using irrigation for crop production. Based on this results, it is therefore recommended that there should be creation of awareness on various opportunities that are available for irrigation farmers participating in social networking.

Yann le Polain *et al.*, (2021) viewed that land system science (LSS) has substantially advanced understanding of land dynamics throughout the world. However, studies that explicitly address the causative role of culture in land systems have been fairly limited relative to those examining other structural dimensions (e.g. markets, policies, and climate). In this paper, the main discussion is on how to better include culture in LSS. Through four examples, we show how aspects of culture influence land systems in myriad ways. Building on existing causal land system models, we propose a conceptual framework for the role of culture in land use and summarize promising methodological innovations for exploring it further. This study concludes with some thoughts on how the study of culture and its integration through reflexive, locally grounded approaches, while challenging, provides new opportunities for the development of LSS.

Mekonnen *et al.*, (2016) empirically discussed the existence of social learning in agriculture in Ethiopia. Random matching within sample technique was used to collect data on social networks and elicit details of the relationships and information exchange between network members, complementing the analysis with information on self-reported networks. It is find that, while kinship or membership in certain groups, informal forms of insurance, or having frequent meetings with network members are all associated with a higher probability of forming an information link, none of these are correlated with observed innovative behavior such as the adoption of row-planting. This may suggest that behavior is more likely to be affected by the nature of information that passes through the network, rather than the number of information links. In support of this, we find that information links that exclusively involve discussions on farming or business matters are indeed associated with a higher likelihood of adopting row-planting. It uses econometric strategies to isolate social learning from that of correlated and contextual effects. After controlling for factors that might otherwise generate spurious correlation, we find a strong evidence of network externalities in the adoption of row-planting techniques and also in farm productivity. The results imply that extension services and other programs that promote agricultural innovations and seek yield improvement may benefit from social networks but they may be more effective if they identify the 'right' networks, that is, the ones that exclusively involve information exchange regarding agriculture. This further implies that investment in group formation, rather than simply using existing networks, may be a beneficial strategy. As noted before, early studies on networks define the latter based on membership to certain groups such as the village, clan or as otherwise determined by social and cultural characteristics.

Enhancing farm resilience has become a key policy objective of the EU's Common Agricultural Policy (CAP) to help farmers deal with numerous interrelated economic, environmental, social, and institutional shocks and stresses. A central theme in resilience thinking is the role of the unknown, implying that knowledge is incomplete and that change, uncertainty, and surprise are inevitable. Important strategies to enhance resilience are exploiting social capital and learning as these contribute to improved knowledge to prepare farmers for change. This paper explores how social capital and learning relate to farm resilience along the dimensions of robustness, adaptation, and transformation. Study the resilience of Dutch arable farmers from the Veenkolonien and Oldambt using a combination of four methods. Qualitative data from semi-structured farmer interviews, focus groups, and expert interviews are combined with quantitative data from farmer surveys. The qualitative data are analysed using thematic coding. Non-parametric tests are used to analyse the quantitative data. Based on methodological triangulation, it was mostly found that convergence in our qualitative and quantitative datasets increasing the validity of the findings.

In essence, with the literatures reviewed in the above, it is evident that there is room for conducting a kind of this research-explores how socio-cultural networks relate to farmland access and utilization in our local districts in order to close the gap in literature and provide new ideology around this concept.

MATERIALS AND METHODS

Study Area, Population and Sampling Processes

The study was carried out in Oriire Local Government Area in Oyo State. It was created in 1989 and has its headquarter in the town Ikoyi. It is bordered by Atiba Local Government Area, Olorunsogo and Surulere LGA. The LGA counts as the largest LGA of the state both in area and in population among others. The population for this study represents all farming households in Oriire Local Government Area of rural Oyo State. Multistage sampling procedure was used to select respondents from the communities for the study. In the first stage, three (3) was randomly selected from the ten (10) political wards in study area, while the second stage involve random selection of four (4) villages from the wards to have twelve (12) villages. The last stage was a systemic sampling of 10 farmers in the selected villages. This gives a sample size of one hundred and twenty (120) respondents. Data was collected through structured questionnaire and focus group discussions.

Data Collection and Method of Data Analysis

The data collected were summarized and described using descriptive statistics (frequency, mean, standard deviation) and inferential statistics while the inferential statistics employed are logit and tobit regressions respectively.

Binary logit regression

Binary logit regression is normally applied to model dichotomous outcome variables. The logit model assumes that while 0 and 1 values are only the observed variable Y response, there is a latent unobserved continuous variable y^* that determines the value of the response variable Y. Therefore, Y^* can be expressed as:

$$Y^* = X^1B + \varepsilon_1$$

Such that, $Y = 1(Y > 0)$. That is, if $Y > 0$ i.e. $(\varepsilon < X^1B)$ otherwise, where Y = Vector of response variable (free access to farmland = 1, 0 otherwise).

X = Vector of explanatory variables, B = logit coefficients and ε_1 = Random error term

X_1 = Nativity

X_2 = Membership

X_3 = Numbers of association they belong

X_4 = Members living within same area

X_5 = Members belonging to same clan/family

X_6 = Members working with others in the village

Tobit regression analysis

In addition, Tobit regression analysis was employed to examine the effect of social capital networks on land use among the farming households. The model for Tobit regression is given by the equation below:

$$LU = B_1X_1 + \pi_1$$

Where LU = Land use (score ranges between one and zero)

X_1 = Membership

X_2 = Numbers of association they belong

X_3 = Members lives within same area

X_4 = Members belonging to same clan/family

X_5 = Collective work activities

X_6 = Time members participate in group activities; π = error term

RESULTS AND DISCUSSION

Summary Statistics of Households' Socio-economic Characteristics

Table 1 shows that the least and the maximum age among the sampled respondents is 0 and 76 with the estimated average age of 45.82 years. Then the highest year spent in school 17 years with estimated average year of 7.28 years while the maximum household size is 18 persons and minimum of 1 person with an estimated mean of approximately 9 persons in a household. It was also revealed that the respondents have highest farming experience of 51 years with estimated mean of 22.54 years, highest income of ₦200000 and least income of ₦120000 with estimated average of ₦384208.3 per year, the least and maximum farm size are 1 and 100 acres with an estimated average of 4.95 acres. It was also revealed that the household belongs to a maximum of 3 organizations with an estimated average of 1.5 organizations.

Table 1. Summary Statistics of selected socio-economic characteristics

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
Age group	120	45.81677	15.29925	0	76
Years spent in school	120	7.283333	5.365911	0	17
Household size	120	9.325	3.611751	1	18
Farming Experience	120	22.54167	12.44274	0	51
Income	120	384208.3	216080.4	120000	2000000
Farm Size	120	4.97	9.194182	1	100
Numbers of association they belong	120	1.5	0.9787662	0	3

Source: Field Survey, 2020.

Logistic Regression for Effect of Socio-cultural Networks on Land Access

Table 2 presents the result of the logit model used to investigate the influence of social groups on land access. Eight explanatory variables were considered in the model from which only six were statistically significant at various levels. They are Nativity, Membership, No of association belonged to, Members belonging to same clan, Collective work activity and Number of time members participate in group activities. The likelihood ratio chi-squared of 36.37 with a p-value of 0.0000 reveals that the model as a whole is statistically significant. Pseudo R squared is 0.2383 which indicate that 23.83% of the variation in the dependent variable of the respondents are explained by the independent variables listed in the table below while 76.17% is catered for by the error term included in the model. The result of the logit regression analysis revealed that nativity was significant at 10% with a positive coefficient and this indicate that the farmers are likely to gain more access to land by being a native of the village.

It further shows that membership in association with a was significant at 1% while belonging to more than one association was significant at 10% positive coefficient which indicates that there is possibility of accessing more lands if they belong to many associations that are relevant in farm work. Claiming to belong to same lineage was significant at 1% and with a positive coefficient which indicates that there is tendency of getting more farm lands if the members belong to same lineage. Collective work participation was significant at 1% and with a positive coefficient which implies that the likelihood of getting access to land if members of the association works together while numbers of time member participate in group activities was significant at 5% and with a negative coefficient which implies that the farmers are not likely to get access to land if the time members participated in group activities is not encouraging.

Table 2. Logistic Regression of socio-cultural networks effect on land access

Explanatory Variables	Coefficients	Standard errors	Z-values	P>/Z/-values
Nativity	0.9957014	0.5259206	1.89*	0.058
Membership	1.546302	0.5592298	2.77***	0.006
Number of association they belong	0.4601115	0.2579883	1.78*	0.075
Members living within same area	-1.173986	0.7161305	-1.64	0.101
Members belonging to same clan/family	2.325003	0.8304925	2.80***	0.005
Members work with others in the village	0.0822029	0.9045577	0.09	0.928

Collective work activities	0.483957	0.1997339	2.42***	0.015
Time members participate in group activities	-0.0724306	0.0297946	-2.43***	0.015
Constant	-3.869695	0.9341536	-4.14	0.000

Source: Field Survey, 2020.

Analysis of effect of socio-cultural networks on land utilization

This section presents the impact of social capital on land (use) utilization within the context of the methodology proposed in the analytical framework. Table 3 revealed the effects of social capital on land use, the likelihood ratio chi-squared of 36.89 with a p-value of 0.0000 reveals that the model as a whole is statistically significant. Pseudo R squared is 0.3573 which indicate that 35.73% of the variation in the dependent variable of the respondents are explained by the independent variables listed in the table below while 64.27% is catered for by the error term included in the model.

The variables that are statistically significant are membership, numbers of association they belong to, members live within same area. Membership was with a positive coefficient and significant at 1% which implies that farmers will be able to use more land by being members of the association. The estimated parameter for numbers of association they belong was significant and with a positive coefficient which implies that there is tendency of getting more land to use if they belong to many association. Members living within the same area was with a negative coefficient and was significant at 5% which implies that the probability of not getting more lands if members of the association are concentrated in one area.

Table 3. Tobit Regression showing the effect of socio-cultural networks on land utilization

Explanatory Variables	Coefficients	Standard errors	t-values	P>/t-values
Membership	0.2531795	0.0792379	3.20	0.002
Number of association they belong	0.0793754	0.0332445	2.93	0.019
Members living within same area	-0.1997423	0.0851853	-2.34	0.021
Members belonging to same clan	-0.1304056	0.093324	-1.40	0.165
Collective work activities	-0.321665	0.0189592	-1.70	0.092
Time members participate in group activities	0.0044134	0.0034573	1.28	-0.204
Constant	0.410707	0.0842795	4.87	0.000
/Sigma.3122521	0.0205281			

Source: Field Survey, 2020.

CONCLUSION/RECOMMENDATION

This study explores how socio-cultural networks relate to farmland access and utilization in Oriire Local Government Area, Oyo State, Nigeria. It provides empirical evidence that social capital has relative implication on farmland access and land utilization in the study area. Also, it was observed that most elements of socio-cultural networks which determined land access and use are linked to organizational and/or family-ties, thereby the study further affirmed that mode of land acquisition is often by inheritance, which denotes ownership. Therefore, the policy on land-use resource management need to factored in the influence of socio-cultural ethics on agricultural land use, especially at the local settings.

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Sustainability of Forest Resource Utilization: A Life Cycle Assessment Study



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Abstract

Sustainability design (as regards to products and services) for least environmental impact is the other of the day. This study assessed the Life Cycle Assessment (LCA) of selected manufacturing materials for home appliance manufacturing was investigated. A household chair as the case study was modelled using Solid works 2023 CAD software with three different manufacturing materials viz. Mahogany, Epoxy plastic and Galvanized steel and their respective environmental impact was assessed through cradle-to-grave principle using GaBi 4 LCA database. Results showed that the CAD and database employed were proficient in handling the LCA processes. Mahogany manufactured chair had 0.173 kg CO_{2e}, 1.2 MJ, 6.0E-4 kg SO_{2e}, and 1.2E-4 kg PO_{4e} contribution to carbon footprint, total energy consumed, air acidification and water eutrophication environmental impact, respectively. Epoxy plastic manufactured chair had 1.4 kg CO_{2e}, 20 MJ, 2.6E-3 kg SO_{2e}, and 5.1E-4 kg PO_{4e} contribution to carbon footprint, total energy consumed, air acidification and water eutrophication environmental impact, respectively. Galvanized steel manufactured chair had 3.7 kg CO_{2e}, 48 MJ, 0.015 kg SO_{2e}, and 1.4E-3 kg PO_{4e} contribution to carbon footprint, total energy consumed, air acidification and water eutrophication environmental impact, respectively. This shows that Mahogany manufactured chair had the lowest environmental impact, which is attributed to its green nature while galvanized steel manufactured chair had the highest environmental impact, which is attributed to its synthetic nature. Therefore, Mahogany has an edge in the production of sustainable household appliance such as chair.

Keywords: Mahogany wood, Galvanized steel, Epoxy plastic life cycle assessment, and Environmental impact

INTRODUCTION

In the recent times, the result of urbanization and industrialization has been highly detrimental on the environment (Adeyi *et al.*, 2018) because of deforestation and release of dangerous manufacturing chemicals into the environment. This had led to global warming and irrational weather changes, amongst other environmental problems. The environmental issues have prompted the development of assessment tools to clarify the impacts so that policy makers and dwellers could make necessary adjustments (Kawata *et al.*, 2012). In addition, this has led to the emergence of Life Cycle Assessment (LCA), an analytic tool to understand the potential or likely environmental impacts concerning a product and or service. To carry out a detailed and reliable environmental impact study, LCA tools are utilized to qualify and characterise the inputs and outputs of the specific system associated to the product, process or service throughout its life cycle (Lee, 2021). With the resulted impact study, user can identify the hotspot within the investigated system that can be very useful in supporting decision-making and product designing. A pictorial representation of LCA process is shown in Figure 1.

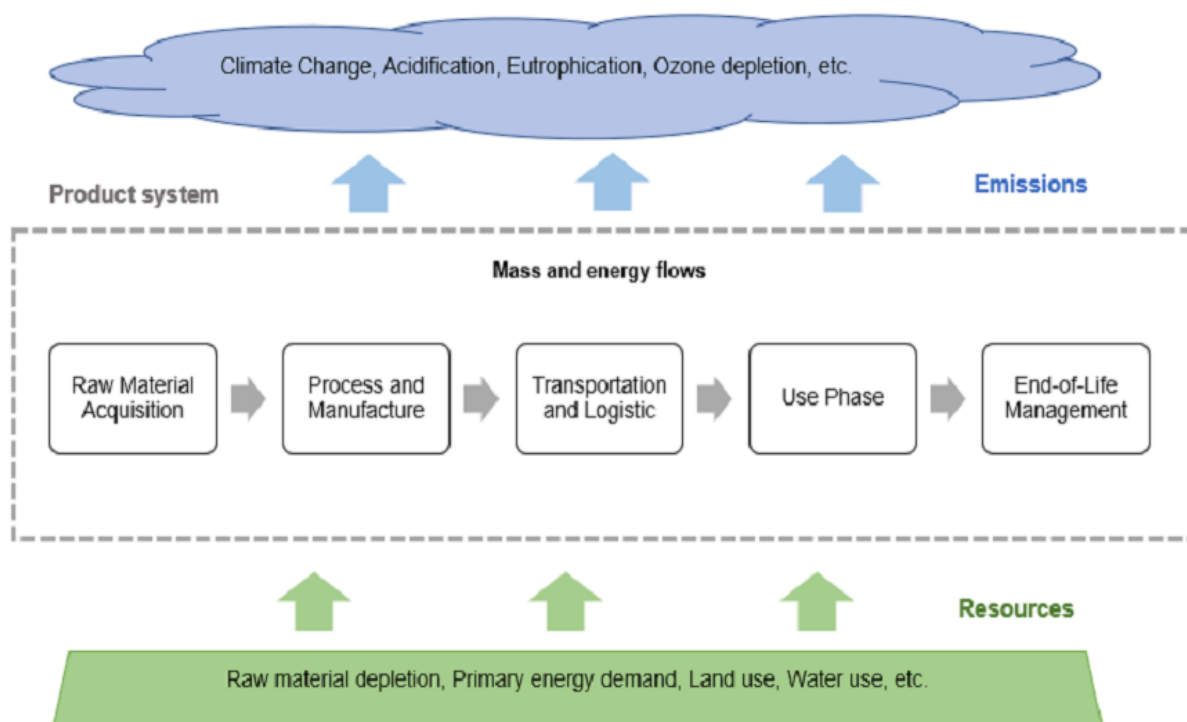


Figure 1 Typical LCA Process (Source: Lee, 2022)

Usually, the LCA of a product is conducted with cradle-to-grave or gate-to-gate principle. The cradle-to-gate includes the procurement of raw material, complete set processing utilized for manufacture, transportation in sub-stages, use phase and final disposal for recycling or incineration as the case may be. The compositional stages form the modelling boundary for the LCA (Yadav *et al.*, 2022). The gate-to-gate is a subset of cradle-to-grave where the modelling boundary could be adjusted at will. Engineering design has progressed because of challenges desiring new solutions (Adeyi, 2023). Traditional engineering designs take care of safety, satisfaction, durability, cost and finesse, amongst other requirements for products and services design and delivery; however, our current realities is asking engineers to also consider the environmental impact of the process, products and services. This will help preserve nature, thus preventing impairment of life. Experience shows that many home appliances including doors, chairs, wardrobe, tables, bed, and others, which were previously manufactured with wood materials; have been substantially substituted with plastics and metallic materials. Although this change of material seems beneficial to product beautification, durability and reduction of pressure on wood products (by lowering deforestation), the fact still remains that plastic and metallic materials may be persistent after their use and impact the environment negatively. In fact, majority of illicitly disposed plastics that have found their way into oceans have been very detrimental to water habitats (Adeyi *et al.*, 2018).

Therefore, this study was carried out to investigate the environmental impact of wood, plastic and metal in household manufactured product. This was achieved by modelling a representative household product viz. Epoxy plastic manufactured chair, Galvanized steel manufactured chair and Mahogany wood resource manufactured chair using Solid works 2023 CAD software, and conduct a comparative life cycle assessment (LCA) study for the modelled chairs using GaBi 4.0 environmental impact assessment (EIA) database.

MATERIALS AND METHODS

LCA tools are applied to quantify the amount of energy used, the consumption of raw materials, the emissions to the atmosphere and the volume of waste generated within the defined system (Yadav *et al.*, 2022). A LCA study procedure for a typical product system is represented in Figure 2.

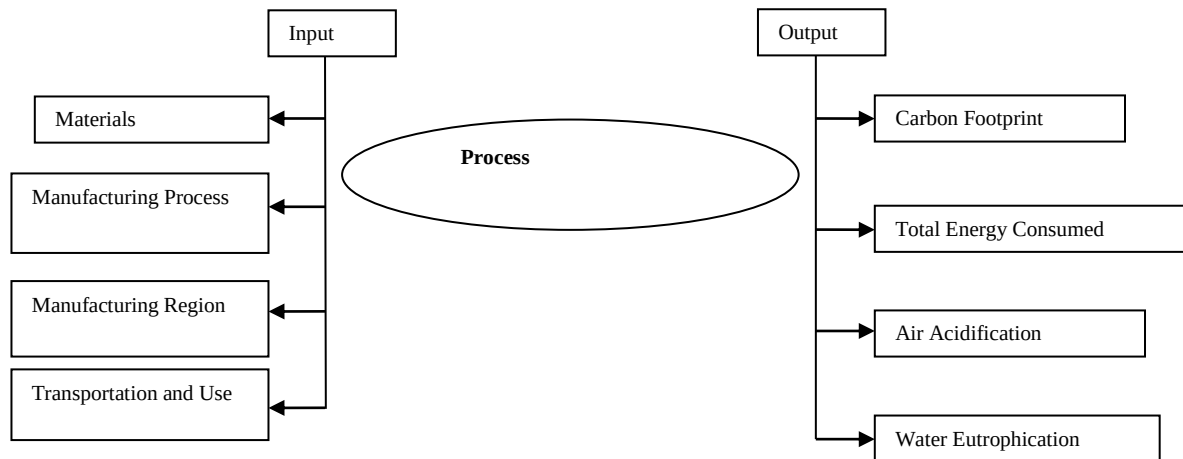


Figure 2 LCA Procedure

In the input category of the LCA modelling, materials phase involves all the steps utilized from mining raw ore to manufacturing of the materials including energy and other resource consumed and transportation that are typically involved in the process. The manufacturing process phase details the environmental impact associated with each process choice, for example, milling, casting, injection moulding and others. As for the manufacturing region, each region of the world uses a different combination of methods to generate electricity (for instance fossil fuels, hydro-electric, nuclear and other) and the measure of energy generation has different environmental impact on the region. The transportation and use phase takes into account the environmental impact of transporting parts from where they are manufactured to where they are used. The distance to travel between regions and the method of transportation (truck, ship, train or air) determines the level of environmental impact. The distance travel between the regions and the method of transportation determines the level of impact. The end of life (EoL) modelling phase refers to what happens to components when their intended use comes to an end. Components can be recycled, go to landfill or incinerated.

In the output category, carbon footprint refers to carbon dioxide and other gasses, which result from the burning of fossil fuels, accumulate in the atmosphere that in turn increases the earth's average temperature. Carbon footprint acts as a proxy for the larger impact factor referred to as global warming potential (GWP). Global warming is blamed for problems like loss of glaciers, extinction of species, and more extreme weather, among others. Total energy consumed refers to a measure of the non-renewable energy sources associated with the part's lifecycle in units of mega joules (MJ). This impact includes not only the electricity or fuels used during the product's lifecycle, but also the upstream energy required to obtain and process these fuels, and the embodied energy of materials, which would be released if burned. Total energy consumed is expressed as the net calorific value of energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are equally taken into account. Air acidification refers to sulfur dioxide, nitrous oxides other acidic emissions to air cause an increase in the acidity of rainwater, which in turn acidifies lakes and soil. These acids can make the land and water toxic for plants and aquatic life. Acid rain can also slowly dissolve manmade building materials such as concrete. This impact is typically measured in units of either kilogram sulfur dioxide equivalent (SO_2), or moles H^+ equivalent. Water eutrophication refers to an overabundance of nutrients that are added to a water ecosystem. Nitrogen and phosphorous from waste water and agricultural fertilizers causes an overabundance of algae to bloom, which then depletes the water of oxygen and results in the death of both plant and animal life. This impact is typically measured in either kg phosphate equivalent (PO_4) or kg nitrogen (N) equivalent.

In this study, the goal was to conduct a cradle to grave analysis that involves the stages of raw material acquisition, processing and manufacturing, transportation and logistics and end-of-life (EoL) management. Assumptions made were that the chairs were built for 10 years usage, and 2, 18 and

80% of the materials used for manufacturing were to be recycled, incinerated and land filled. The Epoxy plastic manufactured chair was used as the baseline for Mahogany wood and galvanized steel manufactured chair because of the prevalence of plastic made chairs in homes, worship centres, offices and relaxation centres.

RESULT AND DISCUSSION

The designed and modelled chairs made of Mahogany wood; Epoxy plastic and Galvanized steel were presented in Figure 3.

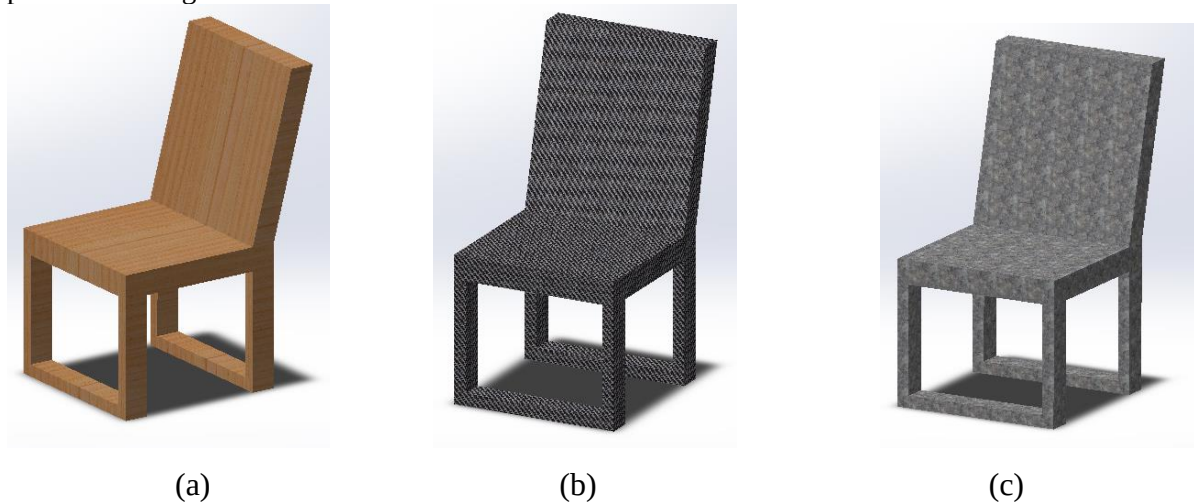
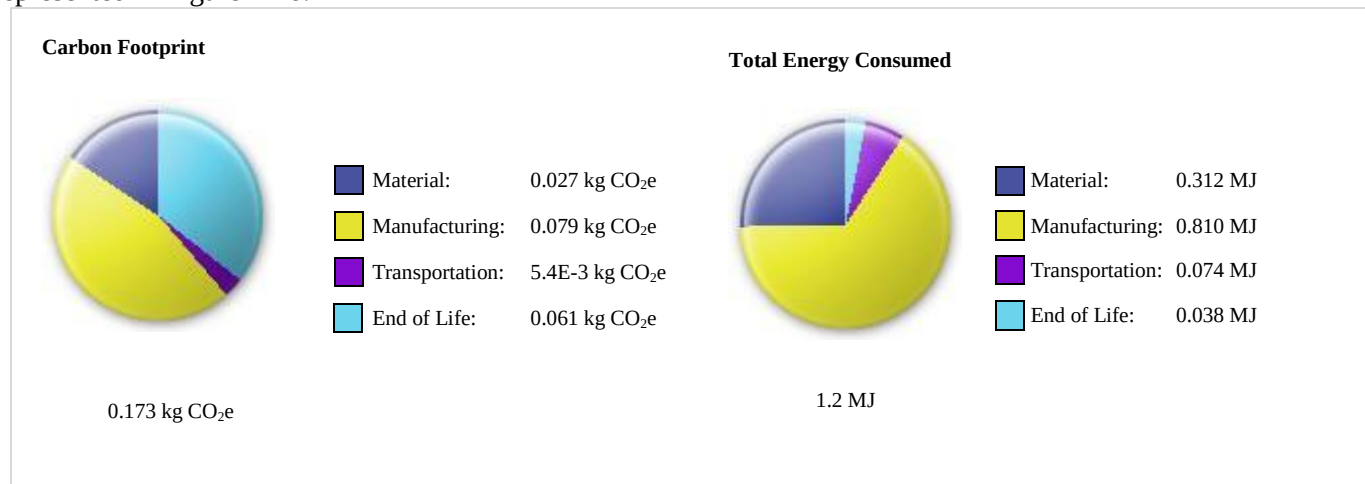


Figure 3 Design and CAD Model of (a) Mahogany Wood, (b) Epoxy Plastic and (c) Galvanized Steel Manufactured Chairs Used in this Study

The LCA result for Mahogany wood, Epoxy plastic and Galvanized steel manufactured chairs is represented in Figure 4 - 6.



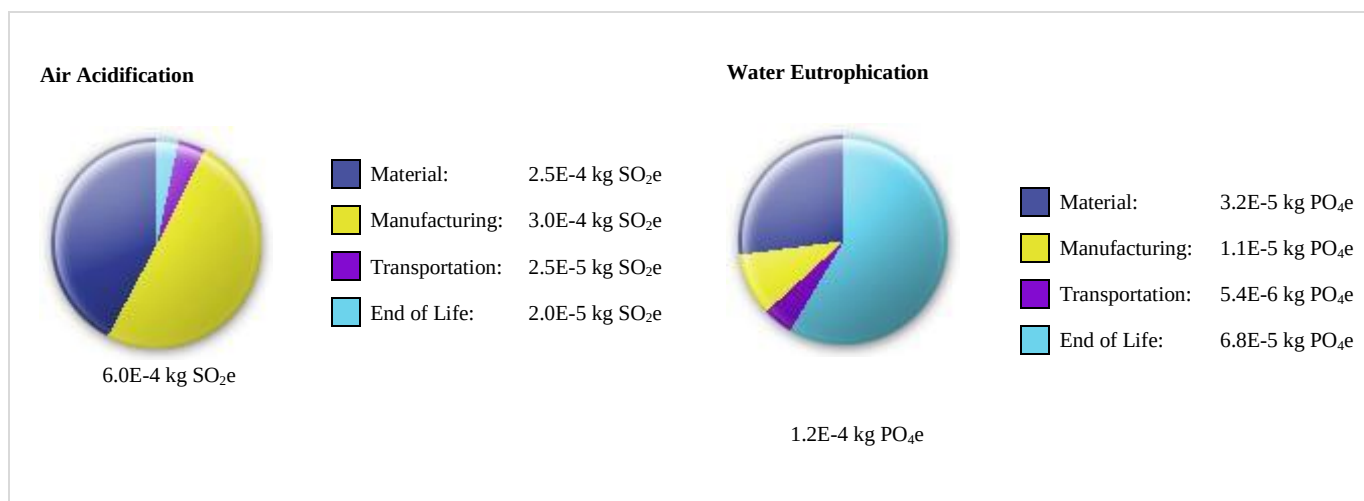


Figure 4 LCA of Mahogany Wood Manufactured Chair

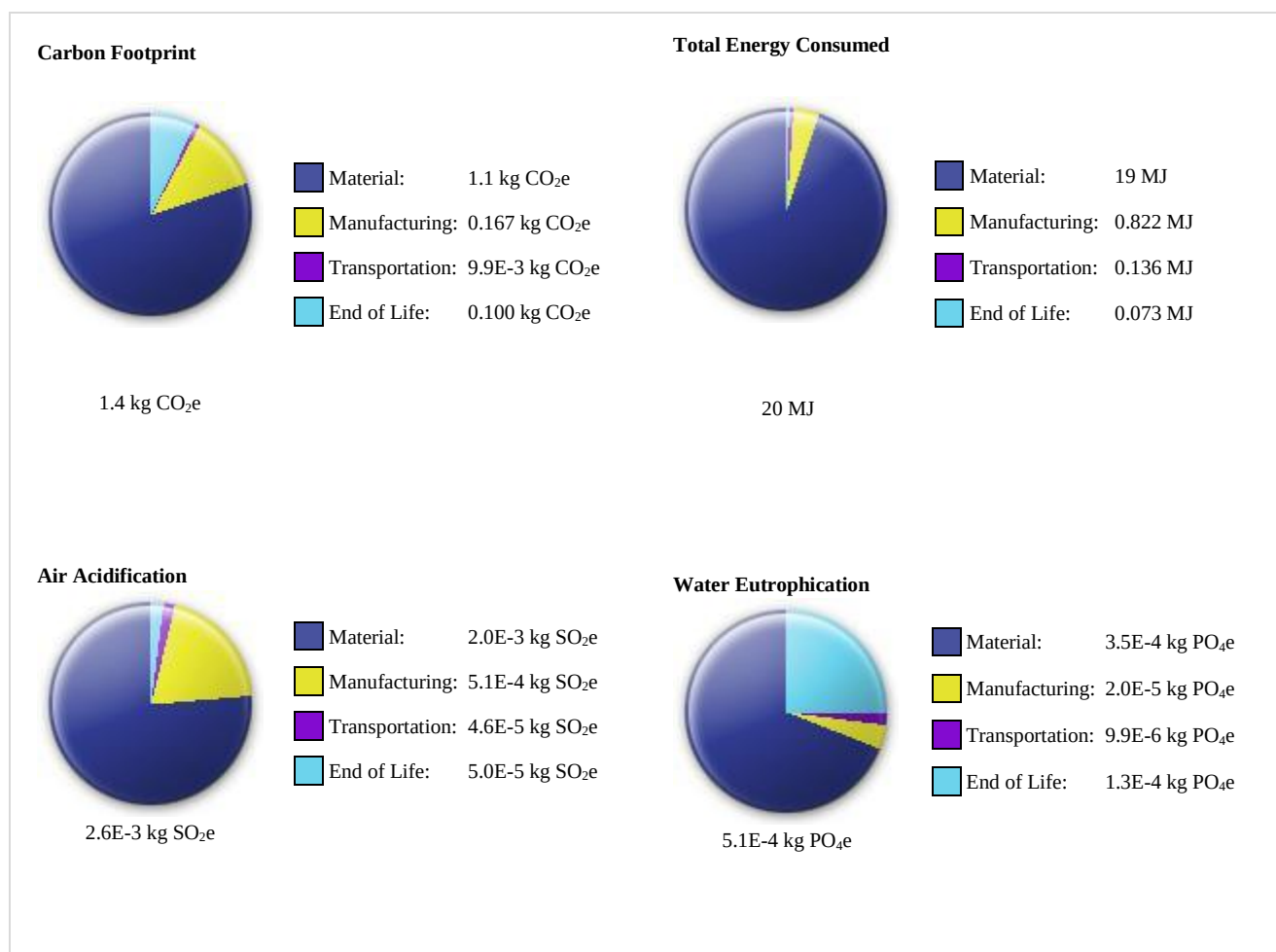


Figure 5 LCA of Epoxy Plastic Manufactured Chair

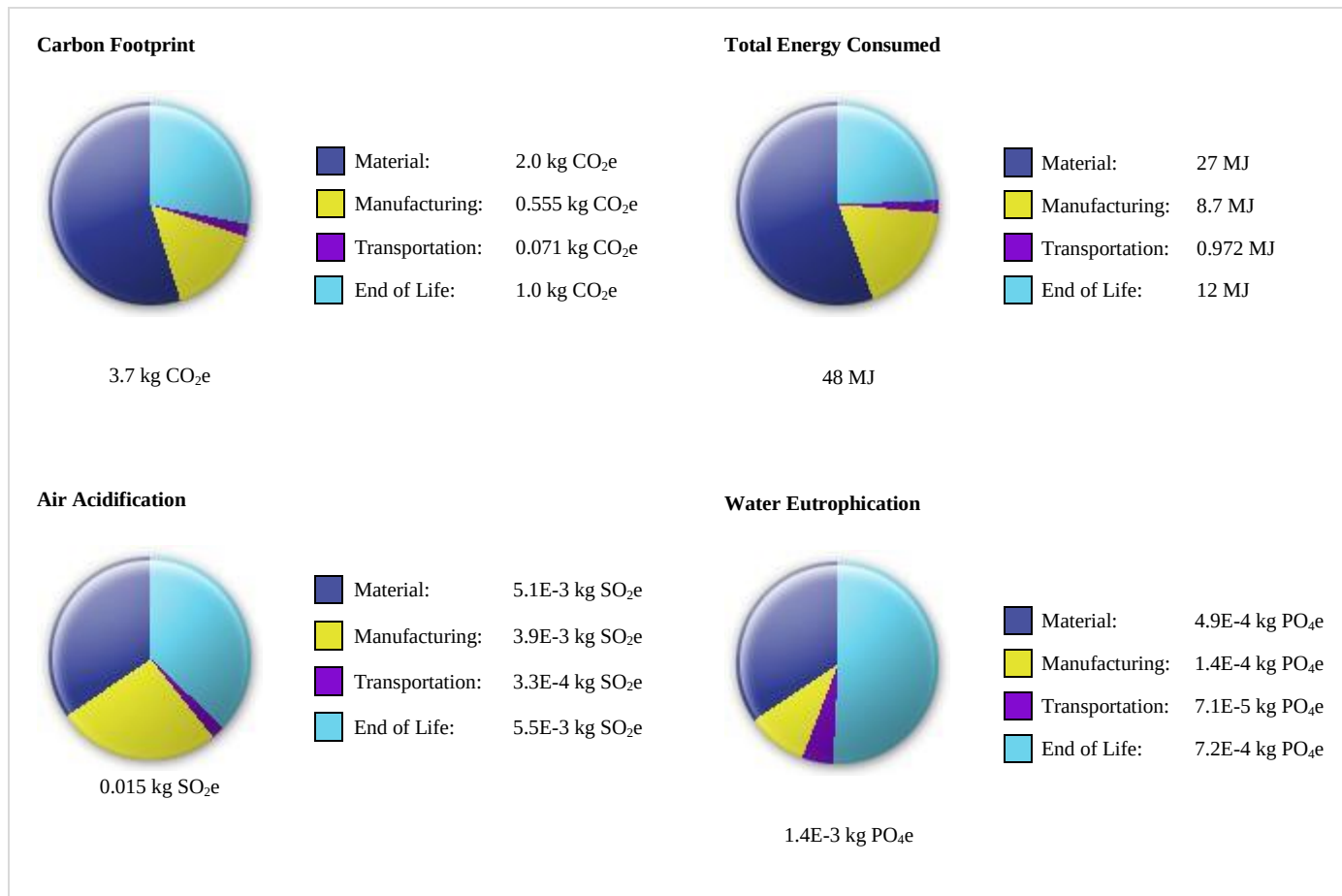


Figure 6 LCA of Galvanized Steel Manufactured Chair

The results show that the order of environment impact increased from Mahogany wood to Epoxy plastic and lastly to Galvanized steel manufacturing materials. In Mahogany wood manufactured chair, the manufacturing phase contributed to the most to carbon footprint, total energy consumed and air acidification environmental impact while EoL contributed the most to water eutrophication impact. In epoxy plastic manufactured chair, material phase contributed mostly to carbon footprint, water eutrophication, total energy consumed and air acidification environmental impact. In Galvanized steel manufactured chair, material phase contributed mostly to carbon footprint and total energy consumed environmental impact while EoL phase contributed mostly to air acidification and water eutrophication.

CONCLUSION

The results in this study showed that application of forest resource (Mahogany wood) to household chair manufacturing has the least negative impact on the environment. This was followed by Epoxy plastic and galvanized steel manufactured chairs. Therefore, it is concluded that Mahogany wood forest resource has the highest sustainability as a household appliance manufacturing material. The seeming pressure of deforestation that will be associated increase application of forest resources can be prevented through a sound afforestation program in the tropical countries, even in the desert using appropriate technologies such as hydrogels.

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Evaluation of Land Use Land Cover Changes of Baturiya Hadejia Wetland National Park, Jigawa State, Nigeria



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Abstract

Land use/land cover changes (LULCC) are usually accompanied by species extinction, reduction in biodiversity and decrease in primary productivity. Land use/land cover change patterns of thirty (30) years were used to project vegetative changes in Baturiya-Hadejia Wetland National Park. To examine the level of land use land cover changes, WGS-84/UTM zone 32N GIS analysis were used to project and describe the overall land use/land cover changes of the Park. Four land use types were identified in the study area; bare surface, dense vegetation, water surface and sparse vegetation. The result showed a decrease in bare surface (BS) area from 36.38% to 9.0%, dense vegetation (DV) increased from 9.46% to 93%, water surface (WS) changed from 6.46% of the total park area to 14%. Sparse vegetation (SP) also changed from 45.18% to (85%). Findings from this study revealed that there were positive significant changes in land used type over a period of 30 years. Hence, the study suggests conservation strategies to protect woody species against anthropogenic pressures, rather than following a strict protectionist approach in the management of the Park.

Keywords: Evaluation, land use, land cover and National Park

INTRODUCTION

Baturiya Hadejia Wetland National Park supports farmers, herdsmen and fishermen who depend on the wetland for their livelihoods (NCF, 2003). Based on natural annual flooding, the wetland performs a number of economic and ecological functions which are critical to local, national, and international communities (Kabir, 2006). Land use/land cover changes (LULCC) are usually accompanied by species extinction, reduction in biodiversity and decrease in primary productivity (FAO, 2001).

Land-use and land-cover change has been considered an important research topic for global environmental change and sustainable development. As an important part of worldwide sustainable development. Many previous studies have focused on revealing the effects of LULCC, e.g., the significant effects on resource production and the influence on climate change, soil erosion, biodiversity, food security, and even threats to public health. However, to examine the process and trends of LULCC via quantitative analysis is a prerequisite to gain a deeper understanding of LULCC, help policy makers set improvement targets in specific areas and adopt appropriate practices. Based on this, the influence of the land-use and land-cover datasets, their high accuracy and long-time scale features, are used to identify patterns and processes of LULCC (Yunfeng *et al.*, 2018).

Deforestation is an important process of LULCC, and it is also a factor that provides feedback for the drivers of land-use change. The effects of LULCC can threaten economic development and food security. Therefore, understanding the deforestation process and the related drivers in a quantitative way is necessary to provide appropriate policy intervention (Barlow, 2016). Biodiversity is the relationship between species and their pattern of richness (Young and Swiacki, 2006). Globally, it has been affected through a series of activities which may broadly be categorized into two. Those that produce direct effects such as hunting, fishing, and over grazing and those that produce indirect effects through destruction (bush burning, road construction) and modification of the environment (WWF, 2014). The National Park, being a tropical rainforest ecosystem consist of broad-leaved

evergreen trees and many species of shrubs, herbs, climbers, lianas, and epiphytes naturally arranged in a multi-story structure (Ajayi and Obi, 2016)

Land use/ land cover was determined over a period of thirty years in this study with the use of remote sensing using geographic information system. Remote sensing has been used in research of land use/land cover changes for many years with different perspectives such as mapping forest fires, vegetation covers and detecting changes in land cover through different periods (Dorren *et al.*, 2003). Use of remote sensing for mapping vegetation is a widely used technique in ecological research since it can quickly determine the formation, distribution, and change of land cover for very large areas (Hoersch *et al.*, 2002).

Geographic Information System (GIS) for forest assessment monitor changing conditions and make intelligent decisions for sustainable care. GIS can be used to assess conditions through historical analysis, stand inventory, soil types, changing weather patterns, and land-use practices. Modeling enables users to test and consider options in both temporal and spatial contexts (MacDonald, 2010).

MATERIALS AND METHODS

Study area

Baturiia Hadejia - Wetlands is a wide expanse of flood plain wetlands situated in North - Western Nigeria. The location lies in the sudano-sahelian zone, which is the zone between the Sudano Savanna in the south and the Sahel in the North. The wetland is found in Yobe State, and includes the Nguru Lake (Saka *et al.*, 2020). Baturiia which is a section of the Hadejia Nguru Wetlands National Park, is located on the Latitude 12°20' N to 12°40' N and Longitude 10°10'0" E to 10°30'0" E in the south (Figure 1). Mean annual rainfall ranges from 600 mm to 850 mm (Ramsar, 2008). The vegetation of the study area is of Sudano - sahelian type, comprising varieties of *Acacia spp*, *Adansonia spp*, *Tamarindus spp*, *Mitrogynus spp*, *Diospiros spp*, *Faidherbia spp*, *Ficus spp* and *Hyphaene spp* e.t.c. The vegetational cover is dense with tall trees (Jigawa State Ministry of Agriculture and Natural Resources Policy – (JSMARP, 2016)

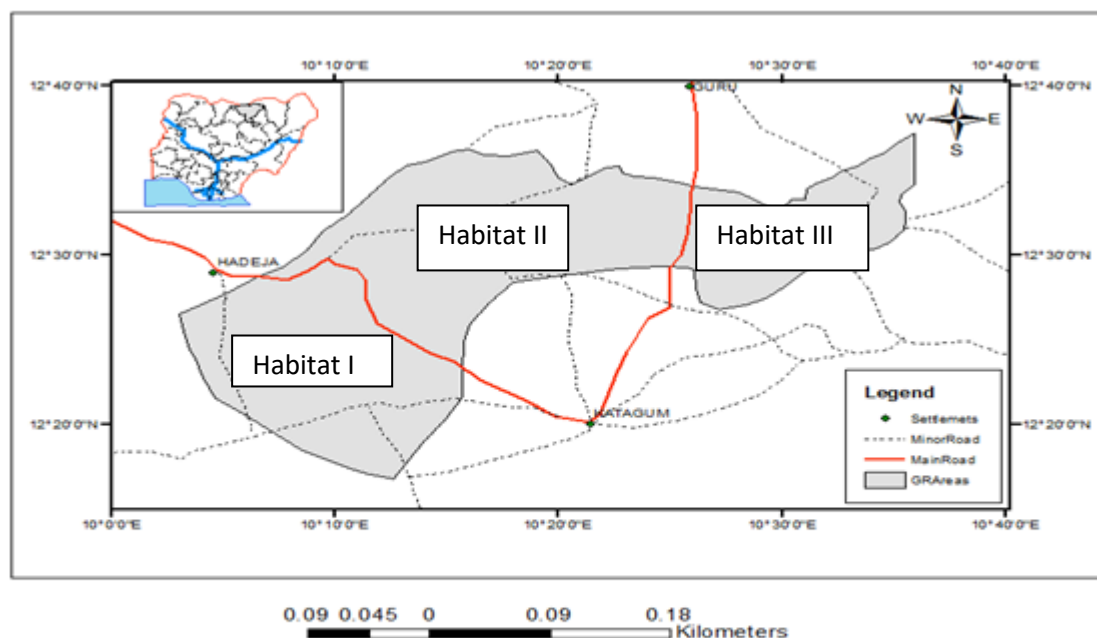


Figure 1: Map of Baturiia Wetland Game Reserve

Source: GIS Laboratory, Geography Department MAUTECH Yola 2017

Figure 1. Map of Baturiia Hadejia Wetland National Park

Sampling Techniques

A reconnaissance survey was done in the study area to assess the general features of the area; different sites in the area were monitored and identified. The land use land cover changes of the study area for a period of thirty years (30 years) was assessed using Remote Sensing Techniques. Data collected ranged from 1990 to 2020 at the interval of ten years (10 years) as adopted by Selçuk Reis (2008).

Data Analysis

Remote sensing GIS Software were used to classify features. The outputs of digital imageries were produced and exported to Arc map for further analysis. WGS 84 / UTM zone 32N GIS analysis were used to generate the level of land use land cover changes in the study area (Abubakar (2015).

RESULTS

Table 1 showed the satellite image classification of Land sat for four variables of land use and cover changes (Figure 2) between 1990-2020. Bare surface, (BS) Dense vegetation, (DV) Water surface (WS), Sparse vegetation (SV) and unclassified variables were identified in percentages of land size.

Table 2 showed the computed variables of bare surface (BS), water surface (WS), sparse vegetation (SP) and dense vegetation (DV). There was a dramatic reduction in; bare surface, land area from 36.38% of the total area of the reserve in 1990, to 9.0%, and a significant increase in dense vegetation from 9.46% in 2020 to (93%). However, the water surface area of the reserve that occupied 6.46% of the total reserve area in 1990 increased to 14% in 2020. Sparse vegetation occupied 45.18% but had a rapid increase to (85%).

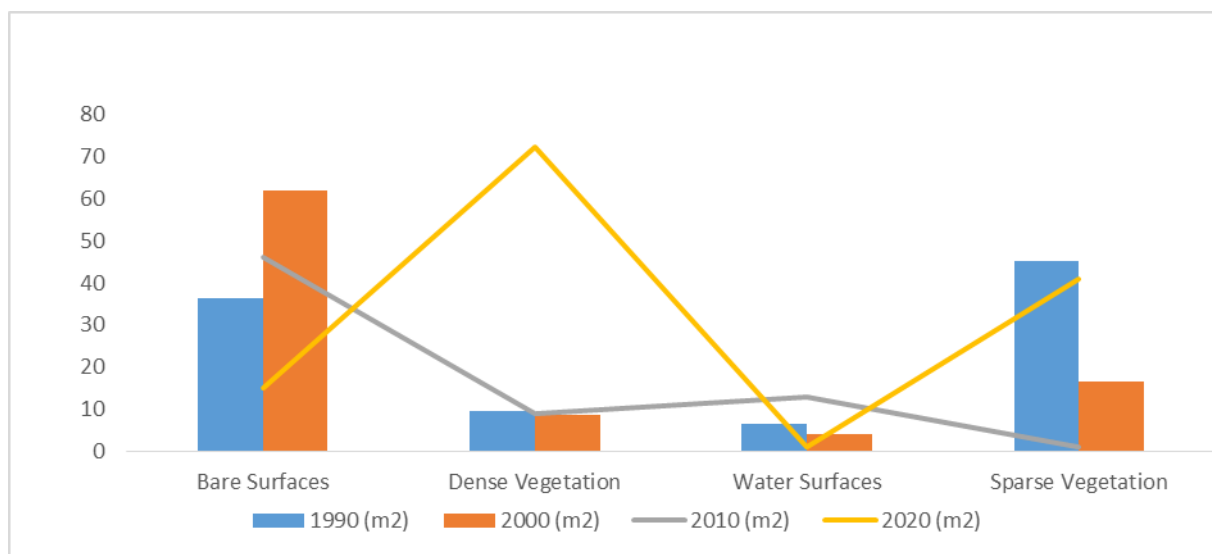


Figure 2. Satellite image classification and distribution between 1990 - 2020

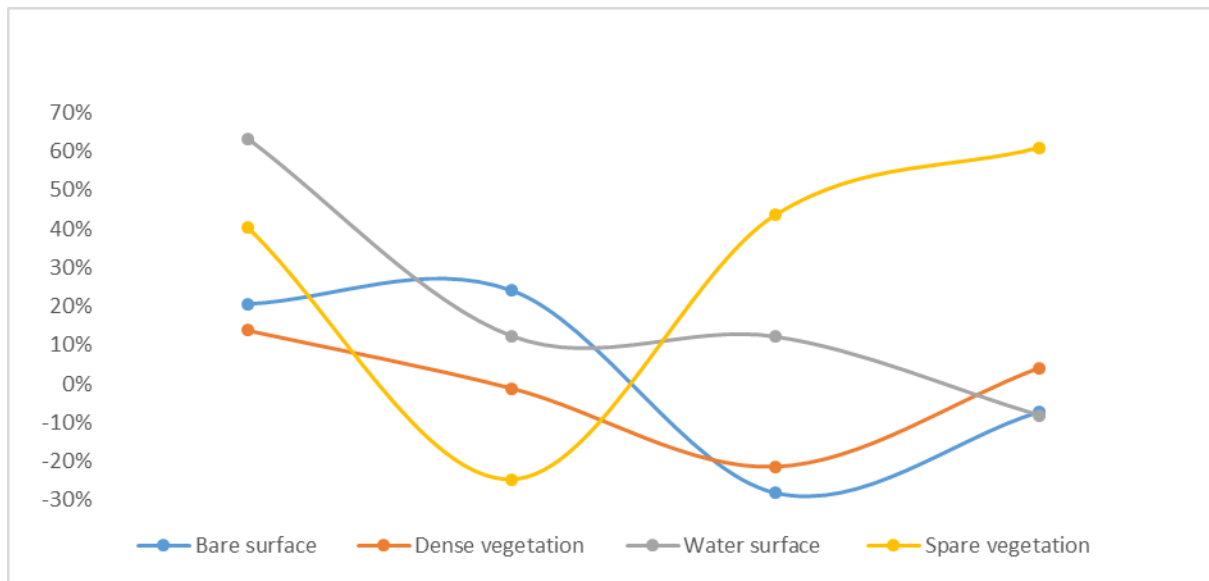


Figure 3. Land use/land cover change patterns between 1990 - 2020

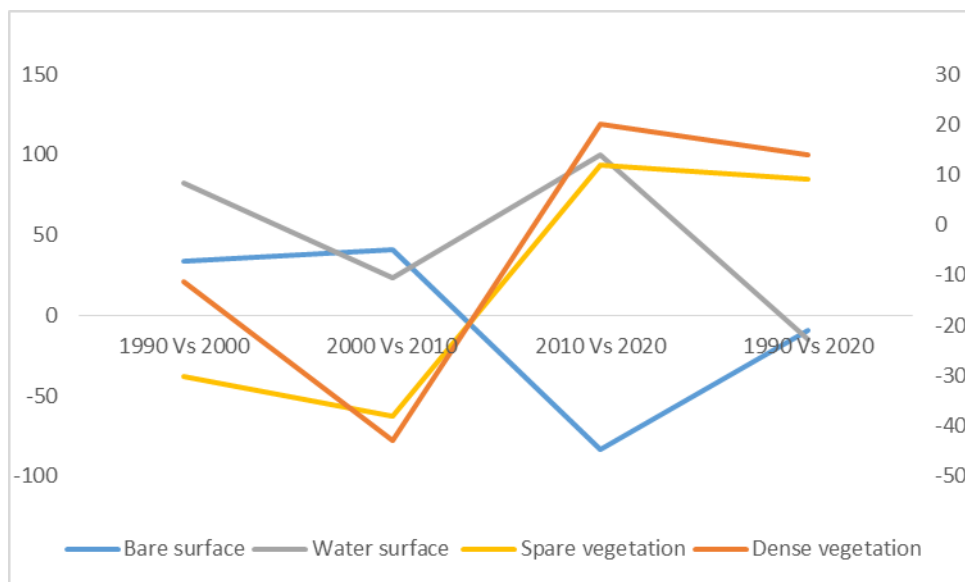


Figure 4. Variation in land use/land cover changes and distribution pattern every ten years

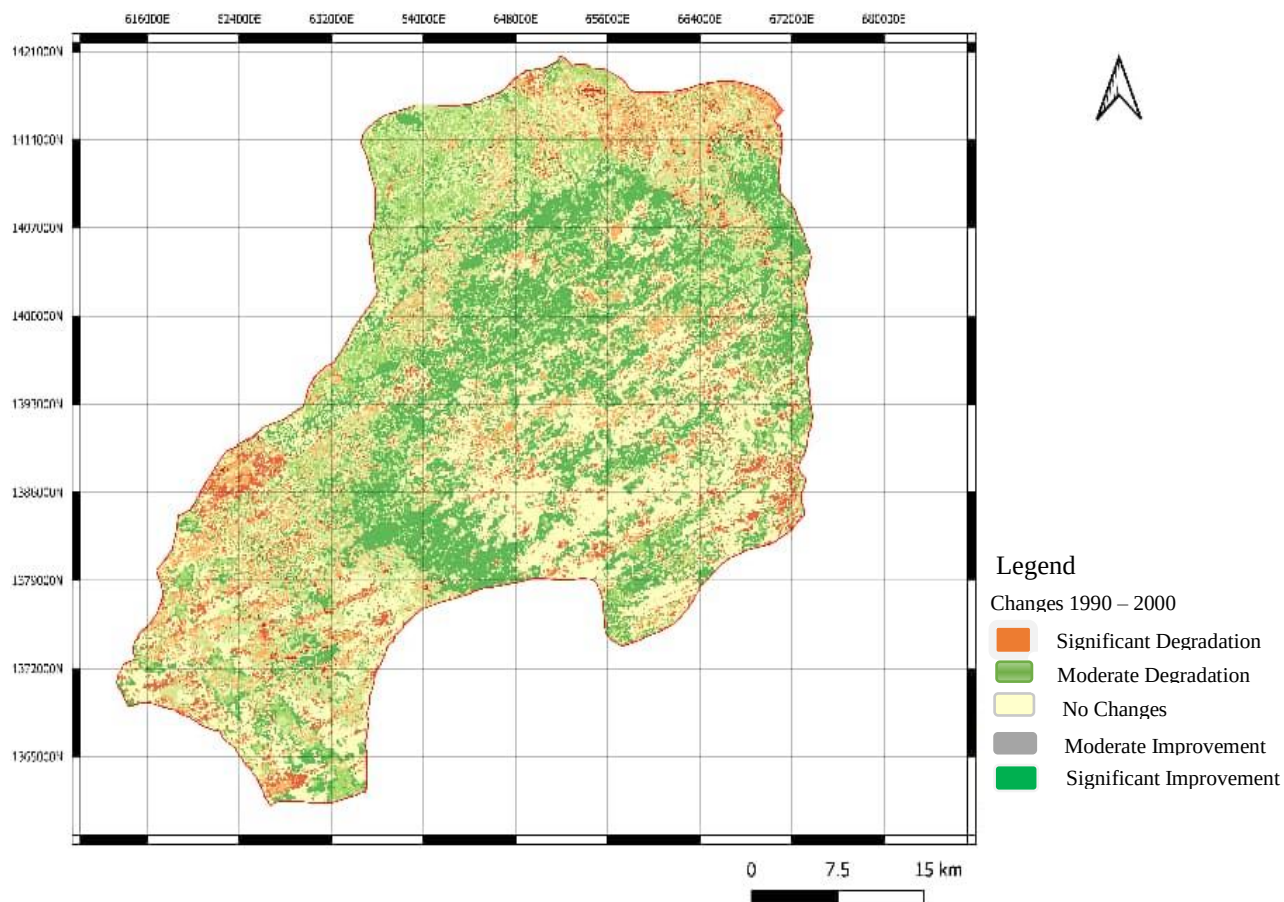


Figure 5. Classification image of land use and land cover changes between 1990-2000

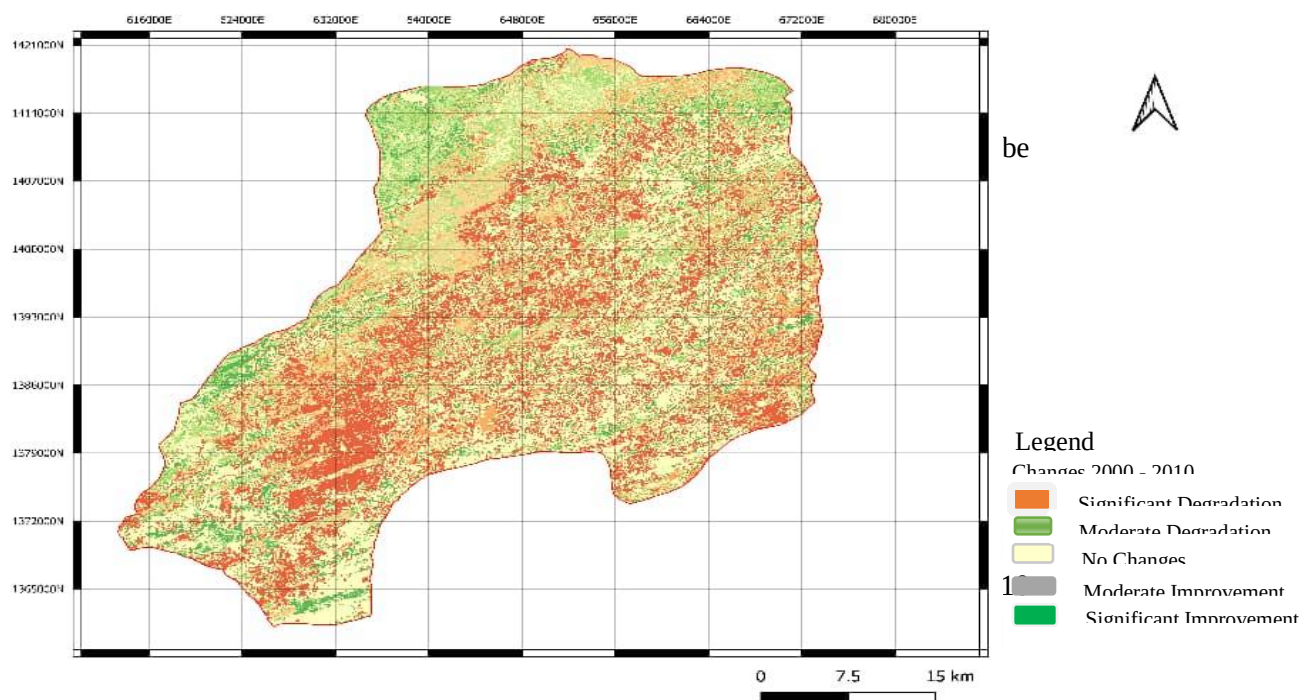


Figure 6: Classification image of land use and land cover changes between 2000-2010

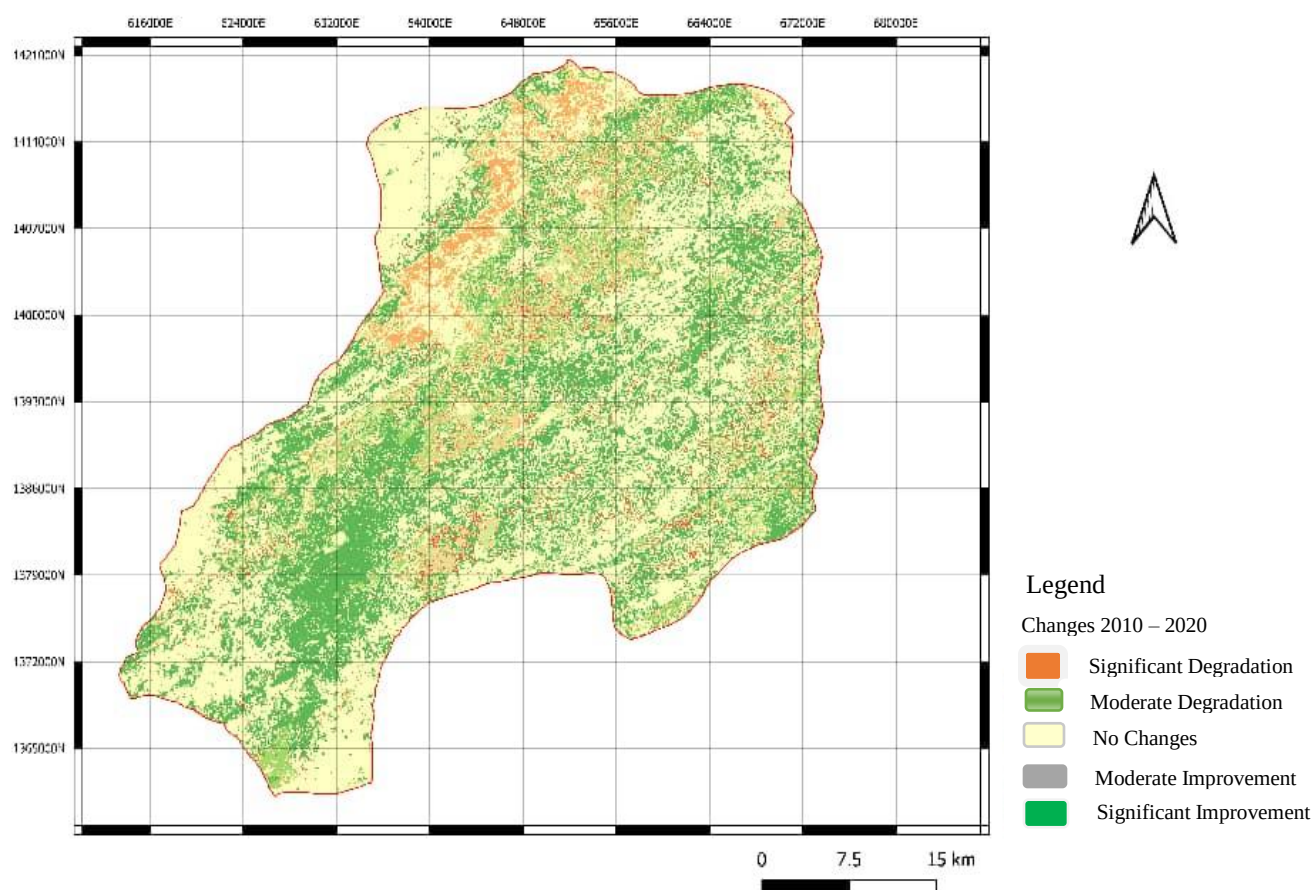


Figure 7. Classification image of land use/ land cover changes between 2010 - 2020

DISCUSSION

It is preferable to use remote sensing data and automated image analysis techniques for consistent and repeated monitoring of land cover changes over large areas and for long periods of time. Several types of remote sensing data including Aerial photography, Optical Multispectral Scanner, Radar, Lidar (Laser) and Video graphic data have been used by forest research and operational agencies to detect, identify, classify, measure and evaluate the various forest cover types and their changes. Four variables: Bare surface, Dense vegetation, Water surface, and Sparse vegetation were identified. This indicated that BS in 1990 recorded 36.38%, year 2000 (62.09%), year 2010 (46.20%) and year 2020 (14.99%). The DV of 1990 was 9.46%, year 2000 (8.63%), year 2010 (8.79%) and year 2020 (72.30%), followed by WS of 1990 with 6.46%, year 2000 (12.71%), 2010 (4.04%) and 2020 (0.89%), and SV of 1990 with (45.18%), 2000 (16.56%), 2010 (0.89%) and 2020 (40.95%) and unclassified variables of 2.53% and 0.31%. The results differ from the findings of Yunfeng *et al.* (2018) who identified water body of 98.74%, woodland of 99.49%, grass land of 96.49% and crop land of 99.04% in the LULCC in Guangxi, China.

From 1990 - 2020, there were significant changes in almost all the variables. Bare soil which occupied 36.38% in 1990 decreased to 14.99% in 2020. Also, the probabilities indicated serious threats faced by the reserve from anthropogenic activities. The DV area of the reserve occupied 9.46% of the reserve in 1990 but increased to 72.30% in 2020. This may be due to climate variability in conformity with the findings of Ezenwa *et al.* (2018). The authors opined that climatic variability affected livelihood choices among rural populace in Baringo County, Kenya and Jigawa State, Nigeria. This increase could be as a result of coppicing management, proper monitoring and increased soil nutrients. This is in conformity with the work of Šrámek *et al.* (2015), who mentioned that coppice management influenced structure, tree

growth and soil nutrients in temperate Turkey. Whereas, WS of the reserve had declined drastically from 6.46% in 1990 to 0.88% in 2020. The anthropogenic activities which were the most common drivers of land use land cover changes, included logging for timber, commercial agricultural development, urban and mining expansion, fuel wood collection, livestock grazing and farming practices (Yunfeng *et al.*, 2018). This result is close to the findings of WWF (2014) and Dutt *et al.* (1994) on the role of remote sensing in forest management in India.

Land use/land cover change patterns over thirty (30) years were used to project future changes (Figure 3). The ten year intervals showed that change patterns and variations were quite drastic in the categories. Between 1990 - 2000, the dense vegetative area in the Park had decreased by 8.63% (-173326570.5m²) from what was obtained in 1990 (9.46% or 190037804.7m²). This is in conformity with what Jatau (2011) found in Gerei forest reserve, Adamawa State, Nigeria, where about 497 ha of forest were lost in just 15 years. Hence, 0.83% of the dense vegetation was cleared and this subsequently gave rise to increase in bare surface area (1246941816m²). In addition, 62.09% increase was observed in water surface (255360906.6m²) i.e. 12.71% from (129661198.7m²) 6.46% of the reserve area. Ezenwa *et al.* (2018) reported that climatic variability was placing pressure on livelihood choices and encouraging the clearing of vegetation among rural populace in Baringo County, Kenya and Jigawa State, Nigeria. Other research (Yunfeng *et al.* 2018; Anons, 2019) have recorded that the most common drivers of land use land cover changes, were commercial agricultural development, logging for timber, urban and mining expansion. The result of 2000 to 2010 revealed significant degradation in the reserve, with a reduction from 3312129.9m² to 126349068.8m² in 10 years. This is attributed to increased logging and other anthropogenic activities in connection to climate variability. A sizable portion of the reserve had been earmarked as farmland and wind mill for farmers and nomadic-Fulani herdsmen to sustain their animals and livelihoods (Isa *et al.*, 2016).

From 2010 to 2020, the sparse vegetative cover of the reserve was significantly improved from 63% to 93% (124345142.8m²). About 30% of reserve had been covered with some vegetation, resulting in a decrease in the bare surface (524140045.8 m²). This result is similar to the finding of Abubakar, (2015), and the positive change may be due to increased precipitation in the reserve (Ezenwa *et al.*, 2018). In addition, coppice management, proper monitoring and supervision have been identified as positive factors (Šrámek *et al.*, 2015). Furthermore, the images of the land use/land cover changes (Figures 5, 6 and 7) revealed significant improvement in the recovery of vegetative cover on the study site.

CONCLUSION

This research evaluated land use/land cover changes in Baturiya Hadejia Wetland National Park. Four land use type were identified in this study i.e. Bare surface, Water surface, Dense vegetation and Sparse vegetation. Findings revealed that there were positive changes (significant improvement) in the vegetation cover over the last 30 years. Nevertheless, conservation strategies are required to protect biodiversity and reduce anthropogenic pressures, rather than following a strict protectionist approach in the management of the Park.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

ACKNOWLEDGMENTS

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Diet, Foraging Ecology and Nest Count of the Black And White Casqued Hornbill (*Bycanistes subeylindricus*) in Okomu National Park Ecotourism Planning, Edo State, Nigeria



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Abstract

This research study examined the diet, foraging ecology and nest count of black and white Casqued Hornbill (*Bycanistes subeylindricus*) in Okomu National Park. The *Bycanistes subeylindricus* is flagship bird species, and studying the diet will help in the conservation thereby promoting ecotourism in the park. This study followed the direct observation method. Field observations were carried with the aid of binoculars (Bushnell 75) and field surveys were conducted during the early morning or late evening when birds were actively feeding with the least amount of disturbance. Each time a visit was made, observations were made regarding the foraging area, the technique of feeding used, the feeding session, the numbers of birds, the type of meals, and any interactions with other bird species. Based on the following traits, cavities were deemed potentially favorable for hornbill nesting: name of the tree species, ecology of the surrounding area, the bole of a tree or a wide branch that is at least 10 cm in length, width, and diameter, and occasionally evidence that a hornbill had lived there, such as old feathers, heaps of seeds, or dried mud used to cover cavities. The results indicated that 36 plants from 18 plant species were used by the bird species in the study area. The Moraceae family has the most plant species with 7, and the Fabaceae family with 5 species. The results showed that six primary plant species account for the majority of *Bycanistes subeylindricus*' diet. *Focus exasperata* had the highest frequency of observation at 34, and *Elaeagnus guineensis*, with a 20 percent consumption rate throughout the year, followed. Plant species were more readily available in the wet season (54% more than in the dry), yet both seasons saw use of 45% and 5% of plant resources.

Keywords: Diet, Foraging ecology, Home range, Nest count, and Ecotourism development

INTRODUCTION

Many species of hornbills have enormous bodies, spectacularly expanded casques, brilliant black-and-white plumage, and loud, far-reaching calls, making them some of the most identifiable birds in the world. Due to their crucial roles as seed dispersers, hornbills are common inhabitants of forests, where they are classified as keystone species (Holbrook and Smith 2000; Kemp 2001). Because they have large home ranges, larger species are sensitive indicators of environmental deterioration (Kemp, 2005). Indigenous peoples from West Africa to New Guinea rely heavily on hornbills as a source of food and for the feathers, beaks, and other parts needed for cultural activities (Kemp, 2001). In Africa, habitat fragmentation, especially of forests, is happening at a very fast rate (Datta, 2008). This makes it unsurprising that habitat destruction and fragmentation have been cited as reasons for the reduction of African Hornbill populations. Northern Ground Hornbills have been known to have home ranges up to 260 km² (Chuaillua, 2018). The Brown-cheeked Hornbill and Black-casqued Hornbill's respective mean home range sizes were 27.16km² and 28.72km², according to radio telemetry data (Holbrook and Smith, 2000).

Hornbills are secondary cavity nesters, using either naturally occurring or cavities that other birds have dug (Kemp, 2005). Hornbills have unusual breeding habits in that the female of most species seals herself

inside a nest cavity and only allows a tiny opening through which the male can feed her until the nesting time is through (Kemp, 2001). Hornbills frequently exhibit strong nest-site fidelity, returning year after year to the same nest cavity (Poonswad *et al.* 2004). A survey of the literature suggests that there are no comprehensive studies on the breeding ecology, despite the fact that (Oliver and Wilkinson, 2017) offered some information on the nesting of Indian Grey Hornbills. There is no doubt that the majority of animals are dominated by their insatiable desire for food as feeding is one of the fundamental behaviors of all animals. The type of food that most animals need and how those meals are supplied have an impact on their structure and behavior (Mudappa, 2000). The Black and White Casqued Hornbill's diet, foraging ecology, and nest site characteristics have not been studied in my country. As a result, this research study will look at the diet composition in relation to seasonal changes in these bird species, the foraging ecology, as well as the roles of fruit availability during the breeding season.

MATERIALS AND METHOD

Study Area

Okomu National Park is a fully-fledged national park that is located in the Ovia Southwest Local Government Area of Edo State, Nigeria. The park was designated as such by Decree 46 of 1999. Only around 15% of the land area that was formerly the Okomu Forest Reserve, which had a total land size of 1200km², is covered by the park, which has a total land area of 181km (N P S, 2016). Its located at 5.267o East and 6.33o North. The National Park is located immediately south of Udo Town, the closest significant settlement, and is about 60 kilometers west of Benin City, the capital of the Edo State. The park's topography is flat and varies from 30 to 60 meters above sea level; some parts have no discernible slope. The Okomu River and a handful of its tributaries effectively drain the area. The water table rises above the surface of the ground in numerous places, creating treeless fresh water lakes and marshes, some of which dry up during the dry season. (Onojeghuo and Onojeghuo, 2015) The park is located in the geological area known as the western coastlands, which is made up primarily of Eocene-era sedimentary rock. Acidic sandy loams, also referred to as "Benin sand," are the type of soil that are formed from deep, loose deltaic and coastal deposits. The area receives between 1524 and 1540 millimeters of rain annually. The driest months are December and January, and the wettest months are July and September. The average annual rainfall is 30°C. In the driest months, the relative humidity does not go below 65%, while in the wettest months, it reaches 100%. The sandy loam is nutrient-poor and acidic. (Isichei, 1995). Lowland rainforest of Guinea and the Democratic Republic of the Congo, with areas of swamp forest, high forest, secondary forest, and open scrubs. Kapok, *Celtis zenkerii*, *Triplochiton scleroxylon*, *Antiaris africana*, *Pycnathus angolensis*, and *Alstonia congensis* are a few examples of common trees. The best illustration of mature secondary forest is seen in the park. Numerous endangered plant and animal species, such as the forest elephant, *Loxodonta cyclotis*, and African Grey Parrot, call it home. In and around the park, there are 45 communities with about 50,000 residents. Large-scale illegal logging, the expansion of surrounding oil and rubber plantations, as well as intrusions by an expanding human population engaged in farming and hunting, pose ongoing threats to the area (Ekeoba, 2015)

the Park for one with a suitable cavity. Approximately three times each week, active nest cavities were examined for the presence or absence of hornbills, the integrity of the mud door, and other factors. They were closely watched (several times per week, for a period of many hours each time) by observers in blinds who recorded all actions saw (perching, flying, calling, feeding female, etc.).

Statistical Analysis

Data collected from the observations were explored with descriptive statistics. The computer PAST Model version 3 was used to analyze bird species diversity, generalized linear model, and SHE analysis

RESULTS

According to the results, *Bycanistes subeylindricus* consumed a variety of foods, including fruits, leaves, seeds, flowers, and insects of several plant species. The results showed that six primary plant species account for the majority of *Bycanistes subeylindricus*' diet. *Ficus exasperata* had the highest frequency of observation at 34, and *Elaeis guineensis*, with a 20 percent consumption rate throughout the year Figure 2, Plant species were more readily available in the wet season (54% more than in the dry), yet both seasons saw use of 45% and 5% of plant resources Figure 3. The Moraceae family has the most plant species with 7, and the Fabaceae family comes in second with 5 Figure 4. The results indicated that 36 plants from 18 plant species were used by the bird species in the study area. Table 1 in the research area, the Black and White Casqued Hornbill consumed 19 insects species from 10 insect families Table 2. The family Formicidae has the second-highest number of species with three 3, followed by the family Scarabaeidae with five species Figure 5 Major insects devoured by Black and White casqued hornbil are of four species. *Macrotermes bellicosus*, has the highest frequency of observation (13), while *Rhychophorus ferrugineus* is second with seven. Twelve 12 cavites were active out of the 18 18 cavites that were found in the study area The greatest DBH value is 360, the highest NH value is 23, the highest DNH value is 106, and the highest MHT value is 40 for *Ceiba pentandra* Table3 The results of the tree type that Black and White Casqued hornbill utilized both hard and soft wood for nesting Table 4

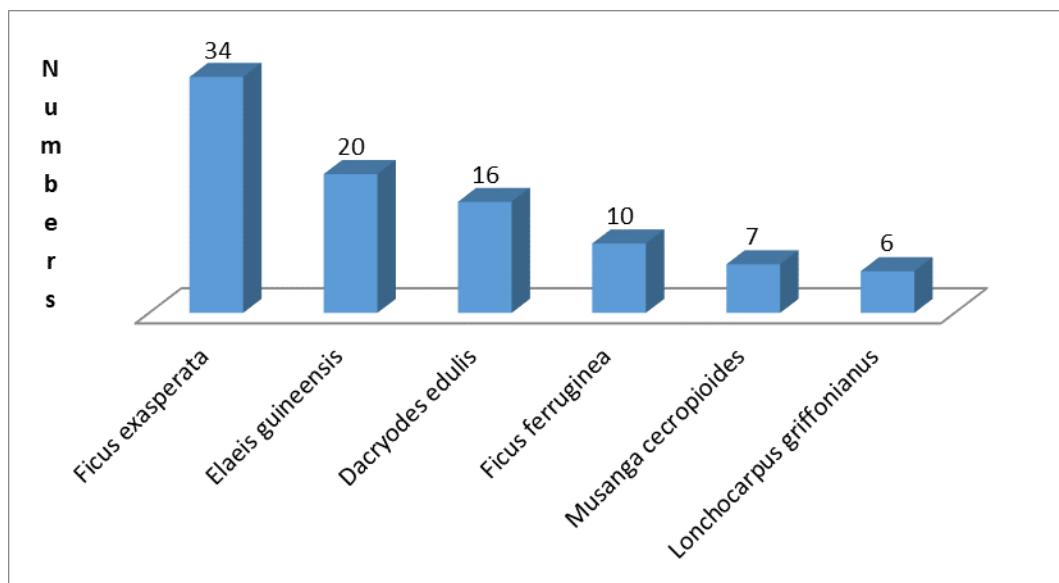


Figure 2: Major diet of Black and White Casqued Hornbill in the study area

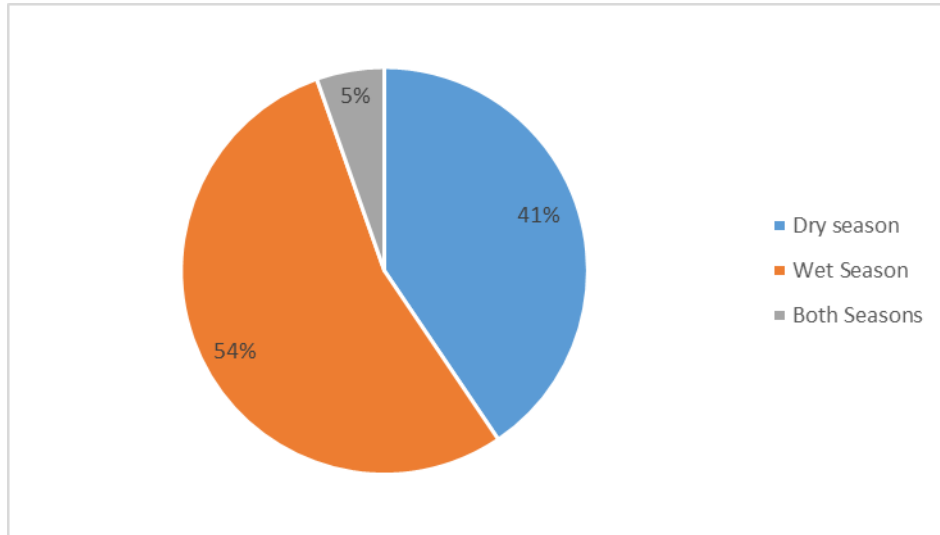


Figure 3, Types of Diet per season in both seasons of the year

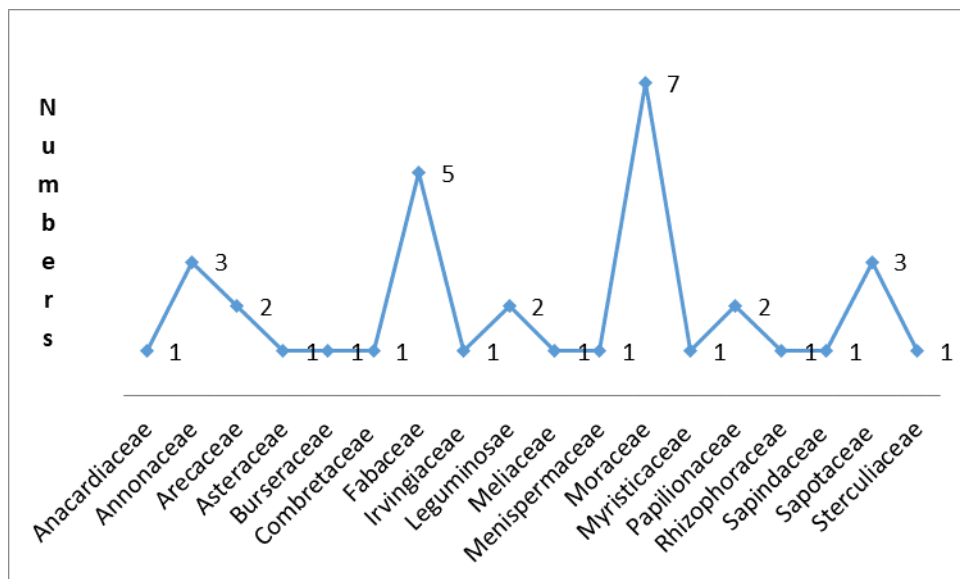


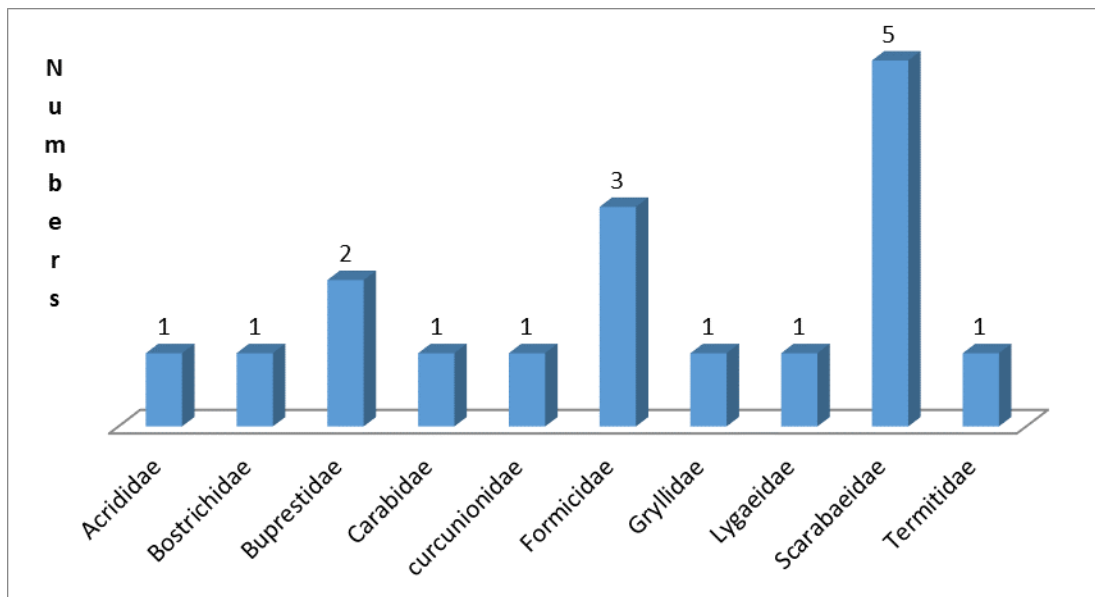
Figure 4: Family composition of plant species consumed in the study area

Table 1: Plant species resources utilized in the study area

Name Tree Species	Family	Parts Utilized	Season	Observations %
<i>Afzelia africana</i>	Fabaceae	Seeds	Dry season	2
<i>Albizia ferruginea</i>	Asteraceae	Seeds	Dry season	1
<i>Blighia sapida</i>	Sapindaceae	Fruits and seeds	Wet season	2
<i>Bosqueia angolensis</i>	Moraceae	Seeds	Wet season	1
<i>Brachystegia eurycoma</i>	Fabaceae	Seeds	Dry season	3
<i>Brachystegia nigerica</i>	Fabaceae	Seeds	Dry season	2
<i>Chrysophyllum albidum</i>	Sapotaceae	Fruits	Wet season	3
<i>Chrysophyllum delevoiyi</i>	Sapotaceae	Fruits	Dry season	3
<i>Chrysophyllum africana</i>	Sapotaceae	Fruits	Wet season	2
<i>Cissampelosmu cronata</i>	Menispermaceae	Seeds	Dry season	2
<i>Cleistopholis patens</i>	Annonaceae	Seeds	Wet season	2
<i>Cola ginganta</i>	Sterculiaceae	Seeds	Dry season	3
<i>Dacryodes edulis</i>	Burseraceae	Fruits	Wet season	16
<i>Daniellia ogea</i>	Fabaceae	Seeds	Dry season	2
<i>Elaeis guineensis</i>	Arecaceae	Fruits	Both seasons	20
<i>Erythrophleumsuaveolens</i>	Leguminosae	Seeds	Dry season	1
<i>Ficus exasperata</i>	Moraceae	Fruits	Wet season	34
<i>Ficus ferruginea</i>	Moraceae	Fruits	Wet season	10
<i>Ficus glumosa</i>	Moraceae	Fruits	Wet season	3
<i>Ficus sur</i>	Moraceae	Fruits	Wet season	2
<i>Guareacedrata</i>	Meliaceae	Seeds	Dry season	1
<i>Hymenoste giaafzelii</i>	Leguminosae	Seeds	Dry season	2
<i>Irvingia grandifolia</i>	Irvingiaceae	Fresh Fruits	Wet season	2
<i>Lonchocarpus griffonianus</i>	Fabaceae	Fresh pods and seeds	Both seasons	6
<i>Monodora tenuifolia</i>	Annonaceae	Seeds	Wet season	1
<i>Musanga cecropioides</i>	Moraceae	Seeds	Wet season	7
<i>Myrianthus arboreus</i>	Moraceae	Ripened Fruits	Wet season	1
<i>Polyalthia suaveolens</i>	Annonaceae	fruits	Wet season	2
<i>Pterocarpus soyauxii</i>	Papilionaceae	Fresh fruits	Dry season	2
<i>Pterocarpus sosun</i>	Papilionaceae	Fresh seeds	Wet season	1
<i>Pycnanthus angolensis</i>	Myristicaceae	Seeds	Dry season	3
<i>Rattan zakeri</i>	Arecaceae	Fruits	Wet season	2
<i>Rothmannia hispida</i>	Rhizophoraceae	Fruits	Dry season	2
<i>Spondia mombin</i>	Anacardiaceae	Fresh fruits	Wet season	2
<i>Sterculia coriata</i>	Sterculiaceae	Fruits	Wet season	1
<i>Tetrapleura tetaptera</i>	Combretaceae	Fresh fruits	Dry season	2

Table 2: Insects species consumed in the study area

Name of Insects	Family	Order	Part Utilized	Observations %
<i>Macrotermes bellicosus</i>	Termitidae	Isoptera	Adult Winged	13
<i>Macrotermes natalensis</i>	Termitidae	Isoptera	Adult Winged	4
<i>Campinotus pinnilucnicus</i>	Formicidae	Hymenoptera	Adult Winged	1
<i>Termopsidae</i>	Formicidae	Hymenoptera	Adult Winged	1
<i>Rhinotermitidae</i>	Formicidae	Hymenoptera	Adult Winged	1
<i>Anomala mixta</i>	Scarabaeidae	Coleoptera	Adult Winged	1
<i>Gymnopleurus fulgidus</i>	Scarabaeidae	Coleoptera	Adult Winged	1
<i>Rhychophorus ferrugineus</i>	curcunionidae	Coleoptera	Whole	7
<i>Apate monachus</i>		Coleoptera	Adult Winged	1
<i>Lycus trabeatus</i>	Bostrichidae	Coleoptera	Adult Winged	2
<i>Sphenoptera trilineata</i>	Carabidae	Coleoptera	Adult Winged	1
<i>Sphenoptera</i> sp.	Buprestidae	Coleoptera	Adult Winged	2
<i>Phrynocolus dentatus</i>	Buprestidae	Coleoptera	Adult Winged	1
<i>Rhychophorus ferrugineus</i>	Scarabaeidae	Coleoptera	Adult Winged	1
<i>Megasoma eleoas</i>	Scarabaeidae	<u>Coleoptera</u>	Adult Winged	6
<i>Glypsus conspicuus</i> West	Scarabaeidae	Hemiptera	Adult Winged	1
<i>Anoplocnemis curvipes</i>	Lygaeidae	Hemiptera	Adult Winged	1
Gryllidae <i>Gryllus bimaculatus</i>	Acrididae	Orthoptera	Adult Winged	1
Acrididae <i>Stobbea</i> sp.	Gryllidae	Orthoptera	Adult Winged	2

**Figure 5: Family composition of consumed in the study area**

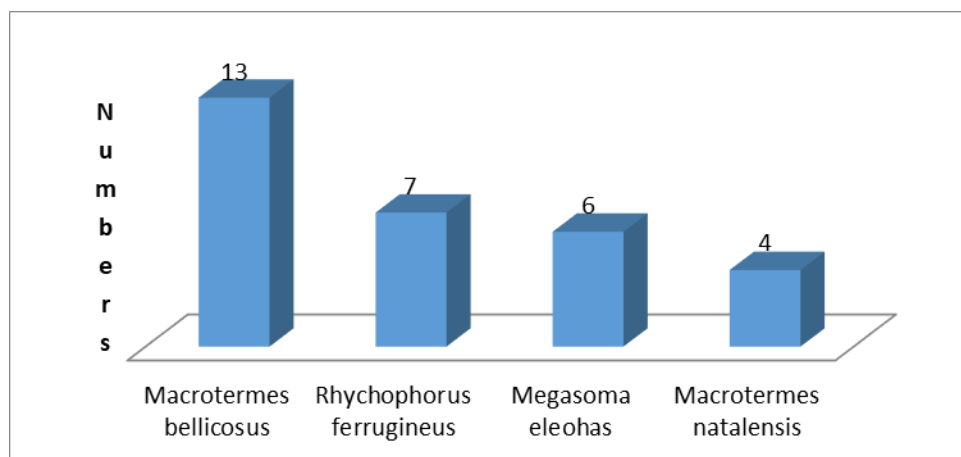


Figure 6: Major insects consumed in the study area

Table 3: Pyto-sociological Parameters of the nest and tree species in the study area

Name of Tree Species	Number	DBH	DNH	NH	MHT
<i>Afzelia africana</i>	Fabaceae	180	82	21	32
<i>Allanblackia floribunda</i>	Clusiaceae	210	96	21.3	39
<i>Alstonia congensis</i>	Apocynaceae	222	98	22.1	36
<i>Antiaris welwitschii</i>	Moraceae	271	97	21.7	37
<i>Brachystegia nigerica</i>	Fabaceae	362	106	23	34
<i>Ceiba pentandra</i>	Bombacaceae	390	122	22.3	40
<i>Celtis zenkeri</i>	Ulmaceae	159	89	21.4	32
<i>Chrysophyllum delevoiyi</i>	Sapotaceae	187	97	21.3	31
<i>Cola ginganta</i>	Sterculiaceae	211	99	21.4	33
<i>Cylicodiscus gabunensis</i>	Leguminosae	153	79	21.8	36
<i>Daniella ogea</i>	Leguminosae	201	89	21.5	34
<i>Guarea cedrata</i>	Meliaceae	167	86	21.2	31
<i>Khaya grandifoliola</i>	Meliaceae	233	99	22.1	36
<i>Memocylon blakeoides</i>	Melastomataceae	145	87	21.5	34
<i>Pycanthu +sangolensis</i>	Myristicaceae	219	92	21.1	35
<i>Tetrapleuratetaptera</i>	Combretaceae	211	96	21	37
<i>Treculiaafricana</i>	Moraceae	235	101	22.3	33

Legend:

DBH-Diameter at breast height; DNH-Diameter at nest height; NH- Nest height and MHT- Mean height of trees

Table4: Tree type where the nest of the bird species are sighted in the study area

Name of Tree Species	Family	Tree Type	Forliage
Afzelia africana	Fabaceae	Softwood	Decidous
Allanblackia floribunda	Clusiaceae	Softwood	Decidous
Alstonia congensis	Apocynaceae	Softwood	Evergreen
Antiaris welwitschii	Moraceae	Hardwood	Decidous
Brachystegia nigerica	Fabaceae	Hardwood	Decidous
Ceiba pentandra	Bombacaceae	Softwood	Decidous
Celtis zenkeri	Ulmaceae	Hardwood	Decidous
Chrysophyllum delevoiyi	Sapotaceae	Softwood	Evergreen
Cola ginganta	Sterculiaceae	Softwood	Decidous
Cylicodiscus gabunensis	Leguminosae	Softwood	Decidous
Daniella ogea	Leguminosae	Hardwood	Decidous
Guareacedrata	Meliaceae	Hardwood	Decidous
Khaya grandifoliola	Meliaceae	Hardwood	Decidous
Memocylon blakeoides	Melastomataceae	Softwood	Softwood
Pycanthus angolensis	Myristicaceae	Hardwood	Hardwood
Tetrapleura tetaptera	Combretaceae	Hardwood	Hardwood
Treulia africana	Moraceae	Softwood	Softwood

DISCUSSION

Bycanistes subeylindricus, like the majority of frugivore species, is found to eat a range of fruits, flowers, leaves, and insects, according to the research. Only a small number and thus diversity of fruit patches (such as trees of a few species in heavy fruit) may be big enough to hold a complete foraging group or flock of frugivores at any given time, claim Cork and Foley in their 2011 paper on the Bycanistes subeylindricus. This is because fruits in tropical forests are patchily distributed in space and time. This corroborates Herrera's (2014) assertion that Black-and-White Casqued Hornfills are likely similar to other frugivores because they are generalists and can eat a variety of fruit sources. The results indicated that 36 plants from 18 plant species were used by the bird species in the study area. The Moraceae family has the most plant species with 7, and the Fabaceae family comes in second with 5. This discovery is identical to that made by Ahmad (2013), who reported that over the course of two breeding seasons, the Dulungan and Tarictic hornbills consumed fruit from about 24 families, 31 genera, and 52 species. The highest number of fruit species were in the Myristicaceae family (5 species), Myrtaceae (3 species), Palmae (3 species), Moraceae (2), and Meliaceae (2). Myristicaceae and Meliaceae produce dehiscent pods with bright, oily arils encasing the seeds, whilst palm trees produce lipid-rich drupes as their fruits. The investigation discovered that the predominant dietary of the species in the study area consists of six main plant species: *Ficus exasperata*, *Elaeis guineensis*, *Dacryodes edulis*, *Ficus ferruginea*, *Musanga cecropioides*, and *Lonchocarpus griffonianus* of Bycanistes subeylindricus. Kinnaird and O'Brien observed comparable outcomes (2007). Who pointed out that figs (12%) and dehiscent, arillate species (30%) are lipopolysaccharide drupes and make up the majority of the fruit species consumed by Asian hornbills (42%). It is well recognized that figs are essential for the proliferation and abundance of hornbills (Leighton 2014). Hornbills and other frugivores prefer liposome fruits, and they only choose figs since these foods are scarce, claims Leighton (2014). However, a growing body of data suggests that figs, rather than substitutes, are many hornbills' favored food (Sitompul *et al.*, 2004). Our study shows that Black and White Casued Hornbill in Okomu National Park depend almost totally on figs during the rainy season, while other frugivores

prefer lipid-rich fruits and only use figs when these are scarce. The amount of insects consumed by this species was discovered to be greater in the late rainy season than the early dry season throughout the mating season. This result supports Teo's (2017) observations that as hornbill chicks reach adulthood, they require more protein, and that the male provides so much meat foods. The palm vegetation next to the national park was observed to be frequented by these bird species. This assessment is comparable to that constructed by Rahman, et al. (2019), who acknowledged that the plantation of palm oil and orchard proceeded to be locations that male Oriental hornbills frequently visited heavily, indicating that they provided essential supplies of food (including insect and fruits). The researchers discovered that the Black and White used a sizable home range inside a national park and relied on tall, emergent trees for food. According to this finding, which is comparable to one made by Leighton (2014), movement across hornbill species was hierarchical and followed body size. Throughout the mating season, the species made use of 18 different nest tree species, representing at least 12 families. This discovery echoes that of Kemp, 2005, who noted that nest selection can take place at any time of the year in territorial pairs but often happens at the start of the mating season in non-territorial species. Also in accordance with Ahmad (2013), who stated that at least 18 families of trees were employed by the 43 different types of nesting trees used by the Sumatra hornbills. Tall trees are used by Black and White Hornbills, and there are particular kinds. They used cavity in both hard and soft wood trees. This observation disagrees with Ahmad, (2013) who reported that most of the Dulungan nests were found in the tree species belonging to the family Dipterocarpaceae, which are favourite nesting trees for all hornbills.

CONCLUSION AND RECOMMENDATION

The results of this study clearly indicate that *Bycanistes subeylindricus* is omnivorous and consumed insects, and fruits, leaves and flowers of some plant species resources available to them in the study area. But, compared to insects, the fruits are consumed in larger proportions. The *Bycanistes subeylindricus* therefore, help in the suppression of insects and help to sustain the capacity in the ecosystem and the *Bycanistes subeylindricus* are useful species for farmers and keep to check on various harmful insects like grasshoppers, beetles, termites, caterpillars etc., which are injurious. They also help in the dispersal of seeds the agricultural crops. The protection of these of bird species is very important to maintain the carrying capacity of their insects in the ecosystem

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