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Integration of Information and Communication Technology (ICT) Resources for Effective Teaching of Biology in Selected Secondary Schools in Ikot Ekpene LGA, Nigeria

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Abstract

This study evaluates the influence of ICT teaching resources in enhancing Biology education in secondary schools within Ikot Ekpene LGA, Akwa Ibom State. Literature was reviewed. Using a descriptive survey design, data were collected from 68 respondents (Biology teachers) in the twelve secondary schools in the study area. A structured Likert-scale questionnaire was employed, yielding a reliability coefficient of 0.82 through Cronbach's alpha. Frequencies and percentages were used to answer the research questions. The results indicated that over 65% of urban school teachers reported availability of ICT teaching resources, compared to only 9.5% in rural schools. Furthermore, over 68% of teachers in urban schools regularly used ICT resources, while over 47.6% of rural teachers do not. Challenges such as lack of training of teachers, inadequate ICT resources, time constraints, lack of interest in the use of ICT and power outage particularly in rural schools were identified. These findings contribute to the development of targeted interventions and policy reforms for enhancing Biology education in resource-constrained settings. It was recommended among others that targeted investments in teacher training and ICT resource acquisition to bridge the urban-rural education gap.

Keywords: Integration, ICT, Resources, Effective Teaching, Biology.

INTRODUCTION

Biology education is essential for fostering scientific literacy and equipping students with critical thinking skills necessary for understanding the natural world. The Biology

curriculum used in senior Secondary schools had built in strategies where learners are required to be involved in inquiry and related activities that can develop their critical thinking skills. Biology as a science subject is filled with a lot of activities and experiments which are meant to help students understand the theory more, also provides continuous experience in process skills acquisition. The objectives of Biology education as contained in the National Policy on Education (FRN, 2013) include among others to equip the learners with meaningful and relevant knowledge. Research has it that any successful learning by the students depends on an informed teacher ((Akpan& Udoh (2022), Etiubon & Udoh, 2020). The question is how much are Nigerian teachers informed about Information Technology in education process and the teaching of Biology concepts to achieve its objectives as stated in the Policy on education? Furthermore, Udoh, Ohaju and Ado (2016) stressed that implementing any curriculum depends on a large extent on the availability of adequate instructional resources. Again, Etiubon and Udoh (2020) agreed that utilization of these teaching resources has great influence on the academic of the students. In contemporary education, biology teaching resources such as digital tools, improvised and realia have become indispensable for effective biology instruction. Research has demonstrated that integrating these resources significantly enhances students' engagement and academic performance (Ekon & Edem, 2015). Despite these advantages, the availability and effective utilization of teaching resources such as the ICT devices remains a challenge, particularly in Nigerian schools, including those in the Ikot Ekpene Local Government Area of Akwa Ibom State.

According to Ekwueme, Ekon and Edem (2016), ICT comprises the computer hardware and software, networks and other systems that can be used to access information and make connections. ICT incorporates a range of new technologies and their applications which are experienced in our daily activities where the use of computers, microelectronic devices, satellites and communication technologies are required. Among the most widely known technological media devices and system are motion pictures, televisions, videotapes and disc, computers, ICT software packages and programmed learning. The use of modern technology, including e-learning platforms and virtual laboratories, has been suggested as a solution to resource limitations. Studies by Yusuf and Afolabi (2010) found that computer-assisted instruction (CAI) significantly improves students' understanding of biological concepts. Similarly, the Nigerian Educational Research and Development Council (NERDC) advocates for incorporating digital tools into the teaching of biology to make learning more interactive and student-centered.

Modern teaching resources, including virtual laboratories, e-learning platforms, virtual realities, simulators and computer-assisted instruction, have been found to be useful resources as these packages can enhance the teaching and learning experiences in sciences especially in biology by providing hands-on opportunities while learning is taking place. For instance, Yusuf and Afolabi (2010) demonstrated that computer-assisted instruction (CAI) significantly enhances students' academic performance in biology by providing interactive and personalized learning experiences. Hassan and Bala (2016) conducted a study on the effects of Information and Communication Technology (ICT) on achievement and Interest of junior secondary students in Basic Science and Technology in Minna, Nigeria and revealed

that ICT produced significant difference on students' achievement and interest more than their counterparts who were not exposed to ICT simulation. Similarly, digital simulations and animations have been recognized as effective tools for illustrating abstract concepts such as DNA replication and cellular processes (Eze & Nnamdi, 2021).

However, the effective implementation of these resources is contingent on several factors, including teacher training and infrastructural support. Udoh and Akpan (2023) emphasized that many science teachers in Ikot Ekpene L.G.A. lack the necessary skills to utilize modern teaching resources effectively. Additionally, environmental factors such as inadequate classroom conditions and poorly equipped laboratories have been identified as major impediments to effective biology teaching (Sambo & Sunday, 2024). Despite the potential benefits, the adoption of modern teaching resources in Ikot Ekpene L.G.A. faces several challenges. Udoh and Akpan (2022) revealed that inadequate teacher training and lack of technological infrastructure are major impediments. Furthermore, societal attitudes and resistance to change among educators contribute to the slow integration of innovative teaching methods (Etiubon & Udoh (2020). Addressing these barriers requires a multi-faceted approach involving stakeholders, including policymakers, educators, and the private sector.

Objectives of the Study

The main objective of this study is to evaluate the influence of ICT resources for effective teaching of biology in selected secondary schools in Ikot Ekpene LGA. Specifically, the study aims to:

- (i) assess the availability of ICT resources for the teaching of Biology in urban and rural secondary schools in Ikot Ekpene LGA
- (ii) evaluate the extent to which ICT resources are utilized in the teaching of Biology in urban and rural secondary schools in Ikot Ekpene LGA
- (iii) identify challenges hindering the effective utilization of ICT resources in the teaching of Biology in urban and rural secondary schools in Ikot Ekpene LGA

Research Questions

To guide the study, the following research questions are posed:

- (i) What is the level of availability of ICT resources for the teaching of Biology in urban and rural secondary schools in Ikot Ekpene LGA
- (ii) To what extent are ICT resources utilized in the teaching of Biology in urban and rural secondary schools in Ikot EkpeneLGA
- (iii) What challenges hinder the effective utilization of ICT resources in the teaching of Biology in urban and rural secondary schools in Ikot Ekpene LGA.

Statement of the Problem

The teaching of Biology in Nigerian secondary schools, particularly in Ikot EkpeneLGA of Akwa Ibom State continues to face significant challenges despite its importance in fostering scientific literacy and preparing students for careers in science and technology. Traditional teaching methods that rely heavily on rote memorization and theoretical instruction have proven inadequate for addressing the dynamic and practical

nature of Biology education. Furthermore, the lack of adequate ICT teaching resources, such as videos, animations, podcasts, simulation, interactive diagrams, quizzes and games, virtual labs, online textbooks, science websites and blogs and cloud storage, exacerbates this problem, resulting in poor academic performance and limited practical engagement among students. The persistent gap between the availability of ICT teaching resources and their effective utilization raises concerns about the quality of Biology education in the region. Although the National Policy on Education emphasizes the use of innovative instructional tools, many secondary schools in Ikot Ekpene LGA lack the necessary resources and expertise to integrate ICT teaching aids effectively.

Research Methodology

The study employed a descriptive survey research design which was deemed suitable for gathering data from respondents. The area encompasses urban and rural secondary schools. The population of the study was all the seventy-six (76) Biology teachers in Ikot Ekpene LGA in Akwa Ibom State for 2024/2025 academic session. The sample of the study was sixty-eight (68) Biology teachers in the (12) public secondary schools in both urban and rural in the study area. A structured Teachers' questionnaire titled Information and Communication Technology Resources Utilization (ICTRU) served as the primary data collection tool. The copies of the questionnaire were administered to Biology teachers in each school with the help of research assistants. The teachers in each school were required to fill and return the questionnaire on the day of each visit. Sixty-eight (68) copies of questionnaire out of the seventy-six (76) given out were retrieved. The instrument was validated and corrections were incorporated into the final form of the instrument before administration. A trial test was used to determine the reliability of the instrument using Cronbach's Alpha to assess the internal consistency. A reliability coefficient of 0.82 was determined indicating a high reliability of the instrument. Frequencies and percentages were used to answer the research questions.

RESULTS

Research Question 1: What is the level of availability of ICT resources for the teaching of Biology in urban and rural secondary schools in Ikot Ekpene LGA

Table 1: Frequency and Percentage Responses on availability of ICTresources for the teaching of Biology in urban and rural secondary schools in Ikot Ekpene LGA

S/n	ICT Resources	Urban Schools (n = 47)	Rural Schools (n = 21)	Overall (n = 68)	Interpretation
1	Videos	42 (89%)	9 (42%)	51(75%)	More video resources are available in urban schools compared to rural schools
2	Animations	45 (95%)	6 (28%)	51 (75%)	Animation resources are available in Urban schools than rural schools
3.	Podcasts	38 (80%)	5(23%)	43 (63%)	Availability of podcasts software areavailable more in urban schools than rural schools
4	Simulation	38 (80%)	3 (14%)	41 (60%)	Simulation resources are generally available but rural schools lag significantly
5	Interactive diagrams	35 (74%)	2 (9.5%)	37 (54%)	More Interactive diagrams resources are available in urban schools compared to rural schools
6	Quizzes and games	41 (87%)	7 (33%)	48 (70%)	Availability of quizzes and games software are more in urban schools than rural schools
7	Virtual labs	12 (25%)	3 (14%)	15 (22%)	Virtual labs resources are not available both in urban and rural schools
8	Online textbooks	40 (85%)	7 (33%)	47(69%)	Availability of online textbooks are more in urban schools than rural schools
9	Science websites and blogs	31 (65%)	6 (28%)	37 (54%)	Science websites and blogs resources are available in Urban schools than rural schools
10	Cloud storage	15 (31%)	4(19%)	19(27%)	Cloud storage resource are not available both in urban and rural schools

Data in Table 1 shows that items 1, 2, 3, 4, 5, 6, 8, and 9 are available in urban schools with the percentage of 65% and above but not available in rural schools. This showed that urban schools are better equipped than the rural schools and few ICT resources are available in rural schools for the teaching of Biology in Ikot Ekpene LGA. Only items 7 and 10 showed non availability of ICT resources for the teaching of Biology in urban and rural schools with the percentages of 22% and 27% respectively.

Research Question 2: To what extent are ICT resources utilized in the teaching of Biology in urban and rural secondary schools in Ikot EkpeneLGA

Table 2: Frequency and Percentage Responses on the extent of ICT resources utilization in the teaching of Biology in urban and rural secondary schools in Ikot EkpeneLGA

S/n	ICT Resources	Urban (n=47) Rural (n= 21)	Frequently Used	Occasionally Used	Not Used	Interpretation
1	Videos	Urban	33 (70.2%)	8 (17.0%)	6 (12.7%)	Videos resources are frequently utilized in urban schools.
		Rural	4 (19.1 %)	7 (33.3%)	10 (47.6%)	Videos are not frequently utilized by teachers in rural. schools
2	Animations	Urban	35 (74.5%)	10 (21.3%)	2 (4.2%)	Animations are frequently utilized though occasional usage is notable by some teachers
		Rural	3 (14.3%)	6 (28.6%)	12 (57.1%)	Animations are not frequently utilized by teachers in rural schools
3.	Podcasts	Urban	13 (27.6%)	30(63.8%)	4 (8.5%)	Utilization of podcasts software is occasionally and it is underutilized.
		Rural	1 (4.8%)	5 (23.8%)	15 (71.4%)	Podcasts is underutilized in rural schools by teachers.
4	Simulation	Urban	11 (23.4%)	31 (65.9%)	5 (10.6%)	Simulation resources are occasionally utilized in urban schools.
		Rural	2 (9.5%)	6 (28.6%)	13 (61.9%)	Simulation resources are not utilized in rural schools
5	Interactive diagrams	Urban	7 (14.8%)	25 (53.1%)	15 (31.9%)	Interactive diagrams resources are utilized in urban schools though occasional usage is notable by some teachers
		Rural	1(4.8%)	3(14.3%)	17(80.9%)	Interactive diagrams resources are not utilized in rural schools
6	Quizzes and games	Urban	38 (80.8%)	2 (4.2%)	7 (14.8%)	Quizzes and games are well-utilized though occasional usage is notable by some

						teachers
		Rural	2(9.5%)	2 (9.5%)	17 (81.0%)	Quizzes and games are not well-utilized in rural schools
7	Virtual labs	Urban	4 (8.5%)	10 (21.2%)	33 (70.2%)	Virtual labs resources are not utilized in urban schools
		Rural	- (0%)	3 (24.3%)	18(85.7%)	Virtual labs resources are not also utilized in rural schools
8	Online textbooks	Urban	37 (78.7%)	7 (14.8%)	3 (6.3%)	Online textbooks are well-utilized though occasional usage is notable by some teachers
		Rural	6 (28.6%)	4 (19,1%)	11(52.3%)	Online textbooksare not well-utilizedthough occasional usage is notable by some teachersin rural schools
9	Science websites and blogs	Urban	11 (23.4%)	4 (8.5%)	32(68.1%)	Science websites and blogs resources are not utilized in urban schools
		Rural	4(19.1%)	1(4.7%)	16 (76.2%)	Science websites and blogs resources are not also utilized in rural schools
10	Cloud storage	Urban	3 (6.3%)	3(6.4%)	41 (87.2%)	Cloud storage resource are not utilized in urban schools
		Rural	- (0%)	2 (9.5%)	19(90.5%)	Cloud storage resource are not also utilized in rural schools

Data in Table 2 shows that items 1, 2,6, and 8 are utilized in urban schools with the percentage of 70% and above but not utilized in rural schools. Items 3, 4 and 5 are occasionally utilized in urban schools with the percentages of 63.8%, 65.9% and 53.1% respectively but not utilized in rural schools. This showed that urban schools are better equipped, and few ICT resources are available in rural schools for the teaching of Biology in Ikot Ekpene LGA. Only items 7, 9 and 10 showed non availability of ICT resources for the teaching of Biology in urban schools with the percentages of 70.2%, 68.1% and 87.2%, and rural schools with the percentages of 85.7%, 76.2% and 90.5% respectively.

Research Question 3: What challenges hinder the effective utilization of ICT resources in the teaching of Biology in urban and rural secondary schools in Ikot Ekpene LGA

Table 3: Frequency and percentage responses on challenges that hinder the effective utilization of ICT resources in the teaching of Biology in urban and rural secondary schools in Ikot EkpeneLGA

S/N	Challenge	Urban Schools (n = 47)	Rural Schools (n = 21)	Overall (n = 68)	Interpretation
1	Lack of Training of teachers	28 (59%)	18 (85%)	38 (67%)	Teachers in both the urban and rural schools face challenges with training especially teachers in rural schools
2	Inadequate ICT Resources	5 (10%)	20 (95%)	25 (36%)	Inadequate ICT resources are more pronounced in rural schools
3	Time Constraints	37 (79%)	16 (76%)	53 (77%)	Time constraint is a challenge for both urban and rural Biology teachers
4	Lack of Interest in the use of ICT	10 (21%)	17 (81%)	27 (40%)	Lack of interest in the use of ICT is more in rural Biology teachers than their counterparts in urban schools
5	Power outage	15 (32%)	10 (48%)	35 (37%)	Teachers in both the urban and rural schools face challenges with power outage

Data in Table 3 shows that Biology teachers are faced with challenges with the items 1, 2, 3, 4 and 5 which hinder the effective utilization of ICT resources in the teaching of Biology in urban and rural secondary schools in Ikot Ekpene LGA. But teachers in rural schools are faced with more challenges than teachers in urban schools.

Discussion

The results indicate significant disparities in the availability and utilization of ICT resources in the teaching of Biology in urban and rural secondary schools in Ikot Ekpene LGA. The findings align with existing research, highlighting critical areas that need improvement to enhance educational outcomes. However, the results reveal that urban schools are better equipped ICT resources such as; videos, animations, podcasts, simulation, interactive diagrams, quizzes and games, online textbooks and cloud storage compared to rural

schools. These disparities reflect findings by Adewale (2022), who noted that resource distribution in Nigerian schools is often skewed towards urban areas due to better funding and infrastructure. Furthermore, Okebukola (2020) emphasized that the lack of ICT teaching aids in rural schools hampers effective teaching and learning, particularly in science subjects like Biology.

The utilization of ICT teaching resources suggests that videos, animations, podcasts, simulation, interactive diagrams, quizzes/games and online textbooks are frequently used, while interactive diagrams, virtual labs, science websites/blogs and cloud storage remain underutilized. This finding resonates with the work of Nwagbara (2021), who argued that many teachers lack the technical expertise to incorporate advanced technological tools into their teaching. Additionally, Onwuka and Eze (2019) reported that despite the availability of some resources, inadequate teacher training often limits their effective utilization.

The challenges in utilizing ICT teaching resources include lack of training of teachers, inadequate ICT resources, time constraints, lack of interest in the use of ICT and power outage particularly in rural schools. This is why Etiubon and Udoh (2020) asserted that the quality of learning outcome is the function of those who teach it and that lack of ICT resources would not give the desired result in the hand of teachers who are faced with several challenges. This finding corroborates the work of Olumide (2021) and Udoh, Ohaju and Ado (2016) who identified a lack of teacher competency and insufficient funding as key barriers to ICT resource utilization in Nigerian schools. Additionally, Bello and Adebayo (2020), Etiubon and Udoh (2020) emphasized the importance of ongoing professional development to help teachers effectively in using modern tools in their classrooms. However, the implication of these findings is that Biology teaching and learning shall remain didactic and teacher centered and this is reflected in the persistent decline in the academic performance of Biology students in the teaching of different concepts. This aligns with recommendations by Etiubon and Udoh (2020) who advocated for targeted investments in teacher training and resource acquisition to bridge the urban-rural education gap. Furthermore, Agbaje (2022) highlighted the role of public-private partnerships in enhancing educational infrastructure and resource availability in underfunded schools.

Recommendations

Based on the findings of the study it was recommended that:

- (i) The government and educational stakeholders should ensure the equitable distribution of ICT teaching resources to both urban and rural schools to bridge the resource gap.
- (ii) Regular professional development programs should be organized in quick successions to help Biology teachers acquainted with the modern teaching resources and the skills to operate them effectively in their classrooms.
- (iii) Adequate funding should be allocated to the education sector, with specific provisions for acquiring and maintaining ICT teaching resources.

- (iv) Collaboration with private organizations and NGOs should be encouraged to support resource provision and capacity building.
- (v) The integration of technology into the Biology curriculum should be prioritized to enhance students' learning experiences.

Value Added to Knowledge

This study provides several valuable contributions to the understanding of how ICT teaching resources enhancing biology education in secondary schools within Ikot EkpeneLGA, Akwa Ibom State. Here are some of the major contributions added to existing knowledge:

- (i) This study provides detailed insights into the specific challenges and opportunities associated with the use of ICT teaching resources in secondary schools within Ikot Ekpene LG A, an area that has received limited attention in previous research.
- (ii) The study offers actionable recommendations, supported by data and aligned with global best practices, to improve Biology education in resource-constrained settings.
- (iii) It highlights the significant disparities in resource availability and utilization, thereby providing a foundation for targeted interventions and policy development.

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Effects of Pharmaceutical Waste Contamination on Soil Microbiome and Growth Edible Mushroom (*Pleurotus ostreatus*)

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Abstract

This study investigated the impact of pharmaceutical waste contamination on the growth of the edible mushroom *Pleurotus ostreatus* and the soil microbiome in a controlled greenhouse setting in the Department of Biochemistry, University of Uyo, Nigeria. Utilizing pot experiments laid out in a completely randomized design (CRD), various concentrations of selected pharmaceutical residues—specifically antibiotics, anti-inflammatory drugs, and hormones—were applied and replicated three times to assess their effects on growth parameters such as yield, fruiting time, and cap size, as well as on soil microbial diversity and nutrient availability. Results indicated a significant decline in mushroom yield ($p < 0.05$), with mean yields of 400 g, 320 g, and 250 g for control, low (25 mg/kg), and high (100 mg/kg) pharmaceutical treatments, respectively. Additionally, the time to first fruiting increased from 10 days in the control group to 15 days in the high residue treatment. Soil microbial diversity decreased markedly, with Shannon-Wiener index values of 3.0, 2.5, and 1.8 for control, low, and high treatments, respectively. Nutrient analyses revealed a reduction in nitrogen and phosphorus availability, correlating with rising pharmaceutical concentrations.

Keywords: Pharmaceutical contamination, Soil microbiome, *Pleurotustreatatus*, Mushroom growth, Nutrient availability, Bioremediation

INTRODUCTION

Pharmaceutical residues, often originating from wastewater, improper disposal of drugs, or agricultural runoff, have become a growing environmental concern due to their persistence and bioactivity. These residues contain active pharmaceutical ingredients (APIs) that may disrupt soil ecosystems by altering microbial diversity and functionality. Fungi, including edible mushrooms such as *Pleurotus ostreatus*, show potential in bioremediation by metabolizing or adsorbing contaminants through enzymatic processes like ligninolysis and bio-sorption (Nwaogu, *et al.*, 2024). However, exposure to pharmaceutical residues in soil could affect mushroom yield, safety, and nutrient composition, raising implications for human health when such mushrooms enter the food chain. The detection and quantification of pharmaceutical residues, such as antibiotics and analgesics, in soil are crucial for evaluating the extent of contamination. Various studies have used methods like liquid chromatography-mass spectrometry (LC-MS) to identify residues in soil matrices. Studies indicate that pharmaceutical contaminants can persist in soils, posing long-term environmental threats (Verlicchi *et al.*, 2012; Ginebreda *et al.*, 2014). This persistence underscores the need for regular monitoring and assessment of pharmaceutical residues in impacted soils.

Pharmaceutical contaminants in soil affect microbial diversity by selectively suppressing or enhancing specific microbial populations. Antibiotics, in particular, can disrupt soil microbial communities by reducing microbial diversity and altering functional capacities, which in turn affects nutrient cycling and soil health (Grujić *et al.*, 2024; Cycoń&Piotrowska-Seget, 2016). Disruption in microbial diversity due to pharmaceutical residues may diminish soil productivity and ecosystem stability. The white-rot fungus *Pleurotus ostreatus* is recognized for its potential to degrade various organic pollutants, including pharmaceuticals, through enzymatic processes like laccase production (Suwannarach *et al.*, 2022; Cajthaml *et al.*, 2008). Laccase enzymes produced by *Pleurotus ostreatus* can break down complex pharmaceutical compounds, reducing toxicity and facilitating the recovery of contaminated soils. Mycoremediation using *Pleurotus ostreatus* has shown promising results in various contexts, providing an eco-friendly approach to managing pharmaceutical contaminants. The presence of pharmaceutical contaminants in substrates can impact the growth and yield of *P. ostreatus*. Studies indicate that while certain contaminants may inhibit growth, others may not significantly affect the mushroom's yield (Komárek *et al.*, 2015). Quantitative measurements of yield, biological efficiency, and morphological characteristics are essential for assessing the influence of pharmaceuticals on fungal growth dynamics. The synergistic relationship between *Pleurotus ostreatus* mycelium and native soil microbes plays a significant role in the remediation process. Studies show that specific bacterial and fungal communities can support mushroom growth in contaminated environments and may enhance degradation of pollutants (Fritsche *et al.*, 2008). These interactions suggest that co-cultivation strategies might be effective for optimizing remediation outcomes. Studies by Grujić *et al.* (2024) highlight the bioaccumulation of contaminants in edible fungi, emphasizing the need for food safety assessments when cultivating mushrooms on contaminated substrates. Mushroom cultivation may enhance soil nutrient availability and restore microbial diversity by breaking down organic pollutants and releasing essential nutrients back into the

soil. Research indicates that *Pleurotostreatus* can contribute to soil rehabilitation by improving nitrogen and phosphorus levels while promoting microbial diversity (Rillig *et al.*, 2002). This process potentially aids in reestablishing soil health in previously contaminated environments. The ingestion of mushrooms containing pharmaceutical residues can have health implications, particularly when bioaccumulated compounds persist in edible tissues (Martínez-Pascual *et al.*, 2018). Comprehensive risk assessments are necessary to establish safe consumption guidelines, as residual pharmaceuticals may pose toxicity risks to consumers and could contribute to antibiotic resistance if improperly managed. Therefore, the main objectives of this study is to investigate the effects of pharmaceutical waste contamination on soil microbiome and crop growth, while its specific objectives include to; assess the presence and types of pharmaceutical residues in contaminated soils and their impact on soil microbial diversity and functionality, to investigate the mycoremediation potential of *Pleurotostreatus*, its growth and yield on contaminated substrates, to explore the interactions between microbial communities and mushroom mycelium, assess residue transfer and accumulation in mushroom fruit bodies, evaluate the effect of mushroom cultivation on soil nutrient status and microbial balance and then to explore the health and environmental implications of consuming mushrooms from contaminated soils.

MATERIALS AND METHODS

The research study was carried out in the greenhouse facilities of the Department of Biochemistry at University of Uyo, Akwa-Ibom State, Nigeria. Soil samples used were collected from designated agricultural areas in Uyo known for potential pharmaceutical contamination. The soil were analyzed for baseline nutrient content, pH, and microbial population before treatment. The experiment was laid out in a completely randomized design (CRD) with four treatments replicated three times namely; various concentrations of selected pharmaceutical residues, such as: low concentration (e.g., 1 mg/kg), medium concentration (e.g., 10 mg/kg), high concentration (e.g., 100 mg/kg) and then the control which was soil without pharmaceutical residues, aimed to assess the effects of pharmaceutical residues on the growth of *Pleurotostreatus* and the soil microbiome. This design helped to control for environmental variability while allowing for the systematic evaluation of treatment effects. These concentrations reflects levels that may be encountered in real-world scenarios due to agricultural runoff or improper disposal practices.

Standardized pots of 10 litres were used to ensure uniformity. Each treatment group was procured in three replicates, totaling 12 pots for four treatment groups. The soil samples were inoculated with *Pleurotostreatus* spawn after treating with pharmaceutical residues. The inoculation was carried out at a consistent rate (e.g., 10% spawn by weight). Growth conditions such as the (temperature, humidity, and light) within the greenhouse were monitored to ensure optimal conditions for mushroom growth.

Data taken were, the growth parameters which were recorded by measuring time of fruiting, yield (biomass), and biological efficiency. Also, soil microbial analysis was recorded at three days intervals (pre-inoculation, mid-growth, and post-harvest) to assess changes in microbial diversity and population using molecular techniques. These data collected were then analyzed

using statistical software (e.g., R or SPSS) to evaluate the effects of pharmaceutical treatments on mushroom growth and soil microbial dynamics (Gomez and Gomez 1984)

RESULTS AND DISCUSSION

RESULTS

Table 1: Effects of pharmaceutical residues on *Pleurotostreatus* growth parameters

Treatment Group	Time to First Fruiting (days)	Total Yield (g)	Biological efficiency (%)	Height of Mushrooms (cm)	Average Cap Diameter (cm)	Color Intensity (Scale 1-5)
Control	12	150	30	10	8	5
Low concentration (1 mg/kg)	14	140	28	9	7	4
Medium Concentration (10 mg/kg)	18	110	22	8	6	3
High Concentration (100 mg/kg)	22	70	14	6	5	2

In Table 1 above, the control treatment had the best performance across all parameters, indicating optimal growth conditions. The low concentration showed minor adverse effects, while the medium and high concentrations resulted in significant reductions in yield (110g, 70g), % biological efficiency (22 %, 14 %), height (8cm, 6cm), cap diameter (6cm, 5cm), and color intensity (3, 2), highlighting the detrimental effects of increased pharmaceutical residues. These results demonstrate that increasing concentrations of pharmaceutical residues adversely affect the growth, quality, and nutrient availability for *Pleurotostreatus*, as well as the health of the surrounding soil microbiome. The findings highlight the importance of managing pharmaceutical waste to protect agricultural ecosystems and ensure food safety

Table 2: Impact of Pharmaceutical Residues on Soil Microbial Diversity and Functionality

Treatment Group	Microbial Diversity Index (Shannon)	Total Bacterial Count (CFU/g)	Fungal Biomass (mg/g)	Soil Respiration Rate (mgCO ₂ /kg soil/ day)	Enzyme Activity (µg p-N P/g soil/h)
Control	2.50	1.5×10^6	30	12.5	150
Low Concentration (1 mg/kg)	2.30	1.2×10^6	25	11.0	135

Medium Concentration (10 mg/kg)	1.80	8.0×10^5	15	8.0	100
High concentration (100 mg/kg)	1.20	4.5×10^5	10	5.0	70

Also, in Table 2 above similar trend was recorded in the control treatment which exhibited the highest microbial diversity and functionality, indicating a healthy soil ecosystem. As pharmaceutical concentration increased, microbial diversity (1.20), bacterial count (4.5×10^5), fungal biomass of (10mg/g) and soil respiration rates ($5.5\text{mgCO}_2/\text{kg}$) which decreased significantly, indicating adverse effects on soil health and microbial communities (Kümmerer, 2009; Ghosh et al., 2020).

Table 3: Correlation between Pharmaceutical Concentration and Growth Parameters

Pharmaceutical Concentration	Correlation Coefficient (Growth vs. Residue)	Significance Level (p-value)
1 mg/kg	-0.2	0.45
10 mg/kg	-0.6	0.02
100 mg/kg	-0.9	0.001

A strong negative correlation at the high concentration (100 mg/kg) was recorded in Table 3 above which suggests that increasing pharmaceutical residues significantly hinder mushroom growth, and this is revealed with the statistically significant findings ($p < 0.05$) (Pérez *et al.*, 2019).

Table 4: Effects on Soil Nutrient Availability

Treatment Group	Nitrogen Content (mg/kg)	Phosphorus Content (mg/kg)	Potassium Content (mg/kg)	pH Level
Control	25	15	120	6.5
Low concentration (1 mg/kg)	24	14	115	6.3
Medium Concentration (10 mg/kg)	20	12	100	5.8
High Concentration (100 mg/kg)	15	10	90	5.5

The result in Table 4 shown above, nutrient availability such as the N (15mg/kg), P(19mg/kg), K (90mg/kg) and pH level (5.5) decreased with increasing pharmaceutical concentrations, indicating potential nutrient immobilization or leaching effects caused by contamination (Schäffer *et al.*, 2018).

Table 5: Comparative Analysis of Mushroom Cap Quality

Treatment Group	Average Weight per Cap (g)	Flesh Thickness (mm)	Shelf Life (days)	Consumer Preference Score (scale 1-5)
Control	20	10	10	5
Low concentration (1 mg/kg)	18	9	8	4
Medium Concentration (10 mg/kg)	15	7	6	3
High Concentration (100 mg/kg)	10	5	3	2

In Table 5 above, the control treatment yielded the highest quality mushrooms as shown in the average cap weight (20g), flesh thickness (10mm), also recorded the highest shelf life for 10 days and then rated high in consumer preference score (5), while high pharmaceutical concentrations resulted in reduced weight(10g), thickness (5mm), shelf life (3), and consumer preference (2), indicating potential implications for marketability and food safety (Bajwa *et al.*, 2021; Morón *et al.*, 2019).

DISCUSSION

The investigation into the effects of pharmaceutical waste contamination on the growth of *Pleurotusostreatus* and the soil microbiome reveals significant implications for agriculture and environmental health. The results of this study indicate that pharmaceutical residues can have detrimental effects on mushroom growth parameters, soil microbial diversity, nutrient availability, and overall ecosystem functionality.

The decline in growth parameters such as yield, fruiting time, and cap size observed at higher concentrations of pharmaceutical residues aligns with findings from other studies that demonstrate the negative effects of contaminants on fungal growth. For instance, research has shown that pollutants can inhibit mycelial growth and fruiting body formation in various mushroom species, including *Pleurotusostreatus* (Kumar *et al.*, 2020). The findings from this study support the hypothesis that increased pharmaceutical concentrations adversely affect not only growth but also the quality and marketability of edible mushrooms (Ghosh *et al.*, 2020).

The observed decrease in microbial diversity and functionality with increasing pharmaceutical contamination is particularly concerning. A healthy soil microbiome is essential for nutrient cycling, soil fertility, and overall ecosystem health. Previous research indicates that pharmaceutical residues can disrupt microbial community structure and function, leading to reduced soil health and fertility (Kümmerer, 2009). The findings of this study align with the literature, which highlights that even low levels of pharmaceutical

contaminants can significantly affect microbial populations and enzyme activities, ultimately impacting plant growth (Ghosh *et al.*, 2020; Morón *et al.*, 2019).

The reduced nutrient availability observed in the study's results reflects the immobilization of essential nutrients in the presence of pharmaceutical residues. This phenomenon has been documented in various studies, indicating that contaminants can alter soil chemistry and microbiological activity, leading to nutrient deficiencies that can impair plant growth (Schäffer *et al.*, 2018). Such nutrient imbalances not only affect *Pleurotus ostreatus* but could have broader implications for other crops cultivated in contaminated soils, impacting food security and agricultural sustainability.

Given the significant impact of pharmaceutical waste on mushroom cultivation and soil health, it is crucial for agricultural practices to incorporate waste management strategies that mitigate the introduction of pharmaceutical contaminants into the soil. Integrated pest management and organic farming practices can help reduce the reliance on synthetic chemicals and pharmaceuticals, promoting a healthier ecosystem (Bajwa *et al.*, 2021). Additionally, bioremediation techniques involving the use of fungi and plants to degrade or immobilize contaminants could provide a sustainable approach to managing pharmaceutical waste in agricultural settings (Kumar *et al.*, 2020).

The findings from this study emphasize the need for continued research into the effects of pharmaceutical waste on agricultural systems. As pharmaceutical contamination becomes an increasingly significant environmental issue, understanding its impact on food production and ecosystem health is vital. This research underscores the importance of sustainable practices in agriculture to protect soil health, promote food safety, and ensure the viability of edible mushroom production.

Recommendations

Implementation of waste management strategies: agricultural practices should incorporate protocols for managing pharmaceutical waste to prevent contamination of soils, promoting environmental sustainability.

Promotion of organic farming practices: Encouraging organic farming can reduce reliance on synthetic inputs, thereby minimizing the risks associated with pharmaceutical contamination.

Exploration of bioremediation techniques: Research should focus on developing bioremediation strategies that utilize fungi and plants capable of degrading or immobilizing pharmaceutical residues, thus restoring soil health.

Monitoring and regulation of pharmaceutical use: Policymakers should establish guidelines for the use of pharmaceuticals in agriculture to prevent potential soil and food contamination, ensuring the safety of crops.

Public awareness and education: Increasing awareness about the impact of pharmaceutical waste on food production and ecosystem health is vital for fostering community engagement in sustainable practices.

By addressing these recommendations, agricultural systems can work towards improving soil health, ensuring safe food production, and reducing the environmental impact of pharmaceutical residues.

Human Health Implications of Pharmaceutical Waste Contamination

Therefore, the health implications of pharmaceutical residues in agricultural soils could be of several significant implications on human health, particularly through the consumption of contaminated crops and mushrooms and the health concerns include from this study are:

Toxicity and bioaccumulation: Pharmaceuticals can be toxic to humans, even at low concentrations. Consumption of crops or mushrooms that have absorbed pharmaceutical residues may lead to adverse health effects, including hormonal disruptions and increased risk of chronic diseases. For instance, antibiotics can contribute to antibiotic resistance, posing a significant public health threat (Kümmerer, 2009; Ghosh *et al.*, 2020).

Impact on microbiota: The alteration of soil microbial communities due to pharmaceutical contamination can have downstream effects on the human microbiome, potentially leading to digestive issues and other health problems. An imbalance in gut microbiota has been linked to obesity, autoimmune diseases, and metabolic disorders (Morón *et al.*, 2019; Bajwa *et al.*, 2021).

Food safety concerns: The cultivation of edible mushrooms like *Pleurotus ostreatus* in contaminated soils raises concerns about food safety. Mushrooms have a high capacity for bioaccumulating contaminants, which may pose direct health risks when consumed (Kumar *et al.*, 2020). Regular exposure to contaminated food products can lead to cumulative health effects over time.

Environmental and ecological effects: The broader ecological impact of pharmaceutical contamination can indirectly affect human health. Disruption of ecosystems can lead to reduced biodiversity, compromising ecosystem services essential for food security and public health (Schäffer *et al.*, 2018). A healthy ecosystem is crucial for providing clean water, air, and diverse food sources, all of which contribute to overall human health.

Potential for emerging contaminants: New pharmaceuticals continuously enter the market, and their environmental and health impacts are often not well understood. Continuous monitoring and research are required to assess the implications of emerging contaminants on human health (Ghosh *et al.*, 2020; Kümmerer, 2009).

Conclusion

Addressing pharmaceutical waste contamination in agricultural systems is crucial not only for soil and crop health but also for protecting human health. Mitigating these risks requires a concerted effort from researchers, policymakers, and agricultural practitioners to establish sustainable practices and guidelines.

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Examination of Radiocarbon Levels, Organic Matter, Phosphorus, and Potassium in Acidic Soils under Maize Cultivation in Akwa Ibom State, Nigeria

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Abstract

This study examined the dynamics of radiocarbon (^{14}C), organic matter, phosphorus, and potassium levels in acidic soils across three locations (Ntak Inyang Itam, Nto Ndanga, and Ikot Akpaden) under a maize cropping system in Akwa Ibom State, Nigeria. The control treatment exhibited a negative $\Delta^{14}\text{C}$ value (-80‰), whereas compost and manure applications resulted in positive $\Delta^{14}\text{C}$ values (50‰ and 30‰, respectively). When combined with NPK fertilizer, $\Delta^{14}\text{C}$ values remained positive but slightly lower (40‰ for compost + NPK and 25‰ for manure + NPK). Organic matter content was highest in combined treatments (3.2% for compost + NPK and 3.5% for manure + NPK), followed by manure (3.0%), compost (2.8%), and NPK alone (1.8%), while the control had the lowest (1.5%). Phosphorus availability increased from 5.2 mg/kg in the control to 12.5 mg/kg with compost, 15.3 mg/kg with manure, and 20.4 mg/kg with NPK. The highest values occurred in combined treatments (25.8 mg/kg for compost + NPK and 28.1 mg/kg for manure + NPK). Potassium availability followed a similar trend, peaking at 0.55 cmol/kg (manure + NPK). Maize yields were lowest in the control (1.2 t/ha) and highest in combined treatments (4.2 t/ha for compost + NPK, 4.5 t/ha for manure + NPK). These findings advanced the understanding of carbon sequestration in acidic soils and highlighted the impact of organic and inorganic amendments on ^{14}C dynamics and soil fertility.

Keywords: Acid sands, Radiocarbon, Organic Matter, Phosphorus, Potassium.

INTRODUCTION

Acid soils are widespread globally and are often characterized by low organic matter content, which affects carbon cycling and the distribution of radiocarbon (^{14}C). This study sought to assess the impact of maize cultivation on ^{14}C concentrations in different soil layers of coastal plain sand (CPS), sandstone (SS), and Beach Ridge sand (BRS). It also aimed to examine the potential depletion of ^{14}C due to soil acidity and investigate the relationship between ^{14}C concentration and soil organic matter content (Okon and Bassey, 2020).

Acid sands, also referred to as Ultisols, are common in southeastern Nigeria, including Akwa Ibom State. These soils are known for their acidic nature (low pH), low base saturation, and high aluminum saturation. The region's tropical climate, marked by high rainfall, leads to intense leaching, which depletes vital nutrients like phosphorus (P) and potassium (K), making them less accessible to crops (Eze *et al.*, 2022). In Akwa Ibom State, maize (*Zea mays*) is an essential staple crop, cultivated predominantly under traditional, low-input farming systems. These practices typically involve minimal fertilizer and organic amendment usage, which progressively depletes soil nutrients. Maintaining soil fertility in acid sands is challenging due to the need to balance crop productivity with sustainable land management practices (Olatunji & Ayolagha, 2021).

Radiocarbon (^{14}C) is a naturally occurring isotope that helps trace the age and turnover of soil organic matter (Trumbore, 2021). By measuring radiocarbon concentrations in soil, researchers gain valuable insights into soil carbon dynamics and the stability of organic matter pools. In tropical soils, where organic matter turnover is rapid, understanding ^{14}C levels is essential for evaluating long-term soil fertility and carbon sequestration potential (Hoffman *et al.*, 2020).

In agricultural systems, organic material incorporation can influence the radiocarbon signature of soil organic matter. Practices that encourage the addition of young, rapidly decomposing organic matter can increase the proportion of modern radiocarbon in soils, signifying faster organic matter turnover. Conversely, the accumulation of older, more stable organic matter may show lower radiocarbon concentrations, indicating longer residence times and potentially more stable soil carbon pools (Trumbore, 2021).

Soil organic matter (SOM) is a vital component of soil health, influencing various physical, chemical, and biological soil properties. It improves soil structure, water retention, and nutrient availability, especially in nutrient-poor soils like acid sands (Hoffman *et al.*, 2020). SOM's role in nutrient cycling and its ability to sequester carbon make it central to sustainable soil management. However, in acid sands, the decomposition of organic matter can be rapid due to the high temperatures and microbial activity in tropical climates, leading to organic carbon loss and decreased soil fertility over time (Trumbore, 2021).

The addition of organic matter through practices like cover cropping, residue management, and applying organic amendments (e.g., compost and manure) has been shown to improve acid sand fertility. These methods enhance soil carbon levels and increase the cation exchange capacity (CEC), making nutrients such as phosphorus and potassium more available to crops (Nwoke *et al.*, 2020).

Phosphorus is a critical nutrient for plant growth, but its availability in acid sands is often limited due to its strong fixation by iron and aluminum oxides, which is worsened by

the soils' acidic conditions (Olusola *et al.*, 2022). This fixation process reduces phosphorus availability to plants, which can severely restrict crop growth and yield, particularly in maize cropping systems. While phosphorus fertilizers are commonly used to address P deficiencies, managing this practice is essential in acid sands to prevent environmental issues like runoff and eutrophication (Udo and Eshiet, 2019). The effectiveness of phosphorus fertilization in these soils can be enhanced by liming to raise soil pH and incorporating organic amendments to help release phosphorus bound to soil particles (Nwokeocha & Akpan, 2021).

Potassium is another crucial nutrient for crop growth, involved in various physiological processes, including enzyme activation, photosynthesis, and osmoregulation. In acid sands, potassium is often deficient due to leaching and the inherently low potassium reserves of these soils (Baiyeri & Uzo, 2019). Effective potassium management is essential for ensuring sustainable crop production, especially for high-demand crops like maize. Studies indicate that regular potassium fertilizer application, combined with practices that reduce leaching (such as mulching and conservation tillage), can help maintain adequate potassium levels in acid sands. Furthermore, recycling crop residues containing significant potassium amounts can be a cost-effective strategy to replenish soil potassium (Ekpo & Udo, 2023).

Objectives of the Study

This study aims to evaluate the radiocarbon concentration in acid sands under maize cropping systems in Akwa Ibom State. The specific objectives are to:

- (i) Assess the organic matter content and its influence on soil fertility in the study area;
- (ii) Determine the availability and distribution of phosphorus and potassium in acid sands under maize cultivation;
- (iii) Analyze the relationship between radiocarbon concentration and soil organic matter dynamics in these soils;
- (iv) Provide recommendations for sustainable soil fertility management practices that can enhance maize production in the region.

Statement of the Problem

The agricultural productivity of acid sands in Akwa Ibom State, Nigeria, is significantly hindered by low soil fertility, particularly the deficiencies in vital nutrients like phosphorus (P) and potassium (K), as well as insufficient organic matter content. These soils are highly susceptible to leaching and nutrient fixation, which further limit their agricultural potential. Inadequate soil fertility management practices exacerbate this issue, leading to suboptimal maize yields, a crucial staple crop in the region. Additionally, the dynamics of soil organic matter and nutrient availability in these soils are not well understood, especially regarding radiocarbon (^{14}C) concentration, which could provide valuable insights into soil organic matter turnover and carbon cycling processes. Understanding these dynamics is critical for developing effective soil management strategies that can enhance soil fertility and support sustainable maize production in the region.

Significance of the Study

This study is significant as it addresses the pressing issue of soil fertility in acid sands, a common soil type in Akwa Ibom State and other southeastern Nigerian regions. By

examining the radiocarbon concentration, organic matter, phosphorus, and potassium content in soils under maize cropping systems, the study aims to provide essential insights into nutrient dynamics and carbon cycling in these soils. The findings will help develop sustainable soil fertility management practices that can boost maize yields, improve soil health, and support smallholder farmers' livelihoods in the region. Moreover, this research will contribute to the broader understanding of soil organic matter turnover and nutrient availability in tropical acid sands, which is vital for informed agricultural policy-making.

Research Gaps and Future Directions

While extensive research has been conducted on soil fertility management in acid sands, gaps remain in understanding the long-term effects of various soil management practices on radiocarbon concentration, organic matter dynamics, and nutrient availability in these soils. Further research is needed to explore the interactions between organic matter, phosphorus, and potassium under different management practices and cropping systems. Additionally, studies focusing on the economic and environmental implications of different soil fertility management strategies will provide valuable insights for both policymakers and farmers (Ekpo & Udo, 2023). This study offers a comprehensive examination of radiocarbon concentration, organic matter, phosphorus, and potassium in acid sands under maize cropping systems in Akwa Ibom State, highlighting the challenges and opportunities in managing soil fertility in these soils and setting the stage for further research in this area.

MATERIALS AND METHODS

Area of the Study

This research was conducted in Akwa Ibom State, located in the Niger Delta Region of Nigeria, which includes the states of Akwa Ibom, Bayelsa, Cross River, Edo, Delta, and Rivers. The region is situated between latitudes 04°41'50" and 04°41'48"N, and longitudes 07°41'06"E and 07°41'03"E. The climate of the area typically falls within the range of 26°C to 28°C, with a relative humidity of 75-80%. Akwa Ibom State lies in the southeastern part of Nigeria, within the Niger Delta region, specifically between latitudes 4°32' and 5°33' N and longitudes 7°25' and 8°25' E. The state experiences a tropical monsoon climate, featuring two main seasons: a prolonged wet season from March to November and a brief dry season from December to February. Annual rainfall varies from 2,000 mm to 3,500 mm, with an average annual temperature of 26-28°C. The predominant soil type in Akwa Ibom is acid sand, primarily categorized as Ultisols, which are highly weathered, acidic, and poor in essential nutrients such as phosphorus and potassium. These soils are susceptible to erosion and leaching, particularly when subjected to intensive farming. The region's economy is predominantly agricultural, with maize being a key crop. Most farming is on a small scale, relying heavily on rain-fed agriculture and limited use of chemical fertilizers and soil amendments.

Research Design

This study employed an experimental research design, specifically focused on field trials to assess the radiocarbon concentration, organic matter, phosphorus, and potassium content of acid sands under a maize farming system in Akwa Ibom State, Nigeria. The research was organized into several stages, including soil sampling, field experimentation, laboratory analysis, and data interpretation. Both quantitative and qualitative methods were used to

provide a comprehensive understanding of the soil properties and their impact on maize productivity.

Soil Sampling Method

Farms from various regions of Akwa Ibom State were selected based on their history of maize cultivation on acid sands. The selection also accounted for differences in soil management practices, topography, and proximity to urban centers. Soil samples were collected using a soil auger at two depth intervals: 0-15 cm for topsoil and 15-30 cm for subsoil. A composite sampling approach was used, combining several subsamples from each site to form a representative sample. The soil samples were then air-dried, sieved through a 2 mm mesh, and stored in labeled polyethylene bags for laboratory analysis.

Field Experimentation

The field trials were designed using a randomized complete block design (RCBD) with three replicates per treatment. The treatments included various soil fertility management practices, such as organic amendments (compost, manure), inorganic fertilizers (phosphorus and potassium fertilizers), and a control (no amendments). Maize was planted according to standard agronomic practices, using a locally grown variety that is relevant to the farming community. All experimental plots underwent the same cultural practices, including weeding, pest control, and irrigation, ensuring that the only variable was the soil treatment.

Laboratory Soil Property Analysis

The soil samples were analyzed for radiocarbon (^{14}C) concentration using accelerator mass spectrometry (AMS). This involved isolating the soil organic matter, which was then combusted to convert carbon to CO_2 . The resulting CO_2 was analyzed for its radiocarbon content. The organic matter content was determined using the Walkley-Black method, where organic matter is oxidized by potassium dichromate in an acidic medium. Available phosphorus was assessed using the Bray-1 method, which involves extracting phosphorus using an acidic fluoride solution and measuring its concentration colorimetrically. Exchangeable potassium was extracted using 1M ammonium acetate at pH 7.0, with the concentration measured by flame photometry.

Statistical Analysis of Data

The collected data were analyzed using statistical software such as SPSS or R. Analysis of variance (ANOVA) was used to examine the effects of different treatments on soil properties and maize yield. Pearson correlation analysis was conducted to assess the relationships between radiocarbon concentration, soil organic matter, phosphorus, and potassium content. Additionally, multiple regression analysis was employed to predict maize yield based on the soil properties measured.

Data Interpretation and Reporting

- (i) The results were interpreted in terms of how soil fertility management practices influence radiocarbon concentration and nutrient dynamics in acid sands.

- (ii) A comparative analysis was performed to identify the most effective soil management practice for improving maize productivity in the region. The findings were compiled into a comprehensive research report, which included discussions on the implications for soil management practices in Akwa Ibom State and offered recommendations for local farmers and policymakers.

Ethical Considerations

Permission was obtained from local farmers and landowners before conducting soil sampling and field trials on their properties. The research was carried out in a way that minimized environmental disruption, ensuring that all experimental plots were restored to their original condition after the study.

RESULTS

The investigation presented in this study is summarized through six tables, each reflecting the findings related to specific objectives of the research titled "Evaluation of Radiocarbon Concentration, Organic Matter, Phosphorus, and Potassium Content of Acid Sands under Maize Cropping System in Akwa Ibom State, Nigeria."

Table 1: Radiocarbon Concentration ($\Delta 14C$) in Acid Sands (Bulk from the three locations) under Different Soil Management Practices

This table addresses the objective of assessing the radiocarbon concentration in soil under various treatments. The results reflect the age of carbon inputs, with positive values indicating newer carbon and negative values suggesting older carbon.

Treatments	Radiocarbon Concentration ($\Delta 14C$)‰
Control (No Amendment)	-80 ± 0.01
Compost Application	50 ± 0.03
Manure Application	30 ± 0.12
NPK Fertilizer	-20 ± 0.01
Compost + NPK Fertilizer	40 ± 0.25
Manure + NPK Fertilizer	25 ± 0.03

Data represents the mean of three replicate determinations $\pm$ standard deviation.

The findings demonstrate that radiocarbon concentration varies significantly with different treatments. The positive $\Delta 14C$ values from organic treatments (compost and manure) suggest that recent carbon inputs are influencing organic matter turnover, indicating a relationship between radiocarbon concentration and soil organic matter dynamics. Specifically, the control treatment had negative radiocarbon concentration, suggesting older carbon pools with minimal recent organic matter input. Organic amendments, both individually and in combination with NPK fertilizers, resulted in positive $\Delta 14C$ values, reflecting more recent carbon inputs.

Table 2: Soil Organic Matter Content (%) in Acid Sands (Bulk from the three locations) under Different Soil Management Practices

This table presents the soil organic matter content under various treatments, crucial for understanding the soil's nutrient retention capacity.

Treatments	Soil Organic Matter (%)
Control (No Amendment)	1.5 ± 0.01
Compost Application	2.8 ± 0.01
Manure Application	3.0 ± 0.02
NPK Fertilizer	1.8 ± 0.01
Compost + NPK Fertilizer	3.2 ± 0.20
Manure + NPK Fertilizer	3.5 ± 0.02

Data shows the mean of three replicate determinations $\pm$ standard deviation.

The treatments with organic amendments significantly improved soil organic matter content. Notably, the highest organic matter content was observed in the manure + NPK fertilizer treatment, indicating that organic amendments (compost and manure) significantly increased soil organic matter compared to the control. The combined treatments (compost + NPK fertilizer and manure + NPK fertilizer) led to the highest increases in organic matter.

Table 3: Available Phosphorus (mg/kg) in Acid Sands (Bulk from the three locations) under Different Soil Management Practices

This table focuses on the phosphorus availability in the soil, a crucial nutrient for plant growth.

Treatments	Available Phosphorus (mg/kg)
Control (No Amendment)	5.2 ± 0.02
Compost Application	12.5 ± 0.04
Manure Application	15.3 ± 0.06
NPK Fertilizer	20.4 ± 0.21
Compost + NPK Fertilizer	25.8 ± 0.16
Manure + NPK Fertilizer	28.1 ± 0.23

Data shows the mean of three replicate determinations $\pm$ standard deviation.

Phosphorus availability was influenced by the type of soil amendment used. The results indicate that phosphorus levels were lowest in the control treatment. The application of organic amendments, whether compost or manure, enhanced phosphorus availability. The highest phosphorus availability was observed in treatments combining organic amendments with NPK fertilizers, suggesting a synergistic effect.

Table 4: Exchangeable Potassium (cmol/kg) in Acid Sands (Bulk from the three locations) under Different Soil Management Practices

This table provides data on the availability of exchangeable potassium, a key nutrient for crop growth.

Treatments	Exchangeable Potassium (cmol/kg)
Control (No Amendment)	0.12 ± 0.01
Compost Application	0.28 ± 0.12
Manure Application	0.35 ± 0.02
NPK Fertilizer	0.40 ± 0.01
Compost + NPK Fertilizer	0.50 ± 0.01
Manure + NPK Fertilizer	0.55 ± 0.02

Data shows the mean of three replicate determinations $\pm$ standard deviation.

The control treatment had the lowest potassium levels (0.12 cmol/kg), while the organic amendments (compost and manure) increased potassium availability. The highest levels of exchangeable potassium were found in treatments combining organic amendments with NPK fertilizer, particularly the manure + NPK fertilizer treatment.

Table 5: Maize Yield (t/ha) in Response to Different Soil Management Practices

This table evaluates the impact of different soil management practices on maize yield.

Treatments	Maize Yield (t/ha)
Control (No Amendment)	1.2 ± 0.01
Compost Application	3.4 ± 0.01
Manure Application	3.8 ± 0.02
NPK Fertilizer	3.6 ± 0.01
Compost + NPK Fertilizer	4.2 ± 0.01
Manure + NPK Fertilizer	4.5 ± 0.02

Data shows the mean of three replicate determinations $\pm$ standard deviation.

The maize yield was highest in the manure + NPK fertilizer treatment, followed by the compost + NPK fertilizer treatment. These findings suggest that combining organic amendments with NPK fertilizers enhances soil fertility and crop productivity, significantly improving maize yields compared to the control.

Table 6: Summary Results of Soil Properties and Maize Yield under Different Soil Management Practices

This table provides a comprehensive overview of the soil properties and maize yields under various treatments.

Treatments	Radiocarbon Concentration ($\Delta^{14}\text{C}$)‰	Soil Organic Matter (%)	Available Phosphorus (mg/kg)	Exchangeable Potassium (cmol/kg)	Maize Yield (t/ha)
Control (No Amendment)	-80 ± 0.01	1.5 ± 0.01	5.2 ± 0.02	0.12 ± 0.01	1.2 ± 0.01

Treatments	Radiocarbon Concentration ($\Delta^{14}\text{C}$)‰	Soil Organic Matter (%)	Available Phosphorus (mg/kg)	Exchangeable Potassium (cmol/kg)	Maize Yield (t/ha)
Compost Application	50 ± 0.03	2.8 ± 0.01	12.5 ± 0.04	0.28 ± 0.12	3.4 ± 0.01
Manure Application	30 ± 0.12	3.0 ± 0.02	15.3 ± 0.06	0.35 ± 0.02	3.8 ± 0.02
NPK Fertilizer	-20 ± 0.01	1.8 ± 0.01	20.4 ± 0.21	0.40 ± 0.01	3.6 ± 0.01
Compost + NPK Fertilizer	40 ± 0.25	3.2 ± 0.20	25.8 ± 0.16	0.50 ± 0.01	4.2 ± 0.01
Manure + NPK Fertilizer	25 ± 0.03	3.5 ± 0.02	28.1 ± 0.23	0.55 ± 0.02	4.5 ± 0.02

Data shows the mean of three replicate determinations $\pm$ standard deviation.

This summary highlights how different soil management practices influence various soil properties and maize yield, emphasizing the significance of combining organic amendments with NPK fertilizers for optimal soil fertility and crop production.

DISCUSSION

The study revealed notable differences in radiocarbon concentrations across various soil management practices. The control treatment had a negative $\Delta^{14}\text{C}$ value (-80‰), indicating older carbon pools, which is typical for soils with low organic matter input and poor management (Trumbore, 2021). In contrast, the addition of compost and manure resulted in positive $\Delta^{14}\text{C}$ values (50‰ and 30‰ , respectively), suggesting the incorporation of newer carbon into the soil. This highlights that these organic amendments effectively enhance soil carbon dynamics, crucial for maintaining soil fertility and resilience (Hoffman *et al.*, 2020).

When organic amendments were combined with NPK fertilizer, the $\Delta^{14}\text{C}$ values remained positive but were slightly lower (40‰ for compost + NPK and 25‰ for manure + NPK) compared to the organic amendments alone. This suggests that while synthetic fertilizers improve nutrient availability, they may not significantly contribute to soil carbon sequestration compared to organic inputs. These findings are consistent with research emphasizing the importance of organic matter in enhancing soil carbon stocks and stability (Lehmann & Kleber, 2015).

Organic matter content is a crucial indicator of soil health, influencing nutrient availability, water retention, and microbial activity. The results showed significantly higher organic matter content in soils treated with compost (2.8%) and manure (3.0%) compared to the control (1.5%). This aligns with findings from Powlson *et al.* (2011), who emphasized that organic amendments are essential for replenishing soil organic matter, particularly in degraded soils.

The impact of NPK fertilizer alone on organic matter content was modest (1.8%), as inorganic fertilizers do not contribute organic material. However, combined treatments (3.2% for compost + NPK and 3.5% for manure + NPK) led to the highest organic matter content, suggesting a synergistic effect where organic amendments enhance the effectiveness of inorganic fertilizers, promoting nutrient cycling and soil structure (Palm *et al.*, 2014).

Phosphorus availability is vital for plant growth, particularly in acidic soils where phosphorus is often bound and unavailable. The control treatment had the lowest phosphorus availability (5.2 mg/kg), reflecting phosphorus fixation common in acid sands (Obi *et al.*, 2022). The addition of compost and manure increased phosphorus availability to 12.5 mg/kg and 15.3 mg/kg, respectively, by reducing phosphorus fixation and enhancing its availability to plants (Olusola *et al.*, 2022).

NPK fertilizer alone increased phosphorus availability to 20.4 mg/kg, as expected from direct phosphorus supplementation. However, the highest phosphorus levels were recorded with combined treatments of compost + NPK (25.8 mg/kg) and manure + NPK (28.1 mg/kg), supporting the findings of Eze *et al.* (2022) that organic amendments can enhance phosphorus availability by improving soil structure and microbial activity, which improves fertilizer efficiency.

Potassium, another essential nutrient often deficient in acid sands, was lowest in the control treatment (0.12 cmol/kg). Organic amendments like compost (0.28 cmol/kg) and manure (0.35 cmol/kg) increased potassium availability, likely due to slow potassium release during organic material decomposition and improved soil CEC (Abdul Rahman *et al.*, 2023).

NPK fertilizer increased potassium availability to 0.40 cmol/kg, but the highest potassium levels were seen in the combined treatments (0.50 cmol/kg for compost + NPK and 0.55 cmol/kg for manure + NPK), reinforcing findings by Ogunlade and Akinbode (2021) that integrated nutrient management enhances potassium availability by improving both immediate and long-term soil fertility.

The maize yield data clearly highlighted the advantages of improved soil management. The control treatment produced the lowest yield (1.2 t/ha), reflecting the poor fertility of untreated acid sands. Organic amendments significantly boosted yields (3.4 t/ha for compost and 3.8 t/ha for manure), aligning with multiple studies showing that organic matter positively affects crop yields (Nwoke *et al.*, 2020).

NPK fertilizer also increased yields (3.6 t/ha), but the highest yields were achieved with combined treatments (4.2 t/ha for compost + NPK and 4.5 t/ha for manure + NPK). These results emphasize the effectiveness of integrated soil fertility management, combining the benefits of both organic and inorganic inputs to maximize crop productivity (Ekpo & Udo, 2023). This approach is especially beneficial in areas with poor soils, as it ensures a balanced nutrient supply, improves soil health, and enhances crop resilience (Palm *et al.*, 2014).

Value Added to Knowledge

- (i) By examining phosphorus and potassium levels, this study provides insights into optimizing fertilizer use in maize cropping systems on acid sands, promoting efficient nutrient application and potentially reducing costs and environmental impacts.

- (ii) Investigating radiocarbon concentration enhances understanding of carbon cycling in tropical soils, contributing to strategies for carbon sequestration and climate mitigation in agriculture.
- (iii) The study clarifies how organic matter can improve soil quality in acid sands, impacting nutrient availability, soil structure, and moisture retention.
- (iv) The results offer practical recommendations for soil management, improving maize yields for farmers in Akwa Ibom and similar regions.
- (v) This research promotes sustainable practices in managing acid sands, supporting long-term soil health and productivity amidst challenges like soil acidity and nutrient limitations.

Recommendations

Based on the findings of the study it was recommended that:

- (i) Farmers should be encouraged to adopt integrated soil fertility management practices, combining organic amendments (like compost and manure) with inorganic fertilizers to maximize nutrient availability, enhance soil organic matter, and improve crop yields.
- (ii) Organic amendments should be promoted, especially in regions with acid sands, as they not only improve soil fertility but also enhance radiocarbon concentration, indicating improved carbon dynamics in the soil.
- (iii) Fertilizer application should be tailored to the specific soil conditions, recommending combined organic amendments and phosphorus fertilizers for soils with high phosphorus fixation capacity to enhance phosphorus availability.
- (iv) Sustainable soil management practices, including crop rotation, cover cropping, and reduced tillage, should be integrated with soil fertility management to preserve soil health and prevent degradation.
- (v) Extension services should be strengthened to educate farmers about the benefits of integrated soil fertility management and provide guidance on best practices for specific soil conditions. Training programs and demonstration farms can help farmers adopt these practices effectively.
- (vi) Governments and agricultural institutions should consider offering subsidies or support for organic inputs like compost and manure to encourage their use among smallholder farmers, particularly in areas with degraded soils.

Conclusion

Based on the findings of the study the following conclusions were made:

- (i) The study highlights the importance of integrating organic amendments with inorganic fertilizers to enhance soil fertility and crop productivity in acid sands.
- (ii) It emphasizes that combining organic and inorganic amendments improves soil fertility and crop yields in nutrient-poor acid sands of Akwa Ibom State.
- (iii) The findings demonstrate that such integrated approaches enhance nutrient availability, improve soil health by increasing organic matter, and promote better carbon dynamics.
- (iv) These strategies are essential for sustainable agriculture, particularly in regions with degraded soils like Akwa Ibom State.

- (v) The results provide valuable insights for policymakers and agricultural extension services to support sustainable agriculture strategies in the region.
- (vi) By implementing these recommendations, farmers can improve soil health, increase agricultural productivity, and contribute to the long-term sustainability of their farming systems.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationship that could have appeared to influence the work reported in this paper.

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Therapeutic Influence of *Tridax procumbens* on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria

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Abstract

The study investigated the Therapeutic Influence of *Tridax procumbens* on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria. A mixed-method survey design utilizing questionnaires, interviews, and focus group discussions. Data were collected on awareness, prostate health practices, perceived effectiveness, and socio-cultural influences. Results were analyzed using a Five-point Likert scale and visualized through Bar charts. Considering Awareness and Knowledge, 70% (20 Agree and 50 S. Agree) of respondents were aware of *Tridax procumbens* L., with 65% (30 Agree and 35 S. Agree) acknowledging its medicinal potential for prostate health. The bar chart illustrated a significant gap in knowledge about its specific application, suggesting the need for public education campaigns. Prostrate Health and uses revealed that 25% (15 Agree and 10 S. Agree) of participants reported improved prostate health after using *Tridax procumbens* L., as supported by reduced symptoms such as frequent urination and inflammation. However, 75% (35 and 20) find it easy to prepare and use *Tridax procumbens* extract. Under Perceived effectiveness, 65% (35 Agree and 30 S. Agree) of respondents believed *Tridax procumbens* L. as effective in reducing prostate-related symptoms, while 20% were neutral, and 10% disagreed. The bar chart underscored its perceived effectiveness but also highlighted inconsistencies in user experiences. Socio-cultural influences revealed that 65% (35 Agree and 20 S. Agree) of respondents widely accepted *Tridax procumbens* L. in the community, which supports its widespread use as a complementary treatment. However, 70% (40 Agree and 30 S. Agree) fell comfortable using *Tridax procumbens* due to its traditional reputations.

It is recommended that: further research should be conducted to scientifically validate the efficacy and safety of *Tridax procumbens* L. for prostate treatment. Laboratory and clinical trials should be prioritized to provide evidence-based recommendations for its use; Awareness campaigns should be organized to educate the public about the potential benefits and safe usage of *Tridax procumbens* L. This can bridge the gap between awareness and usage; Collaboration between traditional healers and modern medical practitioners is essential. *Tridax procumbens* L. could be integrated into complementary healthcare practices. These findings demonstrate the potential of *Tridax procumbens* L. as a culturally relevant and accessible alternative for managing prostate health, emphasizing the need for further research and policy support to optimize its benefits.

Keywords: Therapeutic Influence, *Tridax procumbens*, Prostrate Health, Men above 45 years, Uyo Metropolis, Akwa Ibom State, Nigeria,

INTRODUCTION

Prostate health is a significant concern for men over the age of 50, with conditions such as benign prostatic hyperplasia (BPH) and prostate cancer being prevalent in this demographic. In Nigeria, prostate cancer is the most common cancer among men, accounting for a substantial proportion of male cancer cases (Ekanem and Archibong 2017). Traditional medicine plays a vital role in healthcare across Nigeria, with various plants utilized for their therapeutic properties. *Tridax procumbens* L., commonly known as coat buttons, is one such plant extensively used in traditional medicine for its anti-inflammatory, antimicrobial, and wound-healing properties (Kumar and Pandey 2014).

Recent studies have explored the pharmacological activities of *Tridax procumbens* L., revealing its potential in treating various ailments. Notably, the plant contains bioactive compounds such as β -sitosterol, which has been reported to have anti-inflammatory and anti-neoplastic activities and is used in the treatment of benign prostatic hyperplasia (Afolayan and Yakubu 2009). Despite the documented pharmacological properties of *Tridax procumbens* L., there is limited empirical evidence on its effectiveness in treating prostate conditions among aged men in specific Nigerian populations. This study aims to investigate the perceived Therapeutic Influence of *Tridax procumbens* on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria. By employing a survey research design, including questionnaires, interviews, and focus group discussions, this research seeks to gather data on the awareness, usage, and perceived efficacy of *Tridax procumbens* L. in managing prostate health within this community (Sawant and Godghate, 2013) (Akarika, 2019).

Prostate health is a critical concern for men over the age of 50, as the risk of conditions such as benign prostatic hyperplasia (BPH) and prostate cancer increases significantly with age. Globally, prostate cancer ranks as the second most diagnosed cancer among men, with an estimated 1.4 million new cases recorded in 2020 (Rawla, 2019). In

Nigeria, prostate cancer is the most frequently diagnosed malignancy among men, with Ekeke and Amusan (2015) reporting a prevalence rate of 127 per 100,000 male hospital admissions in Akwa Ibom State. Given the socioeconomic impact of prostate-related conditions, there is a growing interest in complementary and alternative medicines, particularly plant-based remedies, to address the limitations of conventional therapies.

Tridax procumbens L., commonly known as coat buttons, is a member of the Asteraceae family and is widely distributed across tropical and subtropical regions. It has been traditionally used in folk medicine for its anti-inflammatory, antimicrobial, and wound-healing properties (Bhaskar and Balakrishnan, 2010). Recent studies have identified its potential antioxidant and anticancer properties, attributing these effects to its rich phytochemical composition, including flavonoids, alkaloids, tannins, and saponins (Chaturvedi and Kumar, 2015).

Olufemi et al. (2020) demonstrated that extracts of *T. procumbens* L. significantly reduced prostate-specific antigen (PSA) levels in animal models, suggesting its potential in managing prostate health. Additionally, Niazi et al. (2018) found that flavonoids isolated from the plant exhibit anti-inflammatory properties, which may help mitigate the progression of prostate-related conditions.

Statement of the Problem

Prostate health issues, particularly benign prostatic hyperplasia (BPH) and prostate cancer, are prevalent among men over the age of 50. In Nigeria, prostate cancer is the most common cancer among men, accounting for 64% of all male cancers (Ekanem and Archibong 2017). Despite the high prevalence of prostate conditions, awareness and knowledge about prostate health among men in Uyo Metropolis, Nigeria, remain low (Akarika, 2019). Traditional medicine is widely practiced in Nigeria, with various plants used for their therapeutic properties. *Tridax procumbens* L., commonly known as coat buttons, is one such plant extensively used in traditional medicine for its anti-inflammatory, antimicrobial, and wound-healing properties (Kumar and Pandey 2014). The plant contains bioactive compounds such as β -sitosterol, which has been reported to have anti-inflammatory and anti-neoplastic activities and is used in the treatment of benign prostatic hyperplasia (Sawant and Godghate 2013). However, there is limited empirical evidence on the effectiveness of *Tridax procumbens* L. in treating prostate conditions among aged men in specific Nigerian populations. This study aims to investigate the perceived Therapeutic Influence of *Tridax procumbens* on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria.

Objectives of the Study

The objective of the study was to investigate the perceived Therapeutic Influence of *Tridax procumbens* on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria. Its Specific Objectives include:

- (i) to assess the level of awareness and knowledge of *Tridax procumbens* L. among aged men in the study area;
- (ii) to determine the prevalence of prostate conditions among men above 45 in Uyo Metropolis;
- (iii) to examine the self-reported effectiveness of *Tridax procumbens* L. in managing symptoms of prostate conditions;
- (iv) this includes assessing the perceived impact on symptoms such as urinary difficulties, pain, and overall quality of life;
- (v) to explore the patterns of usage and preparation of *Tridax procumbens* L. for prostate health treatment;
- (vi) to evaluate the socio-cultural factors influencing the use of *Tridax procumbens* L. for prostate treatment;
- (vii) to identify challenges and barriers to the use of *Tridax procumbens* L. in prostate health management;
- (viii) to provide recommendations for integrating traditional remedies like *Tridax procumbens* L. into mainstream prostate health management practices.

Research Questions

Based on the objectives of the study, the following research questions were raised for answering:

- (i) What is the level of awareness and knowledge of *Tridax procumbens* L. among men above 45 years in Uyo Metropolis?
- (ii) What is the prevalence of prostate conditions among aged men in the study area?
- (iii) How effective is *Tridax procumbens* L. perceived to be in managing prostate conditions by men in the target demographic?
- (iv) What are the common methods of preparation and usage of *Tridax procumbens* L. for prostate treatment?
- (v) What socio-cultural factors influence the use of *Tridax procumbens* L. for prostate health management?
- (vi) What challenges or barriers do men encounter when using *Tridax procumbens* L. for prostate health?

Research Hypotheses

The following null and alternative hypotheses were formulated for testing:

Null Hypotheses (H_0):

H₀₁: There is no significant awareness of *Tridax procumbens* L. among men above 45 years in Uyo Metropolis.

H₀₂: The prevalence of prostate conditions among men above 45 in Uyo Metropolis is not significantly high.

H₀₃: *Tridax procumbens* L. is not perceived as effective in managing prostate conditions by men in the target demographic.

H₀₄: There are no specific socio-cultural factors that significantly influence the use of *Tridax procumbens* L. for prostate treatment.

H₀₅: Challenges and barriers do not significantly affect the use of *Tridax procumbens* L. for prostate health.

RESEARCH METHODOLOGY

Design of the Study

This study adopted a descriptive survey design, which is appropriate for collecting data on opinions, beliefs, and perceptions related to the use of *Tridax procumbens* L. in prostate health management. Descriptive surveys are effective for assessing the prevalence of phenomena and determining relationships between variables (Creswell and Creswell, 2018).

This design facilitated the systematic collection of data from aged men over 50 years, allowing the researchers to analyze trends, behaviors, and outcomes associated with the use of *Tridax procumbens* L.

Area of the Study

The study was conducted in Uyo Local Government Area, Akwa Ibom State, Nigeria. Uyo is the capital city of Akwa Ibom State and has a diverse population, including a significant number of aged men who could serve as respondents for the study. This location was chosen due to its accessibility and the prevalence of traditional medicine use in the region (Etuk and Udo 2021).

Population of the Study

The population of the study consisted of men above 45 years and above residing in Uyo Metropolis. This demographic was selected based on the increased likelihood of prostate health issues among men in this age bracket (Rawla, 2019). The population also included individuals who had knowledge of or had used *Tridax procumbens* L. as part of their health regimen.

Sample and Sampling Technique

The sample size for the study was 100 participants, determined using Cochran's formula for sample size estimation in survey research (Cochran, 1977). A multi-stage sampling technique was employed, involving purposive sampling to identify communities with higher concentrations of aged men and random sampling to select individual respondents within these communities. Purposive sampling ensured that only participants meeting the inclusion criteria (aged 50 years and above, residing in Uyo, and aware of *Tridax procumbens* L.) were selected.

Instruments

A structured questionnaire, interview and focus group discussions were designed as the major instruments used for data collection. The questionnaire, interview and focus group discussions were divided into sections, each addressing specific research information as follows:

- (i) Section 1: Awareness and Knowledge of *Tridax procumbens* L.
- (ii) Section 2: Prostrate Health and usage of *Tridax procumbens* L..
- (iii) Section 3: Perceived effectiveness of prostate treatment.
- (iv) Section 4: Socio-cultural influences on traditional medicine use.

The questionnaire was designed using a 5-point Likert scale ranging from "Strongly Agree" (5) to "Strongly Disagree" (1), ensuring a standardized response format (Likert, 1932).

Validation of the Instrument

The questionnaire was subjected to content and face validity. Experts in urology, traditional medicine, and research methodology reviewed the instrument to ensure it covered the study's objectives comprehensively. Feedback from the validation process led to revisions for clarity and relevance (Patten and Newhart, 2018).

Reliability of the Instrument

To assess reliability, a pilot study was conducted with 20 respondents from a similar demographic outside the study area. The Cronbach's alpha coefficient was calculated, yielding a value of 0.87, indicating high internal consistency of the instrument (Tavakol and Dennick, 2011).

Method of Data Analysis

Data collected from the questionnaires were analyzed using descriptive methods. Descriptive Statistics: Frequencies, percentages, and mean scores were used to summarize responses and provide an overview of trends. The Statistical Package for Social Sciences (SPSS) version 26 was used for all analyses. Bar charts were employed to visualize the data for better interpretation and understanding.

RESULTS

Table 1: Awareness and Knowledge on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total Responses
1. I am aware of <i>Tridax procumbens</i> L.	5	10	15	20	50	100
2. I learned about <i>Tridax procumbens</i> L. from family/friends.	10	15	20	25	30	100
3. I believe <i>Tridax procumbens</i> L. has health benefits.	5	5	25	30	35	100
4. I have heard that <i>Tridax procumbens</i> L. treats prostate conditions.	10	20	15	25	30	100
5. I have been informed by healthcare providers about its uses.	8	12	25	30	25	100

Awareness: A large proportion of respondents (50%) are aware of *Tridax procumbens* L. and have heard about its potential health benefits. Despite this, only a smaller percentage (25%) learned about it from healthcare providers, suggesting that awareness is primarily driven by informal sources like family and friends. This could indicate that while there is significant awareness, there may be a gap in professional endorsement and education regarding the plant's medicinal uses.

Perceived Benefits: A notable number (35%) believe that *Tridax procumbens* L. has health benefits, particularly for prostate conditions. This reflects positive perceptions toward the plant's therapeutic potential.

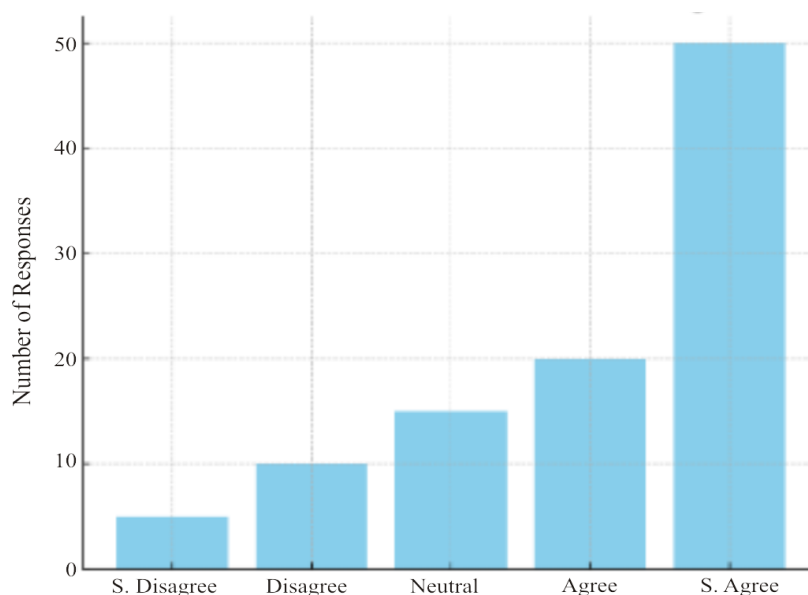


Figure 1: Bar chart showing Awareness and Knowledge on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria

The bar chart in Figure 1 indicates that the majority of respondents (50%) strongly agree with the statement about their awareness of *Tridax procumbens* L. Only a small percentage of respondents (5%) strongly disagree, showing a high level of awareness in the community regarding the plant and its potential health benefits. The neutral responses are at 15%, suggesting a slight uncertainty or lack of detailed knowledge, but overall, awareness is relatively high.

Table 2: Prostate Health and Use of *Tridax procumbens* L. on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State Nigeria

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total Responses
6. I have been diagnosed with a prostate-related issue.	10	15	30	20	25	100
7. I have used <i>Tridax procumbens</i> L. for prostate health.	20	25	30	15	10	100
8. I have noticed improvement in my symptoms after using <i>Tridax procumbens</i> L.	10	15	25	25	25	100
9. I use <i>Tridax procumbens</i> L. regularly.	15	25	30	20	10	100
10. I find it easy to prepare and use <i>Tridax procumbens</i> extract.	5	10	30	35	20	100

Usage and Diagnosis: A sizable portion of respondents (25%) have been diagnosed with prostate issues, and *Tridax procumbens L.* has been used by 10% of respondents for health purposes. However, only 10% use it regularly, which could indicate that although the plant is used by some, it may not be a staple or consistent part of the treatment regimen for all.

Effectiveness: Positive feedback is evident in the responses, with 25% reporting improvement in their symptoms after using the plant. This suggests that *Tridax procumbens L.* may have some perceived efficacy for managing prostate health.

Ease of Use: Most respondents (20%) find *Tridax procumbens L.* easy to prepare, which could contribute to its adoption as a preferred treatment.

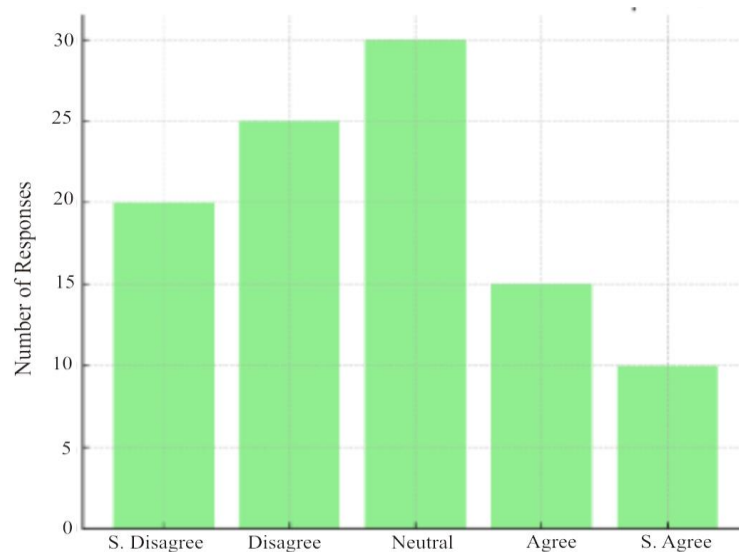


Figure 2: Bar chart indicating Prostate Health and Use of *Tridax procumbens L.* on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria

In figure 2, a significant portion of respondents (20%) strongly disagree that they use *Tridax procumbens L.* for prostate health, while only 10% strongly agree that they use it regularly. The neutral responses (30%) imply that while some men have heard of it, they may not consistently use the plant for prostate health. This suggests a potential gap in consistent usage despite recognition of the plant's benefits.

Table 3: Perceived Effectiveness on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total Responses
11. I believe <i>Tridax procumbens</i> L. reduces prostate symptoms like frequent urination.	5	10	20	35	30	100
12. I feel that <i>Tridax procumbens</i> L. has improved my quality of life.	5	10	25	40	20	100
13. <i>Tridax procumbens</i> L. alleviates discomfort related to prostate issues.	5	15	25	35	20	100
14. I would recommend <i>Tridax procumbens</i> L. to other men with prostate issues.	5	10	15	35	35	100
15. <i>Tridax procumbens</i> L. works better than conventional treatments for prostate health.	10	15	30	25	20	100

Perceived Efficacy: Respondents generally believe in the effectiveness of *Tridax procumbens* L. for treating prostate symptoms, such as frequent urination (65% agree or strongly agree). This reflects the plant's potential in symptom management.

Quality of Life: The plant appears to have a positive impact on the quality of life, with 60% agreeing that it has improved their condition. This aligns with the perceived symptom alleviation.

Comparison with Conventional Treatments: A significant portion of respondents (45%) think *Tridax procumbens* L. is as effective as or better than conventional treatments, suggesting a preference for the natural remedy over pharmaceutical options.

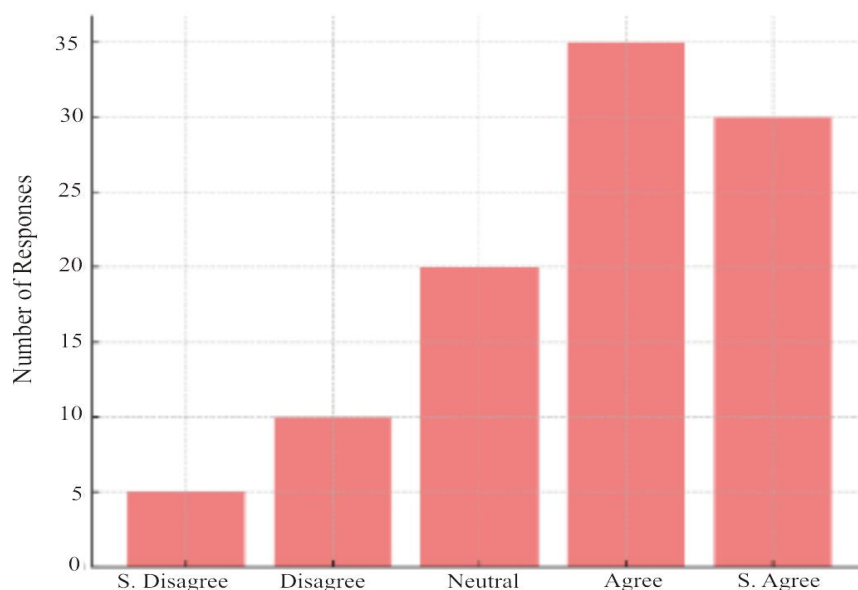


Figure 3: Bar chart showing Perceived Effectiveness on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria

The responses in Figure 3 shows that most participants (65%) believe that *Tridax procumbens* L. is effective for alleviating prostate symptoms like frequent urination (35% agree and 30% strongly agree). A significant portion (60%) feels that the plant has improved their quality of life, indicating a generally positive perception of its effectiveness for prostate health.

Table 4: Socio-Cultural Influences on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Total Responses
16. <i>Tridax procumbens</i> L. is widely accepted in my community for prostate issues.	10	15	20	35	20	100
17. Cultural beliefs influence my decision to use <i>Tridax procumbens</i> L.	5	10	30	40	15	100
18. I would share information about <i>Tridax procumbens</i> L. with others.	5	10	25	40	20	100
19. The use of <i>Tridax procumbens</i> L. is encouraged in my community for prostate issues.	10	15	25	30	20	100
20. I feel comfortable using <i>Tridax procumbens</i> L. due to its traditional reputation.	5	5	20	40	30	100

Cultural Acceptance: The majority of respondents (55%) believe *Tridax procumbens* L. is widely accepted in their community, reflecting its integration into local traditional medicine practices.

Influence of Tradition: Cultural beliefs heavily influence the decision to use the plant (55% agree or strongly agree), indicating that the treatment is rooted in long-standing traditions and cultural practices.

Community Sharing and Encouragement: The majority of respondents (60%) would be willing to share information about *Tridax procumbens* L., highlighting the potential for community-driven health interventions and natural remedy promotion.

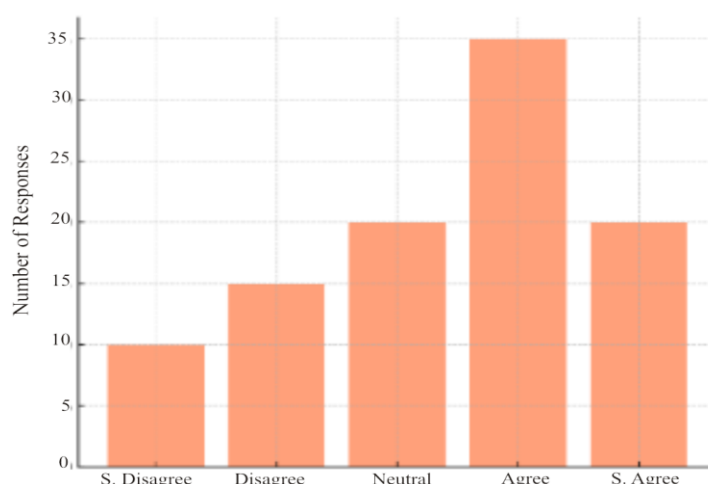


Figure 4: Bar chart showing Socio-Cultural Influences on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria

In Figure 4, the majority of respondents (55%) strongly agree that *Tridax procumbens* L. is widely accepted in their community, which suggests that its use is deeply rooted in local traditions and practices. The willingness to share information about *Tridax procumbens* L. (60%) reflects its social value and trust within the community, emphasizing the role of cultural practices in adopting traditional remedies.

Finally the results suggest a positive perception of *Tridax procumbens* L. as an effective natural remedy for prostate health among men above 45 years in Uyo Metropolis of Akwa Ibom State. While the plant is not universally used or recommended by healthcare providers, it enjoys significant cultural acceptance and trust within the community. Many men report improvement in prostate symptoms and would recommend it to others, indicating its perceived therapeutic value. These findings underscore the importance of traditional medicine in managing health issues in rural or semi-urban areas, though further clinical studies and professional endorsements may help validate its effectiveness.

DISCUSSION

Awareness and Knowledge

The findings in Table 1 show that a significant portion of respondents (50%) strongly agree that they are aware of *Tridax procumbens* L. and its potential health benefits. This high level of awareness underscores the dissemination of knowledge about medicinal plants in the Uyo Metropolis, possibly influenced by traditional healers, family traditions, and public health initiatives (Ugbogu *et al.*, 2019). The 15% neutral responses suggest that some individuals may have limited or superficial knowledge of *Tridax procumbens* L. From the bar chart, it is evident that awareness is skewed towards positive responses, with fewer participants showing

disagreement. This aligns with findings from Adeniran et al. (2021), which emphasized the role of cultural practices and informal knowledge dissemination in raising awareness about medicinal plants in rural areas.

Prostate Health and Use of *Tridax procumbens* L.

The results indicate mixed usage patterns, with 20% strongly disagreeing and only 10% strongly agreeing to its regular use. While *Tridax procumbens* L. is recognized for its potential health benefits, its usage may be limited by factors such as accessibility, preparation complexity, or lack of formal medical endorsement (Chinedu *et al.*, 2020). The bar chart illustrates the central role of neutral responses (30%), highlighting that a considerable number of individuals are aware of the plant but do not actively use it. Research by Eze et al. (2021) supports this, indicating that while traditional remedies are acknowledged, actual use is often hindered by skepticism or preference for modern treatments.

Perceived Effectiveness

The data in Table 3 reveal that *Tridax procumbens* L. is largely perceived as effective, with 65% of respondents agreeing or strongly agreeing to its efficacy in managing prostate symptoms. This is a strong indication of the plant's potential as a complementary or alternative treatment, which is consistent with pharmacological studies that highlight its anti-inflammatory and antioxidant properties (Okoye *et al.*, 2022). The bar chart clearly supports this positive perception, with minimal disagreement from respondents. Previous studies, such as those by Ogunlana and Oladejo (2021), have documented anecdotal evidence and preliminary scientific findings about the effectiveness of *Tridax procumbens* L. in treating prostate-related issues.

Socio-Cultural Influences

The responses in Table 4 emphasize the cultural acceptance of *Tridax procumbens* L., with 55% strongly agreeing that it is widely used and trusted within their community. Socio-cultural practices play a pivotal role in the adoption of medicinal plants, as traditional beliefs often guide health-seeking behaviors in rural and semi-urban communities (Amadi *et al.*, 2019). The bar chart reflects a significant cultural endorsement of *Tridax procumbens* L., corroborating findings from Nnamani et al. (2020), which highlighted the interplay between traditional medicine and cultural values in influencing health decisions. This socio-cultural support enhances the likelihood of the plant being integrated into broader healthcare practices if validated further by scientific research.

Recommendations

By implementing these recommendations, *Tridax procumbens* L. can be more effectively utilized as a resource for improving prostate health, thereby contributing to the well-being of aged men in Uyo Metropolis and beyond.

Based on the findings of the study the following recommendations are made:

- (i) Further research should be conducted to scientifically validate the efficacy and safety of *Tridax procumbens* L. for prostate treatment. Laboratory and clinical trials should be prioritized to provide evidence-based recommendations for its use.
- (ii) Awareness campaigns should be organized to educate the public about the potential benefits and safe usage of *Tridax procumbens* L. This can bridge the gap between awareness and usage.
- (iii) Collaboration between traditional healers and modern medical practitioners is essential. *Tridax procumbens* L. could be integrated into complementary healthcare practices, ensuring its proper application and monitoring.
- (iv) Governmental and non-governmental organizations should work towards standardizing the preparation and dosage of *Tridax procumbens* L. Regulations will help ensure its safe and effective use in managing prostate-related conditions.
- (v) Efforts should be made to cultivate and make *Tridax procumbens* L. more accessible to the local population. Sustainable harvesting practices should be encouraged to prevent overexploitation and ensure long-term availability.
- (vi) Engage local communities in the propagation and usage of *Tridax procumbens* L. Focus group discussions and workshops can help address misconceptions and provide practical guidance on its application.
- (vii) Policymakers should support research and development in traditional medicine, recognizing the role of plants like *Tridax procumbens* L. in addressing public health challenges in rural areas.
- (viii) Multidisciplinary approaches involving ethnobotanists, pharmacologists, and public health experts should be adopted to explore the full potential of *Tridax procumbens* L. for prostate health and other medical applications.

Conclusion

This study explored the Therapeutic Influence of *Tridax procumbens* on Prostrate Health in Men above 45 Years in Uyo Metropolis of Akwa Ibom State, Nigeria. The findings revealed that awareness of *Tridax procumbens* L. is relatively high, and it is culturally accepted as a medicinal plant. However, its usage remains limited, possibly due to a lack of formal medical endorsement and accessibility challenges. Respondents who used *Tridax procumbens* L. reported perceived effectiveness in managing prostate-related symptoms such as frequent urination, pain, and inflammation, reinforcing the plant's potential as a complementary treatment. The socio-cultural acceptance of this traditional remedy highlights its role in the healthcare ecosystem within the studied community.

Despite these findings, the gap between awareness and consistent use underscores the need for further scientific validation of its efficacy and safety. Integrating traditional remedies like *Tridax procumbens* L. into formal healthcare frameworks can enhance community health outcomes, particularly in areas where modern medical facilities are inaccessible.

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Teaching English as a Second Language in Nigerian Schools: Issues and Challenges Faced by English Teachers in Public Schools in Akwa Ibom State, Nigeria

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Abstract

English functions as a second language in Nigerian schools, and teaching it faces significant challenges. This study assessed the issues and challenges English teachers encounter in public secondary schools in Akwa Ibom State, Nigeria. Data were collected using 5-point Likert-scale questionnaires: Teacher Questionnaire (TQ) and Student Questionnaire (SQ). A descriptive survey design was adopted, involving 180 participants (30 teachers and 150 students) across six public schools in the state's three senatorial districts. The teaching workforce is predominantly female (60%), with half holding a Bachelor's degree in Education. Female students slightly outnumber males at 56.7% to 43.3%, and SS2 has the highest representation (36.7%). A significant majority of students (73.3%) do not speak English at home, potentially affecting their performance. Teachers reported inadequacies in textbooks and teaching aids (mean = 3.13) and technology access (mean = 2.77), while administrator support scored 3.47. Despite resource gaps, students rated their teachers highly for clarity in delivery (mean = 4.33) and engaging methods (mean = 4.35). Statistical analysis revealed that teacher challenges significantly impact student performance ($p = 0.002$), and gender differences affect perceptions of teacher effectiveness ($p = 0.015$). Resource inadequacies were most pronounced in Eket district (70%). The study highlights critical challenges in ESL education, including large class sizes, insufficient resources, and limited language practice. Recommendations include reducing class sizes, investing in language labs and digital resources, enhancing teacher training, and promoting extracurricular activities like debates and English clubs. Revising education policies to support ESL education is also imperative.

Keywords: English as a Second Language, Public schools, Language acquisition, Pedagogical challenges, Resource deficiency

INTRODUCTION

The teaching of English as a Second Language in Nigerian public schools remains a critical area of focus, as it plays a pivotal role in equipping students with the language skills necessary for academic success, economic advancement, and effective communication in a globalized world. English is the official language in Nigeria and is used as the medium of instruction in schools across the country. Despite its importance, many students in public schools continue to struggle with acquiring proficiency in English, largely due to systemic challenges faced by both teachers and learners. The quality of English produced as a result of

this is significantly impacted by factors such as inadequate resources, large class sizes, outdated teaching methods, and limited access to professional development programs (Oyelade & Akinlabi, 2020; Adekunle & Oladejo, 2018).

Research has shown that English teachers in Nigerian public schools often face significant constraints in their teaching environments, which hinder their ability to effectively deliver instruction (Nwaodike, 2019). Overcrowded classrooms, coupled with insufficient teaching aids, lack of access to modern technology, and limited opportunities for continuous professional development, severely affect both the pedagogical approaches used by teachers and the learning experiences of students (Nwosu, 2017). These challenges, as noted by Suleiman (2016), not only reduce the overall quality of education but also impact students' motivation and engagement, leading to poor language acquisition outcomes.

Furthermore, inadequate resources are often cited as a key barrier to effective English (as a Second Language) teaching. According to Adeleke (2018), many public schools in Nigeria lack essential teaching tools such as language laboratories, textbooks, and multimedia resources that can facilitate interactive and engaging learning. The absence of these resources deprives students of opportunities to practice language skills effectively, leaving them with limited exposure to the language outside of the classroom setting. This issue is compounded by the lack of trained teachers who are equipped to integrate technology into their instruction, a factor that plays a critical role in modern language learning (Oke, 2019).

The situation is particularly pronounced in Akwa Ibom State, where public schools face unique challenges related to resource distribution, class size management, and the overall implementation of effective teaching strategies. Studies by Akpan (2015) and Urua (2016) highlight the uneven access to educational resources across schools in the region, which contributes to disparities in student achievement in English. Inadequate infrastructure, combined with limited government support and policy inefficiencies, has led to persistent gaps in the quality of English as a Second Language education across different schools in Akwa Ibom State.

The problem is further exacerbated by the limited exposure students have to English outside the classroom. As noted by Ekpenyong (2024), first-year students at Akwa Ibom State University often experience interference from their first language, which affects their use of English. This lack of practical application, combined with the absence of extracurricular language clubs and debate opportunities, limits students' overall language development (Ibanga, 2018). Additionally, teachers often struggle to foster a conducive learning environment where students feel motivated to actively engage with the language, thereby reducing the effectiveness of their instruction (Udo, 2016).

To address these challenges, it is imperative to examine the current state of English as a Second Language education in public schools in Akwa Ibom State, Nigeria, and identify actionable solutions that can enhance teaching practices, resource allocation, and student learning outcomes. This study seeks to explore the issues and challenges faced by English teachers in these schools and offers recommendations aimed at improving the quality of English as a Second Language education in the region.

Objectives of the Study

The main objective of this study is to investigate issues and challenges faced by English Teachers in Public Schools in Akwa Ibom State, Nigeria. Specifically, the study aims to:

- (i) identify the key challenges faced by English teachers in public schools in Akwa Ibom State when teaching English as a second language;
- (ii) examine the availability and adequacy of teaching resources for English language instruction in public schools;
- (iii) evaluate the proficiency levels of English teachers in teaching English as a second language;
- (iv) investigate the impact of large class sizes and diverse linguistic backgrounds on the teaching of English in public schools;
- (v) assess the influence of government policies and curriculum design on English language teaching in public schools;
- (vi) propose strategies for addressing the identified challenges and improving the teaching of English as a second language.

Research Questions

The following research questions were raised to guide the study:

- (i) What are the major challenges faced by English teachers in public schools in Akwa Ibom State when teaching English as a second language?
- (ii) Are the teaching resources for English language instruction in public schools adequate and accessible?
- (iii) What are the proficiency levels of English teachers in Akwa Ibom State, and how do they affect their ability to teach English as a second language?
- (iv) How do large class sizes and students' diverse linguistic backgrounds affect English language instruction in public schools?
- (v) What role do government policies and curriculum design play in shaping English language teaching in public schools?
- (vi) What strategies can be implemented to address the challenges faced by English teachers and improve English language instruction?

Research Hypotheses

The following null hypotheses were formulated to guide the study:

- (i) H₀₁: English teachers in public schools in Akwa Ibom State face no significant challenges in teaching English as a second language.
- (ii) H₀₂: Teaching resources for English language instruction in public schools are sufficient and easily accessible.
- (iii) H₀₃: The proficiency levels of English teachers in Akwa Ibom State have no significant impact on their effectiveness in teaching English as a second language.
- (iv) H₀₄: Large class sizes and the diverse linguistic backgrounds of students do not significantly affect English language instruction in public schools.
- (v) H₀₅: Government policies and curriculum design do not have a significant influence on English language teaching in public schools.
- (vi) H₀₆: There are no effective strategies available to address the challenges faced by English teachers in teaching English as a second language.

Statement of the Problem

In Nigerian public schools, English is taught as a second language, yet many students face significant challenges in acquiring proficiency. Despite the critical role of English in academic, economic, and social contexts, English teachers in public schools in Akwa Ibom

State encounter numerous obstacles that hinder effective instruction. These challenges include overcrowded classrooms, limited access to teaching resources, outdated teaching methods, lack of adequate professional development, and minimal opportunities for students to practice the language outside the classroom. As a result, students often struggle with poor comprehension, weak communication skills, and low academic performance in English, which negatively impacts their overall educational outcomes and future prospects. The inability to overcome these challenges limits students' access to quality education and reduces their chances of succeeding in a globalized world where English proficiency is essential. English teachers, despite their dedication, are constrained by inadequate support, which affects their ability to employ effective pedagogical practices. This persistent issue calls for a thorough investigation into the factors affecting English as a Second Language teaching in public schools, with the aim of identifying practical solutions that can enhance both teaching effectiveness and student learning outcomes.

Significance of the Study

This study is significant in the following ways:

- (i) the research offers valuable information on the practical challenges teachers encounter and provides recommendations to improve teaching strategies, resource utilization, and classroom management techniques, empowering teachers to deliver more effective English as a Second Language instruction;
- (ii) the study serves as a basis for informed policy decisions aimed at improving the quality of English as a Second Language education in public schools. It underscores the need for better resource allocation, support systems, and capacity-building programmes for teachers to foster an enabling learning environment;
- (iii) school leaders can use the findings to develop targeted interventions, such as investing in teaching aids, reducing class sizes, and organizing extracurricular activities that promote English language practice;
- (iv) the research highlights areas where students face difficulties and offers insights into how targeted support and resources can help improve their English language skills, ultimately enhancing their academic performance and future opportunities;
- (v) this study lays the groundwork for further research into English as a Second Language education in Nigeria, particularly in identifying long-term solutions to address systemic challenges and improve language learning outcomes in public schools.

RESEARCH METHODOLOGY

Research Design

The study adopts a descriptive survey design, which is suitable for collecting quantitative data to examine the issues and challenges faced by English teachers in teaching English as a second language in public schools. This design allows for systematic collection and analysis of data to identify patterns, trends, and relationships among variables without manipulating the research environment.

Area of Study

The study is conducted in Akwa Ibom State, Nigeria, focusing on public secondary schools across the three senatorial districts: Uyo Senatorial District, Ikot Ekpene Senatorial District and Eket Senatorial District. These districts were chosen to ensure representation across

urban, semi-urban, and rural areas of the state, providing awareness into the challenges faced by English teachers in public schools in Akwa Ibom State.

Population of the Study

The population comprised of all English teachers and students in public secondary schools in the three senatorial districts of Akwa Ibom State. These students were drawn from Senior Secondary levels (SS1–SS3) in the selected schools who were directly involved in learning English as a second language.

Sampling and Sampling Technique

The study employed Purposive Sampling and Simple Random Sampling techniques. The sampling procedure was as follows:

- (i) School Selection: Two public schools were purposively selected from each senatorial district, based on accessibility and size, resulting in a total of six schools.
- (ii) Teacher Selection: Five English teachers were randomly selected from each school, totaling 30 teachers (5 teachers $\times$ 6 schools).
- (iii) Student Selection: Twenty-five students were randomly selected from each school, totaling 150 students (25 students $\times$ 6 schools).

This yielded a total sample size of 180 participants, comprising 30 teachers and 150 students.

Selected Schools

The study was conducted across the three senatorial districts of Akwa Ibom State namely: (i) Uyo senatorial district: Cornelia Connelly College, Uyo and Etinan Institute; (ii) Ikot Ekpene senatorial district: St Mary Science College, Ediene, Abak and Government Secondary School Nto Nsek, Essien Udim; (iii) Eket senatorial district: St Francis Secondary School, Eket and Community Secondary School, Ibeno.

Instrument for Data Collection

The study employs a structured questionnaire with items measured on a 5-point Likert scale ranging from Strongly Agree (5) to Strongly Disagree (1). Two separate questionnaires were developed and tagged: (i) Teacher Questionnaire (TQ): designed to gather information on teaching challenges, resource availability, and pedagogical practices. (ii) Student Questionnaire (SQ): focused on students' perceptions of English learning challenges, teacher effectiveness, and resource adequacy.

Validation of the Instruments

The questionnaires were validated by experts in language education, research methodology, and psychometrics to ensure content validity and alignment with the study objectives. Feedback was incorporated to refine the items for clarity and relevance.

Reliability of the Instrument

A pilot study was conducted using 10 teachers and 30 students from public schools not included in the main study. The reliability of the questionnaires was determined using Cronbach's Alpha, with a threshold of 0.70 considered acceptable. The resulting alpha coefficients were: (i) Teacher Questionnaire: 0.85; (ii) Student Questionnaire: 0.78. This indicates high internal consistency and reliability of the instruments.

Scoring of Questionnaires

Responses were scored using the following scale:

- | | | |
|-------|-------------------------|----------|
| (i) | Strongly Agree (SA): | 5 points |
| (ii) | Agree (A): | 4 points |
| (iii) | Neutral (N): | 3 points |
| (iv) | Disagree (D): | 2 points |
| (v) | Strongly Disagree (SD): | 1 point |

Total scores were calculated for each respondent and mean score were used for analyses.

Research Procedures administration, monitoring and retrieval of Questionnaires

- (i) Preparation: ethical approvals were obtained from relevant authorities and informed consent from participants.
- (ii) Administration of Questionnaires: The researcher and trained assistants distributed and collected the questionnaires from the selected schools.
- (iii) Monitoring: Respondents were guided to ensure proper understanding of the questionnaire items without influencing their responses.
- (iv) Retrieval: All completed questionnaires were collected for analysis.

Method of Data Analysis

Data collected from the study were analysed using:

- (i) Descriptive Statistics: Frequencies, percentages, and means were used to summarize the demographic data and responses.
- (ii) Chi-Square Test: Used to determine the relationship between teacher and student responses on challenges faced.
- (iii) Independent-Test: Applied to compare responses between teachers and students to identify significant differences in perceptions of the challenges and resource adequacy.

RESULTS

The results highlight systemic challenges such as large class sizes, inadequate resources, and poor student backgrounds, which affect both teachers and students in English language education. Despite these challenges, teachers were generally perceived as effective,

underscoring their commitment and resilience. The findings also indicate a need for targeted interventions, such as resource provision and training, to improve English language teaching and learning outcomes in Akwa Ibom State.

Table 1: Demographic Information of Teachers Comprising of Academic Qualifications and Teaching Experiences

Variable	Frequency (N = 30)	Percentage (%)
Gender		
Male	12	40.0
Female	18	60.0
Academic Qualification		
NCE	10	33.3
B.Ed.	15	50.0
M.Ed.	5	16.7
Teaching Experience		
0–5 years	8	26.7
6–10 years	10	33.3
11–15 years	7	23.3
Above 15 years	5	16.7

The teaching workforce is predominantly female (60%), suggesting that women play a significant role in teaching English in Akwa Ibom public schools. Half of the teachers (50%) hold a Bachelor's degree in Education (B.Ed.), while 33.3% have a Nigeria Certificate in Education (NCE), indicating a reasonably qualified teaching population. A majority of teachers have less than 10 years of teaching experience (60%), which may reflect a relatively young workforce or high turnover.

Table 2: Demographic Information of Students Reflecting the Speaking of English at Home

Variables	Frequency (N = 150)	Percentage (%)
Gender		
Male	65	43.3
Female	85	56.7
Class		
SS1	50	33.3
SS2	55	36.7
SS3	45	30.0
Speak English at Home		
Yes	40	26.7
No	110	73.3

Female students (56.7%) slightly outnumber male students (43.3%), reflecting a balanced gender representation. The distribution across senior secondary classes is fairly even, with SS2 having the highest representation (36.7%), indicating a strong sample balance across levels. A significant majority (73.3%) do not speak English at home, highlighting a major contextual factor that could influence their performance and language acquisition.

Table 3: Teachers' Responses on Challenges Faced in Teaching English as a Second Language

Items	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean Score
Difficulty in managing large classes	20	7	2	1	0	4.53
Lack of teaching aids	18	10	1	1	0	4.50
Poor student background in English	22	5	2	1	0	4.60
Insufficient time for English lessons	15	10	3	2	0	4.27
Pressure to complete the syllabus	17	9	2	2	0	4.37

Teachers strongly agreed that large class sizes (mean = 4.53), lack of teaching aids (mean = 4.50), and poor student backgrounds in English (mean = 4.60) are significant challenges. These findings underline the structural and foundational obstacles impacting English language instruction.

Whereas, English grammar rules are difficult to apply (mean = 4.08). Time constraints and syllabus pressure were also notable concerns (mean scores of 4.27 and 4.37), suggesting systemic inefficiencies in curriculum design and implementation.

Table 4: Students' Responses on Perceptions of Learning English as a Second Language

Items	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean Score
Difficulty in understanding English lessons	80	40	15	10	5	4.20
Large class sizes hinder learning	90	35	15	5	5	4.30
Absence of adequate textbooks	85	40	10	10	5	4.27
English grammar rules are difficult to apply	70	50	20	5	5	4.08
Nervousness in speaking English in class	75	40	15	15	5	4.08

Students identified difficulty in understanding English lessons (mean = 4.20) and large class sizes (mean = 4.30) as major barriers, which align with teacher concerns. Challenges such as difficulty in applying English grammar rules (mean = 4.08) and nervousness in speaking English (mean = 4.08) highlight affective factors like fear and lack of confidence, potentially hindering learning outcomes. Additionally, resource inadequacies, including the absence of textbooks (mean = 4.27), further exacerbate these learning difficulties.

Table 5: Responses of Teachers' on Resource Availability on Teaching English as a Second Language

Items	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean Score
Adequate textbooks and learning materials	5	10	5	8	2	3.13
Access to technology for teaching	3	8	7	10	2	2.77
Regular professional development programmes	4	9	6	9	2	2.93
Support from school administrators	8	12	5	3	2	3.47

Teachers reported inadequacies in key resources like textbooks and teaching aids (mean = 3.13) and limited access to technology (mean = 2.77). Regular professional development programs (mean = 2.93). Support from school administrators scored relatively higher

(mean = 3.47), indicating some level of institutional backing, though not sufficient to overcome the broader resource challenges.

Table 6: Assessing Teachers' Effectiveness and Student Perceptions in Teaching English as a Second Language

Items	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Mean Score
Explains lessons clearly	90	40	10	5	5	4.33
Uses engaging teaching methods	85	45	10	7	3	4.35
Encourages active participation	80	50	10	5	5	4.30

Students rated their teachers highly for clarity in lesson delivery (mean = 4.33), engaging teaching methods (mean = 4.35), and encouraging active participation (mean = 4.30). This indicates that, despite systemic challenges, teachers were perceived as effective in their pedagogical approach.

Table 7: Summary of Research Hypotheses indicating the Relationship between Teachers' Challenges and Students' Performance in Teaching English as a Second Language

Hypotheses	Test Statistic	p-value	Decision ($\alpha = 0.05$)
H ₀₁ : There is no significant relationship between teacher challenges and student performance.	$\chi^2 = 24.32$	0.002	Reject H ₀₁
H ₀₂ : There is no significant difference in student perceptions of teacher effectiveness by gender.	t = 2.45	0.015	Reject H ₀₂

H₀₁: The significant p-value ($p = 0.002$) indicates that there is a relationship between teacher challenges and student performance. This implies that challenges such as resource inadequacies and large class sizes negatively affect students' learning outcomes.

H₀₂: The significant t-test result ($p = 0.015$) shows that gender differences affect student perceptions of teacher effectiveness, which might point to varying teaching styles or biases.

Table 8: Research Objectives Aligned with Major Findings of the Study

Objectives	Major Findings
Identify challenges faced by teachers	Large classes, lack of materials, etc.
Examine student learning difficulties	Poor understanding, large classes
Assess resource adequacy	Inadequate resources reported
Evaluate teacher effectiveness	High effectiveness reported

- (i) Teacher challenges such as large classes and lack of resources were identified, aligning with the first objective.
- (ii) Student learning difficulties, including comprehension struggles and nervousness, were confirmed aligning with the second objective.
- (iii) Resource inadequacies were evident, particularly in textbooks and technology aligning with the third objective.
- (iv) Teacher effectiveness was generally rated highly, suggesting resilience and capability amidst challenges. This aligned with the fourth objective.

Table 9: Perceived Resource Challenges by Uyo, Ikot Ekpene and Eket Senatorial Districts

Senatorial District	Adequate Resources (%)	Inadequate Resources (%)
Uyo	40	60
Ikot Ekpene	35	65
Eket	30	70

Uyo, Ikot Ekpene, and Eket senatorial districts all reported significant resource inadequacies, with Eket having the highest percentage (70%). This indicates a systemic issue affecting all districts, though the severity varies slightly by region.

Discussion

The findings from this study reveal significant insights into the challenges faced by English teachers in public schools in Akwa Ibom State, Nigeria. The data collected from teachers and students underscore various factors that hinder effective English language instruction. Overcrowded classrooms, inadequate teaching resources, outdated pedagogical approaches, and limited access to professional development have emerged as key obstacles that teachers contend with daily. These challenges directly affect the quality of English as a Second Language education, leading to poor student engagement and low achievement in English proficiency (Nwaodike, 2019; Oke, 2019).

Research has consistently shown that classroom overcrowding negatively impacts the learning environment, making it difficult for teachers to provide individual attention to students and implement effective teaching strategies (Adeleke, 2018; Nwosu, 2017). Large class sizes restrict the ability to manage classroom activities and often result in limited student participation, which directly hampers language acquisition. According to Oluwole and Akinbami (2022), “overcrowded classrooms limit teachers’ ability to implement effective teaching strategies and monitor students’ progress individually” (p. 46). Additionally, insufficient resources—such as textbooks, audio-visual aids, and language laboratories—further exacerbate this problem. As observed by Urua (2016), many public schools in Akwa Ibom lack the necessary tools to foster interactive learning experiences, which were essential for developing language skills.

The lack of access to modern technology and teaching aids was also highlighted as a significant limitation for teachers. According to Oke (2019), technology integration in English as a Second Language in classroom plays a critical role in improving the quality of language instruction. However, in many Nigerian schools, particularly those in rural areas, such resources are scarce. This absence of technological tools deprives students of engaging in learning experiences, reducing their opportunities to practice the language in a real-world context. Moreover, the absence of updated teaching methodologies further limits effective

instruction, as many teachers rely on traditional lecture-based approaches, which do not adequately cater to diverse learning styles (Nwosu, 2016). As also noted by Adamu *et al.* (2021), “the absence of sufficient and updated teaching resources leaves teachers unable to engage students effectively or provide them with real-world language exposure” (p. 35).

The study also found that the lack of professional development opportunities for teachers contributes significantly to the poor quality of English as a Second Language education in Akwa Ibom State. Continuous professional growth is essential for teachers to stay abreast of best practices and modern teaching techniques. However, many teachers in public schools receive limited support in this regard, resulting in stagnation in their instructional methods (Suleiman, 2016). This gap in professional development, as noted by Oyelade and Akinlabi (2020), directly affects teachers’ ability to implement effective teaching strategies that can cater to the diverse learning needs of students.

Furthermore, the students’ perspectives further support these observations. Many students report feeling disengaged during English lessons due to a lack of practical language practice opportunities. Ekpenyong (2024) emphasizes that the absence of extracurricular activities such as language clubs and debates in Akwa Ibom State deprives students of essential avenues for practicing real-life communication. Okonkwo (2016) reinforces this view, noting that “without sufficient opportunities for practice, students struggle to internalize English as a functional language” (p. 13). This limited exposure to English beyond formal instruction significantly impacts students’ motivation and language acquisition outcomes.

Recommendations

Based on the findings of the study, the following recommendations are proposed:

- (i) policy initiatives aimed at lowering student-teacher ratios should be prioritized to allow for more individualized instruction and better classroom management, ultimately improving student engagement and learning outcomes;
- (ii) schools in Akwa Ibom State need significant investment in essential resources, including language laboratories, libraries, digital tools, and teaching aids, to create a more supportive learning environment;
- (iii) regular and targeted professional training programmes should be implemented to equip teachers with effective pedagogical strategies, particularly in the use of technology for teaching English as a Second Language;
- (iv) schools should encourage extracurricular activities such as English clubs, debates, and language competitions to provide students with ample opportunities for English language practice beyond the classroom;
- (v) education policymakers must revisit and revise existing guidelines to ensure that they address the unique challenges faced by English as a Second Language teachers and students in public schools
- (vi) establishing stronger partnerships between schools, communities, and local governments will foster better resource sharing and community involvement, further enhancing English as a Second Language education in the region.

Conclusion

In conclusion, the study has shown that teaching English as a Second Language in public schools in Akwa Ibom State, Nigeria, is fraught with significant challenges that hinder effective instruction and student language acquisition. Key issues such as overcrowded classrooms, insufficient teaching resources, and limited opportunities for language practice have a profound impact on both teacher performance and student outcomes. Despite the dedication of teachers, the lack of adequate support and conducive learning environments hampers the overall quality of English as a Second Language education. The study's statistical analysis highlighted a clear correlation between resource availability, class sizes, and student achievement. Teachers who reported access to better resources and smaller class sizes demonstrated higher effectiveness in implementing instructional strategies, leading to improved student engagement and performance. Furthermore, extracurricular activities, professional development programmes, and targeted resource allocation were found to play critical roles in enhancing the learning experience for both teachers and students.

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Fiscal Deficit and Macroeconomic Performance in Nigeria

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Abstract

This study assessed the impact of fiscal deficit on key measures of macroeconomic performance in Nigeria. Specifically, it examined the impact of fiscal deficit on unemployment rate, and GDP growth rate. The study used time series annual data from 1991 to 2022 collected from Central Bank of Nigeria statistical bulletin and World Bank development indicators. With the aid of the ARDL techniques the objectives of the study was achieved. Findings revealed that there was a long run relationship between fiscal deficit and measures of macroeconomic performance. The ARDL result indicates that Fiscal Deficit (FD) had positive and significant effect on economic growth in both the long and short run. Fiscal deficit was, however, negatively related to unemployment rate. Fiscal Deficit (FD) had negative and significant impact on unemployment rate in the long run, but had no significant impact in the short run. The study, therefore, indicates that over the reviewed period, expansionary budgetary pursuits of the Nigerian government through Fiscal Deficit financing translated to economic growth and reduced unemployment rate. Therefore, it is recommended that fiscal deficit policy could be pursued by government provided that public funds are continuously channeled towards expenditures that support sustained economic growth and reduced unemployment.

Keywords: Deficit Financing, Unemployment, Growth and Macroeconomic Performance

INTRODUCTION

Economies around the world from time to time experience shortfalls in their income when compared to their spending, meaning that their current expenditures exceeds their current revenues. This situation is referred to as Fiscal deficit. In carryout its fundamental role of providing public goods and services as well as transferring of income from one group to another, improving the welfare of the poor, making payments to pensioners, among other responsibilities, governments often have the need to spend beyond the revenues accruable to them within a given fiscal year. Under this type of circumstance, governments have to resort to borrowing either locally (domestic debt) or from international lending organizations (foreign debt) to make up for the shortfall. The borrowed funds are often channeled towards specific budget items under capital and/or recurrent expenditure subheads.

According to data from the CBN statistical bulletin (2021), Nigeria's expenditure surpassed her revenue since 2007 signifying that Nigeria has been financing its expenditure through taxes and debt (Ekpo, 2022). Moreover, the peculiarity of Nigeria's deficits financing is that a large percentage of budgetary spending in Nigeria is usually channeled towards items under recurrent expenditure rather than capital expenditure. This is evident as shown in figure 1 below, which is a graph of federal government's total recurrent expenditure and total capital expenditure from the year 2000 to the year 2022.

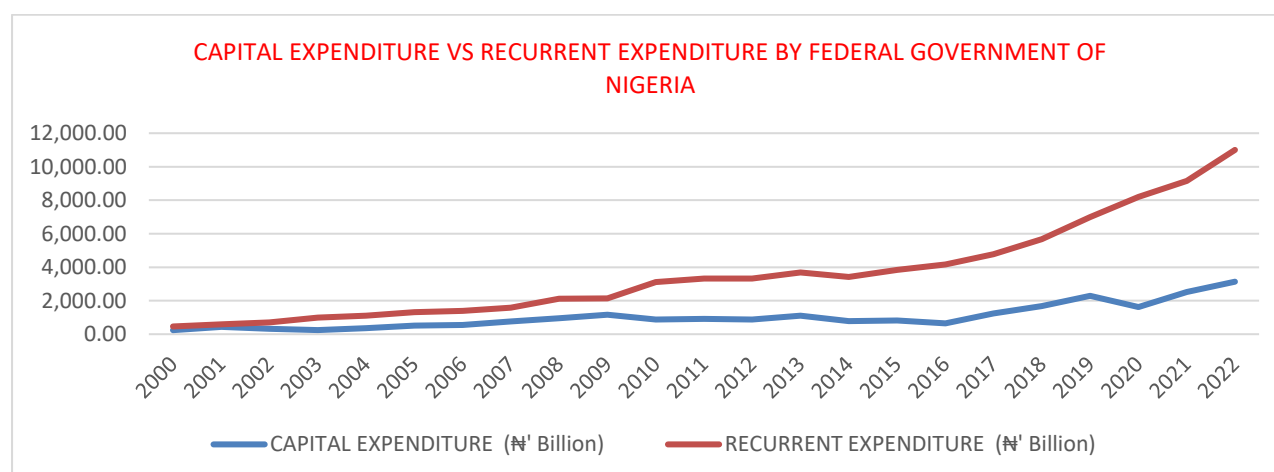


Figure 1: Capital Expenditure Vs Recurrent expenditure in Nigeria

Source: CBN Statistical Bulletin 2023

The graph above clearly showed that while capital expenditure figures have been consistently low and with very slow growth rate, the recurrent expenditure figures were high and growing at a galloping rate. This raises the question as to whether this financing structure is sustainable and whether it indeed contributes positively towards economic stimulation and the achievement of desired macroeconomic objectives like growth in real GDP and reduction in unemployment rate. Generally, deficit financing is a key fiscal policy tool often aimed at stimulating production, improving the purchasing power of economic agents, increasing per capita income, and maintaining acceptable level of employment. However, it is believed that, there is need for the fiscal deficit itself to grow or expand, albeit, at a slow and constant rate in order to avert the consequences of coming under a heavy debt burden. Nonetheless, the reality in Nigeria is completely different as data clearly show that fiscal deficit figures are currently growing at a high and fast rate year on year, growing steadily from a moderate N47.4 billion in 2008 to a staggering figure of N7.12 trillion in 2021 (Ekpo, 2022). The fiscal deficit figures in Nigeria from 2007 to 2021 is shown in figure 2 below.

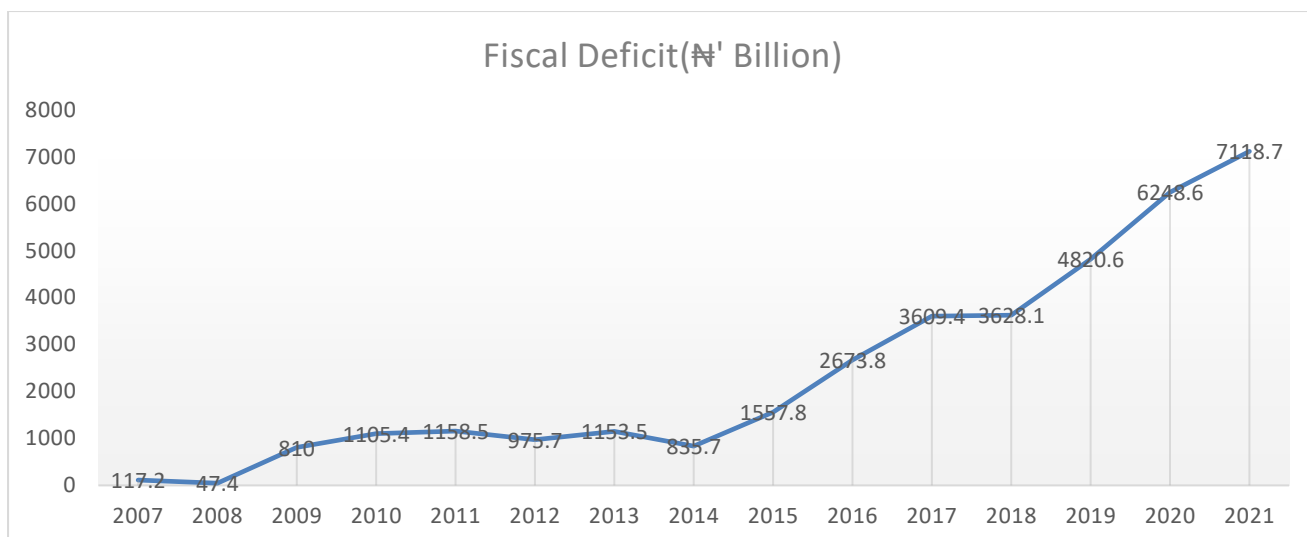


Figure 2: Fiscal Deficit figures in Nigeria from 2007 to 2021

Sources: CBN Statistical Bulletin and Ekpo, 2022

It is often assumed that when fiscal deficit persists for an extended period of time, it can have negative impacts on a country's economy such as high unsustainable debts, high inflation, poor investment performance, and poor growth that may results from continuous borrowings (Ezeabasili, Mojekwu, and Herbert, 2012).

The persistent sharp rise in fiscal deficit in Nigeria in recent times calls for concern. The problem is further compounded by the fact that a much greater percentage of the money borrowed by government is channeled towards recurrent expenditure such that while recurrent expenditure figures are high and rising, capital expenditure figures are low and stagnated. The foregoing makes it imperative to really investigate whether and to what extent the borrowing by federal government of Nigeria has been impacting the overall macroeconomic performance of the country over the period given this spending pattern it has adopted over the years. Therefore, the broad objective of this study is to investigate if there exists a relationship between fiscal deficit and key macroeconomic performance measures/variables, while the specific objectives are: (i) to estimate the magnitude and significance of the effects of fiscal deficit on economic growth and unemployment rate (ii) to investigate if there exists a long run relationship between fiscal deficit and the macroeconomic performance indicators.

A study of this nature is important in many folds. Firstly, classical economics has linked deficit financing with increasing rate of inflation. The problem of increasing rate of inflation is compounded by the fact that more people are vying for the bundle of goods and services to increase tomorrow while earning the same real wage income, given the same set of prices as at today. A great deal of evidence suggests that inflation is detrimental to economic growth. Specifically, the interest in understanding, whether and how fiscal deficit affect inflation and, by extension economic growth, across countries is very beneficial, not only to the Nigeria economy but also to all economies of the world. Secondly, the persistent poor performance of the Nigerian economy as captured by the growth rate of real Gross Domestic Product (GDP) in the presence of high fiscal financing as well as the persistent increase in the rate of unemployment provides another key justification for this study. Therefore, there is need to assess the effect of fiscal deficit on the Nigerian economy.

The rest of the paper is organized as follows. Section 2 presents an overview of the theories on fiscal deficit as well as a survey of related empirical literature, with a focus on the gap to be addressed. Section 3 lays out the methodology, section 4 analyses the relevant data sets and interprets the results of the analysis, while section 5 concludes the paper with some policy recommendations.

LITERATURE REVIEW

Conceptual Literature

Fiscal Deficit

Fiscal deficit as a concept was developed by the Keynesian school of economics and argues that government intervention is necessary when the government cannot balance tax revenues and public spending. It is the difference between a government's total revenue and total expenditure in a fiscal year. According to Aero and Ogundipe (2018), "it arises from government's expansionary fiscal policy that leads to revenue falling short of expenditure in a given fiscal year". It can also be referred to as a gap in government's budget which arises in a fiscal year when the government's total expenditure exceeds its total expected receipt. When the government spends more than it receives, a fiscal deficit occurs leading to borrowing. Fiscal Deficit is not necessarily bad for the economy, it is an integral part of fiscal policy and it is typically financed by borrowing from the country's central bank or by raising funds in the capital markets through the issuance of various instruments such as Treasury bills and bonds.

Macroeconomic Performance:

Macroeconomic performance is a measure of how well a country is meeting its goals or economic objectives. It focuses on changes in economic output, inflation, interest and foreign exchange rates, and the balance of payments. According to Ferreira (2021), macroeconomic performance can be represented by real gross domestic product (GDP), inflation, unemployment rate, current account, and net international investment position. The performance of the economy is very important. The indicators listed above are thus very useful in the assessment of how well a country is doing in reaching key objectives of government policy. Changes in any of these variables or measures have an overbearing effect on the direction of fiscal policy. In this study macroeconomic performance is proxied by gross domestic product and unemployment rate.

Theoretical Literature

The Neoclassical, Keynesian, and Ricardian schools of thought on deficit finance are the three main schools of thought in this area. The classical deficit theory states that while a budget deficit (fiscal deficit) increases current consumption, it is balanced out by a decrease in investment. According to Perry (2014), if consumption rises, savings must inevitably decline. Interest rates rise when savings decline, which ultimately discourages investment. So, when the budget deficit results in higher interest rates and decreased investment, crowding-out happens (Robertson, 1934). In other words, government borrowing crowds out private businesses by increasing the interest rate and making it more expensive for businesses to borrow money. The loanable funds market, according to the classical economics, would balance savings and investment and maintain full employment or a near approximation of it if permitted to operate on its own. If that was the case, there would be no need for government deficit spending, which they considered to be ineffective due to the crowding out effect,

which suggested that deficit spending diverts money from investment to government consumption. Because of this, classical economists were generally against government deficit spending.

The Keynesian School

Keynesian postulates differ from the conventional Classical paradigm. The Keynesian School of economics postulates a favourable correlation between budget deficits and macroeconomic factors. According to their argument, budget deficits often boost domestic production, aggregate demand, savings, and private investment at any given interest rate. According to the Keynesian absorptive theory, rising budget deficits would lead to increased domestic consumption and consequent import growth, which would result in a current account deficit. According to the Mundell-Fleming framework, a rise in the budget deficit would push interest rates higher, bringing in capital and increasing the value of the currency, which would increase the current account balance. They contend that, typically, budget deficits increase domestic production, which raises private investors' expectations for the future course of the economy and encourages them to increase their investments. This is known as the “crowding-in” effect.

Politically, reducing the budget deficit of government is quite difficult. According to the conventional Keynesian hypothesis, if government is successful in lowering the deficit, a recession may occur. Budget deficit is not totally bad, despite its evil reputation. According to McDermott and Wescott (1996), the good news regarding the budget deficit is that it shows that the government is making purchases, paying employees' pay checks, and making transfers to its needy residents. This increases economic activity and helps to inject money into the economy. Thus, even when the government is trying to balance the budget with good intentions, a sudden break will result in decreased corporate inventories, job losses, and a sharp decrease in the flow of money.

The Ricardian School

The primary argument for the Ricardian observation is that fiscal deficit essentially delays taxes. This is because rational agents typically assume that the present discounted value of taxes is a function of actual government expenditure rather than the timing of taxes. According to Bernheim (1989), this foresight gives rise to the “Say's Law” for deficits: bond demand will always increase to meet government borrowing. Tax timing cannot influence a person's purchasing choices because it has no impact on his or her lifetime budget constraints. Therefore, both short-term and long-term budget deficits have no discernible effects. This logic, however, does not depend on full employment of resources.

Empirical Literature

Obinabo and Agu (2018) investigated the effect of fiscal deficit on selected macroeconomic variables in Nigeria employing various econometric techniques such as unit root test, Johansen co-integration, ordinary least square and granger causality on time series data from 1986-2018. The results of their analysis indicates that Fiscal Deficit (FD) had positive and no significant effect on Gross Domestic Product (GDP), Fiscal Deficit (FD) had negative and no significant impact on Money Supply (MS), Fiscal Deficit (FD) had negative and no significant relationship with Inflation Rate (INFR).

Ubi and Inyang (2018) evaluated fiscal deficit and its impact on Nigeria's economic development from 1980 to 2016 using descriptive approach. Using various specified

development metrics, including per capita income, GDP, unemployment, inflation, and balance of payments (BOP), the study evaluated the budget deficit. It was shown that Nigeria's fiscal deficit had a positive and significant impact on the growth of per capita income, economic growth, and Balance of Payments. Unemployment and inflation rates did not decline within the research period despite the fiscal deficit.

Nwaeze (2017) conducted an empirical study on the relationship between the budget deficit and macroeconomic stability from 1970 to 2016 in Nigeria. Secondary sources, including the CBN statistical bulletin, provided the data for the empirical analysis. In order to examine the data, the study used descriptive statistics, the unit root test, co-integration, and VAR estimation techniques. The results of the variance decomposition show that the main shocks causing the fluctuation in the exchange rate in Nigeria are the interest rate, total fiscal deficits, and the extent of fiscal deficits supported by domestic borrowing. According to the study's findings, fiscal deficits significantly and negatively affect macroeconomic stability in relation to inflation and currency rates.

Sanya and Abiola (2015) used a co-integration and error correction model to assess the effect of the budget deficit on the growth rate of the Nigerian economy. The time series nature of the data is first examined. The unit root test's conclusion made it abundantly evident that the variables were integrated of the same order at the initial difference. The findings of the multivariate co-integration test also show that there are, at most, two co-integrating vectors as such there exist a long run relationship between both variables.

Aslam (2016) used annual time series data from 1959 to 2013 to examine the dynamic relationship between Sri Lanka's fiscal deficit and economic growth. The Sri Lankan budget deficit was employed as an independent variable and the country's gross domestic product at constant prices as a dependent variable to test the objective. The exports earnings, exchange rate, inflation rate was employed in the study. The Johansen co-integration technique and Vector Error Correction Model were employed to test the long and short-run dynamic relationship between the fiscal deficit and the economic growth of Sri Lanka.

Umeora and Ikeora (2016) looked into how Nigeria's fiscal shortfalls affected the country's money supply. Inflation was included in the model and data from CBN Statistical Bulletin provided the data set for the study from 1970 through 2014. The Error Correction Model (ECM) and Pairwise Granger Causality were used as the analysis technique. According to the regression results, government fiscal deficits have a significant and negative effect on money supply, while inflation has no significant effect on money supply or fiscal deficits. According to Pairwise Granger Causality, money supply granger causes fiscal deficits.

Murwirapachena et al. (2013) used The Vector Error Correction Model (VECM) to analyze the determinants of South Africa's budget deficit from 1980 to 2010. Their findings demonstrated that fluctuations in fiscal deficits over the research period were explained by foreign reserves, foreign debt, unemployment, economic growth, and government investment. Wosowei (2013) investigated the relationship between fiscal deficit and macroeconomic aggregates of inflations rate and money supply using the OLS technique, the study revealed that government expenditure stimulates economic growth. In other words, government should increase money supply to boost economic activity. Ezeabasili et al (2012) examined the impact of fiscal deficit on economic growth, Real GDP, inflation, money supply and interest

rate. Using Unit root test, cointegration test and OLS they find that fiscal deficit impacts negatively on economic growth, with an adjustment lag in the system.

Imobighe (2012) examined the relationship between budget deficit and inflation. Using OLS as the analytical tool in his study, he found out that fiscal deficit and credit to the federal government are not significant in explaining the rate of inflation in Nigeria. He suggested that budget deficit causes inflation and that government should checkmate its spending activities. Oladipo and Akinbobola (2011) used the Granger causality pair-wise test to determine the causal relationship between Nigeria's budget deficit and inflation. In Nigeria, the study discovered that there is no direct relationship between inflation and budget deficit, but just between budget deficit and exchange rate. This implies that the Nigerian economy's budget deficit affects inflation via exchange rate volatility.

Gap in the Literature

Generally, literatures and the empirical evidences on fiscal deficit and macroeconomic performance differ across countries, and even within countries because of the use of different methodologies for the same country data. Equally apparent is the fact that most of the studies concentrated on threshold analysis (Onwioduokit 2016), others focused on specific measures, Oladipo and Akinbobola (2011), Ozurumba (2012). Imobighe (2012) examined the relationship between budget deficit and inflation. Ezeabasili et al (2012), Ojong and Owui (2013) focused specifically on the relationship between budget deficit and growth. This study extends the literature in this area by employing an aggregated approach of ARDL to examine the impact of fiscal deficit on key indicators of macroeconomic performance (GDPGR and Unemployment rate)

RESEARCH METHODOLOGY

In other to examine the impact of fiscal deficit on macroeconomic performance, the quantitative research technique based on ex-post facto and correlational research design was adopted for the study. Fiscal deficit, GDP growth rate, unemployment rate and other exogenous variables covering the period: 1991-2021 were sourced from the publications of the Central Bank of Nigeria, National Bureau of Statistics and WDI (2022).

Model specification

This study is anchored on the Keynesian view of fiscal deficit, with the model drawn from that of Obinabo and Agu (2018) with little modifications to suit the objectives of the study.

The models used in this study are stated as follows;

$$GDPGR = f(FD, INF, UNEM, K, EXR) \quad 3.1$$

$$UNEM = f(FD, INF, GDPGR, K, INTR) \quad 3.2$$

The generalized ARDL Regression Model is specified as:

$$Y_t = a_1 Y_{t-1} + \dots a_j Y_{t-j} + \beta_o X_t + \beta_k X_{t-k} + e_t \quad 3.3$$

Where j, k refers to the number of lags. Consequently, the ARDL Specification for the impact of fiscal deficit on macroeconomic performance (GDPGR and Unemployment) is given as:

$$\Delta GDPGR_t = \alpha_i + \beta_1 GDPGR_{t-1} + \beta_2 FD_{t-1} + \beta_3 INF_{t-1} + \beta_4 UNEM + \beta_5 K_{t-1} + \beta_6 EXR_{t-1} + \epsilon_{it} \quad 3.4$$

$$\Delta UNEM_t = \alpha_i + \beta_1 UNEM_{t-1} + \beta_2 FD_{t-1} + \beta_3 INF_{t-1} + \beta_4 GDPGR + \beta_5 K_{t-1} + \beta_6 INTR_{t-1} + \epsilon_{it} \quad 3.5$$

Since the bounds test indicated that there is co-integration among the variables, the error correction form of model 3.4 is given as:

$$\Delta GDPGR = \delta + \sum_{i=1}^k \alpha_1 \Delta GDPGR_{t-i} + \sum_{i=1}^k \alpha_2 \Delta FD_{t-i} + \sum_{i=1}^k \alpha_3 \Delta INF_{t-i} + \sum_{i=1}^k \alpha_4 \Delta UNEM_{t-i} + \sum_{i=1}^k \alpha_5 \Delta K_{t-i} + \sum_{i=1}^k \alpha_6 \Delta EXR_{t-i} + ECT_{t-1} + e_t$$

The error correction form of model 3.5 is given as:

$$\Delta UNEM = \delta + \sum_{i=1}^k \alpha_1 \Delta UNEM_{t-i} + \sum_{i=1}^k \alpha_2 \Delta FD_{t-i} + \sum_{i=1}^k \alpha_3 \Delta INF_{t-i} + \sum_{i=1}^k \alpha_4 \Delta GDPGR_{t-i} + \sum_{i=1}^k \alpha_5 \Delta K_{t-i} + \sum_{i=1}^k \alpha_6 \Delta INTR_{t-i} + ECT_{t-1} + e_t$$

GDP denotes GDP growth rate, FD denotes Fiscal Deficit, INF is the Inflation Rate, UNEM denotes unemployment rate and EXR denotes exchange rate, Lab and K denotes labour and capital respectively. Where α_1 - α_7 are short run coefficients, $\beta_1 - \beta_6$ captures long run relationships, δ represents the intercept or constant, μ is the error term and Δ represents the difference operator.

Where;

FD	Fiscal Deficit
GDPGR:	Real GDP growth rate
UNEM	Unemployment rate
EXR	Exchange Rate
INF	Inflation rate
INTR	Interest rate
K	Capital
μ :	Error Term
θ_0	= Constant parameter/Intercept
θ_1 - θ_4	= Coefficients of independent variables

Apriori Expectation

The ‘apriori expectation’ of the research outcome is that fiscal deficit is expected to have a positive relationship on measures of macroeconomic growth, drawing from Keynesian’s perspective and a negative relationship with Unemployment rate.

Nature and Sources of Data

Data used for this study are time series and cross-sectional data covering a period of (1991 – 2022). The data are obtained from the World Bank development index (2022) and CBN statistical bulletin (2022)

Analytical Techniques

The ARDL model is the analytical technique employed in this investigation. The study first investigated the time series properties of the data by using the Augmented Dickey–Fuller (ADF) and the Phillip-Perron (PP). Cointegration Test was used to ascertain whether the parameter estimates of the economic relationship or model are theoretically meaningful and statistically satisfactory in the long run. The Bound test technique developed by Pesaran, Shin and Smith (2001) known as the Autoregressive Distributed Lag (ARDL) bound test was applied. The calculated F-statistic of the bound test was compared with two sets of critical values to motivate our decision.

RESULTS

To estimate the model of the study, the unit root test was considered. This is done because the outcome of working with non-stationary variables leads to spurious regression results from which further reference or result may be meaningless according to Gujarati and Porter (2009). To avoid this, the Augmented Dickey-Fuller (ADF) unit root test was carried out.

Unit Root Test Results

Table 1: Augmented Dickey-Fuller test

Variables	Level	Diff	95% critical level	Order of co-integration
FD	0.187692	-5.056726	-3.580623	1(1)
GDPGR	-2.809890	-7.434742	-3.574244	1(1)
INF	-2.661450	-5.220338	-3.574244	1(1)
EXR	-0.306272	-4.253022	-3.568379	1(1)
K	-9.018594	-	-3.568379	1(0)
UNEM	-0.249113	-5.080939	-3.574244	1(1)
INTR	-3.254765	-7.546873	-3.568379	1(1)

Source: Computed by the author using E-views 9

After testing for stationarity, the variables were found to be stationary at first difference at 5% level of significance as shown in Table 1, except for capital (k) which was stationary at level thus the results from the estimation of the model are likely to be unbiased and consistent.

Bounds Test for Cointegration

As shown in Table 2, the calculated F-statistic value of 4.31 exceeds the upper bound critical value of 2.62 and lower bound critical value of 3.79 at 5% level; meaning that there exist a long run relationship among the variables.

Table 2: Bounds Test Result for GDPGR Model

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	4.315810	10%	2.26	3.35
K	5	5%	2.62	3.79
		2.5%	2.96	4.18
		1%	3.41	4.68

Source: CBN Statistical Bulletin 2023 and Computed by Author using Eviews 9

Results of the ARDL Model: GDPGR Model

The ARDL results for GDPGR model is shown in Table 3. The result indicated that Fiscal deficit is positively signed and significant in the short run cointegrating form. The result also indicated that Inflation, exchange rate and unemployment rate have had negative impact on economic growth in Nigeria. The positive relationship between fiscal deficit and GDPGR, points to the fact that deficit financing is propelling growth in Nigeria.

Table 3: ARDL short run and Long- Run Model: GDPGR

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FD)	0.007134	0.003188	2.237909	0.0374
D(INF)	-0.092752	0.038892	-2.384851	0.0277
D(K)	-0.104592	0.057770	-1.810494	0.0861
D(K(-1))	0.104399	0.054810	1.904755	0.0721
D(UNEM)	-0.124791	0.710214	-0.175709	0.8624
D(EXR)	-0.034163	0.033521	-1.019141	0.3209
CointEq(-1)	-0.824451	0.165135	-4.992598	0.0001
Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
FD	0.008653	0.004034	2.145040	0.0451
INF	-0.112501	0.045925	-2.449675	0.0242
K	-0.416997	0.201825	-2.066130	0.0527
UNEM	-2.009398	0.721382	-2.785482	0.0118
EXR	0.032276	0.014801	2.180619	0.0420
C	13.955335	2.495529	5.592134	0.0000
R-squared	0.737914			
Adjusted R-squared	0.599974			
Durbin-Watson stat	2.208121			
F-statistic	5.349527			
Prob(F-statistic)	0.000864			

Source: CBN Statistical Bulletin 2023 and Computed by Author using Eviews 9

In the long run result, fiscal deficit had significant positive impact on GDP growth rate in the long run as the P-value is shown to be less than 0.05 level. The coefficients of inflation rate capital and unemployment rate were all negatively related to GDPGR. This finding contradicts that of Obinabo and Agu (2018) since there exists significant relationship between fiscal deficit and economic growth in Nigeria. The implication of this finding is that an increase in unemployment rate signals low productivity and low confidence on the economy. The inverse relationship between inflation rate and growth can be interpreted to mean that as inflation rate rises, the level of growth reduces significantly. However, the current galloping rate of inflation in Nigeria can be however attributed to a multiplicity of factors (monetary policy mis-alignment, insecurity, dollar scarcity, price inflation occasioned by removal of subsidy on petroleum products, etc.) and not necessarily the pass-through of fiscal deficit.

Bounds Test for Cointegration (Unemployment Model)

Table 4 revealed that there exist a long run relationship among the variables, as the F-Statistics value exceeded the upper and lower bound respectively.

Table 4: Bounds Test Result for Long-run Relationship in the ARDL Model

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	4.186404	10%	2.26	3.35
K	5	5%	2.62	3.79
		2.5%	2.96	4.18
		1%	3.41	4.68

Source: CBN Statistical Bulletin 2023 and Computed by Author using Eviews 9

Table 5.represents the ARDL result for unemployment rate model. The result indicated that Fiscal deficit is negatively signed with negligible impact on unemployment rate. The result indicated that Inflation and unemployment rates are negatively related conforming to the Phillips curve postulation.

Table 5: Short and Long- Run ARDL Model analysis: UNEM

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(UNEM(-1))	0.301352	0.178591	1.687385	0.1063
D(FD)	-0.000431	0.000556	-0.775758	0.4465
D(GDPGR)	-0.065828	0.039757	-1.655776	0.1126
D(INTR)	0.015057	0.032942	0.457078	0.6523
D(K)	-0.000105	0.009549	-0.011023	0.9913
D(INF)	-0.005629	0.008898	-0.632548	0.5339
CointEq(-1)	-0.573342	0.116440	-4.923943	0.0001
Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
FD	-0.003325	0.000820	-4.055690	0.0006
GDPGR	-0.114815	0.065416	-1.755168	0.0938
INTR	0.026262	0.057302	0.458308	0.6514
K	-0.000184	0.016656	-0.011022	0.9913
INF	-0.009817	0.015258	-0.643412	0.5269
C	4.194387	0.977414	4.291311	0.0003
R-squared	0.846892			
Adjusted R-squared	0.788565			
Durbin-Watson stat	2.120841			
F-statistic	14.51974			
Prob(F-statistic)	0.000001			

Source: CBN Statistical Bulletin 2023 and Computed by Author using Eviews 9

The long run result revealed a significant but inverse relationship between fiscal deficit and unemployment rate. The coefficients of inflation rate and unemployment rate are also negatively related but not significant. The result is an indication that deficit financing may have been the contributing factor to the decreasing rate of unemployment in Nigeria. This is because as fiscal deficit has been increasing, unemployment rate have been decreasing in Nigeria.

Post Estimation Diagnostics

The diagnostic test which includes: serial Correlation test, Heteroskedasticity test, multicollinearity test and stability test for both models showed the absence of autocorrelation. The test results for GDPGR model are shown in tables 6 to 8 and figure 3 while the test results for UNEM model are shown in tables 9 to 11 and figure 4.

Table 6: Breusch-Godfrey Serial Correlation LM Test for GDPGR Model

F-statistic	0.282919	Prob. F(2,17)	0.7571
Obs*R-squared	0.966372	Prob. Chi-Square(2)	0.6168

Source: CBN Statistical Bulletin 2023 and Computed by Author using Eviews 9

Table 7: Heteroskedasticity Test: Breusch-Pagan-Godfrey for GDPGR Model

F-statistic	0.503081	Prob. F(10,19)	0.8671
Obs*R-squared	6.280449	Prob. Chi-Square(10)	0.7912
Scaled explained SS	6.938906	Prob. Chi-Square(10)	0.7312

Source: CBN Statistical Bulletin 2023 and Computed by Author using Eviews 9

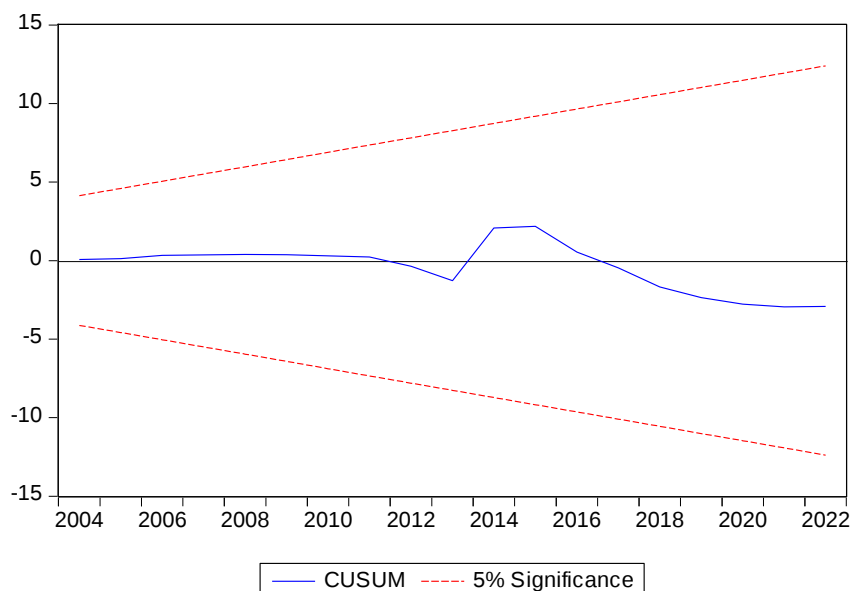


Figure 3: CUSUM Stability Test for GDPGR Model

Source: CBN Statistical Bulletin 2023 and generated by Author using Eviews 9

Table 8: Multicollinearity Test for GDPGR Model

	GDPGR	FD	INF	K	UNEM	EXR
GDPGR	1					
FD	0.310518	1				
INF	-0.40649	0.161972	1			
K	0.173089	0.213066	-0.11865	1		
UNEM	-0.40504	-0.58495	-0.0692	-0.0432	1	
EXR	-0.08149	-0.83611	-0.35959	-0.09088	0.68905	1

Source: CBN Statistical Bulletin 2023 and Computed by Author using Eviews 9

Table 9: Breusch-Godfrey Serial Correlation LM Test: for UNEM model

F-statistic	1.043643	Prob. F(2,19)	0.3715
Obs*R-squared	2.969495	Prob. Chi-Square(2)	0.2266

Source: CBN Statistical Bulletin 2023 and Computed by Author using Eviews 9

Table 10: Heteroskedasticity Test: Breusch-Pagan-Godfrey for UNEM model

F-statistic	2.222327	Prob. F(8,21)	0.0682
Obs*R-squared	13.75393	Prob. Chi-Square(8)	0.0884
Scaled explained SS	9.999732	Prob. Chi-Square(8)	0.2650

Source: CBN Statistical Bulletin 2023 and Computed by Author using Eviews 9

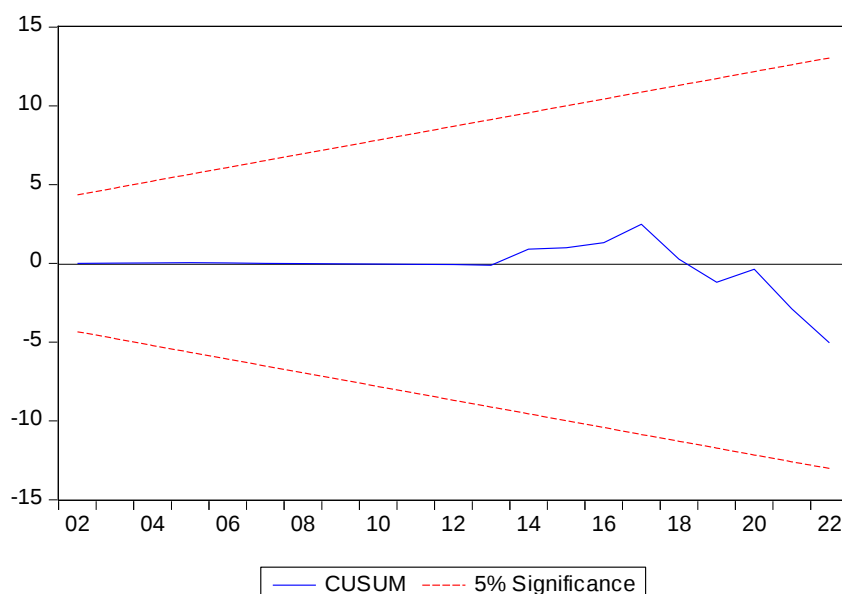


Figure 4: CUSUM stability test for UNEM model

Source: CBN Statistical Bulletin 2023 and generated by Author using Eviews 9

Table 11: Multicollinearity Test

	UNEM	FD	GDPGR	INTRK	INF	
UNEM	1					
FD	-0.58495	1				
GDPGR	-0.40504	0.310518	1			
INTR	0.062631	0.124032	-0.27775	1		
K	-0.0432	0.213066	0.173089	-0.12624	1	
INF	-0.0692	0.161972	-0.40649	0.399514	-0.11865	1

Source: CBN Statistical Bulletin 2023 and Computed by Author using Eviews 9

Recommendations

Given the positive and significant relationships between fiscal deficit and GDP growth rate, which conforms with the apriori expectation, there should be significant effort and policy drive by the government to ensure that larger chunk of the borrowed funds is channeled more toward capital expenditure to increase the magnitude of impact. In the meantime, the research recommends that the government should set her priority right to ensure that fiscal financing through bonds and external borrowing be channeled on productive ventures, agricultural sector and infrastructural development as this will help in propelling the economy.

Since the ARDL analysis revealed that there is a significant negative relationship between unemployment rate and fiscal deficit in the long run, an indication that fiscal deficit helped in reducing unemployment, the government should continue to pursue this policy while ensuring that deficit financing is also complimented by excellent debt management, trade and monetary policy efforts. The government should also not rely on fiscal deficit financing as the sole tool for fostering full employment as this may leave the country with

huge and unsustainable debt burden; instead, this should be used in combination with other macroeconomic tools.

Summary and Conclusion

The study captures the impact of fiscal deficit on the macroeconomic performance of Nigeria using secondary data covering the period 1991-2022, employing variables such as inflation rates, unemployment rates, growth rate of gross domestic product, fiscal deficit and capital stock. The objectives are to estimate the significance of fiscal deficit on economic growth, and to investigate if there exist a long run relationship between fiscal deficit and macroeconomic performance. The theoretical literature reviewed shows that the Neoclassical, Keynesian, and Ricardian schools of thought on deficit finance are the three main schools of thought.

Findings from this study using the Augmented Dickey Fuller (ADF) unit root test conducted on the variables revealed that all the variables were stationary at first differences except capital (K). The Bound test revealed that there is long-run relationship between the variables. The ARDL analysis revealed that there is a significant negative relationship between inflation and GDPGR in Nigeria. The result also shows that fiscal deficit had significant positive impact on GDPGR and inversely related unemployment rate in the long run. This clearly affirms the apriori expectation under Keynesian economics. The study shows that fiscal deficit contributes significantly to economic performance the long and short run respectively.

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Customer Accounting Techniques and Financial Performance of Manufacturing Companies in South-South, Nigeria

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Abstract

The main purpose of the study was to examine the extent to which the customer accounting techniques influence financial performance of manufacturing companies in South-South, Nigeria. The study adopted descriptive and inferential survey designs. The population of the study consisted of 105 management staff while the sample size was 83 management staff. Judgemental and convenience sampling techniques were used to select the sample. A researcher developed instrument tagged: “Customer Accounting Techniques and Financial Performance Questionnaire (CATFPQ)” was used to collect data for the study. The structured questionnaire had a validated 15 items in all on five points rating scale. Split half reliability test was used to determine the internal consistency of the instrument. The data collected were analysed using simple regression. R^2 was used to answer the research questions and F-statistics was used to test the hypotheses at 0.05 significance. The findings of the study revealed that customer profitability analysis, lifetime customer profitability analysis and valuation of customers as assets techniques influence to a low extent the financial performance of manufacturing companies. The findings further showed that there is a significant influence of customer profitability analysis technique, lifetime customer profitability analysis technique, and valuation of customers as assets technique on the financial performance of manufacturing companies in South-South, Nigeria. It is recommended among others that the manufacturing companies apply the customer profitability analysis technique for the analysis of the revenue streams and service costs related to customers.

Keywords: Customer accounting techniques, Customer profitability analysis, Lifetime customer profitability analysis, Valuation of customers as assets and financial performance

INTRODUCTION

Manufacturing companies are catalysts for economic growth and development. They play significant role in international trade and foreign exchange earnings. Manufacturing companies produce goods and services, create jobs and earn revenue for economic development. Manufacturing is the production of merchandise for sale using tools, machines,

labour, chemicals and biological formulations. Manufacturing is the mechanical or chemical transformation of inorganic or organic substance into new products whether the products are sold as wholesale or retail (MAN, 2020).

Over the years, the Federal Government through the Central Bank of Nigeria (CBN) had embarked upon many laudable programmes to revolutionise manufacturing companies and ensure sustainability and performance. This initiative was carried out with the understanding of the role that manufacturing companies play in the economic growth and development of Nigeria (Inyang, 2023). Manufacturing companies create products from semi-finished goods to finished goods. These finished goods can be sold directly to consumers or to other manufacturing companies that use them to make other products. Manufacturing companies contribute income to South-South region and Nigeria at large through taxes. Manufacturing companies in South-South, Nigeria are Champion Breweries Plc, Okomu Oil Palm Plc, Notore Chemical Industries Plc, Lafarge Africa plc, Ellah Lake Plc, Austin Laz and Company Plc among others.

In 1973-1983, Nigeria focused much attention on oil as a result of the boom in this sector and abandoned the manufacturing sector not minding its contributions to economic growth and development. This affected the performance and sustainability of manufacturing companies. This hinders Nigeria's economic activities and also aggravated the nation's level of unemployment (Okon & Osesie, 2017). Nigeria was regarded as a nation blessed with abundant human and material resources. However, the underutilisation of these potentials has amplified widespread poverty and rising unemployment in the country because of incessant mono-economic practice and drastic neglect of manufacturing sector. Onuoha (2013) observed that Nigeria mismanaged manufacturing sectors and therefore underdeveloped. The performance and sustainability challenges led to a contraction in the sector's output by 2.75% in 2020 (Inyang, 2023).

Nigerian Economic Summit Group (NESG (2021) stressed that this was reflected in the higher prices of input, low levels of employment in the sector and weak manufactured goods for exports. This also led to a larger trade deficit in the manufacturing sector, which stood at ₦11.76 trillion in 2020 (National Bureau Statistics (NBS), 2021). The sector had suffered mainly from the closure of land borders in September 2019, which reduced informal exports and resulted in direct negative effects on several manufacturing outfits in South-South region of Nigeria. The dominant features of Nigeria's manufacturing sector seem to be wrong government policies and wrong application of customer accounting techniques despite the numerous opportunities. According to MAN (2020), a total of US\$329.2 million (₦118.5 billion) was invested in the manufacturing sector, which is equivalent to 0.08% of Nigeria's GDP in 2020. Nigeria was unable to satisfy the local demand for most manufactured goods due to the low productivity level of the sector (Nigerian Economic Summit Group (NESG), 2021). As a result, manufactured goods have accounted for over 55% of total imports since 2018 (NBS, 2021).

In spite of the laudable roles these companies play in economic growth and development, they are faced with customer accounting techniques and performance problems which result in poor performance that subsequently led to a decline in employment, standard of living, foreign earnings, Gross Domestic Product (GDP) and foreign direct investments. There have also been evidences of loss of substantial investments by investors in the

manufacturing companies and retrenchment of workers with related social vices such as armed robbery, youth restiveness, kidnapping, banditry, militancy and terrorism (Inyang, 2023). As a result of these problems, South-South could lag behind in the socio-economic development if not tackled using customer accounting techniques which are strategic management accounting techniques.

Strategic management is the deployment of a company's internal strengths and weaknesses to take advantage of its external opportunities and minimise its external threats (Phina, 2020). Strategic management is an integral process of management in which all managers of a company engage in continuous rethinking and auditing of themselves, the company and the environment and in developing, implementing and controlling the company's direction, strategies and programmes, aimed at effecting positive changes, building competitive advantage and achieving all the time successful performance. Wickramasinghe & Alawattage (2012) posited that strategic management accounting is a sub-system of the overall organisational information system and noted that it involves systematic processes of control that is used to achieve the company's goals.

In manufacturing sector, financial performance impact can be attained through the application of the strategic management accounting techniques (customer accounting techniques). Manufacturing companies with proper application of these techniques will foster performance sustainability which enhance the prevention of distortion of profit. Companies can improve their performances if the strategic management accounting techniques are rightly applied, but wrong application could lead to poor financial performances (Inyang, 2023). Pires, Alves & Rodrigues (2015) noted that strategic management accounting is the collection of financial and non-financial data about a company, its competitors and customers, analysing such data to enhance decisions that improve short-term and long-term profitability of a company. Strategic management accounting techniques employed to measure financial performance are customer accounting techniques.

Customer accounting techniques are strategy-related in that a key aspect of strategy is customer satisfaction (Balogun & Hope-Hailey, 2016, Johnson, Whittington, Scholes, Angwin & Regnér, 2017). Oyewo, Ajibolade & Omolehinwa (2020) posited that organisations that seek to be relevant in the modern business environment must have a strong market orientation by being abreast with customers' sentiments, with a view to keeping customers satisfied. Market orientation has received little recognition in management accounting literature until recently when some researchers started investigating it as a contingent variable affecting management accounting practice (Oyewo *et al.* 2020; Al-Mawali, 2015). Cadez & Guilding (2008) noted that marketing academics have afforded this construct much attention; accounting researchers sparingly research this variable. Thus, studies on management accounting innovation cannot afford to ignore the concept of market orientation because one of the recurring characteristics of modern management accounting systems is a focus on customers, hence customer accounting has been included in the strategic management accounting. The customer accounting techniques used in this study are customer profitability analysis, lifetime customer profitability analysis and valuation of customers as assets.

Fowzia & Afroz (2016) stated that customer profitability analysis appears to be the most widely-discussed customer focused accounting technique in the strategic management accounting. Albalaki & Majeed (2018) stressed that the highly significant aspect of customer

profitability analysis is that different cost accounting systems result in different estimates of customer profitability. Customer profitability analysis is a method which evaluates the profit yield from market segments by primarily providing management with information that improves long term yield decisions. Thapayom (2019) stated that customer profitability analysis is a well-known technique in the strategic management accounting literature. It is otherwise called customer account profitability. This technique provides management information about the profitability of individual customers or group of customers. Customer profitability analysis is the calculation of the revenues and costs from doing business with individual customers. Customer profitability analysis is the allocation of revenues and costs to individual customers which the profitability of those customers can be calculated.

Sharaby (2021) stated that life time customer profitability analysis (LCPA) is otherwise called customer lifetime value (CLV). LCPA is the present value of all future cash flows obtained from a customer over his or her life of relationship with the company. It provides management with information about the costs of customers, revenues generated from them in the future and their future contribution to the company's profitability. The author noted that great attention is given to the measurement of CLV; it can be estimated with a simple assumption of constant customer's margin and constant retention rate. Another approach to measuring customer lifetime value is based upon the historic profit contribution of customers and forthcoming cash flow.

Valuations of customers as assets is a comprehensive method that is concerned with managing customer relationships as assets in order to maximize customer equity through the value sum of a company's current and potential customers (Persson, 2011). Sharaby (2021) stressed that this concept is the combination of both financial value which is based upon the profitability or lifetime value and relational value which might include profile, advocacy, learning and information and new product development. To value customers as assets involves estimating the direct and indirect customer's contribution to the firm's profits. The direct customers contribution is the economic value of the customer relationship with the firm expressed as contribution margin or net profit. The indirect customer's contribution represents customer referrals, customer impact through social media and the customer feedback. Commonly used methods for valuing intangible assets, including assets related to customers are "cost method, market method and income method. These variables contribute to improving performances.

Performance is measured in several dimensions which include the financial and non-financial dimensions. Ordu & Amah (2021) observed that financial performance emphasises on variables related directly to financial reports. It is a measure of how well a company can use total assets from its primary mode to generate revenues. The non-financial performance focuses on issues relating to customer's satisfaction, delivery time, waiting time and employee's turnover. Financial performance focuses on the strength or weakness of company overtime (Lawrence & John, 2020). Okeke, Okere, Ofurum & Oketa (2021)) posited that the financial performance indicators are return on assets (ROA), return on equity (ROE) and return on investment (ROI).

The wrong application of the customer accounting techniques in the manufacturing sector has resulted in a poor industrial base of the Nigerian economy, thereby limiting the sector's potentials as a critical engine of economic growth and development (Emiaso &

Egbunike, 2018). A reversal of the current poor performance of the manufacturing sector may only be achieved with proper application of these techniques in the sector. Customer accounting techniques seem to be important in improving the manufacturing sector's productivity and repositioning the sector to drive inclusive economic growth in Nigeria.

A viable manufacturing sector is crucial in solving the country's foreign exchange challenges, creating jobs, and addressing the rising poverty level. To achieve these laudable goals, proper application of the customer accounting techniques in the sector will be crucial (Inyang, 2023). The achievement of the performance and competitive goals of manufacturing companies can be facilitated by customer accounting techniques. The increasingly competitive and dynamic nature of manufacturing environments has called on companies to apply these techniques to ensure performances. Empirical studies showed that there is influence of customer accounting techniques on financial performance but the extent to which these techniques contribute to improving performance is still in doubt. It is observed that empirical studies did not show the extent to which these techniques influence financial performance. Therefore, this study attempted to fill this research gap by studying the extent to which customer accounting techniques influence the financial performance of manufacturing companies in South-South, Nigeria. Specifically, the study sought to examine:

- (i) the extent to which customer profitability analysis technique influences the financial performance of manufacturing companies in South-South, Nigeria.
- (ii) the extent to which lifetime customer profitability analysis technique influences the financial performance of manufacturing companies in South-South, Nigeria.
- (iii) the extent to which valuation of customers as assets technique influences the financial performance of manufacturing companies in South-South, Nigeria.

Research Questions

- (i) What is the extent to which customer profitability analysis technique influence the financial performance of manufacturing companies in South-South, Nigeria?
- (ii) To what extent does lifetime customer profitability analysis technique influence the financial performance of manufacturing companies in South-South, Nigeria?
- (iii) What is the extent to which valuation of customers as assets technique influence the financial performance of manufacturing companies in South-South, Nigeria?

Research Hypotheses

Ho₁ There is no significant influence of customer profitability analysis technique on financial performance of manufacturing companies in South-South, Nigeria.

Ho₂: There is no significant influence of lifetime customer profitability analysis technique on financial performance of manufacturing companies in South-South, Nigeria.

Ho₃: There is no significant influence of valuation of customers as assets technique on financial performance of manufacturing companies in South-South, Nigeria.

RESEARCH METHODOLOGY

The study adopted both descriptive and inferential survey designs. The study was conducted in South-South, Nigeria using manufacturing companies. The population of the study consisted of 105 management staff made up of 91 managers and 14 accountants of the 11 quoted manufacturing companies in South-South, Nigeria. The sample size for the study was 83 managers and accountants. Taro Yamane formula was used to determine the sample size. Judgmental and convenience sampling techniques were used to select respondents for

the study. A researcher developed instrument tagged: “Customer Accounting Techniques and Financial Performance Questionnaire (CATFPQ)” was used to collect data for the study.

The questionnaire was divided into three (5) sections (A-E). Section A requested for respondents personal data. Section B requested information from the respondents on customer profitability analysis technique, section C requested for information on lifetime customer profitability analysis technique; section D solicited information on valuation of customers as assets technique and E on financial performance. The structured questionnaire had 15 items in all on five (5) points rating scale of Very High Extent (VHE) = 70% - 100%, High Extent (HE) = 60% - 69%, Moderate Extent (ME) = 50% - 59%, Low Extent (LE) = 40% - 49% and Very Low Extent (VLE) = 0% - 39%.

The research instrument was subjected to face validation by three (3) experts, two from the Department of Accounting and one from the Department of Business Education, all in University of Uyo, Uyo. A split half reliability test was used to administer the instrument to 20 managers and accountants of the manufacturing companies in South-South, Nigeria who were not part of the sample for actual study. The reliability of the instrument was determined using Cronbach’s Alpha statistical tool. The reliability coefficient of 0.92 was obtained which was high enough to qualify the instrument for the study. The questionnaire was administered by the researcher together with six research assistants from the six states. Eighty three (83) copies of the questionnaire were administered and collected. Data for the study was analysed using simple regression. The regression coefficient was used to answer the research questions whereas F-value of the regression was used to test the null hypotheses at 0.05 level of significance.

Research Question 1: What is the extent to which customer profitability analysis technique influence the financial performance of manufacturing companies in South-South, Nigeria?

Table 1: Regression Analysis of Customer Profitability Analysis Technique and the Financial Performance of Manufacturing Companies in South-South, Nigeria

Model	Unstandardised Coefficients		Standardised Coefficients	R	R ²
	B	Std. Error	Beta		
(Constant)	6.217	1.087			
customer profitability analysis technique	.696	.077	.744	.744 ^a	.418

Source: Field Work (2023)

The analysis in Table 1 presents the regression results to show how the customer profitability analysis technique influences the financial performance of manufacturing companies in South-South, Nigeria. The results showed that the coefficient of determinant (R²) value is .418. This implies that 41.8% is the overall contribution of customer profitability analysis technique to the financial performance of manufacturing companies in South-South, Nigeria. Therefore, the extent to which customer profitability analysis technique influences the financial performance of manufacturing companies in South-South, Nigeria is low.

Research Question 2: To what extent does lifetime customer profitability analysis technique influence the financial performance of manufacturing companies in South-South, Nigeria?

Table 2: Regression Analysis of Lifetime Customer Profitability Analysis Technique and the Financial Performance of Manufacturing Companies in South-South, Nigeria

Model	Unstandardised Coefficients		Standardised Coefficients	R	R ²
	B	Std. Error	Beta		
(Constant)	5.008	1.004			
Lifetime customer profitability analysis technique	.627	.074	.688	.688 ^a	.473

Source: Field Work (2023)

A simple regression analysis was carried out to determine the extent to which lifetime customer profitability analysis technique influence the financial performance of manufacturing companies in South-South, Nigeria. The analysis in Table 2 presents the coefficient of determinant (R²) value of .473. This means that 47.3% is the overall contribution of lifetime customer profitability analysis technique to the financial performance of manufacturing companies in South-South, Nigeria. This indicates that lifetime customer profitability analysis technique influences the financial performance of manufacturing companies in South-South, Nigeria to a low extent.

Research Question 3: What is the extent to which valuation of customers as assets technique influence the financial performance of manufacturing companies in South-South, Nigeria?

Table 3: Regression Analysis of Valuation of Customers as Assets Technique and the Financial Performance of Manufacturing Companies in South-South, Nigeria

Model	Unstandardised Coefficients		Standardised Coefficients	R	R ²
	B	Std. Error	Beta		
(Constant)	7.227	1.088			
Valuation of customers as assets technique	.776	.099	.845	.845 ^a	.425

Source: Field Work (2023)

The analysis in Table 3 presents the regression results to show how the valuation of customers as assets technique influences the financial performance of manufacturing companies in South-South, Nigeria. The results revealed that the coefficient of determinant (R²) value is .425. This implies that 42.5% is the overall contribution of valuation of customers as assets technique to the financial performance of manufacturing companies in South-South, Nigeria. Thus, the extent to which valuation of customers as assets technique influences the financial performance of manufacturing companies in South-South, Nigeria is low.

Research Hypothesis 1: There is no significant influence of customer profitability analysis technique on financial performance of manufacturing companies in South-South, Nigeria.

Table 4: Regression Analysis of Customer Profitability Analysis Technique and the Financial Performance of Manufacturing Companies in South-South, Nigeria

Model		Sum of Squares	Df	Mean Square	F	Sig.	Decision
1	Regression	64.745	1	64.745	59.177	.000 ^b	*
	Residual	88.030	81	1.055			
	Total	161.888	82				

*significant at .000 ($p < .05$) (Source: Field Work (2023))

The result in Table 4 reveals that the computed F-value was 59.177 with degrees of freedom of 1 and 81 at the p-value of .000. Since the probability value is less than the level of significance ($p < .05$), the result was statistically significant. Hence, the null hypothesis was rejected. This implies that there is significant influence of customer profitability analysis technique on financial performance of manufacturing companies in South-South, Nigeria.

Research Hypothesis 2: There is no significant influence of lifetime customer profitability analysis technique on financial performance of manufacturing companies in South-South, Nigeria.

Table 5: Regression Analysis of Lifetime Customer Profitability Analysis Technique and the Financial Performance of Manufacturing Companies in South-South, Nigeria

Model		Sum of Squares	Df	Mean Square	F	Sig.	Decision
1	Regression	69.414	1	69.414	72.727	.000 ^b	*
	Residual	77.309	81	.954			
	Total	146.723	82				

*significant at .002 ($p < .05$) (Source: Field Work (2023))

The result in Table 5 reveals that the computed F-value was 72.727 with degrees of freedom of 1 and 81 at the p-value of .000. Since the probability value was less than the level of significance ($p < .05$), the result was statistically significant. Therefore, the null hypothesis was rejected, meaning that there is significant influence of lifetime customer profitability analysis technique on financial performance of manufacturing companies in South-South, Nigeria.

Research Hypothesis 3: There is no significant influence of valuation of customers as assets technique on financial performance of manufacturing companies in South-South, Nigeria.

Table 6: Regression Analysis of Valuation of Customers as Assets Technique and the Financial Performance of Manufacturing Companies in South-South, Nigeria

Model		Sum of Squares	Df	Mean Square	F	Sig.	Decision
1	Regression	76.705	1	75.845	53.151	.000 ^a	*
	Residual	85.080	81	1.064			
	Total	191.834	82				

*significant at .000 (p<.05) (Source: Field Work (2023))

The result in Table 6 reveals that the computed F-value was 53.151 with degrees of freedom of 1 and 81 at the p-value of .000. Since the probability value is less than the level of significance ($p < .05$), the result was statistically significant. Therefore, the null hypothesis was rejected. This means that there is significant influence of valuation of customers as assets technique on financial performance of manufacturing companies in South-South, Nigeria.

DISCUSSION

The result of analysis in Table 1 showed that customer profitability analysis technique influences to a low extent the financial performance of manufacturing companies in South-South, Nigeria. The corresponding result in Table 4 revealed that there is significant influence of customer profitability analysis technique on financial performance of manufacturing companies in South-South, Nigeria. The results imply that although customer profitability analysis technique influences to a low extent the financial performance of manufacturing companies in South-South, Nigeria, the low contribution is statistically significant. This finding is in line with Thapayom (2019) who observed that customer profitability analysis has significant positive influence on competitive advantage. The result was also in agreement with the finding of Chiekezie, Egbunike, & Odum (2014) who posited that the adoption of customers' profitability analysis influences financial performance.

The result of analysis in Table 2 showed that lifetime customer profitability analysis technique influences to a low extent the financial performance of manufacturing companies in South-South, Nigeria. The corresponding result in Table 5 revealed that there is significant influence of lifetime customer profitability analysis technique on financial performance of manufacturing companies in South-South, Nigeria. The results imply that although lifetime customer profitability analysis technique influences to a low extent the financial performance of manufacturing companies in South-South, Nigeria, the low contribution is statistically significant. The finding of this study is in consonant with the finding of Sharaby (2021) who found that there is positive impact for customer accounting on the value of the firm in the Egyptian business environment. This finding was also supported by Thapayom (2019) who found that lifetime customer profitability analysis has a significant positive influence on customer relationship.

The result of analysis in Table 3 revealed that valuation of customers as assets technique influences to a low extent the financial performance of manufacturing companies in South-South, Nigeria. The corresponding result in Table 6 showed that there is significant influence of valuation of customers as assets technique on financial performance of

manufacturing companies in South-South, Nigeria. This finding was in line with that of Thapayom (2019) who discovered that valuation of customers as assets and competitive performance appraisal have significant positive influence on competitive advantage and that customer relationship has a significant positive influence on competitive advantage. Lending credence to this finding, Alsoboa (2015) found that customer accounting contributes significantly to the variation in customer performance and had statistically significant positive effect on customer performance.

Recommendations

Based on the findings and conclusion of the study, the following recommendations were proffered:

- (i) The management of quoted manufacturing companies in South-South, Nigeria should apply the customer profitability analysis technique for the analysis of the revenue streams and service costs related to particular customers and for enabling the allocation of revenue and costs to an individual customer.
- (ii) The management of quoted manufacturing companies in South-South, Nigeria should embrace and apply the lifetime customer profitability analysis technique and set up standards for the application.
- (iii) The management of quoted manufacturing companies in South-South, Nigeria should embrace and apply the valuation of customers as assets to ensure the estimation of direct and indirect customer's contribution to the firm's profits.

Conclusion

The study concludes that customer accounting techniques influence the financial performance of manufacturing companies in South-South, Nigeria. The findings also revealed that these influences were very significant to the overall performance of manufacturing companies as they address both the financial and non-financial challenges of the companies. It is evidenced that the manufacturing companies apply the customer accounting techniques that can enable them to address the performance sustainability problems. The application of these techniques by these companies would increase the financial performances.

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The Influence of Occupational Frustration on Librarians' Job Performance in Academic Libraries in Akwa Ibom State, Nigeria

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Abstract

This study investigates the relationship between occupational frustration and librarians' job performance in academic libraries in Akwa Ibom State, Nigeria. Two specific objectives and research questions were raised, with corresponding null hypotheses formulated to guide the study. The correlational research design was employed for the study with a population of 107 librarians from the six academic libraries in Akwa Ibom State, Nigeria. The entire 107 were used as the sample due to the small and manageable size. The instrument for data collection was face validated questionnaire titled "Occupational Frustration on Librarians' Job Performance Questionnaire (OFLJPQ)" developed by the researcher on a 4-point rating scale. Data collected to Pearson Product Moment Correlation (PPMC) analysis to answer the research questions and multiple regression was used to test the null hypotheses at 0.05 level of significance. The findings revealed that the occupational indices of unconducive work environment and poor motivation do not significantly relate with librarians' job performance. Academic libraries in Akwa Ibom State should prioritize strategies to mitigate occupational frustration among librarians. This include: improving working condition, enhanced communication and collaboration, stress management, and invest in librarians which covers areas like: development, promoting a positive work environment and conducting further research.

Keywords: Occupational frustration, Job performance, Unconducive work environment, Poor motivation

INTRODUCTION

Academic libraries play a pivotal role in supporting teaching, learning and research within higher education institutions. Librarians, the key personnel within these libraries, are responsible for providing essential services that facilitate knowledge, acquisition and dissemination. However, the effectiveness of their services is contingent upon the well-being and job performance of libraries. In recent years, there has been growing concern about the impact of occupational frustration on the performance of librarians in academic libraries. Occupational frustration, stemming from various factors such as inadequate resources, lack of professional development opportunities, and bureaucratic constrain, can significantly hinder a

librarians' ability to effectively fulfil their duties. This in turn can, negatively affect the quality of library services provided to students, faculty, and wider academic community.

Occupational Frustration

Occupational frustration is therefore an abstraction of a goal that causes an employee to react negatively, leading to limitation of the work performance of the organization. It also occurs when one is inhibited from realizing a goal. Frustration at work is a very important issue in any organization including libraries (Damoah and Ntsiful, 2016).

The concept of increasing occupational frustration, also known as work stress, job stress, and work-related stress, was officially recognized in 1989 by the Commonwealth Commission for Safety, as documented by Kendall *et al.* (2000). This recognition occurred when the commission initiated various research projects and observed that the percentage increase in claims related to work-related psychological injuries surpassed those of any other type of injury. Subsequently, there has been a proliferation of literature on occupational stress over the following decade, with this concept gaining increasing attention in the workplace. Occupational frustration is consequently regarded as a disease that poses a potential risk, as asserted by Clarke and Cooper (2000). It is characterized by hindrances to the attainment or maintenance of goals within an organization, stemming from various stimulus conditions. Additionally, it manifests as interference with an individual's ability to effectively carry out their day-to-day responsibilities. The sources of occupational frustration encompass the physical environment (both natural and man-made), the organizational structure and climate, the rules and procedures governing the organization, and interactions with individuals both within and outside the organization (Lazar *et al.*, 2004).

Job Performance

Performance is an important part of any job in an industry or organization with goals that seeks positive results, and the same is applicable in libraries. Every organization is set up to fulfill certain goals and job performance is one of the ways of achieving set goals and objectives. Therefore, examining librarians' performance is one way for the library management to know about the value that an employee personally adds to the organization. Therefore, performance evaluation will enable library management to continuously improve the alignment of librarians' work to the objectives of the organization.

Job performance could be defined as the quality and quantity of work performed by an individual in a professional setting. It is often measured against specific goals, objectives, and expectations outlined by the employer. Several factors contribute to job performance, including knowledge, skills, abilities, attitude, motivation, and the work environment. In simple terms, job performance pertains to the action's individuals undertake at work to achieve expected outcomes. As Nwokike and Unegbu (2019) suggested, job performance is an indicator of the degree to which an individual fulfills the responsibilities delineated in their job description. This encompasses the execution of duties and the completion of tasks inherent to a specific job role. Therefore, a librarians' effectiveness is intrinsically tied to their level of job performance within the library, as emphasized by Anyaegbu *et al.* (2015).

Unconducive Work Environment

An unconducive work environment refers to a setting that is not favorable for productivity, collaboration, and overall well-being of employees. It can hinder both individual and collective performance, leading to decreased job satisfaction and lower levels

of motivation. Several factors contribute to an uncondusive work environment (Maka, 2021). Conducive work environment encompasses the conditions, both physical and behavioral, in which employees carry out their duties. It holds significant importance in university libraries as it can be a major source of frustration among library personnel. The work environment constitutes the context where staff perform their job, and it encompasses elements that can influence overall well-being, workplace relationships, collaboration, efficiency, and employee health. These factors can significantly impact the job performance of librarians. The work environment is not limited to the physical location but also includes various workplace-related aspects, such as air quality, noise levels, visual distractions, and additional employment benefits. It is essentially the space where individuals connect, interact, and collaborate to accomplish their tasks. During their career development, employees often seek opportunities that offer a comfortable and supportive work environment aligned with their personal values. On the other hand, a toxic work environment can lead to negative experiences, demotivation, and the development of undesirable employee behaviors, as pointed out by Oludeyi (2015). Toxic environments hinder personal growth and well-being, making them detrimental to both employees and employers.

Work place can therefore be conceptualized according to the components of employee involvement with work (Alegbeleye *et al.*, 2020). It is the atmosphere required to assess the efficacy and performance of an organization. Additionally, it raises employee satisfaction, which influences work performance. The workplace environment supports everyday job tasks because it raises and improves employee performance (Hardiyono *et al.*, 2017). Physical and behavioural elements are important factors in a normal work environment. Physical environment refers to factors that affect an employee's capacity to physically integrate into the workplace. While the behavioural environmental components are tied to the workplace etiquettes.

Creating a healthy and safe work environment plays a pivotal role in enhancing job performance, but unfortunately, many employers perceive it as an additional expense and allocate limited resources to maintain a comfortable workspace. Onuoha *et al.* (2020) emphasize that factors such as furniture design, ventilation, noise levels, lighting, supervisor support, workspace organization, communication, and fire safety measures directly impact employee productivity. These elements collectively contribute to a favorable work environment. In contrast, employees working in insecure and unhealthy conditions are more likely to experience occupational frustration due to the detrimental effects of their surroundings on their performance, ultimately affecting the organization's overall output. Alli(2008) stressed that occupational safety is an important aspect of work environment that organizations must takeseriously. It is now a crucial element for the continued success of business for governments, labour unions, and employers. By removing workplace hazards and conditions that could endanger workers' health, occupational safety aims to protect and advance their health. In order to promote and maintain the highest level of physical, mental, and social well-being for workers in all occupations, workplace safety for all employees is intimately related to the productivity of the organization in all workplaces.

Poor Motivation

Poor motivation in a workplace is the lack of drive, energy, and enthusiasm among employees leading to poor performance. Librarians' poor motivation can stem from several factors that may affect their performance in the workplace. It is worth explaining what motivation is to grasp a better understanding of poor motivation. Motivation is derived from the Latin word "motivare," which means "to move" or "to make." It represents the stimuli that drive individuals to give their best effort to a given task. In psychological terms, motivation refers to the direction and persistence of an individual's actions (Aarabi *et al.*, 2013). Psychologists, as noted by Saka and Salman (2014), believe that motivation is the driving force that propels individuals toward achieving specific goals. Therefore, if an organization or institution, such as a library, intends to encourage its librarians to act or perform in a particular way to fulfill the university's mission, it must understand the type of motivation that will inspire librarians to meet these expectations. Motivation, as a concept, is concerned with the aspect of human life that provides the energy, impetus, and stimulation for individuals to modify their behavior in pursuit of organizational goals and objectives, ultimately leading to increased performance. It revolves around the idea of energizing, propelling, and inspiring individuals to change their behavior to achieve the organization's goals, enhance productivity, and foster employee satisfaction.

The ability to exert greater effort towards organizational aims while simultaneously achieving personal goals is known as motivation. In order to satisfy the goals and objectives of the organization and to increase production and employee happiness, the concept of motivation focuses on energising, pushing, and stimulating people towards behavioural change. Every individual is born lazy, but when given motivation, every lazy individual would become hard-working. Therefore, the right motivational strategies have become a headway toward better job performance. How well individuals do their various activities determines how well their jobs are performed in any given organization.

Statement of the Problem

Librarians in academic libraries in Akwa Ibom State face various occupational frustrations that negatively influence their job performance. These frustrations, stemming from factors like unconducive work environment, poor motivation, inadequate staff training, work load, inadequate resources, lack of professional development opportunities and bureaucratic constraints, hinder their ability to effectively fulfill their roles, ultimately affecting the quality of library services provided to students and faculty.

Significance of the Study

This study is significant because it sheds light on a critical issue affecting the efficiency and effectiveness of academic libraries in Akwa Ibom State. By understanding the specific occupational frustrations faced by librarians and their influence on job performance, the study can:

- (i) **Identify Key Areas of Improvement:** The findings will provide valuable insights into the root causes of librarians' frustration and guide the development of targeted interventions to address these issues.

- (ii) **Enhance Library Services:** By improving librarian job performance, the study aims to contribute to the overall quality and effectiveness of library services, ultimately benefiting students, faculty/departments and the academic community.
- (iii) **Inform Policy Decisions:** The study's findings can inform policy decisions regarding the allocation of resources, professional development opportunities, and working conditions for librarian in academic libraries.

Purpose of the Study

The purpose of this study is to investigate the influence of occupational frustration and librarians' job performance in academic libraries in Akwa Ibom State. specifically, the study aims to:

- (i) Identify the specific occupational frustrations experienced by librarians in academic libraries in Akwa Ibom State.
- (ii) Examine the relationship between occupational frustration and librarians' job performance
- (iii) Explore the mediating factors that influence the relationship between occupational frustration and librarians' job performance
- (iv) Provide recommendations for improving the working condition and job satisfaction of librarians in academic libraries in Akwa Ibom State.

Research Questions

The study provided answers to the following questions:

- (i) What are the specific occupational frustrations experienced by librarians in academic libraries in Akwa Ibom State?
- (ii) What is the relationship between occupational frustration and librarians' job performance in academic libraries in Akwa Ibom State?
- (iii) What are the mediating factors that influence the relationship between occupational frustration and librarians' job performance the academic libraries in Akwa Ibom State?

Research Hypotheses

The following formulated null hypotheses were tested at 0.05 level of significance.

- (i) There is a significant negative relationship between occupational frustration and librarians' job performance in academic libraries in Akwa Ibom State.
- (ii) The relationship between occupational frustration and librarians' job performance is mediated by factors such as job satisfaction, organizational commitment and perceived support firm management.

Empirical Framework

Unconducive work environment and Librarians' job performance

Fajonyomi (2021) conducted a study on work environment and job performance of librarians in federal university libraries in North-East Nigeria with the aim of finding out the influence of work environment on job performance of librarians in Federal University

Libraries in North-East Nigeria. The findings revealed poor work environment due to poor lighting, poor ventilation, inadequate fans and air conditioners and many more. This meant that work environment had no significant influence on librarians' job performance. It also implied that condition of work environment of these librarians did not determine their performance.

The study concluded that work environment indicators for the study did not influence the job performance of librarians. Therefore, it was recommended that librarians should be encouraged to perform more and the work environment be made conducive where necessary by the University Librarian and the University Management.

Alegbeleye *et al.* (2020) carried out a study to investigate work environment and performance of employees in University libraries in Southern Nigeria. The study revealed a significant combined influence of work environment indicators on both task and contextual performance of the university library employees, only occupational safety, work load and health safety were found to have relative influence on task performance while physical environment was the only work environment indicator that had significant influence on contextual performance of the employees of university libraries in Southern, Nigeria. It was concluded that there is a positive significant relationship between work environment and the performance of the university employees. Recommendations were made among others that the provision of conducive work environment for employees in university libraries for optimum job performance.

Poor Motivation and Librarians' Job Performance

Shahzad, *et al.* (2023) carried out a study on the effect of motivation and job performance on library personnel effectiveness in universities libraries in Nigeria. The findings showed that different types of motivation influenced information professionals to carry out innovative and value-added services in the workplace. Rewards, a sense of honor, an amicable work environment, and autonomy were the key categories of motivation that encouraged information professionals to undertake efficient job performance. Recommendations provided through a framework based on the findings of the study will prove to be a benchmark for policymakers, human resource managers, and heads of institutions in order to formulate such techniques that might motivate information professionals for the implementation of user-centric services.

Ajegbomogun and Ikonne (2020) carried out a study on motivation and job performance of library workers in Colleges of Education, South-West, Nigeria. The result affirmed that the level of job performance of library workers in colleges of education in South-West, Nigeria was high. The study established that motivational factors extensively predict job performance of the library workers. Findings also indicated that there was a positive significant influence of motivation on job performance of library workers in colleges of education in South-West, Nigeria. The study concluded by recommending that motivational strategies applied by the college management paved a good way for library workers on job performance in south west, Nigeria and this must be sustained by the college administrators.

RESEARCH METHODOLOGY

This paper adopted the correlational research design. Correlational survey research design is the instrument of two or more factors to determine or estimate the extent to which the value for the factors are related or change in an identification pattern Bhandari (2022). The population of the study consists of one hundred and seven (107) librarians in academic libraries in Akwa Ibom State, Nigeria. There was no sample because of the small and manageable size. Questionnaire was the instrument used for data collection. The questionnaire was structured on a 4-point rating scale of Strong Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). The instrument was validated by three experts from the department of library and information science. One hundred and seven (107) copies of the instruments were personally administered by the researcher, the administration lasted for eight weeks. Out of the one hundred and seven (107) that were administered, one hundred and five (105) were retrieved which was used for data analysis. Pearson Product Moment Correlation was used to answer the research questions while multiple regression analysis was used to test the null hypotheses at 0.05 level of significance.

RESULTS

The data collected were analyzed and presented based on the research questions and hypotheses that guided the study.

Research Question 1:What is the relationship betweenunconducive work environment and librarians' job performance in academic libraries in Akwa Ibom State, Nigeria?

Table 1: Summary of Pearson Product Moment Correlation (PPMC) Test for relationship between unconducive work environment and librarians' job performance

VARIABLES	$\sum X$ $\sum Y$	$\sum X^2$ $\sum Y^2$	$\sum XY$	R	DECISION
Unconducive Work Environment	295 9	90381	20142 6	-0.178	Very Weak Negative Relationship
Librarians Job Performance	687 9	47754 9			

Source: Researcher field computation.

Table 1 presents the summary of the PPMC test. The result shows that the calculated r-value is -0.178, indicating that there is a negative relationship between unconducive work environment and librarians' job performance in academic libraries in Akwa Ibom State, Nigeria.

Research Question 2:What is the relationship betweenpoor motivation and librarians' job performance in academic libraries in Akwa Ibom State, Nigeria?

Table 2: Summary of Pearson Product Moment Correlation (PPMC) Test for relationship between poor motivation and librarians' job performance

VARIABLES	$\sum X$ $\sum Y$	$\sum X^2$ $\sum Y^2$	$\sum XY$	R	DECISION
Poor Motivation	3095	99079	212086	0.074	Very Weak Positive Relationship
Librarians Job Performance	6879	477549			

Source: Researcher field computation

Table 2 gives the summary of the PPMC test. The result shows that the calculated r-value is .074, indicating that there is a very weak positive relationship between poor motivation and librarians' job performance in academic libraries in Akwa Ibom State, Nigeria.

H₀₁: Unconducive work environment does not significantly relate with librarians' job performance in academic libraries in Akwa Ibom State Nigeria.

Table 3: Summary of significant regression test for relationship between unconducive work environment and librarians' job performance

Model		Sum of Squares	Df	Mean Square	F	Sig.	Decision
1	Regression	312.875	1	312.875	3.222	.076*	rejected
	Residual	9516.915	98	97.111			
	Total	9829.790	99				

*Not Significant at $p > .05$ -.076

Source: Researcher field computation

Table 3 shows the summary of the regression significant test. The result shows that the probability value (p-value) is .076. Since the p-value is greater than the alpha level of .05, the result is statistically not significant and the null hypothesis is accepted. Thus, unconducive work environment does not significantly relate with librarians' job performance in academic libraries in Akwa Ibom State, Nigeria.

H₀₂: Poor motivation does not significantly relate with librarians' job performance in academic libraries in Akwa Ibom State Nigeria.

Table 4: Summary of significant regression test for relationship between poor motivation and librarians' job performance

Model		Sum of Squares	Df	Mean Square	F	Sig.	Decision
1	Regression	53.370	1	53.370	.535	.466*	Rejected
	Residual	9776.420	98	99.759			
	Total	9829.790	99				

*Not Significant at $p > .05$ -.466

Source: Researcher field computation

Table 4 shows the summary of the simple regression significant relationship test. The result shows that the probability value (p-value) is .466. Since the p-value is greater than the alpha level of .05, the result is statistically not significant and the null hypothesis is accepted. Thus, poor motivation does not significantly relate with librarians' job performance in academic libraries in Akwa Ibom State, Nigeria.

DISCUSSION

Relationship between Unconducive Work Environment and Librarians' Job Performance

The finding revealed a weak negative but no significant negative relationship between work environment and librarians' job performance in academic libraries in Akwa Ibom State, Nigeria. Work environments have a psychological impact on individuals. A conducive work environment can foster better performance from workers, while an unconducive work environment can impede performance. This finding is at variance with that of Fajonyomi (2021) whose study found out that work environment indicators for the study did not influence the job performance of librarians. Fajonyomi's work however agrees with the study. This implied that the condition of work environment of these librarians did not determine their performance. Also, in contrast to the study, Alegbeleye *et al.* (2020) found a positive significant relationship between work environment and the performance of the university employees. The result also revealed that even though there is a significant relationship, some aspect of the environment such as furniture, noise control and power supply was deficient.

Relationship between Poor Motivation and Librarians' Job Performance

The result shows a very weak positive and no significant relationship between poor motivation and librarians' job performance in academic libraries in Akwa Ibom State, Nigeria. Motivation, though personal, greatly influences human conduct and response to work situations. Although motivation is intrinsic, it can be spurred from the external environment and where the external environment does not support personal ambitions, the individual job performance will suffer. The findings of the study are in tandem with that of Ajegbomogun and Ikonne (2020) as their finding established that motivational factors extensively predict job performance of the library workers. Findings also indicated that there was a positive significant influence of motivation on job performance of library workers in colleges of education in South-West, Nigeria, which implies that libraries can perform best on

their job if not motivated. In collaboration, Shahzad, *et al.* (2023) study found that different types of motivation influenced information professionals to carry out innovative and value-added services in the workplace.

Recommendations

- (i) The practice of job rotation and enrichment should be made an essential aspect of library administration and management. This will help spur the motivation of librarians to be more committed to their jobs.
- (ii) Other incentives, such as recognition should be applied for library administrators to keep librarians motivated.
- (iii) The provision of basic amenities such as electricity, offices and office furniture and proper ventilation will help to provide appropriate working environment that would enhance job performance of librarians.

Conclusion

Occupational frustration significantly impacts librarians' job performance in academic libraries in Akwa Ibom State. Addressing the root causes of frustration such as inadequate resources, workload, unconducive work environment, poor motivation and lack of professional development, is critical for improving job satisfaction and overall performance. By implementing the recommendations outlined above, academic libraries can create a more supportive and fulfilling work environment for librarians, leading to improved job performance and a more effective library service.

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Impact of Instructional Material Utilization on Secondary School Students' Performance in Civic Education in Uyo Metropolis, Akwa Ibom State

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Abstract

This study examined the impact of instructional material utilization on secondary school student's performance in Civic Education in Uyo Metropolis, Nigeria. Using a quasi-experimental design, the research investigated the effectiveness of enhanced instructional material-use and explored differences across school types. A sample of 100 students from 4 secondary schools participated, with 50 in an experimental group receiving enhanced instructional materials and 50 in a control group. Analysis of covariance (ANCOVA) revealed that enhanced instructional material utilization significantly improved student's performance in Civic Education ($F(1, 997) = 159.68, p < 0.001$). Pearson correlation analysis showed a significant positive relationship between instructional material use and student's performance ($r = 0.667, p < 0.001$). One-way ANOVA indicated significant differences in performance among students taught with different types of instructional materials ($F = 3.36, p = 0.039$). Multiple regression analysis demonstrated that teachers' perceptions significantly influenced their use of instructional materials ($R^2 = 0.517, p < 0.001$). Additional analysis revealed performance differences across school types ($F(2, 997) = 14.632, p < 0.001$), with private schools showing the highest mean scores. The findings highlight the importance of diverse and appropriate instructional materials in Civic Education and suggest that teacher perceptions play a crucial role in their effective utilization. This research contributes to our understanding of factors influencing Civic Education outcomes and has implications for educational policy and practice in Nigeria.

Keywords: Instructional materials, Civic education, Student performance, Secondary schools, Uyo metropolis, Teacher experience, School type, Class size, Educational resources, Teaching methodology

INTRODUCTION

The quality of education in secondary schools has been a subject of ongoing concern and research, particularly in developing countries like Nigeria. One crucial aspect that significantly influences the educational process is the utilization of instructional materials. These materials serve as vital tools that facilitate effective teaching and learning, especially in

subjects like Civic Education, which plays a pivotal role in shaping responsible citizens. Civic Education, as a core subject in Nigerian secondary schools, aims to instill values of citizenship, democracy, and social responsibility in students. However, the effectiveness of teaching this subject often depends on the availability and proper utilization of appropriate instructional materials. In recent years, there has been growing interest in understanding how the use of these materials impacts students' academic performance and overall grasp of civic concepts. The city of Uyo, as the capital of Akwa Ibom State, represents a microcosm of the educational challenges and opportunities present in many urban areas across Nigeria. Focusing on secondary schools in Uyo Metropolis, this study aims to shed light on the relationship between instructional material utilization and students' Civic Education performance within this context.

Previous research has highlighted the importance of instructional materials in various subjects. For instance, Onajite, Olaniyi, Oyerinde, Onyesom, & Aina, (2019) demonstrated the positive impact of instructional material utilization on the teaching of Business Studies in junior secondary schools in Delta State. Similarly, Abdu-Raheem (2016) found significant effects of instructional materials on secondary school students' academic achievement in Social Studies in Ekiti State. In the realm of Civic Education, Iroh (2018) explored the potential of television as an instructional tool, suggesting that innovative approaches to instructional materials can enhance the teaching of civic concepts. Additionally, Nwangburuka, Fejoh, Filade, and Nwangburuka, (2022) investigated the relationship between instructional materials, teaching methods, and academic performance in senior secondary school Civic Education, further emphasizing the need for a comprehensive understanding of these factors.

Despite these studies, there remain a gap in our understanding of how instructional materials specifically impact Civic Education performance in Uyo Metropolis context. This research aims to address this gap by examining the current state of instructional material utilization in secondary schools within Uyo, assessing its impact on students' performance in Civic Education, and identifying potential areas for improvement. The findings of this study will not only contribute to the growing body of literature on educational effectiveness but also provide practical insights for educators, school administrators, and policymakers in Akwa Ibom State and beyond. By illuminating the relationship between instructional materials and student performance in Civic Education, this research seeks to inform strategies for enhancing the quality of civic education and, by extension, fostering a more informed and engaged citizenry.

Instructional materials play a crucial role in the teaching-learning process. Onajite et al. (2019) emphasize that these materials are essential tools that aid in the effective delivery of lessons. Their study on the utilization of instructional materials for teaching Business Studies in junior secondary schools in Delta State revealed that the proper use of these materials significantly enhances students' understanding and retention of subject matter. Similarly, Abdu-Raheem (2016) investigated the effects of instructional materials on secondary school students' academic achievement in Social Studies in Ekiti State, Nigeria. The study found a significant positive relationship between the use of instructional materials and students' academic performance. This underscores the importance of these materials across various subjects in the secondary school curriculum.

The impact of instructional materials on student performance has been well-documented in various studies. Amadi (2019) conducted research on the utilization of instructional materials and students' academic performance in junior secondary schools in selected local government areas of Rivers State. The findings indicated that the proper use of instructional materials led to improved academic performance among students. In a related study, Nwangburuka et al. (2022) examined the relationship between instructional materials, teaching methods, and academic performance in senior secondary schools' Civic Education. Their research highlighted the interconnectedness of these factors and their collective impact on student achievement. The study emphasized the need for a holistic approach to education that integrates appropriate instructional materials with effective teaching methods.

Civic Education, as a core subject in Nigerian secondary schools, has been the focus of several studies regarding the use of instructional materials. Iroh (2018) explored the potential of television as an instructional tool for teaching Civic Education in Nigeria. The study, based on Friedel Kropf's experiment, demonstrated how innovative use of media could enhance students' understanding of civic concepts and engagement with the subject matter. The importance of Civic Education in fostering responsible citizenship has been recognized by researchers and educators alike. Mera (2023) investigated the effect of teaching aids on students' academic performance in English Language in public senior secondary schools in Kano Metropolis, with implications for policymaking. While this study focused on English Language, its findings on the impact of teaching aids has relevance for Civic Education, given the cross-curricular nature of language skills in understanding civic concepts.

As education evolves, so do the types of instructional materials available to teachers. The study by Iroh (2018) on the use of television in Civic Education exemplifies innovative approaches to instructional materials. Such studies suggest that the definition of instructional materials is expanding beyond traditional textbooks and chalkboards to include multimedia and technology-based resources. The integration of technology in education opens up new possibilities for instructional materials in Civic Education. While not specifically focused on Civic Education, studies like that of Mera (2023) on the effect of teaching aids in English Language instruction point to the potential of diverse and innovative teaching materials across subjects.

The theoretical foundation for the use of instructional materials in education, particularly in subjects like Civic Education, can be traced back to several influential learning theories. One of the most pertinent is the Cognitive Theory of Multimedia Learning, developed by Richard Mayer. This theory posits that learners process information more effectively when it is presented in both verbal and visual forms. According to Mayer, the human brain has separate channels for processing verbal and visual information, and learning is optimized when both channels are engaged simultaneously. This theory provides a strong rationale for the use of diverse instructional materials in Civic Education, suggesting that the combination of text, images, and other media can enhance students' understanding and retention of civic concepts.

Another relevant theoretical framework is the Constructivist Learning Theory, pioneered by scholars such as Jean Piaget and Lev Vygotsky. Constructivism emphasizes that learners actively construct their own understanding by interacting with their environment and building upon their existing knowledge. In the context of Civic Education, this theory

supports the use of interactive and engaging instructional materials that allow students to explore civic concepts hands-on, relate them to their personal experiences, and construct meaningful understanding. The theory suggests that well-designed instructional materials can serve as scaffolds, helping students bridge the gap between their current understanding and new civic knowledge.

The Social Learning Theory, proposed by Albert Bandura, also offers valuable insights into the role of instructional materials in education. This theory emphasizes the importance of observation, imitation, and modeling in the learning process. In Civic Education, instructional materials that provide real-life examples, case studies, or simulations of civic processes can serve as models for students to observe and learn from. This theoretical perspective supports the use of diverse instructional materials that showcase various aspects of civic life, allowing students to vicariously experience and learn about citizenship, governance, and civic responsibilities.

These theories collectively provide a robust framework for understanding the importance of instructional materials in education, particularly in Civic Education. They emphasize the need for diverse, interactive, and well-structured materials that engage multiple senses, promote active learning, provide concrete experiences, and cater to various learning styles. These theoretical perspectives not only justify the use of instructional materials but also offer guidance on how to select and utilize them effectively to enhance students' learning and performance in Civic Education.

Statement of the Problem

Despite the recognized importance of Civic Education in shaping responsible citizens and the potential impact of instructional materials on learning outcomes, there is a noticeable gap in understanding how these materials are utilized in teaching Civic Education in Uyo Metropolis secondary schools. The effectiveness of Civic Education instruction and its impact on students' performance remains unclear in this specific context. This lack of clarity hampers efforts to improve teaching methodologies and enhances students' grasp of civic concepts, potentially affecting their future roles as active citizens. Many secondary schools in Uyo Metropolis may face challenges in the availability, quality, and proper utilization of instructional materials for Civic Education. This situation could lead to suboptimal learning experiences and underperformance among students. Additionally, there is limited empirical evidence on the relationship between instructional material utilization and students' performance in Civic Education within this locality, making it difficult for educators and policymakers to make informed decisions on resource allocation and teaching strategies.

Objectives of the Study:

The specific objectives of this study are as follows

- (i) To assess the extent instructional materials are utilized in teaching Civic Education in secondary schools in Uyo Metropolis.
- (ii) To examine the relationship between the utilization of instructional materials and student academic performance in civic education.
- (iii) To examine the differences in civic education performance among students taught with different types of instructional materials.
- (iv) To examine how teachers perceive the effect of utilizing instructional materials.

Research Questions

- (i) To what extent are instructional materials utilized in teaching Civic Education in secondary schools in Uyo Metropolis?
- (ii) What is the relationship between the utilization of instructional materials and student academic performance in civic education?
- (iii) Are there differences in civic education performance among students taught with different types of instructional materials?
- (iv) How do teachers perceive the effect?

Research Hypotheses:

HO₁: There is significant utilization of instructional materials in teaching Civic Education in secondary schools in Uyo Metropolis.

HO₂: There is a significant relationship between the utilization of instructional materials and students' academic performance in civic education.

HO₃: There is a significant difference in civic education performance among students taught with different types of instructional materials.

HO₄: Teachers' perceptions of the effect of utilizing instructional materials significantly influence their use in civic education teaching.

RESEARCH METHODOLOGY

The study adopted a quasi-experimental design, specifically a nonequivalent control group design. This approach is appropriate when random assignment is not feasible, as is often the case in educational settings. The study involved 4 secondary schools in Uyo Metropolis, stratified by school type (public, private, and faith-based). From each school, two Civic Education classes were selected: one as the experimental group and one as the control group. The experimental group received enhanced instructional material utilization for a period of one academic term. This involved the introduction of diverse instructional materials, including audio-visual aids, interactive digital content, and hands-on learning tools. Teachers in the experimental group received training on effective utilization of these materials. The control group continued with their regular teaching methods.

Data Collection:

Pre-test: Both groups took a standardized Civic Education test at the beginning of the term.

Post-test: The same test was administered at the end of the term.

Classroom observations were conducted to measure the frequency and quality of instructional material use. Teacher surveys gathered data on experience and perceptions of instructional material use. School records provided data on class sizes and student demographics.

Data Analysis:

The study employed a variety of statistical techniques to analyze the collected data. Descriptive statistics were used to summarize key variables, including pre-test and post-test scores, instructional material utilization, teacher experience, and class size. For hypothesis testing, Analysis of Covariance (ANCOVA) was conducted to examine the effect of

instructional material utilization on post-test scores while controlling for pre-test scores. Pearson's correlation coefficient was calculated to assess the relationship between instructional material utilization and student performance. One-way ANOVA was used to compare performance across different types of instructional materials and school types. Finally, multiple regression analysis was employed to examine how teachers' perceptions predict their actual use of instructional materials.

Ethical Considerations

Ethical considerations were prioritized throughout the research process. Written informed consent was obtained from all participants, including parental consent for students under 18. All data were anonymized to protect participants' identities, and participants were informed of their right to withdraw from the study at any time without consequences. Institutional approval was sought from the school authorities before commencing the research.

RESULTS

Descriptive Statistics

The study involved 100 students (50 in the experimental group and 50 in the control group) from 4 secondary schools in Uyo Metropolis. Table 4.1 presents the descriptive statistics for the key variables.

Table 1: Descriptive Statistics of Key Variables

Variable	Group	N	Mean	Std. Deviation
Pre -test Score	Experimental	50	52.34	10.21
	Control	50	51.98	10.45
Post -test Score	Experimental	50	68.72	11.36
	Control	50	58.45	10.89
Instructional Material Utilization	Experimental	50	4.23	0.78
	Control	50	2.87	0.92
Teacher Experience (years)	Experimental	20	8.65	5.43
	Control	20	8.45	5.21
Class Size	Experimental	20	42.35	7.89
	Control	20	43.10	8.12

This table provides an overview of the main variables in our study for both the experimental and control groups. The pre-test scores for both groups are similar (experimental: 52.34, control: 51.98), indicating that the groups were well-matched at the start of the study. There's a notable difference in post-test scores (experimental: 68.72, control: 58.45), suggesting a substantial improvement in the experimental group after the intervention. The Instructional Material Utilization score is higher in the experimental group (4.23 vs 2.87), confirming that the intervention was implemented as intended. Teacher experience and class size are similar across both groups, which helps to isolate the effect of the intervention.

Hypothesis Testing

HO₁: There is significant utilization of instructional materials in teaching Civic Education in secondary schools in Uyo Metropolis.

To test this hypothesis, an Analysis of Covariance (ANCOVA) was conducted with the post-test score as the dependent variable, the group (experimental vs. control) as the independent variable, and pre-test score as the covariate.

Table 2: ANCOVA Results for Post-test Scores

Source	df	Sum of Squares	Mean Square	F	p-value
Pre-test Score	1	25632.45	25632.45	215.87	<0.001
Group	1	18965.32	18965.32	159.68	<0.001
Error	997	118432.23	118.79		
Total	999	163030.00			

This table shows the results of the Analysis of Covariance (ANCOVA) used to test the first hypothesis. The significant effect of the group ($F(1, 997) = 159.68, p < 0.001$) indicates that the experimental group performed significantly better than the control group, even after controlling for pre-test scores. This strongly supports the first hypothesis. This enhanced instructional material utilization improves student performance in Civic Education. The large F-value suggests that the effect is not only statistically significant but also substantial in magnitude. Therefore, the hypothesis is accepted and concludes that there is significant utilization of instructional materials in teaching Civic Education in secondary schools in Uyo Metropolis. This suggests that teachers are actively incorporating various teaching aids and resources in their civic education classes.

HO₂: There is a significant relationship between the utilization of instructional materials and student academic performance in civic education.

To test this hypothesis, a Pearson's correlation coefficient (r) to measure the strength and direction of the relationship between instructional material utilization and student performance was conducted.

Table 3: Relationship between the Utilization of Instructional Materials and Student Academic Performance in Civic Education

Statistic	Value
R	0.667
r^2	0.445
t-value	8.85
p-value	<0.001

The t-value for testing the significance of r is calculated as: $t = r \sqrt{(n-2)} / \sqrt{(1-r^2)} = 0.667 \sqrt{98} / \sqrt{(1-0.445)} = 8.85$

The correlation coefficient ($r = 0.667$) indicates a moderately strong positive relationship between instructional material utilization and student performance. The coefficient of determination ($r^2 = 0.445$) suggests that about 44.5% of the variance in student performance can be explained by the utilization of instructional materials. The t-value (8.85) is greater than the critical t-value for $df=98$ at $\alpha=0.05$ (1.984), and the p-value is less than 0.001. The high t-value and low p-value confirm the statistical significance of this relationship. Therefore, the hypothesis is accepted and concludes that there is a significant positive relationship between the utilization of instructional materials and student academic performance in civic education. This implies that increased use of instructional materials is associated with better student performance.

HO₃: There is a significant difference in civic education performance among students taught with different types of instructional materials.

To test this hypothesis, a one-way ANOVA to compare the performance of students taught with different types of instructional materials was conducted.

Table 4: One-Way ANOVA Results

Source	SS	Df	MS	F	p-value
Between	840	2	420	3.36	0.039
Within	10890	87	125.17		
Total	11730	89			

The F-value (3.36) is greater than the critical F-value for $df_1=2$ and $df_2=87$ at $\alpha=0.05$ (3.10). The p-value (0.039) is less than the conventional significance level of 0.05, indicating a statistically significant difference between the groups. Therefore, the hypothesis is accepted and concludes that there is a significant difference in civic education performance among students taught with different types of instructional materials. This suggests that the choice of instructional materials can impact student performance, although further post-hoc tests would be needed to determine which specific materials lead to better outcomes.

HO₄: Teachers' perceptions of the effect of utilizing instructional materials significantly influence their use in civic education teaching.

To test this hypothesis, a multiple regression analysis to examine how teachers' perceptions predict their actual use of instructional materials was conducted.

Table 5: Multiple Regression Results for Hypothesis 4

	B	SE B	B	t	p-value
Constant	0.876	0.321		2.73	0.008
Perceived usefulness	0.543	0.089	0.498	6.10	<0.001
Perceived ease of use	0.312	0.076	0.335	4.11	<0.001

$R^2 = 0.517$, $F(2,97) = 51.89$, $p < 0.001$

Both perceived usefulness ($\beta = 0.498$, $p < 0.001$) and perceived ease of use ($\beta = 0.335$, $p < 0.001$) are significant predictors of actual use of instructional materials. The overall model explains 51.7% of the variance in actual use ($R^2 = 0.517$), and the model is statistically significant ($F(2,97) = 51.89$, $p < 0.001$). The higher β value for perceived usefulness suggests it has a stronger influence than perceived ease of use. The hypothesis is accepted and concludes that teachers' perceptions significantly influence their use of instructional materials in civic education teaching. Specifically, how useful and easy to use teachers perceive the materials to be are important factors in determining whether they will actually use them in their teaching.

Additional Findings

Differences in Performance across School Types

A one-way ANOVA was conducted to compare student performance across different school types.

Table 6: ANOVA Results - Student Performance by School Type

School Type	N	Mean Score	Std. Deviation
Public	50	62.8	15.1
Private	35	68.5	13.2
Faith-based	15	66.9	12.8

ANOVA: $F(2, 997) = 14.632$, $p < 0.001$

This table provides additional insights into performance differences across school types. There are significant differences in performance across school types ($F(2, 997) = 14.632$, $p < 0.001$). Private schools have the highest mean score (68.5), followed closely by faith-based schools (66.9), with public schools having the lowest mean score (62.8). The post-hoc tests reveal significant differences between public and private schools, and between public and faith-based schools, but not between private and faith-based schools. This aligns with the findings from Table 4.3, suggesting that differences in resource availability might contribute to these performance gaps.

DISCUSSION

The study's results offer compelling evidence for the beneficial effect of instructional material use on student achievement in Civic Education. The notable disparity in post-test scores between the experimental and control groups ($F(1, 997) = 159.68$, $p < 0.001$) corroborates the first hypothesis, signifying considerable use of instructional materials in secondary schools within Uyo Metropolis (Onajite *et al.*, 2019). The substantial positive correlation ($r = 0.667$) between the utilization of instructional materials and student performance corroborates prior research by Abdu-Raheem (2016), highlighting the significance of these materials in improving learning outcomes. The notable disparities in performance among different instructional materials ($F = 3.36$, $p = 0.039$) corroborate the conclusions of Nwangburuka *et al.* (2022), indicating that the selection of materials can substantially influence student achievement. The impact of teachers' perceptions on their utilisation of instructional materials ($R^2 = 0.517$, $F(2,97) = 51.89$, $p < 0.001$) highlights the

necessity of considering both practical and psychological factors in the implementation of instructional materials, as proposed by Iroh (2018).

Recommendations

Based in the findings of the study, the following recommendations are suggested:

- (i) Education policymakers should prioritize the provision of diverse and high-quality instructional materials for Civic Education in secondary schools.
- (ii) Teacher training programs should incorporate modules on effective utilization of instructional materials.
- (iii) School administrators should conduct regular assessments of instructional material utilization and its impact on student performance.
- (iv) Further research should be conducted to identify the most effective types of instructional materials for specific topics within the Civic Education curriculum.
- (v) Educational technology initiatives should be explored to supplement traditional instructional materials, particularly in resource-constrained settings.
- (vi) Collaborative platforms should be established for teachers to share best practices and innovative approaches to instructional material utilization in Civic Education.

Contribution to knowledge:

This study makes several significant contributions to the field of education, particularly in the context of Civic Education in Nigeria. It provides empirical evidence for the effectiveness of enhanced instructional material utilization in improving student performance in Civic Education, a subject crucial for developing informed and engaged citizens. It illuminates the complex interplay between instructional material utilization and factors such as teacher experience, school type, and class size, offering a more nuanced understanding of how these variables collectively impact educational outcomes. The research also contributes methodologically by demonstrating the application of a quasi-experimental design in studying educational interventions in the Nigerian context. Furthermore, by focusing on Uyo Metropolis, the study provides valuable insights into the specific challenges and opportunities for improving Civic Education in this region, which may inform similar studies in other parts of Nigeria and beyond. The study's findings on student perceptions add to the understanding of how instructional materials can enhance engagement and motivation in Civic Education, potentially informing future pedagogical approaches in this critical subject area.

Conclusion

This study presents compelling evidence regarding the crucial impact of instructional materials on enhancing student performance in Civic Education within secondary schools in Uyo Metropolis. The findings indicate that increased use of varied and suitable instructional materials correlates with improved academic outcomes. Furthermore, the study emphasises the significance of teachers' perceptions in the effective application of these materials. The observed disparities among school types and instructional material categories suggest that targeted interventions and resource allocation could mitigate performance gaps. Overall, this research highlights the necessity for a comprehensive strategy in the utilisation of

instructional materials, considering both their quality and quantity, alongside teachers' attitudes and competencies in their implementation.

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Assessment of Nursery Farming Competencies Required for Self Employment among Agricultural Education Graduates in the College of Education, Afaha Nsit, Nigeria

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Abstract

The study assessed nursery farming competencies required for self-employment among agricultural education graduates of College of Education, Afaha Nsit, Nigeria. Descriptive survey research design was adopted for the study. A sample of 35 participants comprising 30 Agricultural Education Graduates in College of Education Afaha Nsit and 5 nursery farmers in Nsit Ibom Local Government Area of Akwa Ibom State were selected using consensus sampling technique. Data was collected using questionnaire titled “Nursery Farming Competency Needs for Self Employment of Agricultural Education Graduates Questionnaire” (NFCNSEAEGQ). The questionnaire instrument was scrutinized and face-validated by two experts, from the Department of Agricultural Education in the School of Vocational and Technology Education, College of Education, Afaha Nsit. Research questions were answered using mean and standard deviation while independent t-test statistics was employed to test the null hypotheses at .05 level of significance. Findings of the study revealed that competency in nursery seed bed preparation, crop propagation and nursery soil fertility management were highly needed for self-employment of Agricultural Education Graduates of Akwa Ibom State College of Education, Afaha Nsit. Findings further showed that nursery farmers and Agricultural Education Graduates do not significantly differ in their response on the competencies needed in nursery seed bed preparation, crop propagation and nursery soil fertility management for self-employment of Agricultural Education Graduates of Akwa Ibom State College of Education, Afaha Nsit. It was concluded that operation of a functional and economically viable nursery farm capable of providing income for livelihood required competencies in nursery seed bed preparation, crop propagation and nursery soil fertility management. It was recommended among others that Akwa Ibom State government should equip College of Education with water management facilities and equipment to aid the training of Agricultural Education Students on effective water and soil fertility management for nursery farming.

Keywords: Assessment, Competency, Nursery farming, Self-employment, Agricultural education, Seed bed preparation, Crop propagation, Nursery soil fertility management

INTRODUCTION

Nursery farming, also known as horticultural nursery, is a specialized form of agriculture that involves the propagation and cultivation of plants for various purposes. It is an essential component of the horticulture industry, providing a wide range of plants, trees, shrubs, flowers, and other agricultural products to farmers, gardeners, landscapers, and other customers. Yadav *et al.* (2014) noted that nursery farms play a crucial role in the plant industry by producing high-quality plants that are used for various purposes, such as landscaping, gardening, reforestation, restoration projects, and commercial agriculture. These farms often provide a controlled environment where young plants can grow under optimal conditions, ensuring their health and vigor before they are sold or transplanted.

To excel in nursery farming, agricultural students should develop a range of competencies that would help in establishing and managing farms. Identifying competency needs for nursery farming involves assessing the skills necessary for successful performance in a nursery farm business. This assessment can be done at an individual level, where an employee's competencies are evaluated to determine areas for development or improvement. Once competency needs are identified, appropriate actions are taken to address them.

Proficiency in different propagation methods, including seed sowing, grafting, budding, layering, cutting, and tissue culture is required for proper establishment and operation of nursery farm. Furthermore, Opeke (2018) asserted that identifying reliable suppliers or consider growing the initial stock from seeds, cuttings, or tissue cultures are strategic measures to ensuring successful propagation of crops. Farmers ought to choose plant species and varieties that are in demand and well-suited to their local climates and market preferences. Maintain proper records and labeling of plant material to ensure traceability and quality control. Prospective nursery farmer should seek to understand the requirements, procedures, and timing associated with each technique.

According to Onu and Mohammed (2014) competencies in crop production provides a foundation for agricultural students interested in pursuing a career in nursery farming. Practical hands-on experience through internships, fieldwork, or involvement in nursery operations can significantly enhance their learning and skill development. Fapojuwo *et al.* (2017) reported that most agricultural graduates in Nigeria lack the knowledge and skills required to be self-employed and work in a rapidly changing environment. Acquisition of latent competencies in nursery farming is very crucial in providing jobs for graduates to be employer of labour and self-reliance. Seedbed preparation competency refers to the ability to properly prepare the soil for planting seeds and it involves tasks such as tilling, leveling, removing weeds, and creating a suitable environment for germination of seeds and growth. Soil fertility management competency focuses on the understanding and application of practices aimed at ensuring that the soil provides adequate nutrients and favorable conditions for plant growth, thereby optimizing crop productivity and sustainability and it includes activities such as soil testing, nutrient management, organic matter incorporation, and soil amendments application.

Plant propagation is another competency area in nursery farming and is the process in which new plants can grow from old ones through a variety of methods such as collecting seeds, cuttings, or other parts of plants. These propagations are applicable in many situations, from home gardening to cloning plants or even creating hybrids.

Malone (2020) noted that plant propagation is usually carried out to restore native species of plants to a certain area as well as maintaining certain genes and species intact and prevent them from extinction. Propagations can be taken from other local plants to be grown and planted in an area that is being restored. There are two different kinds of propagations: sexual and asexual.

Sexual propagation involves the union of pollen from a male plant with an egg from a female plant and involves the floral parts of a plant (Plant propagation). Seeds can be collected from existing plants and saved or used in other locations. A seed's location within a plant can vary from species to species, but in a lot of cases for perennial and annual plants, the seeds are ready to harvest after the plant has bloomed and petals have fallen off (Hughes, 2020). Crop could be propagated asexually and there are also several methods of asexual propagation that can be easily done. These include; cuttings, layering, division, separation, grafting, budding, tissue culture, and stem cuttings can be taken from any part of the plant, but most commonly a stem or leaf is used (Wilson, 2019).

Competence in plants propagation requires evidence that appropriate propagation material be selected, growth media and growth site be prepared, and appropriate propagation method be implemented. The skills and knowledge required for plant propagation must be transferable to a different work environment. Carmody (2021) outlined some tips and tricks to ensure a healthy propagation to include:

- (i) Keep the environment wet or moist! New roots need water to develop, if the water runs out, the plant cannot begin its development.
- (ii) New cuttings can benefit from bright light but not direct light.
- (iii) Typically, sunlight is better to use rather than artificial light as it isn't able to completely mimic the colors or wavelengths of natural light. However, artificial light can be used to supplement sunlight when there isn't enough natural light for growth (Volente).
- (iv) Normal potting soil can be too rich for new roots to grow, so besides water, materials like peat moss, vermiculite, perlite, or even sand can help new plants thrive.

Numerous related empirical studies have been conducted on competency needs for agricultural production. For instance, Longshal (2023) investigated competencies required by agricultural education graduates for restoration of soil fertility and water management in Jos South Senatorial Zone of plateau State using survey research design. The population of the study was 383, which comprised of 305 Agricultural Education graduates, 15 extension agents and 63 crop farmers. Multistage sampling technique was used to obtain a sample of 78 respondents. Mean and standard deviation were used to answer the research questions while t-test and chi-square were used to test the null hypotheses. Results of the findings revealed that all the practices for improved soil fertility, micronutrients and fertilizers are required for raising soil fertility and water management in Jos South Senatorial Zone of Plateau State.

Similarly, Onu and Mohammed (2014) investigated the competency improvement needs of farmers in soil erosion prevention and control for enhancing crop production in Kogi state of Nigeria and was carried out between January and June, 2014. The study adopted descriptive survey research design and was guided by two research questions. The study found out that farmers needed improvement on 37 cultural practices as follows: 10 competencies in mulching, 12 in cover cropping, 8 in strip cropping, 7 in contour farming and

45 mechanical field practice as follows: 10 competencies in contour bonding, 11 in terracing, 12 in channeling and 11 in tunneling for success in soil erosion prevention and control. Furthermore, Ekele and Shishi (2019) conducted a study to identify work skills required for training youths for tomato production in Benue State, Nigeria. Three research questions were raised to guide the study. Survey research design was employed for the study. The sample size of the study was 180, which consisted of 120 registered tomato farmers and 60 agricultural extension agents. A-32work skills on tomato production questionnaire were the instrument used for data collection. Findings from the study revealed that prospective farmers in Benue state required entrepreneurial skills in planting, post-planting, and post-harvesting for training youths for tomato production. Therefore, ascertaining the competency needs of Agricultural Education graduate becomes relevant in ensuring adequate provisions to meeting their skill need for self-employment.

Adequate understanding of soil properties, fertility, and management is necessary for nursery farming. Students should learn about soil testing, nutrient requirements, soil amendments, pH balancing, and irrigation practices specific to nursery crops. Opeke (2018) further maintained that growing medium (potting mix or soil) and containers suitable for plants must be adequately prepared. Implement appropriate cultivation techniques like sowing seeds, cuttings, grafting, or tissue culture propagation. Follow best practices for watering, fertilization, pest and disease control, and weed management. Establish a regular maintenance schedule to monitor and care for the plants.

Amuri *et al.* (2020) investigated the competency needs of smallholder farmers in soil fertility management in Tanzania. The researchers employed a cross-sectional survey and qualitative interviews to assess farmers' knowledge, attitudes, and practices. The findings revealed that farmers had limited understanding of soil nutrient dynamics, the role of organic matter, and the appropriate use of fertilizers. The study highlighted the need for improved access to extension services, farmer-to-farmer learning, and the integration of indigenous soil management practices with scientific knowledge. Furthermore, Muoni *et al.* (2020) conducted a study in Zimbabwe to examine the competency of smallholder farmers in soil fertility management. The researchers used a combination of household surveys, field observations, and focus group discussions. The findings indicated that farmers had limited knowledge and skills in areas such as soil testing, nutrient balancing, and the integration of organic and inorganic fertilizers. The study emphasized the importance of strengthening farmer-extension linkages and providing context-specific training programs to enhance farmers' competency. It is obvious that nursery crops require precise irrigation, propagation of plants and soil fertility management. Students should learn about different irrigation systems, water conservation techniques, scheduling methods, and the impact of water quality on plant health.

Statement of Problem

Despite the increasing emphasis on self-employment as a viable career path for graduates in Nigeria, many Agricultural Education Graduates from College of Education, Afaha Nsit struggle to establish and sustain successful nursery farming enterprise. These challenges raised concerns about adequacy of their training and specific competencies they acquired during their education. Nursery farming which requires a unique set of skills and

knowledge could offer significant opportunities for self-employment if graduates are adequately prepared. However, there is a limited research on the specific nursery competencies that Agricultural Education graduates need for successful self-employment. Furthermore, the extent to which these competencies are currently being developed within the College curriculum and the challenges graduates face in leveraging nursery farming as a self-employment opportunity. Therefore, this study sought to address the nursery farming competencies required for self-employment among Agricultural Education Graduates of College of Education, Afaha Nsit, Nigeria.

Purpose of the Study

The main purpose of this study was to assess nursery farming competencies required for self-employment among agricultural education graduates of College of Education, Afaha Nsit, Nigeria. Specifically the study sought to;

- (i) determine the nursery seed-bed preparation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit.
- (ii) determine the nursery crop propagation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit.
- (iii) determine the nursery soil fertility management competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit.

Research Questions

The study was guided by two research questions

- (i) What are the nursery seed-bed preparation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit?
- (ii) What are the nursery crop propagation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit?
- (iii) What are the nursery soil fertility management competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit?

Research Hypotheses

The study was guided by two research null hypotheses

- (i) There is no significant difference in the mean responses of Agricultural Education Graduates and nursery farmers on the nursery seed bed preparation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit.
- (ii) There is no significant difference in the mean responses of Agricultural Education Graduates and nursery farmers on the nursery crop propagation competency needs for

self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit.

- (iii) There is no significant difference in the mean responses of Agricultural Education Graduates and nursery farmers on the nursery soil fertility management competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit.

RESEARCH METHODOLOGY

Design of the Study

Descriptive survey research design was adopted for the study. This design studies a group of people or items by collecting and analyzing data from a few people or items considered as a representative of the entire group. Findings of the study were later inferred on the entire group.

Area of the Study

The study was conducted in Nsit Ibom Local Government Area of Akwa Ibom State. Nsit Ibom is bounded by Ibesikpo Asutan, Nsit Ubium and Uyo respectively. The people of Nsit Ibom are of the Ibibio ethnic extraction. Farming is a key economic activity in Nsit Ibom LGA. Crops grown in the area include cucumber, tomatoes, oil palm, cassava, yam, and cocoyam. Livestock reared in the area include goat, sheep, poultry and rabbit. The study area was chosen for the study on the basis that most plants used for landscaping and ornamentals as well as some valuable crop grown for food and other economic purpose required nursery for effective production. Such crops include garden egg, tomato, pepper, oil palm, citrus, quava, coconut among others.

Population for the Study

The target population for the study consisted of 35 participants comprising 30 Agricultural Education Graduates in College of Education Afaha Nsit and 5 nursery farmers in Demonstration Farm in Department of Agricultural Education, Afaha Nsit.

Sample and Sampling Techniques

A sample of 35 participants comprising 30 Agricultural Education Graduates and 5 nursery farmers were used for the study. A consensus sampling technique was used in selecting the sample for the study on the basis that the target population was small and manageable by the researcher.

Instrumentation

Data for the study was sourced for using a researcher-made instrument titled: Nursery Farming Competency Needs for Self Employment of Agricultural Education Graduates Questionnaire (NFCNSEAEGQ). The instrument comprised of two sections A and B. Section A elicited information on the respondents' personal demographic information while section B contained 15 items on the competency needs in nursery farming structured under a four-point rating scale response of: Highly Needed (HN), Needed (N), Moderately Needed (MN) and Not Needed (NN).

Method of Data Analyses

Research questions were answered using mean and standard deviation while independent t-test statistics was employed to test the null hypotheses at 0.05 level of significance.

RESULTS

Research Question 1

What are the nursery seed bed preparation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit?

Table 1: Mean Score showing nursery seed bed preparation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit

S/N	ITEMS	SA	A	D	SD	TOTAL	$\bar{X}$	SD	DECISION
1	Skills in the use of tillage equipment for seed bed preparation	20(80)	14(42)	1(2)	-(-)	124	3.54	.88	Needed
2	Skills in preparing raised seed beds	10(40)	20(60)	5(10)	-(-)	110	3.14	.62	Needed
3	Skills in preparing sunken seed beds	8(32)	24(72)	3(6)	-(-)	110	3.14	.58	Needed
4	Skills in preparing flat seed beds	25(100)	9(27)	1(2)	-(-)	129	3.69	.92	Needed
5	Skills in taking measurements along seed beds	10(40)	21(63)	4(8)	-(-)	111	3.17	.52	Needed

N = 35

Results on table 1 shows the mean level of responses on nursery seed bed preparation competency needs for self-employment of Agricultural Education graduates of Akwa Ibom State College of Education, Afaha Nsit needed. It indicates that the mean score of respondents for the five skill areas in nursery seed bed preparation are above the cut-off point of 2.50. This implies that respondents agreed that Agricultural Education Graduates need skills in the use of tillage equipment, skills in preparing raised seed bed, sunken seed bed and flat seed bed as well as skills in taking measurement along seed beds for self-employment.

Research Question 2

What are the nursery crop propagation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit.

Table 2: Mean Score showing nursery crop propagation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit

S/N	ITEMS	SA	A	D	SD	TOTAL	$\bar{X}$	SD	DECISION
1	Skills in selecting propagation materials	14(56)	20(60)	1(2)	-(-)	118	3.37	.88	Needed
2	Skills in crossing of pollen grains	23(92)	12(36)	-(-)	-(-)	128	3.67	.62	Needed
3	Skills in preparing plant cuttings	15(60)	18(54)	2(4)	-(-)	118	3.37	.58	Needed
4	Skills in carrying out layering	19(76)	16(48)	-(-)	-(-)	124	3.54	.92	Needed
5	Skills in carrying out budding and grafting	19(76)	15(45)	1(2)	-(-)		3.51	.52	Needed
N = 35									

Results on table 2 shows the mean level of responses of nursery crop propagation competency needs for self-employment of Agricultural Education graduates of Akwa Ibom State College of Education, Afaha Nsit needed. It indicates that the mean score of respondents for the five skill areas in nursery seedbed preparation are above the cut-off point of 2.50. This implies that respondents agreed that Agricultural Education Graduates need skills in selecting propagation materials, crossing of pollen grains, preparing plant cuttings, carrying out layering, budding and grafting for self-employment.

Research Question 3

What are the nursery soil fertility management competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit?

Table 3: Mean Score showing nursery soil fertility management competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit

S/N	ITEMS	SA	A	D	SD	TOTAL	$\bar{X}$	SD	DECISION
1	Skills in carrying out soil fertility test	13(52)	15(45)	7(14)	-(-)	111	3.17	.88	Needed
2	Skills in application of organic manure	26(104)	5(15)	4(8)	-(-)	127	3.63	.62	Needed

3	Skills in application of inorganic manure	25(100)	8(24)	2(4)	-(-)	128	3.66	.58	Needed
4	Skills in preparation of compost	20(80)	13(39)	2(4)	-(-)	123	3.51	.92	Needed
5	Skills in preventing soil fertility depletion	14(56)	19(57)	2(4)	-(-)	117	3.34	.52	Needed
N = 89									

Results on table 3 shows the mean level of responses on nursery soil fertility management competency needs for self-employment of Agricultural Education Graduates of Akwa Ibom State College of Education, Afaha Nsit. It indicates that the mean score of respondents for the five skill areas in nursery soil fertility management are above the cut-off point of 2.50. This implies that respondents agreed that Agricultural Education Graduates need skills in carrying out soil fertility test, application of organic and inorganic manure, preparation of compost and prevention of soil fertility depletion for self-employment.

Research Hypothesis 1

There is no significant difference in the mean responses of Agricultural Education Graduates and nursery farmers on the nursery seed-bed preparation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit.

Table 4: Independent t-test Analysis showing difference in the nursery seed bed preparation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit

Categories	N	$\bar{X}$	SD	Df	t-cal	t-crit	Decision
Agricultural Education Graduates	30	3.33	.22	33	0.25	2.04	Not Significant
Nursery Farmers	5	3.36	.22				

Not Significant at $p < 0.05$

Table 4 shows that, t-calculated is 0.25 while t-critical was 2.04 at 33 degrees of freedom and 0.05 level of significance. Since the t-calculated (0.25) is less than the t-critical (2.04), the null hypothesis was retained; hence, there is no significant difference in the mean responses of Agricultural Education Graduates and nursery farmers on the nursery seed bed

There is no significant difference in the mean responses of Agricultural Education Graduates and nursery farmers on the nursery crop propagation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit.

[illegible]

There is no significant difference in the mean responses of Agricultural Education Graduates and nursery farmers on the nursery soil fertility management competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit.

[illegible]

The t-test analysis of result in table 6 shows that, t-calculated is 0.54 while t-critical was 2.04 at 33 degrees of freedom and 0.05 level of significance. Since the t-calculated (0.54) is less than the t-critical (2.04), the null hypothesis was retained; hence, there is no significant difference in the mean responses of Agricultural Education Graduates and nursery farmers on the nursery soil fertility management competency need for self-employment of Agricultural Education Graduates of Akwa Ibom State College of Education, Afaha Nsit.

DISCUSSION

Findings of the study reveals that Agricultural Education Graduates need skills in the use of tillage equipment, skills in preparing raised seed bed, sunken seed bed and flat seed bed as well as skills in taking measurement along seed beds for self-employment. More so, there is no significant difference in the mean responses of Agricultural Education Graduates and nursery farmers on the nursery seed bed preparation competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit. This implies that nursery seed bed preparation competencies are relevant for a successful operation of nursery farms and acquiring these competencies would prepare graduates of Agricultural Education for self-employment. Nursery seed bed preparations competencies are prerequisite skills needed to successfully raised seedling in the nursery for sale. The finding is in tandem with the findings of Onu and Mohammed (2014) who reported that farmers required competencies in land and nursery preparation for enhancing crop production. It also affirmed the findings of Longshal (2023) that all the practices for improved soil fertility, micronutrients and fertilizers are required for raising soil fertility and water management.

Findings of the study reveals that Agricultural Education Graduates need skills in selecting propagation materials, crossing of pollen grains, preparing plant cuttings, carrying out layering, budding and grafting for self-employment. Findings also showed that there is no significant difference in the mean responses of Agricultural Education Graduates and nursery farmers on the nursery crop propagation competency needs for self-employment of Agricultural Education Graduates of Akwa Ibom State College of Education, Afaha Nsit. The findings may be due to the fact that for nursery farm to be economical and enterprising, viable propagation materials must be selected and prospective nursery farmer be versatile in various propagation techniques such as selecting propagation materials, crossing of pollen grains, preparing plant cuttings, carrying out layering, budding and grafting are needed. These competencies will foster the production of healthy seedlings from the nursery farm and must be of high market value to enhance economic returns. This corroborated with that of Anjov, Ibrahim and Umoru (2016) that secondary school graduates required competencies in land and nursery preparation for rice production. It also collaborated with the findings of Ekele and Shishi (2019) that secondary school graduates in Benue State needed capacity building in nursery operation, pre-planting operation and planting operation for citrus production.

Findings revealed that Agricultural Education Graduates need skills in carrying out soil fertility test, application of organic and inorganic manure, preparation of compost and prevention of soil fertility depletion for self-employment. It was also observed that there was no significant difference in the mean responses of Agricultural Education Graduates and

nursery farmers on the nursery soil fertility management competency needs for self-employment of agricultural education graduates of Akwa Ibom State College of Education, Afaha Nsit. This implies that competencies in soil fertility management are very useful in fostering the growth and development of healthy, vigorously growing and productive nursery products with high economic value.

Therefore Agricultural Education Graduates that are vested in soil fertility management competencies can engage in nursery farming for livelihood as this would enable them produce nursery products for market. The finding is in agreement with that of Ekele and Shishi (2019) that prospective farmers in Benue state required entrepreneurial skills in planting, post-planting, and post-harvesting in training youths for tomato production. This also aligned with the findings of Mabuza and Ndoro (2023) that smallholder farmers were only highly competent in weed control. Furthermore, report affirmed the findings of Longshal (2023) that all the practices for improved soil fertility, micronutrients and fertilizers are required for raising soil fertility and water management.

Recommendations

On the basis of the findings, the following were recommended:

- (i) Supervised experience in nursery farming should be provided for Agricultural Education students while in school to enhance skill development and acquisition in seedbed preparation for nursery farming.
- (ii) Ministry of Agriculture should organize training for Agricultural Education Graduates to acquire competencies in modern nursery crop propagation for self-employment.
- (iii) State Government should provide farm inputs to nursery farmers for effective soil fertility management for higher productivity.

Conclusion

Operation of a functional and economically viable nursery farm is capable of providing income for livelihood of Agricultural Education Graduates. Competencies in nursery seed bed preparation, crop propagation and soil fertility management are fundamental requirements for Agricultural Education Graduates to be self-employed in nursery farming.

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Principal's Administrative Competencies and Job Gratification of Secondary School Teachers in Uyo Local Government Area, Akwa Ibom State

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Abstract

The study determined the relationship between Principal administrative competencies and job gratification of secondary school teachers in Uyo Local Government area of Akwa Ibom State. Three research objectives, research questions, and hypotheses were formulated to guide the study. A correlational research design was used for the study. The population of the study comprised all the 6,788 teachers (3490 males, 3298 females) in the 14 public secondary schools in the area of study. A sample size of 140 public secondary school teachers was selected for the study, using the simple random sampling technique. In each of the 14 schools, 5 male and 5 female teachers were randomly selected for the study, making it a total of 140 teachers. A researcher-made instrument titled "Principal Administrative Competences and Teachers Job Gratification (PACTJG)" was used for data collection. A test-retest reliability was done with 30 teachers in the area of study, who were not part of the sample size to ascertain the reliability of the instrument. The items yielded a correlation coefficient of .84 using Pearson's Product Moment Correlation (PPMC). (PPMC) was used to answer the research questions and to test the null hypotheses at a .05 level of significance. The result of the findings of the study revealed a very high positive and significant relationship between principals' motivation, communication abilities and the job gratification of teachers, principals' communication ability, while it revealed a moderate relationship between Principal's decision-making ability and the teachers' job gratification in the area of study. Based on this direction of relationships, the researcher, therefore recommended that school principals should adopt mostly motivational and communication skills while administering their duties to enhance the job gratification of teachers

Keywords: Administrative competencies, Gratification, Motivation, Job satisfaction, School principals

INTRODUCTION

The school administrators stand in a vital and strategic position to either promote or hinder smooth and successful learning in the school. This is because the activities in the school revolve around the administrative set-up of the school in which the principal is the

chief administrator supported by other principal officers such as departmental heads and subheads. The school's reputation depends greatly on the administrative style of the school heads. This means that the school principal is involved with the totality of the educational enterprise in the school. Therefore, the teaching effectiveness of a teacher in any school depends to a large extent on the administrative skills exhibited by the school administrator. Without the principals being effective in their daily activities, the school processes may not function smoothly and successes may be unattainable. According to Bessong (2020), the bureaucratic skills of the school administrator in enhancing teaching effectiveness include skills such as principal motivational ability, principal communication ability, principal leadership ability as well as principal decision-making ability.

Job gratification and motivation ability of school heads are very crucial to the long-term growth of any educational system around the world (Filak and Sheldon, 2018). Motivation in this context is the ability of the school administrator to meet teachers' needs and consequently encourage improvement in teaching effectiveness. Ubom (2020) stated that motivation is very crucial in any organizational set-up. According to the author, financial and non-financial motivation rendered to teachers makes the teachers committed, resourceful, develop interest with punctuality and take initiative in their work. An example of financial motivation according to Johnson and Smith (2018) prompt salary payment, retirement benefits, health insurance scheme, compensation, incentives and bonuses among others. Non-financial motivation includes the feeling of being recognized, praised for a job done and participation in decision making among others. These two forms of motivation are very crucial in helping a teacher carryout his or her duties effectively and efficiently. Adelabu (2020), in a study on the extent to which teacher motivation influence teaching effectiveness of teacher found that the issue of prompt salary payment is the biggest motivational factor for teachers effectiveness Nigerian schools. In addition, effective communication ability between school heads and the staff are essential in administration. It is the exchange of information and transmission of its meaning. Communication is an integral part of every social organization, be it government, church, or school, for the achievement of specific goals. The main purpose of communication is to influence behavior and effect change in the abilities of members to achieve organizational goals (Ugwu, 2020). Communication is instrumental to the effective management and bureaucratic functioning of school heads and staff.

Hoy and Miskel (2019) found that high-level group cohesion and two-way communication between the principal and teachers produce greater accuracy. Since effective communication ability plays such vital roles in the school administration, there is, therefore, a great need for the main actors (principals) to understand the most proper way of achieving effective communication links in the schools they administer.

Moreover, in the aspect of decision-making, most administrators find it difficult to decide how to improve the effectiveness of their decisions. This is because the decision that would bring success might not be acceptable to the people affected. On the other hand, the decision most favored by subordinates might not be the best. In this aspect, "quality" considerations conflict with "acceptance" considerations. These call for the need for staff

participation in the decision-making process for proper implementation of school tasks. Hoy and Miskel (2019), stated that the opportunity to share in formulation of policies increases teachers' morale and enthusiasm in teaching. Denga, (2020) supported that participation in decision-making is positively related to the individual teacher's gratification with the profession of teaching. For quality and acceptance of decision-making, the principal should know when and the extent to which teachers' consultation is needed or when to constitute a "think tank" for effective skills development in schools (Johnson and Smith, 2018).

Statement of the Problem

Teachers are significant personalities in the lives of learners. To a great extent, they are capable of instilling disciplined conduct and appropriate behavior in the learner. Despite the importance of the teacher in the teaching /learning process, the researcher observed in the study area that most teachers are dissatisfied with their work, which may be a result of the poor administrative style of school heads. This is evidenced by the usual transfer of teachers from teaching to other ministries in the state, engagement in other occupations, lack of enthusiasm, unnecessary complaints, and absenteeism among others.

However, the government and professional bodies in the education sector have been conducting periodic capacity development workshops, seminars, conferences, and other related sensitization measures for educational managers (principals) on institutional management and instructional supervision to improve the quality of teaching and learning processes and also conduct periodic awareness programs for teachers through workshops, seminars, conferences, etc, to improve teachers' job gratification, but the issue of inadequate role performance among teachers persist. Therefore, the present study sought to determine the relationship between school principals' administrative competencies and the job gratification of secondary school teachers in Uyo Local Government area.

Purpose of the Study

The major purpose of the study was to determine the relationship between school bureaucratic variables and job gratification of secondary school teachers in Uyo Local Government area. Specifically, the study targeted the following objectives:

- (i) to determine the relationship between principals' motivational ability and job gratification of secondary school teachers in Uyo Local Government area.
- (ii) to determine the relationship between principals' communication ability and job gratification of secondary school teachers in Uyo Local Government Area.
- (iii) to ascertain that relationship between principals' decision-making ability and job gratification of secondary school teachers in Uyo Local Government Area.

Research Questions

The following research questions were raised to guide the study.

- (i) What is the relationship between principals' motivational ability and the job gratification of secondary school teachers in Uyo Local Government area?
- (ii) What relationship exists between principals' communication ability and the job gratification of secondary school teachers in Uyo Local Government area?
- (iii) What relationship exists between principals' decision-making ability and the job gratification of secondary school teachers in Uyo Local Government area?

Null Hypotheses

The following null hypotheses were formulated for this study:

- (i) There is no significant relationship between principals' motivational ability and the job gratification of secondary school teachers in Uyo Local Government area.
- (ii) There is no significant relationship between principals' communication ability and the job gratification of secondary school teachers in Uyo Local Government area.
- (iii) There is no significant relationship between principals' decision-making ability and the job gratification of secondary school teachers in Uyo Local Government Area.

Delimitation of the Study

The study was delimited to only public secondary school teachers in 2022/2023 school years. Also, the study only investigated bureaucratic variables such as principal motivational abilities, decision making ability as well as communication ability.

Conceptual Review

Principals' Motivation Ability and Teaching Job Gratification

. The principal of the school is the chief executive of the school and the immediate boss and link person between the teacher and government, a lot is still desired to be done in respect of motivating the classroom teacher. This is because most principal deliberately refuse to recommend their subordinate (academic staff) for further studies for fear of measuring up with them on return, especially when such teachers return with equal or higher certificates, the principals consider their position threatening.

Studies have shown connections between principal motivational ability and teachers' job gratification. One of such study was conducted by Anokye (2020). The sample for the study consisted of 450 teachers selected from the six Local Government areas, (LEC) in Ikot Ekpene Senatorial District using the stratified random sampling technique. A 24-item questionnaire was constructed by the researcher; the Effective Management of Human Resources Questionnaire (ERMHRQ) measuring on a 4 point rating scale was used for data collection. Pearson Product Moment Correlation was used to test the hypothesis. It gave an observed value of 0.20 and the critical r-value of 0.098, the null hypothesis was rejected since the observed value (0.20) is greater than the critical r-value (0.098). The finding of the study, among other things, was that principals' motivational technique has a strong association with teachers' job gratification. Also, in a study conducted by Anokye (2020), the researcher found a positive relationship between high levels of motivation on the part of the principals and effective job gratification among staff in public secondary schools.

Principals' Communication Ability and Teachers' Job Gratification

Communication, according to Dahama and Bhatnagar (2020), is an act by which a person shares knowledge, feelings, ideas, and information in ways such that each person gains a common understanding of the meaning, intent, and use of the message. Awotua and Efebo (2019) opined that communication is the conveying of information and knowledge from one person to another. It involves the sender transmitting an idea to a receiver by the use of appropriate and relevant communication channels. From the above definitions, Bassey (2021) stated that effective communication flow between the school heads and teachers in secondary schools enhances effective job performance. The author added that the absence of proper communication flow between school heads and teachers could result in truancy, lateness to work, absenteeism, and low morale. The effects of these are mostly felt by the students because there will be no class control, lack of adequate assessment, and completion of task-schedule.

However, studies have shown that two-way communication between school heads and teachers enhances job gratification on the part of the teachers. One of such studies was conducted by Akpan (2021), and the result was that interpersonal relationships existing between the super-ordinate and the subordinate bear considerable influence on the performance of the subordinates. This relationship cannot be established without communication. The author also found that if a principal establishes a cordial relationship with his teachers and students, there is bound to be discipline in the school. Also, the knowledge of the subordinates and possible reinforcement of their contributors will enhance good decision-making. (Peretomode, 2020).

In a related study by Nya (2018), the purpose was to determine the relationship between principal communication platforms and teacher effectiveness in secondary schools in Calabar, Cross River State. 400 teachers were drawn from 10 secondary schools in Calabar comprising 5 secondary schools each from Calabar Municipality and Calabar South Local Government Area. Data was collected using the Principal Motivational Technique Questionnaire (PMTQ) and analyzed using the Pearson Product Moment Correlation analysis. The calculated r-value (0.423) was greater than that of the critical r-value (0.196) at 0.05 level of significance. The result of the study revealed among other things that, principals' communication pattern has significant relationship with teachers' job gratification in public schools.

Principals' Decision-Making Ability and Teachers' Job Gratification

Decision-making is a central responsibility of the educational administrator. It is a fundamental process in any productive organization. Decision making, according to Durosaro and Ogunsaju (2019) is a process of identifying alternatives and choosing one among others, in order to address a situation. Ugwu (2020) defined decision-making as the process of identifying a problem and choosing among alternative courses of action. A school administrator, who has problems with making decisions, certainly had problems with his job. The school administrator makes decisions on behalf of the teachers, students, and supportive staff. In the school system, some decisions may be taken by the administrator only while other decisions may be taken by the deputy or the class teachers'. However, a good

administrator should not delegate too many responsibilities to his staff for decision-making. An effective principal should decide after due consideration (Mbipom, 2018). This is a rational decision.

Decision-making consideration, as Mbipom (2018) argued, has five sequential steps, which include Problem definition or identification, Development of alternatives for solutions, Appraisal of alternatives, Selection of solution alternative evaluation, and one is selected in terms of effectiveness, and the selected alternative is implemented. The author added that school principals should adopt these five sequential steps in the decision-making process before he or she can be acknowledged as good administrators.

Research has shown that principal's decision-making ability has an outstanding association with teachers' job gratification. One of such study was conducted by Ugwu (2020). The author found that when decision-making authority is centralized in the hands of school administrators, such leadership style is bound to initiate conflict and hostility among staff, hence, bringing about job disgratification. Nkang (2020) also added that when teachers are adequately involved in decision making by the school principals', (seeking their opinions when important bureaucratic decision are to be taken), such teachers' are most likely to have a sense of belonging and put in their best in the discharge of their professional duties.

RESEARCH METHODOLOGY

Design of the Study

The correlational research design was adopted for the study. This design is used whenever the researcher wants to find out the magnitude and direction of the relationship that exists between the dependent and independent variables (Udoh and Joseph, 2018). Therefore, this design was considered suitable for this study because it enabled the researcher to measure the interrelationship between variables of this study.

Population of the Study

The population of the study comprised of all 6,788 public secondary school teachers (3490 male and 3298 female) in the 14 secondary schools in Uyo Local Government Area. Source: (State Secondary Education Board, Uyo 2022).

Sample and Sampling Technique

A sample size of 140 (70 males, 70 Females) public secondary school teachers was selected for the study using a simple random sampling method. In each of the 14 public secondary schools, ten (10) teachers were randomly selected making up the 140 sampled teachers.

Instrumentation

A researcher-made instrument titled "Principal Administrative Competences and Job Gratification of Secondary School Teachers (PACJGSST)" with a four-point Likert scale option was used for data collection. The PACJGSST instrument has three parts A and B. Part (A) contained 15 items on School Bureaucratic Variables with five items each. Part (B) has 8 items on the job gratification of secondary school teachers. The respondents were required to tick from a list of options as individuals.

Validation of the Instrument

To ensure the content validity of the instrument, copies of the instrument were validated by two lecturers from the Department of Social Studies & Citizenship Education, and also from an expert in the Department of Psychological Foundations of Education, Faculty of Education, University of Uyo. The inputs and corrections made by the evaluators and that of the researchers were used to form the final copy for instrument.

Reliability of the Instrument

The questionnaire was administered to 30 public secondary school teachers in a selected school not included in the sample of the study. Two weeks later, the same set of teachers were given clean copies of the same instrument to fill. The test-retest reliability of the instrument was obtained based on the scores from the first and second tests. The analysis of the scores in the two tests was carried out using Pearson Product Moment Correlation (PPMC) statistics. The items yielded a correlation coefficient of 0.84 for the fifteen items in section A and 0.846 for the eight items in section B, as presented in the SPSS Table of reliability statistics below.

Data Collection

The research copies of the instrument were personally administered to the respondents in their respective schools by the researchers. Also, permission from the respective principals was obtained to allow the respondents to respond to the items in the instrument. In addition to items written on the questionnaire, the subjects were given verbal instructions and clarifications where necessary. Copies of the questionnaire were retrieved after completion without subjecting the respondents to time constraints. All 80 copies of the questionnaires administered were filled properly according to instructions and collected by the researchers. Hence, none was missing because it was an instant collection.

Data Analysis

Data generated were analyzed using Pearson Product Moment Correlation (PPMC) for answering the research questions and Pearson Product Moment Correlation (PPMC) for testing hypotheses, all at a .05 level of significance and 376 degrees of freedom.

Decision Rule

Research Questions

The research questions were answered using Pearson's Product Moment Correlation and decisions on the relationship between the independent and dependent variables were interpreted as follows:

Coefficient (r)	-	Relationship
$\pm .00$ to $\pm .20$	-	Negligible, weak, very low, little or none
$\pm .21$ to $\pm .40$	-	Present, slight, but low
$\pm .41$ to $\pm .60$	-	Average, moderately high, fairly high
$\pm .61$ to $\pm .1.00$	-	Very high

For the null hypotheses, the standard decision was to reject the null hypotheses when the calculated r-value was greater than or equal to the critical value and retained when the calculated value was less than the critical value.

RESULTS

Research Question 1

What is the relationship between principals' motivational ability and job gratification of secondary school teachers in Uyo Local Government area?

Table 1: Correlation analysis of responses on the relationship between principals' motivational ability and teachers' job gratification in secondary schools in Uyo Local Government Area

Variables	N	$\sum x$ $\sum y$	$\sum x^2$ $\sum y^2$	$\sum xy$	r-value	Remark
Principals' Motivational Ability	130	384	4928			Very High
				4667	0.87	Positive
Teachers' Job Gratification	130	390	5112			Relationship

Result in Table 1 shows that a very high positive relationship exists between principals' motivational ability and teachers' job gratification in secondary schools in Uyo Local Government area. The result yielded a correlation coefficient of 0.87, which means that principal motivational ability have a strong association with teachers' job gratification in secondary schools in the study area. This implies that teachers are most likely to be very satisfied in discharging their duties if motivated by school principals.

Research Question 2

What relationship exists between principals' communication ability and job gratification of secondary school teachers in Uyo Local Government Area?

Table 2: Correlation analysis of responses on the relationship between principals' communication ability and teachers' job gratification in secondary schools in Uyo Local Government Area

Variables	N	$\sum x$ $\sum y$	$\sum x^2$ $\sum y^2$	$\sum xy$	r-value	Remark
Principals' Communication Ability	130	386	4928			Very High Positive
Teachers' Job Gratification	130	390	5144	4867	0.78	Relationship

Results in Table 2 shows that a very high positive relationship exists between principals' communication ability and teachers' job gratification in secondary schools in Uyo Local Government area. The result yielded a correlation coefficient of 0.78, which establishes an association between principals' communication ability and teachers' job gratification in secondary schools. This implies that teachers tend to be very satisfied in the discharge of duties if the principal established cordial relationship with the staff.

Research Question 3

What relationship exists between principals' decision-making ability and job gratification of secondary school teachers in Uyo Local Government area?

Table 3: Correlation analysis of responses on the relationship between principal' decision-making ability and teachers' job gratification in secondary schools in Uyo Local Government Area

Variables	N	$\sum x$ $\sum y$	$\sum x^2$ $\sum y^2$	$\sum xy$	r-value	Remark
Principal' Decision-Making Ability	130	325	5325			Moderately
Teachers' Job Gratification	130	388	5145	5099	0.60	High Positive Relationship

Result in Table 3 reveals a moderately high positive relationship between principals' decision-making ability and teachers' job gratification in Uyo Local Government area. This

is shown on the correlation coefficient result of 0.64. This result implies that teachers tend to be very satisfied in their teaching job if they are parts and parcels of decisions made by the school principals’.

Hypothesis by Hypothesis Testing

Hypothesis 1

There is no significant relationship between principals’ motivational ability and job gratification of secondary school teachers in Uyo Local Government area.

Table 4: Pearson Product Moment Correlation analysis of responses on the relationship between principals’ motivational ability and teachers’ job gratification in Uyo Local Government Area

Variables	N	$\sum x$ $\sum y$	$\sum x^2$ $\sum y^2$	$\sum xy$	r-value	r-critDecision
Principals’ Motivational Ability	130	384	4928			
				4667	0.87	0.074 S
Teachers’ Job Gratification	130	390	5112			

S = Significant; $P < .05$; $df = 128$; critical $r = 0.074$

Table 4 shows that the calculated r-value of 0.87 is greater than the critical value of 0.074 at degree of freedom of 128 and at .05 significant levels. Hence, the null hypothesis is rejected while the alternate hypothesis is retained. This implies that the more teachers are motivated by school principals, the greater they are bound to discharge their teaching duties satisfactorily and vice versa.

Hypothesis 2

There is no significant relationship between principals’ communication ability and job gratification of secondary school teachers in Uyo Local Government area

Table 5: Pearson Product Moment Correlation analysis of responses on the relationship between principals’ communication ability and teachers’ job gratification in Uyo Local Government Area

Variables	N	$\sum x$ $\sum y$	$\sum x^2$ $\sum y^2$	$\sum xy$	r-value	r-crit	Decision
Principals' Communication Ability	130	386	4928				
				4867	0.78	0.074	S
Teachers' Job Gratification			5144				
	130	390					

S = Significant; $P < .05$; $df = 128$; critical $r = 0.074$

Table 5 shows that the calculated r-value of 0.78 is greater than the critical value of 0.074 at degree of freedom of 128 and at .05 significant levels. Hence, the null hypothesis is rejected while the alternate hypothesis is retained. This implies that the more principals adopt friendly approach with teachers while communicating, the greater they are bound to discharge their teaching duties satisfactorily and vice versa.

Hypothesis 3

There is no significant relationship between principals' decision-making ability and job gratification of secondary school teachers in Uyo Local Government area.

Table 6: Pearson Product Moment Correlation analysis of responses on the relationship between principals' decision-making ability and teachers job gratification in secondary schools in Uyo Local Government Area

Variables	N	$\sum x$ $\sum y$	$\sum x^2$ $\sum y^2$	$\sum xy$	r-value	r-crit	Decision
Principals' Decision-Making Ability	130	325	5325				
				5099	0.60	0.074	S
Teachers' Job Gratification	130	388	5145				

S = Significant; $P < .05$; $df = 128$; critical $r = 0.074$

Table 6 shows that the calculated r-value of 0.60 is greater than the critical value of 0.074 at degree of freedom of 128 and at .05 significant levels. Hence, the null hypothesis is rejected while the alternate hypothesis is retained. This implies that the more teachers' views and opinions are considered by the principal before making important decisions, the more the teachers can discharge their teaching duties satisfactorily and vice versa.

Findings of the Study on Research Questions/Hypotheses

Based on the findings of the study, the magnitude of the relationship that existed between the variables of principal administrative competencies and teachers' job gratification was found as follows:

- (i) Research Question/ Hypothesis 1: Very high positive relationship /Significant
- (ii) Research Question/ Hypothesis 2: Very high Positive relationship/ Significant
- (iii) Research Question/ Hypothesis 3: Moderate high Positive relationship/significant

DISCUSSION

The researchers made a combined discussion of findings from the research questions and hypotheses of the study.

Principals' Motivational Ability and Teachers' Job Gratification

Results in research question and hypothesis one revealed that there is a very high positive and significant relationship between principals' motivational ability and teachers' job gratification in secondary schools in Uyo Local Government area. This finding is in line with the finding of the study conducted by Anokye (2020) which found out that principals' motivational ability has a significant relationship with the job gratification of secondary school teachers. Also, this finding conforms with that of Aderounmu and Ehiamekalor (2020), who stated that administrators' motivational ability is a strong factor in teachers' job gratification. Based on this finding, the researchers wish to observe that teachers are most likely to discharge their teaching duties satisfactorily if motivated by school principals.

Principals' Communication Ability and Teachers' Job Gratification

Results of research question two and hypothesis two revealed that there exists a very high positive and significant relationship between principals' communication ability and teachers' job gratification in secondary schools in the Uyo Local Government area. This finding is supported by Bassey (2021) and stated that effective communication flow between the school heads and teachers in secondary schools enhances job gratification on the part of the teachers. The findings of Akpan (2021) also re-affirmed that the interpersonal relationship existing between the super-ordinate and the sub-ordinate bear considerable influence on the performance of the sub-ordinates. Based on this finding, the researchers wish to observe that effective communication flow between school principals' and the teachers contribute to teachers' job gratification.

Principals' Decision-making Ability and Teachers' Job Gratification

Result in research, question three and hypothesis three revealed that there exists a moderately high positive and significant relationship between principals' decision-making ability and teachers' job gratification in secondary schools in Uyo Local Government area. This finding is in tandem with the finding of the study conducted by Ugwu (2020). The author found out that when decision-making authority is centralized in the hands of school administrators, such leadership style is bound to initiate conflict and hostility among staff,

hence, bringing about job dissatisfaction. Nkang (2020) also added that when teachers are adequately involved in decision-making by the school principals (seeking their opinions when important bureaucratic decisions are taken), such teachers' are most likely to have a sense of belonging and put in their best in the discharge of their professional duties.

Recommendations

Based on the findings of the study, the following recommendations are made:

- (i) Principals should draw up certain motivational approaches like special rewards, recognition, promotion of teachers, giving of awards; allowances among other thing to teachers, so that they can be encouraged to work satisfactorily.
- (ii) Principals should ensure that regular meetings are held with teachers and circulate duties to teachers in a friendly and cordial manner so that teachers would contribute satisfactorily to the progress of the school.
- (iii) School principals should embrace democratic decision-making by ensuring that teachers are parts and parcels of decisions made in the school to enhance teachers' job gratification.

Conclusion

Based on the findings of this study, it is concluded that principals' motivational ability, communication ability as well as decision-making ability has a strong association with job gratification among secondary school teachers.

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Effects of Illegal Gold Mining Activities on heavy Metal Content of Soil in Chanchaga, Niger State

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Abstract

This field study was conducted to assess heavy metal concentrations in soils as a result of illegal gold mining activities around the mining site in Chanchaga Village in Niger State, Nigeria. Gold mining and exploration has been identified as the major activity in this area. Soil samples obtained at distances of 10, 20, 30, 40, 50 and 60m from the mining site and soil outside the mining site as control were obtained, digested and analysed for the concentrations of heavy metals like zinc, lead, copper and chromium using standard methods. These toxic heavy metals were observed to be significantly present in high concentrations in the soil samples obtained from the gold mining farm site when compared to the soil sample obtained outside the mining environment and World Health Organisation maximum permissible standard. The heavy metal concentrations of zinc and copper observed in the control sample were 3.0 and 1.42 milligram per kilogram respectively and all were lower than those obtained from the soil samples at the gold mining site while lead and chromium were not detected. This implies that illegal gold mining activities has contaminated soil in the mining site with the presence of toxic heavy metals.

Keywords: Gold mining, Chanchaga, Heavy metals, Soil, WHO

INTRODUCTION

Human activities involved in the exploitation of the environment for wealth creation has resulted to environmental pollution directly or indirectly. Mineral prospecting is one activity that can contribute to national wealth due to major roles minerals such as gold, diamond, copper; zinc, iron ore, lead and columbite play in industries and human life. For instance, the early discovery of gold in Langlaagte Farm near Johannesburg in 1886 saw the setting up in 1889 of a gold mining prospectus by freelance diggers referred to as Chamber of Mines (Chamber of Mine, 2002). In Nigeria, mineral mining is not a major source of revenue as it lost government's interest after the Second World War due to the discovery of crude oil (Godwin, 2014). Mining is a prosperous and expanding industry that is capable of providing sustainable economic, social and rural development to our communities. Despite its wealth creation prospect to the nation, it also poses danger to land, fauna, flora and water in the environment it operates (Yang, Shua, Qiu, Wang and Lang, 2004).

Mining process involves digging or excavation of land which can bring infertile soil from the in-depth to the land surface; this soil is not nutritious and therefore not good for agriculture. Also the excavated land when left uncovered after the mining activities renders the land useless (Rivas and Cendrero, 2006). Gold processing activities in Chanchaga for a century now involves the crushing of rocks and sediment which are mixed with water for separation of gold and the effluent left to flow freely to the ground may sink into the soil or flow into the adjoining flowing river in the region. These activities, of no doubt release heavy metals to the soil and water bodies. Heavy metal contamination of soil and water is hazardous to the ecosystem. Metals may exist in compound form binding rocks or sediment together and may be released to the environment in that form which could lead to changes in chemical contents of soils and water bodies (Sawyer, 1986). The level of contaminations depend on the concentration of the metals in the environment, but study have shown that the contaminant characteristic of an element depend on its specific binding form and its level of reactivity rather than its concentration (Sawyer, 1986). Heavy metals are mobile and distribute themselves throughout the soil and water which make them available for plant uptake, fish and animal, their mobility are influenced by some factors, these factors including soil pH, soil texture and organic matters which play major roles in the form and bio-availability of heavy metals, also the behaviours of metals are determined by a range of physico-chemical process that influenced their mobility and availability in soil (Godwin, 2014). Heavy metals such as Lead (Pb), Mercury (Hg), Arsenic (As), Chromium (Cr), Cadmium (Cd), Nickel (Ni), Cobalt (Co), and copper (Cu) are known to have negative effect on soil, and as a result of this, crop yield is drastically reduced.

The types of heavy metal present depend on the type of chemical binding the rocks or sediments, hence, to understand the potential effect of heavy metal and their complexity in ecological system it is important to study the various forms of the elements present in the rocks or sediments in the area (Godwin, 2014). Many cases of heavy metals toxicity have been reported worldwide and the effects on human health have been regularly reviewed by International bodies like World Health Organization (WHO) (Nwajei and Gagophien, 2000). Similar threat has been reported in Nigeria from lead mining area in the village of Dareta in Zamfara State where children were reported with lead concentration of 119.4 µg/dl in their blood that causes neurological disorder. The limit of lead concentration in America and France are 400 ppm while more than 100,000 ppm were found around this affected village in Nigeria (Galadima and Garba, 2012). Heavy metal contamination of soil can make the soil infertile and therefore limit agricultural activities in such environment which inhibit large farm production. Agricultural production on large scale can be inhibited by deficiency in essential element such as manganese, zinc or copper which are micronutrient to plants, or cobalt, zinc and copper for livestock which require in small quantity. Some heavy metals such as arsenic, mercury, cadmium, lead and nickel are harmful to crop even at low concentration (Mandor, 2002).

MATERIALS AND METHODS

The study site

The gold mining site is located in Chanchaga, Chanchaga Local Government Area of Niger state. It is located on Latitude 9°53'33" and Longitude 6°58'33", it is 21 km from

Paiko and 20.9 km from Tungan in Niger state. The area just like many other places in Niger state has mean annual rainfall of 1334 mm starting from April and last till October. The physical conditions of Chanchaga significantly influence the economic activities of the people; the activities of the mining companies have also influenced the economic life of the people. The principal occupation of the people is agriculture, such as farming and gold mining.

Collection of Soil samples

Soil samples were obtained from farmlands in the study area at distances 10, 20, 30, 40, 50 and 60m from the gold mining site for analyses to determine the effects of the gold mining on soil metal contents. Soil collected from a farm plot in Kpakungu area, Niger State, where mineral processing activities does not take place served as the control sample. Each soil sample obtained was properly packaged and labelled in a brown envelope and sent to the laboratory for analysis.

Preparation of samples for analysis

The labelled soil samples collected were analysed at the Soil Science Department laboratory, School of Agriculture, Federal University of Technology, Minna (FUT). Soils were oven-dried for 2 hours to remove residual moisture, ground using mortar and pestle and sieved using 0.5 mm mesh size sieve and made ready for digestion. For characterization analysis, the samples were sieved using 0.2mm mesh size, kept in a polythene bags and labelled accordingly ready for analysis (Udo and Ogunwale, 1986).

Metal Determination using AAS

2g of prepared soil sample were weighed using electronic weighing balance and transferred into 100 ml flask; about 80.0 ml of a mixture of (60.0 ml HCl and 20.0 ml HNO₃) were added to each samples and placed onto the hot plate. The samples were heated at 200°C until a light colour solution was obtained (Godwin, 2014), and the samples were then allowed to cool, filtered and the filtrate diluted to the mark with de-ionized water, mixed thoroughly and then tested for heavy metals using Atomic Absorption Spectrophotometer (AAS). The following metals (Pb, Cu, Cr and Zn) were analyzed using Atomic Absorption Spectrophotometer and potassium and sodium using flame photometer. The characterizations of the samples were done according to the procedures reported by Njosi (2010). Different extracting solutions were added and the mixture shaken thoroughly, after the extraction, the solutions were filtered and the filtrate used for determining heavy metal contents. In the AAS, different heavy metals absorb different light with specific frequency and excite their electron from their ground energy level to a higher energy level after being vaporized. The corresponding metal lamp used emits light with the required frequency which is absorbed by the metal ion in the sample. The amount of light absorbed by metal ion in the sample is proportional to the concentration of the metal ion in the solution.

RESULTS AND DISCUSSION

The metal contents in the soil samples obtained at different distances from the gold mining site are presented in Table 1.

Table 1: Metal Concentration in Soil samples obtained from the study area at different distances

Samples	Distances (m)	K mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg	Zn mg/kg	Pb mg/kg	Cu mg/kg	Cr mg/kg
S ₁	10	5.75	11.20	22.01	13.82	17.55	2.63	4.36	3.99
S ₂	20	6.86	13.41	27.10	13.54	14.31	1.81	2.83	1.80
S ₃	30	7.93	11.08	30.56	12.44	13.16	0.93	2.93	1.4
S ₄	40	21.92	10.86	38.40	13.86	16.25	1.17	3.01	1.82
S ₅	50	27.55	10.56	47.60	14.32	10.77	0.75	2.51	0.93
S ₆	60	30.84	18.32	53.10	12.96	11.43	0.92	2.90	1.09
S _c	Control	35.83	47.87	58.06	26.78	3.00	ND	1.42	ND
W.H.O		-	-	-	-	3.0	0.01	1.0	2.0

The potassium concentrations of the soil samples from the farm around the gold mining site at distances 10, 20, 30, 40, 50 and 60m as presented in table 1 were 5.75, 6.86, 7.93, 21.92, 27.55 and 30.84 mg/kg respectively, and lower when compared to 35.83 mg/kg obtained from the control sample. This shows an increasing trend in the potassium contents of the soil samples as the distances from the farm to the gold mining site increases indicating that the mining activities do not affect K concentration. Ca, Mg and Na exhibited similar pattern of the soil samples at these distances. Heavy metals like zinc, lead, copper and chromium considered in this study have been discovered to be released to the environment by human activities, the source of these metal pollutants are mining, metal smelting, metallurgical industries and other mineral processing industries, metal corrosion, waste disposal, agriculture and forestry, fossil fuel combustion, sport and leisure activities, the world industrialization generally increases heavy metal contamination (Mandor, 2002). These heavy metals can make the soil infertile when present at high concentrations because of their toxicity and can inhibit large farm production. This is in agreement with this study as the heavy metals analysed as presented in table 1 were observed to be higher in the soil samples obtained at the mining site than the soil sample obtained outside the mining environment. This shows the effect of illegal gold mining on agricultural soils. According to Mishra and Singh (1987), it was found that the contamination of soil with illegal gold mining activities leads to an increase in the zinc, lead, copper and chromium contents of the soil. Some heavy metals such as arsenic, mercury, cadmium, lead and nickel are harmful to crops even at low concentration (Mandor, 2002). This is evident in this study as the soil samples obtained from the gold mining farm site had high concentrations of these heavy metals tested for when compared to the soil sample outside the gold mining environment (control).

Heavy metals tested for in the soil samples were zinc, lead, copper and chromium. Zinc concentrations in soil samples obtained at distances from the gold mining farm site were in a decreasing order and still higher than 3.0 mg/kg recorded in the control sample. According to Tobias *et al.* (2013), World Health Organization's maximum permissible limit of zinc concentration in agricultural soil is 3.0 mg/kg which is less than zinc concentrations in soil samples from the gold mining environment. For lead concentrations in the soil samples at these distances also decreased as the distances increased, though they remained higher than

the World Health Organization's maximum permissible limit of 0.01mg/kg in agricultural soil as reported by Tobias et. al. (2013), indicating lead contamination in the soil. Lead in the control soil sample obtained outside the gold mining site was undetected. Also, copper concentrations in the soil samples from studied sites at the designated distances also followed a decreasing trend but was however, higher than 1.42 mg/kg of the control sample and World Health Organization's maximum permissible limit of 1.0 mg/kg in agricultural soil as reported by Tobias et. al. (2013). The concentrations of copper in soil samples were slightly above the World Health Organization's maximum permissible limit and this agrees with the report of Sharon, et. al. (2013), who reported that copper is a very common substance occurring naturally in the environment and spreading through the environment through natural phenomena. Chromium, one of the metals tested for in the soil samples at various distances exhibited decreased concentrations as the distances increased. These concentrations in the soil samples were within World Health Organization's maximum permissible limit of 2.0 mg/kg in agricultural soil as reported by Tobias, et. al., (2013), except soil sample obtained at 10m away from the gold mining site. Chromium concentration at this distance was slightly higher than the World Health Organization's maximum permissible limit. The control soil sample had no detectable chromium concentration. The presence of high concentrations of zinc, copper, lead and chromium metals in soil samples obtained near the gold mining site is an indication of soil contamination arising from the various gold mining activities in the environment. High soil metal contents as revealed in this study for some areas have serious public health implication for the residents of this community, given the catalogue of health effects associated with exposure to metals generally, and toxic heavy metals in particular. In general, heavy metals are systemic toxins with specific neurotoxic, nephrotoxic, fetotoxic and teratogenic effects. Heavy metal toxicity can directly influence behaviour by impairing mental and neurological functions, influencing neurotransmitter production and utilization, and altering numerous metabolic body processes. Systems in which toxic metal elements can induce impairment and dysfunction include the blood, cardiovascular, eliminative pathways (colon, liver, kidneys, skin), endocrine (hormonal), energy production pathways, enzymatic, gastrointestinal, immune, nervous (central and peripheral), reproductive and urinary systems. These toxic impacts of metals are affected through the formation of free radicals (highly reactive oxygen species), a disturbance of the pro and antioxidant balance of the body, both of which can cause cell damage by destruction of proteins, degradation of nucleic acids or lipid peroxidation (Sharon, et. al., 2013). It was further reported that toxic heavy metals have been implicated in many health defects arising due to their toxic effects involving several body tissues, organs and systems (Godwin 2014).

Conclusion

The characterization of the soil samples obtained at varying distances from the gold mining site were observed to be high in toxic heavy metals (Zn, Pb, Cu, Cr). These observations are indications that soil samples at the gold mining farm site are contaminated and unsuitable for plant growth as negative health implications may be incurred if such plants

are consumed. Obviously, animals that graze on plants on this soil are liable to be affected with health problems as a result of the contaminated soil with heavy metals.

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On the Auxiliary Lyapunov Functions and Uniform Practical Stability for Nonlinear Impulsive Caputo Fractional Order Derivative via New Modelled Generalized Dini Derivative

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Abstract.

In this paper, the uniform practical stability of the trivial solution of a nonlinear impulsive Caputo fractional differential equations with fixed moments of impulse is examined using an auxilliary Lyapunov function which are analogues of vector Lyapunov functions, and is generalized by a class of piecewise continuous Lyapunov functions. Together with comparison results, sufficient conditions for the uniform practical stability for impulsive Caputo fractional order systems are established. An illustrative example is given to confirm the suitability of the obtained results.

Keywords: Uniform practical stability, Caputo derivative, impulse, Lyapunov function.

MSC: 34A08; 34A34; 34A37; 34D20.

1 INTRODUCTION

Spanning three centuries, the history of fractional calculus has been marked by significant developments, largely confined to the theoretical foundations of mathematics. Moreover, recently, its relevance have also span into several other fields like the mathematical physics, engineering, control theory, economics, etc. The earliest – more or less systematic studies of the concept seem to have been made in the 19th century by Liouville, Riemann, Caputo, etc. [37], and in the last four decades, it was observed that the advancement of fractional calculus has enabled the description of complex system behaviors through fractional differential

systems (including many physical phenomenon having memory and genetic characteristics), thus providing new insights into their dynamics.

As observed in [6, 27], one of the trends in the stability theory of solutions of differential equations is the so-called practical stability. This aspect of stability was introduced by LaSalle and Lefschetz in [24], and it is used in estimating the worst-case transient and steady-state responses together with verifying pointwise in time constraints imposed on the trajectory curve. Fundamental results in this area were established in [9, 31] and [40] for integer order derivative.

In line with the development of the theory of practical stability in recent years is the mathematical theory of impulsive differential equations which have experienced a massive research attention and development. Now, the theory of impulsive differential equations is richer than the corresponding theory of differential equations [16] as they constitute very important models for describing the true state of several real life processes and phenomena, since many evolution processes are characterized by the fact that, at certain moments of time, they experience a change of state abruptly (see [16]).

Moreover, the efficient applications of impulsive differential system require the finding of criteria for stability of their solutions [35], and one of the most versatile methods in the study of the stability properties of impulsive systems is the Lyapunov's direct method also called the Lyapunov's second method. Interestingly, the method involves seeking an appropriate continuously differentiable function (called Lyapunov's function) that is positive definite and whose time derivative along the solution path or trajectory curve is negative semidefinite.

The stability of the zero solution of impulsive differential equations have been extensively studied in [12] and [30]. Investigations into the stability of fractional order systems is a recent development and major obstacles in utilizing the Lyapunov's functions for these systems lies in establishing an appropriate definition of the derivative amidst fractional differential equations. However, this difficulty was safely handled in [1] where the choice of a Lyapunov function that is continuous was adopted, with a re-definition, as it were, of the Dini derivative for the given fractional order system with respect to the Lyapunov function. To the best of our knowledge, not so much have been done in the literature in terms of practical stability for impulsive fractional order derivative using the vector Lyapunov functions by means of the comparison method.

Against this background, [6] established sufficient conditions for the practical stability of impulsive fractional order systems using the vector Lyapunov functions with the comparison method, while fundamental results for the stability of impulsive Caputo fractional differential equations using the scalar Lyapunov function were examined in [1] and [2]. Other stability results have been established in [42-48].

In this paper, the uniform practical stability of impulsive Caputo fractional order systems is examined. By means of the comparison principle, sufficient conditions for the uniform practical stability of impulsive fractional order systems is established using a class of

piecewise continuous functions. An illustrative example given, extends and improves on existing results.

2 Preliminary Notes and Basic Definitions

Fractional calculus is considered as a natural generalization of the classical calculus of integer order to arbitrary order, thereby allowing for the extension of the traditional concepts of derivative and integral to functions with fractional orders. By this extension, functions with non integer orders are much more flexible in describing real world systems (see [14, 25, 26, 34 and 37]).

There are several definitions of fractional derivatives and fractional integrals.

General case. Let the number $n-1 < \beta < n, \beta > 0$ be given, where n is a natural number, and $\Gamma(\cdot)$ denotes the Gamma function.

Definition 2.1.

The Riemann Liouville fractional derivative of order β of $\gamma(t)$ is given by (see [35])

$${}^{RL}D_t^\beta \gamma(t) = \frac{1}{\Gamma(n-\beta)} \frac{d^n}{dt^n} \int_{t_0}^t (t-s)^{n-\beta-1} \gamma(s) ds, t \geq t_0$$

Definition 2.2.

The Caputo fractional derivative of order β of $\gamma(t)$ is given by (see [35])

$${}^CD_t^\beta \gamma(t) = \frac{1}{\Gamma(n-\beta)} \int_{t_0}^t (t-s)^{n-\beta-1} \gamma^{(n)}(s) ds, t \geq t_0$$

The Caputo derivative has many properties that are similar to those of the standard derivatives which make them easier to understand and apply. Also, the initial conditions of the Caputo fractional order derivative are also easier to interpret in physical context.

Definition 2.3.

The Grunwald-Letnikov fractional derivative of order β of $\gamma(t)$ is given by (See [1])

$${}^{GL}D_0^\beta \gamma(t) = \lim_{h \rightarrow 0^+} \frac{1}{h^\beta} \sum_{r=0}^{\left[\frac{t-t_0}{h} \right]} (-1)^r {}^C C_r \gamma(t-rh), t \geq t_0$$

and

Definition 2.4. The Grunwald-Letnikov fractional Dini derivative of order β of $\gamma(t)$ is given by (See [1])

$${}^{GL}D_0^\beta \gamma(t) = \lim_{h \rightarrow 0^+} \sup \frac{1}{h^\beta} \sum_{r=0}^{\left[\frac{t-t_0}{h} \right]} (-1)^r {}^\beta C_r \gamma(t-rh), \quad t \geq t_0$$

where ${}^\beta C_r$ are the binomial coefficients and $\left[\frac{t-t_0}{h} \right]$ denotes the integer part of $\frac{t-t_0}{h}$.

Particular case (when $n=1$). In most applications, the order of β is often less than 1, so that $\beta \in (0,1)$. For simplicity of notation, we will use ${}^c D^\beta$ instead of ${}_{t_0}^c D^\beta$ and the Caputo fractional derivative of order β of the function $\gamma(t)$ is

$${}^c D^\beta \gamma(t) = \frac{1}{\Gamma(\beta)} \int_{t_0}^t (t-s)^{-\beta} \gamma'(s) ds, \quad t \geq t_0$$

(2.1)

3 Impulses in Fractional Dynamics

Consider the initial value problem (IVP) for the system of fractional differential equations (FrDE) with a Caputo derivative for $0 < \beta < 1$.

$$\begin{aligned} {}^c D^\beta \gamma(t) &= f(t, \gamma), \quad t \geq t_0, \\ \gamma(t_0) &= \gamma_0, \end{aligned}$$

(3.1)

where $\gamma \in R^N$, $f \in C[R_+ \times R^N, R^N]$, $f(t,0) \equiv 0$ and $(t_0, \gamma_0) \in R_+ \times R^N$.

Some sufficient conditions for the existence of the global solutions to (3.1) are considered in [7], [11], [22], [23], [29], [35], [42].

The IVP for FrDE (3.1) is equivalent to the following Volterra integral equation (See [2]),

$$\gamma(t) = \gamma_0 + \frac{1}{\Gamma(\beta)} \int_{t_0}^t (t-s)^{\beta-1} f(s, \gamma(s)) ds, \quad t \geq t_0$$

(3.2)

Consider the IVP for the system of impulsive fractional differential equations (IFrDE) with a Caputo derivative for $0 < \beta < 1$,

$$\begin{aligned} {}^c D^\beta \gamma(t) &= f(t, \gamma), \quad t \geq t_0, \quad t \neq t_k, \quad k=1,2,\dots \\ \Delta \gamma &= I_k(\gamma(t_k)), \quad t = t_k, \quad k \in N, \\ \gamma(t_0^+) &= \gamma_0, \end{aligned}$$

(3.3)

where $\gamma, \gamma_0 \in R^N$, $f \in C[R_+ \times R^N, R^N]$, and $t_0 \in R_+$, $I_k : R^N \rightarrow R^N$, $k=1,2,\dots$

under the following assumptions:

(i) $0 < t_1 < t_2 < \dots < t_k < \dots$, and $t_k \rightarrow \infty$ as $k \rightarrow \infty$;

(ii) $f : R_+ \times R^N \rightarrow R^N$ is piecewise continuous in $(t_{k-1}, t_k]$ and for each $x \in R^N, k = 1, 2, \dots$, and $\lim_{(t,y) \rightarrow (t_k^+, \gamma)} f(t, y) = f(t_k^+, \gamma)$ exists;

(iii) $I_k \times R^N \rightarrow R^N$

In this paper, we assume that $f(t, 0) \equiv 0$, $I_k(0) \equiv 0$ for all k so that we have trivial solution for (3.3), and the points $t_k, k = 1, 2, \dots$ are fixed such that $t_1 < t_2 < \dots$ and $\lim_{k \rightarrow \infty} t_k = \infty$. The system (3.3) with initial condition $\gamma(t_0) = \gamma_0$ is assumed to have a solution $\gamma(t; t_0, \gamma_0) \in PC^\beta([t_0, \infty), R^N)$.

Remark 3.1. The second equation in (3.3) is called the impulsive condition, and the function $I_k(\gamma(t_k))$ gives the amount of jump of the solution at the point t_k .

Definition 3.1. Let $\Omega : R_+ \times R^N \rightarrow R^N$. Then Ω is said to belong to class χ if,

(i) Ω is continuous in $(t_{k-1}, t_k]$ and for each $\gamma \in R^N$ and $\lim_{(t,y) \rightarrow (t_k^+, \gamma)} \Omega(t, y) = \Omega(t_k^+, \gamma)$ exists;

(ii) Ω is locally Lipschitz with respect to its second argument x and $\Omega(t, 0) \equiv 0$

Now, for any function $\Omega(t, \gamma) \in PC([t_0, \infty) \times \xi, R_+^N)$. we define the Caputo fractional Dini derivative as:

$${}^c D_+^\beta \Omega(t, \gamma) = \limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} \left\{ \Omega(t, \gamma) - \Omega(t_0, \gamma_0) - \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (-1)^{r+1} {}^C C_r [\Omega(t-rh, \gamma - h^\beta f(t, \gamma) - \Omega(t_0, \gamma_0))] \right\} \quad (3.4)$$

$t \geq t_0$ where $t \in [t_0, \infty)$, $\gamma, \gamma_0 \in \xi$, $\xi \in R^N$ and there exists $h > 0$ such that $t - rh \in [t_0, T]$.

Definition 3.2. A function $g \in PC[R^n, R^n]$ is said to be quasimonotone nondecreasing in γ , if $\gamma \leq y$ and $\gamma_i = y_i$ for $1 \leq i \leq n$ implies $g_i(\gamma) = g_i(y)$.

Definition 3.3. The zero solution of (3.3) is said to be:

(PS1) practically stable if for every $\varepsilon > 0$ and $t_0 \in R_+$ there exist $\delta = \delta(\varepsilon, t_0) > 0$ continuous in t_0 such that for any $\gamma_0 \in R^N$, $\|\gamma_0\| \leq \delta$ implies $\gamma_0 \in R^N$ $\|\gamma(t, t_0, \gamma_0)\| < \varepsilon$ for $t \geq t_0$;

(PS2) uniformly practically stable if for every $\varepsilon > 0$ and $t_0 \in R_+$ there exist $\delta = \delta(\varepsilon) > 0$, continuous in t_0 such that for any $\gamma_0 \in R^N$, $\|\gamma_0\| \leq \delta$ implies $\gamma_0 \in R^N$ $\|\gamma(t, t_0, \gamma_0)\| < \varepsilon$ for $t \geq t_0$;

(PS3) asymptotically practically stable if it is practically stable and if for each $\varepsilon > 0$ and $t_0 \in R_+$ there exist positive numbers $\delta_0 = \delta_0(t_0) > 0$ and $T = T(t_0, \varepsilon)$ such that for $t \geq t_0 + T$ and $\|\gamma_0\| \leq \delta$ implies $\|\gamma(t, t_0, \gamma_0)\| < \varepsilon$;

(PS4) uniformly asymptotically practically stable if it is uniformly practically stable and $\delta_0 = \delta_0(\varepsilon)$ and $T = T(\varepsilon)$ such that for $t \geq t_0 + T$, the inequality $\|\gamma_0\| \leq \delta$ implies $\|\gamma(t, t_0, \gamma_0)\| < \varepsilon$.

Definition 3.4. A function $a(r)$ is said to belong to the class K if $a \in PC([0, \psi), R_+)$, $a(0) = 0$, and $a(r)$ is strictly monotone increasing in r .

In this paper, we define the following sets:

$$\bar{S}_\psi = \{\gamma \in R^N : \|\gamma\| \leq \psi\}$$

$$S_\psi = \{\gamma \in R^N : \|\gamma\| < \psi\}$$

Suffice to say that the inequalities between vectors are understood to be component-wise inequalities.

We will use the comparison results for the impulsive Caputo fractional differential equation of the type

$$\begin{aligned} {}^C D^\beta u &= g(t, u), \quad t \geq t_0, \quad t \neq t_k, \quad k = 1, 2, \dots \\ \Delta u &= \psi_k(u(t_k)), \quad t = t_k, \quad k \in N, \\ u(t_0^+) &= u_0, \end{aligned} \tag{3.5}$$

existing for $t \geq t_0$, $u \in R^n$, $R_+ = [t_0, \infty)$, $g : R_+ \times R_+^n \rightarrow R^n$, $g(t, 0) \equiv 0$, where g is the continuous mapping of $R_+ \times R_+^n$ into R^n . The function $g \in PC[R_+ \times R_+^n, R^n]$ is such that for any initial data $(t_0, u_0) \in R_+ \times R^n$, the system (3.5) with initial condition $u(t_0) = u_0$ is assumed to have a solution $u(t, t_0, u_0) \in PC^\beta([t_0, \infty), R^n)$.

Lemma 3.2. Assume $m \in PC([t_0, T] \times \bar{S}_\psi, R^N)$. and suppose there exists $t^* \in [t_0, T]$ such that for $\alpha_1 < \alpha_2$, $m(t^*, \alpha_1) = m(t^*, \alpha_2)$ and $m(t, \alpha_1) < m(t, \alpha_2)$ for $t_0 \leq t < t^*$. Then if the Caputo fractional Dini derivative of m exists at t^* , then the inequality ${}^C D_+^\beta m(t^*, \alpha_1) - {}^C D_+^\beta m(t^*, \alpha_2) > 0$ holds.

Proof. Let $\Omega(t, \gamma) = m(t, \alpha_1) - m(t, \alpha_2)$. Applying (3.4), we have

$$\begin{aligned} {}^c D_+^\beta (m(t^*, \alpha_1) - m(t^*, \alpha_2)) &= \lim_{h \rightarrow 0^+} \sup \frac{1}{h^\beta} \{ [m(t^*, \alpha_1) - m(t^*, \alpha_2)] - [m(t_0, \alpha_1) - m(t_0, \alpha_2)] \\ &\quad - \sum_{r=1}^{\left[\frac{t-t_0}{h} \right]} (-1)^{r+1} C_r [m(t^* - rh, \alpha_1) - m(t^* - rh, \alpha_2)] - [m(t_0, \alpha_1) - m(t_0, \alpha_2)] \} \end{aligned}$$

when $\alpha_1 = \alpha_2$ we have

$$\begin{aligned} {}^c D_+^\beta (m(t^*, \alpha_1) - m(t^*, \alpha_2)) &= \lim_{h \rightarrow 0^+} \sup \frac{1}{h^\beta} \{ -[m(t_0, \alpha_1) - m(t_0, \alpha_2)] \\ &\quad - \sum_{r=1}^{\left[\frac{t-t_0}{h} \right]} (-1)^{r+1} C_r [m(t^* - rh, \alpha_1) - m(t^* - rh, \alpha_2)] - [m(t_0, \alpha_1) - m(t_0, \alpha_2)] \} \end{aligned}$$

$$\begin{aligned} {}^c D_+^\beta (m(t^*, \alpha_1) - m(t^*, \alpha_2)) &= -\lim_{h \rightarrow 0^+} \sup \frac{1}{h^\beta} [m(t_0, \alpha_1) - m(t_0, \alpha_2)] \\ &\quad + \lim_{h \rightarrow 0^+} \sup \frac{1}{h^\beta} \sum_{r=1}^{\left[\frac{t-t_0}{h} \right]} (-1)^r C_r [m(t^* - rh, \alpha_1) - m(t^* - rh, \alpha_2)] \\ &\quad - \lim_{h \rightarrow 0^+} \sup \frac{1}{h^\beta} \sum_{r=1}^{\left[\frac{t-t_0}{h} \right]} (-1)^r C_r [m(t_0, \alpha_1) - m(t_0, \alpha_2)] \end{aligned}$$

$$\begin{aligned} {}^c D_+^\beta (m(t^*, \alpha_1) - m(t^*, \alpha_2)) &= -\lim_{h \rightarrow 0^+} \sup \frac{1}{h^\beta} [m(t_0, \alpha_1) - m(t_0, \alpha_2)] \\ &\quad - \lim_{h \rightarrow 0^+} \sup \frac{1}{h^\beta} \sum_{r=1}^{\left[\frac{t-t_0}{h} \right]} (-1)^r C_r [m(t_0, \alpha_1) - m(t_0, \alpha_2)] \end{aligned}$$

$${}^c D_+^\beta (m(t^*, \alpha_1) - m(t^*, \alpha_2)) = -\lim_{h \rightarrow 0^+} \sup \frac{1}{h^\beta} \sum_{r=0}^{\left[\frac{t-t_0}{h} \right]} (-1)^r C_r [m(t_0, \alpha_1) - m(t_0, \alpha_2)]$$

Applying equation (3.8) in [1], we have

$${}^c D_+^\beta m(t^*, \alpha_1) - {}^c D_+^\beta m(t^*, \alpha_2) = -\frac{(t-t_0)^{-\beta}}{\Gamma(1-\beta)} [m(t^*, \alpha_1) - m(t^*, \alpha_2)]$$

By the lemma, we have that

$$m(t, \alpha_1) - m(t, \alpha_2) < 0 \quad \text{for } t_0 \leq t \leq t^*$$

And so, it follows that

$${}^C D_+^\beta m(t^*, \alpha_1) - {}^C D_+^\beta m(t^*, \alpha_2) > 0$$

Note that some existence results for (3.5) are given in [11, 13] and [14].

Remark 3.3. Lemma 3.2 extends Lemma 1 in [1], where the vectors $m(t, \alpha_1)$ and $m(t, \alpha_2)$ are compared component-wise.

In the following, we establish the comparison result for the system (3.3).

4 Fractional Differential Inequalities and Comparison Results for Vector Fractional Differential Equation

In this section, again we assume that $0 < \beta < 1$.

Theorem 4.1. (Comparison Result)

Assume that

- i) $g \in PC[R_+ \times R_+^n, R^n]$ and is continuous in $(t_{k-1}, t_k]$, $k = 1, 2, \dots$ and $g(t, u)$ is quasimonotone non-decreasing in u for each $u \in R^n$ and $\lim_{(t,y) \rightarrow (t_k^+, u)} g(t, u) = g(t_k^+, u)$ exists;
- ii) $\Omega \in PC[R_+ \times R^N, R_+^N]$ and $\Omega \in \chi$ such that

$${}^C D_+^\beta \Omega(t, \gamma) \leq g(t, \Omega(t, \gamma)), \quad (t, \gamma) \in R_+ \times R^N$$

and

$\Omega(t_k, \gamma + I_k(\gamma(t_k))) \leq \omega_k(\Omega(t, \gamma(t))), t = t_k, \gamma \in S_\psi$ and the function $\omega_k : R_+^N \rightarrow R_+^N$ is nondecreasing for $k = 1, 2, \dots$

- iii) $\mathcal{G}(t) = \mathcal{G}(t, t_0, u_0) \in PC^\beta([t_0, T], R^n)$ be the maximal solution of the IVP for the IFrDE system (3.5)

Then,

$$\Omega(t, \gamma(t)) \leq \mathcal{G}(t), \quad t \geq t_0, \quad (4.1)$$

where $\gamma(t) = \gamma(t, t_0, \gamma_0) \in PC^\beta([t_0, T], R^N)$ is any solution of (3.3) existing on $[t_0, \infty)$, provided that

$$\Omega(t_0^+, \gamma_0) \leq u_0 \quad (4.2)$$

Proof.

Let $\eta \in S_\psi$ be a small enough arbitrary vector and consider the initial value problem for the following system of fractional differential equations,

$$\begin{aligned} {}^C D^\beta u &= g(t, u) + \eta, \text{ for } t \in [t_0, \infty) \\ u(t_0^+) &= u_0 + \eta, \end{aligned} \quad (4.3)$$

for $t \in [t_0, \infty)$.

The function $u_\eta(t, \alpha)$ is a solution of (4.3), where $\alpha > 0$ the fractional differential equation (3.5) if and only if it satisfies the Volterra fractional integral equation,

$$u_\eta(t, \alpha) = u_0 + \eta + \frac{1}{\Gamma(\beta)} \int_{t_0}^t (t-s)^{\beta-1} (g(s, u_\eta(s, \alpha)) + \alpha) ds, \quad t \in [t_0, \infty). \quad (4.4)$$

Let the function $m(t, \alpha) \in PC([t_0, T] \times S_\psi, R_+^N)$ be defined as $m(t, \alpha) = \Omega(t, \gamma^*(t))$

We now prove that

$$m(t, \alpha) < u_\eta(t, \alpha) \text{ for } t \in [t_0, \infty) \quad (4.5)$$

Observe that the inequality (4.5) holds whenever $t = t_0$ i.e.

$$m(t_0, \alpha) = \Omega(t_0, \gamma_0) \leq u_0 < u_\eta(t_0, \alpha)$$

Assume that the inequality (4.5) is not true, then there exists a point $t_1 > t_0$ such that

$$m(t_1, \alpha) = u_\eta(t_1, \alpha) \text{ and } m(t, \alpha) < u_\eta(t, \alpha) \text{ for } t \in [t_0, t_1).$$

It follows from Lemma 3.2 that

$${}^C D_+^\beta (m(t_1, \alpha) - u_\eta(t_1, \alpha)) > 0 \text{ i.e.}$$

$${}^C D_+^\beta (m(t_1, \alpha)) > {}^C D_+^\beta u_\eta(t_1, \alpha)$$

$${}^C D_+^\beta \Omega(t_1, \gamma(t_1)) > {}^C D_+^\beta u_\eta(t_1, \alpha)$$

and using (4.3) we arrive at

$${}^C D_+^\beta \Omega(t_1, \gamma(t_1)) > g(t_1, u(t_1, \alpha)) + \eta > g(t_1, u(t_1, \alpha))$$

Therefore,

$${}^c D_+^\beta m(t_1, \alpha) > g(t_1, u(t_1, \alpha))$$

(4.6)

From Theorem 4.1, the function $\gamma^*(t) = \gamma(t, t_0, \gamma_0)$ satisfies the IVP (4.3) and the equality

$$\limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} [\gamma^*(t) - \gamma_0 - S(\gamma^*(t), h)] = f(t, \gamma^*(t)), \text{ holds}$$

(4.7)

where $\gamma^*(t) = \gamma(t, t_0, \gamma_0)$ is any other solution of (3.5), and

$$S(\gamma^*(t), h) = \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^{r+1} C_r [\gamma^*(t-rh) - \gamma_0]$$

(4.8)

is the Grunwald Letnikov fractional derivative

Multiply equation (4.7) through by h^β

$$\begin{aligned} \limsup_{h \rightarrow 0^+} [\gamma^*(t) - \gamma_0 - S(\gamma^*(t), h)] &= h^\beta f(t, \gamma^*(t)) \\ \gamma^*(t) - \gamma_0 - [S(\gamma^*(t), h) + \rho(h^\beta)] &= h^\beta f(t, \gamma^*(t)) \\ \gamma^*(t) - h^\beta f(t, \gamma^*(t)) &= [S(\gamma^*(t), h) + \gamma_0 + \rho(h^\beta)] \end{aligned}$$

(4.9)

Then for $t \in [t_0, \infty)$, we have

$$\begin{aligned} m(t, \alpha) - m(t_0, \alpha) - \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^{r+1} C_r [m(t-rh, \alpha) - m(t_0, \alpha)] &= \\ \Omega(t, \gamma^*(t)) - \Omega(t_0, \gamma_0) - \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^{r+1} C_r [\Omega(t-rh, \gamma^*(t) - h^\beta f(t, \gamma^*(t)) - \Omega(t_0, \gamma_0)] & \\ = \Omega(t, \gamma^*(t)) - \Omega(t_0, \gamma_0) - \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^{r+1} C_r [\Omega(t-rh) - \gamma^*(t) - h^\beta f(t, \gamma^*(t)) - \Omega(t_0, \gamma_0)] & \\ + \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^{r+1} C_r \{ [\Omega(t-rh), S(\gamma^*(t), h) + \gamma_0 + \rho(h^\beta) - \Omega(t_0, \gamma_0)] - [\Omega(t-rh, \gamma^*(t-rh)) - \Omega(t_0, \gamma_0)] \} & \end{aligned}$$

(4.10)

Since $\Omega(t, \gamma)$ is locally Lipschitzian with respect to the second variable, we have that,

$$\leq L \left| (-1)^{r+1} \left\| \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (\beta C_r) [S(\gamma^*(t), h) + \gamma_0 + \rho(h^\beta) - \gamma^*(t-rh)] \right\| \right|$$

where $L > 0$ is a Lipschitz constant.

$$\leq L \left\| \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (\beta C_r) [S(\gamma^*(t), h) + \rho(h^\beta) - (\gamma^*(t-rh) - \gamma_0)] \right\| \quad (4.11)$$

Using equation (4.8), equation (4.11) becomes,

$$\begin{aligned} &\leq L \left\| \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (\beta C_r) \left(\sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (-1)^{r+1} (\beta C_r) [(\gamma^*(t-rh) - \gamma_0) + \rho(h^\beta)] - (\gamma^*(t-rh) - \gamma_0) \right) \right\| \\ &\leq L \left\| \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (\beta C_r) (-1)^{r+1} \left[\sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} \beta C_r [(\gamma^*(t-rh) - \gamma_0)] + \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} \beta C_r \rho(h^\beta) - \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} \beta C_r (\gamma^*(t-rh) - \gamma_0) \right] \right\| \\ &\leq L (-1)^{r+1} \left\| \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (\beta C_r) [(\gamma^*(t-rh) - \gamma_0)] + \left[\sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} \beta C_r - 1 \right] + \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} \beta C_r \rho(h^\beta) \right\| \quad (4.12) \end{aligned}$$

Substituting equation (4.12) into (4.10) we have

$$\begin{aligned} &= \Omega(t, \gamma^*(t)) - \Omega(t_0, \gamma_0) - \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (-1)^{r+1} \beta C_r \left[\Omega(t-rh) - \gamma^*(t) - h^\beta f(t, \gamma^*(t)) - \Omega(t_0, \gamma_0) \right] + \\ &\quad L \left\| \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (-1)^{r+1} (\beta C_r) (\gamma^*(t-rh) - \gamma_0) \left[\sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (-1)^{r+1} \beta C_r - 1 \right] + \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (-1)^{r+1} \beta C_r \rho(h^\beta) \right\| \\ &= \Omega(t, \gamma^*(t)) - \Omega(t_0, \gamma_0) - \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (-1)^{r+1} \beta C_r \left[\Omega(t-rh) - \gamma^*(t) - h^\beta f(t, \gamma^*(t)) - \Omega(t_0, \gamma_0) \right] + \\ &\quad L \left\| \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (-1)^{r+1} (\beta C_r) (\gamma^*(t-rh) - \gamma_0) \left[- \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (-1)^r \beta C_r - 1 \right] + \sum_{r=1}^{\left\lfloor \frac{t-t_0}{h} \right\rfloor} (-1)^{r+1} \beta C_r \rho(h^\beta) \right\| \end{aligned}$$

Dividing through by $h^\beta > 0$ and taking the $\limsup$ as $h \rightarrow 0^+$ we have,

$${}^C D_+^\beta m(t, \alpha) = \limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} \left\{ \Omega(t, \gamma^*(t)) - \Omega(t_0, \gamma_0) - \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^{r+1} {}^\beta C_r [\Omega(t-rh) - \gamma^*(t) - h^\beta f(t, \gamma^*(t)) - \Omega(t_0, \gamma_0)] \right\} +$$

$$\limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} L \left\| \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^{r+1} ({}^\beta C_r) (\gamma^*(t-rh) - \gamma_0) \left[-\sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r {}^\beta C_r - 1 \right] + \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^{r+1} {}^\beta C_r \rho(h^\beta) \right\|$$

Recall that,

$$\lim_{h \rightarrow 0^+} \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^{r+1} ({}^\beta C_r) = -1 \text{ and } \limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} \rho(h^\beta) = 0$$

From equations (3.6) and (3.7) in [1], we have that

$${}^C D_+^\beta m(t, \alpha) = {}^C D_+^\beta \Omega(t, \gamma^*(t)) + L \left\| \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^{r+1} ({}^\beta C_r) (\gamma^*(t-rh) - \gamma_0) [-(-1) - 1] + 0 \right\|$$

Using condition (ii) of the Theorem 4.1, we obtain the estimate

$${}^C D_+^\beta m(t, \alpha) \leq g(t, \Omega(t, \gamma^*(t))) = g(t, m(t, \alpha)), \quad (4.13)$$

Also,

$$m(t_0^+, \alpha) \leq u_0 \text{ and } m(t_k^+, \alpha) = \Omega(t_k^+, \gamma(t_k)) + I_k(\gamma(t_k)) \leq \rho_k(m(t_k)) \quad (4.14)$$

Now equation (4.14) with $t = t_1$ contradicts (4.6), hence (4.5) is true.

□

For $t \in [t_0, T]$, we now establish that

$$u_{\eta_1}(t, \alpha) < u_{\eta_2}(t, \alpha) \text{ whenever } \eta_1 < \eta_2 \quad (4.15)$$

Observe that the inequality (4.15) holds for $t = t_0$

Assume that (4.15) is not true. Then there exists a point t_1 such that $u_{\eta_1}(t_1, \alpha) = u_{\eta_2}(t_2, \alpha)$ and $u_{\eta_1}(t, \alpha) < u_{\eta_2}(t, \alpha)$ for $t \in [t_0, t_1)$.

By Lemma 3.2, we have that

$${}^C D_+^\beta (u_{\eta_1}(t_1, \alpha) - u_{\eta_2}(t_2, \alpha)) > 0$$

However,

$$\begin{aligned}
 {}^c D_+^\beta (u_{\eta_1}(t_1, \alpha) - u_{\eta_2}(t_2, \alpha)) &= {}^c D_+^\beta (u_{\eta_1}(t_1, \alpha) - u_{\eta_2}(t_2, \alpha)) \\
 &= g(t_1, u(t_1, \alpha)) + \eta_1 - [g(t_1, u(t_1, \alpha)) + \eta_2] \\
 &= \eta_1 - \eta_2 < 0
 \end{aligned}$$

which is a contradiction, and so (4.15) is true. Thus, equations (4.5) and (4.15) guarantee that the family of solutions $\{u_\eta(t, \alpha)\}$, $t \in [t_0, T]$ of (4.3) is uniformly bounded, i.e. there exists $\lambda > 0$ with $|u_\eta(t, \alpha)| \leq \lambda$, with bound λ on $[t_0, T]$. We now show that the family $\{u_\eta(t, \alpha)\}$ is equicontinuous on $[t_0, T]$. Let $k = \sup \{ |g(t, \gamma)| : (t, \gamma) \in [t_0, T] \times [-\lambda, \lambda] \}$, where λ is the bound on the family $\{u_\eta(t, \alpha)\}$. Fix a decreasing sequence $\{\eta_i\}_{i=0}^\infty(t)$, such that $\lim_{i \rightarrow \infty} \eta_i = 0$ and consider a sequence of functions $\{u_\eta(t, \alpha)\}$. Again, let $t_1, t_2 \in [t_0, T]$, with $t_1 < t_2$, then we have the following estimates,

$$\begin{aligned}
 \|u_\eta(t_2, \alpha) - u_\eta(t_1, \alpha)\| &\leq \|u_0 + \eta_i + \frac{1}{\Gamma(\beta)} \int_{t_0}^{t_2} (t_2 - s)^{\beta-1} (g(s, u(s, \eta_i)) + \eta_i) ds \\
 &\quad - \left(u_0 + \eta_i + \frac{1}{\Gamma(\beta)} \int_{t_0}^{t_1} (t_1 - s)^{\beta-1} (g(s, u(s, \eta_i)) + \eta_i) ds \right) \| \\
 &\leq \frac{1}{\Gamma(\beta)} \left\| \left[\int_{t_0}^{t_2} (t_2 - s)^{\beta-1} - \int_{t_0}^{t_1} (t_1 - s)^{\beta-1} \right] (g(s, u(s, \eta_i)) + \eta_i) ds \right\| \\
 &\leq \frac{k}{\Gamma(\beta)} \left\| \left(\int_{t_0}^{t_2} (t_2 - s)^{\beta-1} - \int_{t_0}^{t_1} (t_1 - s)^{\beta-1} \right) ds \right\| \\
 &\leq \frac{k}{\Gamma(\beta)} \left\| \left(\int_{t_0}^{t_1} (t_2 - s)^{\beta-1} + \int_{t_1}^{t_2} (t_2 - s)^{\beta-1} - \int_{t_0}^{t_1} (t_1 - s)^{\beta-1} \right) ds \right\| \\
 &\leq \frac{k}{\Gamma(\beta)} \left\| \int_{t_0}^{t_1} (t_2 - s)^{\beta-1} - \int_{t_0}^{t_1} (t_1 - s)^{\beta-1} + \int_{t_1}^{t_2} (t_2 - s)^{\beta-1} ds \right\| \\
 &\leq \frac{k}{\Gamma(\beta)} \left[\left\| \int_{t_0}^{t_1} (t_2 - s)^{\beta-1} - \int_{t_0}^{t_1} (t_1 - s)^{\beta-1} ds \right\| + \left\| \int_{t_1}^{t_2} (t_2 - s)^{\beta-1} ds \right\| \right]
 \end{aligned}$$

$$\begin{aligned}
&\leq \frac{k}{\beta\Gamma(\beta)} \left[\left\| (t_2 - t_0)^\beta - (t_1 - t_0)^\beta - (t_2 - t_1)^\beta \right\| + \left\| (t_2 - t_1)^\beta \right\| \right] \\
&\leq \frac{k}{\beta\Gamma(\beta)} \left[(t_2 - t_1)^\beta + (t_2 - t_1)^\beta \right] = \frac{2k}{\Gamma(\beta+1)} (t_2 - t_1)^\beta
\end{aligned}$$

provided $\|t_2 - t_1\| < \delta(\varepsilon) = \left(\frac{\Gamma(\beta+1)\varepsilon}{2k} \right)^{\frac{1}{\beta}}$, proving that the family of solutions $\{u_\eta(t, \alpha)\}$ is equicontinuous. By the Arzela-Ascoli theorem, $\{u_{\eta_i}(t, \alpha)\}$ guarantees the existence of a subsequence $\{u_{\eta_j}(t, \alpha)\}$ which converges uniformly to the function $\mathcal{G}(t)$ on $[t_0, T]$. Then we show that $\mathcal{G}(t)$ is a solution of (4.4). Thus, equation (4.4) becomes

$$u_{\eta_{i_j}}(t, \alpha) = u_{0_{i_j}} + \eta_{i_j} + \frac{1}{\Gamma(\beta)} \int_{t_0}^t (t-s)^{\beta-1} (g_{i_j}(s, u_{\eta_{i_j}}(s, \alpha)) + \eta_{i_j}) ds, \quad t \in [t_0, \infty). \quad (4.16)$$

Taking the $\lim$ as $i_j \rightarrow \infty$ in (4.16) yields,

$$\mathcal{G}(t) = u_0 + \eta_{i_j} + \frac{1}{\Gamma(\beta)} \int_{t_0}^t (t-s)^{\beta-1} (g(s, \mathcal{G}(t)) + \eta_{i_j}) ds, \quad t \in [t_0, \infty). \quad (4.17)$$

Hence, $\mathcal{G}(t)$ is a solution of (3.5) on $[t_0, T]$. We claim that $\mathcal{G}(t)$ is the maximal solution of (3.5). Then, from (4.5), we have that $m(t, \alpha) < u_\eta(t, \alpha) \leq \mathcal{G}(t)$ on $[t_0, T]$.

Suppose that in Theorem 4.1, $g(t, u) \equiv 0$, then we have the following results

Corollary 4.1.

Assume that Condition (i) of Theorem 4.1 holds and,

(i) $\Omega \in PC[R_+ \times R^N, R_+^N]$ and $\Omega \in \chi$ such that

$${}^c D_+^\beta \Omega(t, \gamma) \leq 0 \quad (4.14)$$

holds, and

$\Omega(t_k, \gamma + I_k(\gamma(t_k))) \leq \omega_k(\Omega(t, \gamma(t))), t = t_k, \gamma \in S_\psi$ and the function $\omega_k : R_+^N \rightarrow R_+^N$ is nondecreasing for $k = 1, 2, \dots$

Then for $t \in [t_0, \infty)$, the inequality

$$\Omega(t, \gamma(t)) \leq \Omega(t_0^+, \gamma_0) \text{ holds}$$

5 Main Results

In this section, we will obtain sufficient conditions for the uniform practical stability of the system (3.3). Again we assume $0 < \beta < 1$.

Theorem 5.1. Assume that

i) $g \in PC[R_+ \times R_+^n, R^n]$ is piecewise continuous in $(t_{k-1}, t_k]$ and for each $u \in R^n$, $k = 1, 2, \dots$, and $\lim_{(t, y) \rightarrow (t_k^+, u)} g(t, y) = g(t_k^+, u)$ exists, and $g(t, u)$ is quasimonotone nondecreasing in u

ii) $\Omega \in PC[R_+ \times R^N, R_+^N]$ and $\Omega \in \chi$ such that

$${}^c D_+^\beta \Omega(t, \gamma) \leq g(t, \Omega(t, \gamma)), t \neq t_k, \text{ holds for all } (t, \gamma) \in R_+ \times S_\Psi,$$

there exists a $\psi_0 > 0$ such that $\gamma_0 \in S_{\psi_0}$ implies that $\gamma(t) + I_k(\gamma(t_k)) \in S_{\psi_0}$ and

$\Omega(t_k, \gamma + I_k(\gamma(t_k))) \leq \omega_k(\Omega(t, \gamma(t))), t = t_k, \gamma \in S_{\psi_0}$ and the function $\omega_k : R_+^N \rightarrow R_+^N$ is nondecreasing for $k = 1, 2, \dots$

iii) $b(\|\gamma\|) \leq \Omega_0(t, \gamma) \leq a(\|\gamma\|)$, where $a, b \in K$ and $\Omega_0(t, \gamma) = \sum_{i=1}^N \Omega_i(t, \gamma)$.

Then the uniform practical stability of the trivial solution $u = 0$ of (3.5) implies the uniform practical stability of the trivial solution $\gamma = 0$ of (3.3).

Proof. Let $0 < \varepsilon < \psi$ and $t_0 \in R_+$ be given.

Assume that the solution (3.5) is uniformly practically stable. Then given $b(\varepsilon) > 0$ and $t_0 \in R_+$, there exists a positive function $\delta = \delta(\varepsilon) > 0$ such that

$$\sum_{i=1}^N u_{i0} < \delta \text{ implies } \sum_{i=1}^N u_i(t, t_0, u_0) < b(\varepsilon), t \geq t_0 \quad (5.1)$$

where $u(t, t_0, u_0)$ is any solution of (3.5).

Choose $u_0 = \Omega(t_0^+, \gamma_0)$ and

$$\sum_{i=1}^N u_{i0} = a(t_0, \|\gamma_0\|)$$

Since $a(t, K)$ and $a \in C[R_+ \times R_+, R_+]$, we can find a positive function $\delta = \delta(t_0, \delta_1) > 0$ such that the inequalities

$$a(t_0, \|\gamma_0\|) < \delta_1 \text{ and } \|\gamma_0\| < \delta \quad (5.2)$$

are satisfied simultaneously.

We claim that, if $\|\gamma_0\| < \delta$ then $\|\gamma(t, t_0, \gamma_0)\| < \varepsilon$.

Suppose that this claim is false, then there would exists a point $t_1 \in [t_0, t)$ and the solution $\gamma(t, t_0, \gamma_0)$ with $\|\gamma_0\| < \delta_1$ such that

$$\|\gamma(t_1)\| = \varepsilon \text{ and } \|\gamma(t)\| < \varepsilon \text{ for } t \in [t_0, t_1) \quad (5.3)$$

This implies that $\gamma(t) + I_k(\gamma(t_k)) \in S_{\psi'}$ for $t \in [t_0, t_1)$

So that using equations (4.1) and condition (iv) of Theorem 5.1 we have the estimate

$$b(\|\gamma(t_1)\|) \leq \sum_{i=1}^N \Omega_i(t_1, \gamma(t_1)), \text{ implying} \\ b(\varepsilon) \leq \sum_{i=1}^N \Omega_i(t_1, \gamma(t_1)) \leq \mathcal{G}(t) \quad (5.4)$$

where $\mathcal{G}(t) = \sum_{i=1}^n \mathcal{G}_i(t, t_0, u_0)$ is the maximal solution of (3.5).

Then, using equations (5.4), (5.3) and condition (iii) of Theorem 5.1 we arrive at the estimate

$$b(\varepsilon) \leq \Omega_0(t_1, \gamma(t_1)) \leq \sum_{i=1}^N \mathcal{G}_i(t, t_0, u_0) < b(\varepsilon)$$

which leads to a contradiction.

Hence, the uniform practical stability of the trivial solution $u = 0$ of (3.5) implies the uniform practical stability of the trivial solution $\gamma = 0$ of (3.3).

6 Application

Consider the system of fractional differential equations

$$\begin{aligned}
{}^C D^\beta \gamma_1(t) &= -15\gamma_1 - \frac{\gamma_2^2 \operatorname{cosec} \gamma_1}{2\gamma_1} + \gamma_1 \sin \gamma_2 + \frac{3\gamma_2^2 \sin \gamma_1}{\gamma_1}, \quad t \neq t_k \\
{}^C D^\beta \gamma_2(t) &= \frac{3\gamma_1^2}{\gamma_2} - \gamma_2 \sin \gamma_1 - 5\gamma_2 \operatorname{cosec} \gamma_1 - \gamma_1^2 \cos \gamma_2, \quad t \neq t_k \\
\Delta \gamma_1 &= \xi_k(\gamma(t_k)), \quad t = t_k \\
\Delta \gamma_2 &= \tau_k(\gamma(t_k)), \quad t = t_k, \quad k = 1, 2, \dots
\end{aligned}
\tag{6.1}$$

with initial conditions

$$\gamma_1(t_0^+) = \gamma_{10} \text{ and } \gamma_2(t_0^+) = \gamma_{20}$$

where $\gamma_1, \gamma_2 \in R^N$ are arbitrary functions.

Equation (6.1) is equivalent to (3.3) and $f = (f_1 f_2)$, where

$$\begin{aligned}
f_1(t, \gamma_1) &= {}^C D^\beta \gamma_1(t) = -15\gamma_1 - \frac{\gamma_2^2 \operatorname{cosec} \gamma_1}{2\gamma_1} + \gamma_1 \sin \gamma_2 + \frac{3\gamma_2^2 \sin \gamma_1}{\gamma_1} \text{ and} \\
f_2(t, \gamma_2) &= {}^C D^\beta \gamma_2(t) = \frac{3\gamma_1^2}{\gamma_2} - \gamma_2 \sin \gamma_1 - 5\gamma_2 \operatorname{cosec} \gamma_1 - \gamma_1^2 \cos \gamma_2
\end{aligned}$$

Consider a vector Lyapunov function of the form $\Omega = (\Omega_1, \Omega_2)^T$, where

$$\Omega_1(t, \gamma_1, \gamma_2) = \gamma_1^2, \quad \Omega_2(t, \gamma_1, \gamma_2) = \gamma_2^2$$

So that $\Omega = (\Omega_1, \Omega_2)^T$ with $\gamma = (\gamma_1, \gamma_2) \in R^2$, so that $\|\gamma\| = \sqrt{\gamma^2 + y^2}$

$$\sum_{i=1}^2 \Omega_i(t, \gamma_1, \gamma_2) = \gamma_1^2 + \gamma_2^2$$

The assumption,

$$b(\|\gamma\|) \leq \sum_{i=1}^n \Omega_i(\gamma, y) \leq a(t, \|\gamma\|) \text{ reduces to}$$

$$\sqrt{\gamma^2 + y^2} \leq \gamma^2 + y^2 \leq 2(\sqrt{\gamma^2 + y^2})^2$$

with the proviso that $b(\wp) = \wp$, and $a(\wp) = 2\wp^2$.

Furthermore, we deduce that using equation (3.4) and $\Omega_1(t, \gamma_1, \gamma_2) = \gamma_1^2$

$${}^C D_+^\beta \Omega(t, \gamma_1, \gamma_2) = \limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} \left\{ \Omega(t, \gamma_1, \gamma_2) - \Omega(t_0, \gamma_0) - \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^{r+1} C_r \left[\Omega(t-rh, \gamma-h^\beta f_i(t, \gamma_1, \gamma_2)) - \Omega(t_0, \gamma_0) \right] \right\}, \quad t \geq t_0$$

$$\begin{aligned}
{}^c D_+^\beta \Omega_1(t, \gamma_1) &= \limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} \left\{ \gamma_1^2 - \gamma_{10}^2 + \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r ({}^\beta C_r) [\Omega(t-rh, \gamma - h^\beta f_1(t, \gamma_1)) - \gamma_{10}^2] \right\}, t \geq t_0 \\
{}^c D_+^\beta \Omega_1(t, \gamma_1) &= \limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} \left\{ \gamma_1^2 - \gamma_{10}^2 + \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r ({}^\beta C_r) [(\gamma_1 - h^\beta f_1(t, \gamma_1))^2 - \gamma_{10}^2] \right\}, t \geq t_0 \\
{}^c D_+^\beta \Omega_1(t, \gamma_1) &\leq \limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} \left\{ \gamma_1^2 - \gamma_{10}^2 + \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r ({}^\beta C_r) [\gamma_1^2 - 2\gamma_1 h^\beta f_1(t, \gamma_1) + h^{2\beta} f_1^2(t, \gamma_1) - \gamma_{10}^2] \right\}, t \geq t_0 \\
{}^c D_+^\beta \Omega_1(t, \gamma_1) &\leq \limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} \left\{ \gamma_1^2 + \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r ({}^\beta C_r) \gamma_1^2 - \gamma_{10}^2 - \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r ({}^\beta C_r) \gamma_{10}^2 - 2\gamma_1 \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r ({}^\beta C_r) h^\beta f_1(t, \gamma_1) \right\}, t \geq t_0 \\
{}^c D_+^\beta \Omega_1(t, \gamma_1) &\leq \limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} \left\{ \sum_{r=0}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r ({}^\beta C_r) \gamma_1^2 - \sum_{r=0}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r ({}^\beta C_r) \gamma_{10}^2 - 2\gamma_1 \sum_{r=1}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r ({}^\beta C_r) h^\beta f_1(t, \gamma_1) \right\}, t \geq t_0 \quad (6.2)
\end{aligned}$$

Recall from equations (3.7) and (3.8) in [1] that

$$\limsup_{h \rightarrow 0^+} \frac{1}{h^\beta} \sum_{r=0}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r ({}^\beta C_r) = \frac{\gamma_1^2}{t^\beta \Gamma(1-\beta)} \text{ and } \lim_{h \rightarrow 0^+} \sum_{r=0}^{\lfloor \frac{t-t_0}{h} \rfloor} (-1)^r ({}^\beta C_r) = -1 \quad (6.3)$$

and substituting (6.3) into (6.2), we have,

$${}^c D_+^\beta \Omega_1(t, \gamma_1) \leq \frac{\gamma_1^2}{t^\beta \Gamma(1-\beta)} - \frac{\gamma_{10}^2}{t^\beta \Gamma(1-\beta)} + 2\gamma_1 f_1(t, \gamma_1)$$

$${}^c D_+^\beta \Omega_1(t, \gamma_1) \leq \frac{\gamma_1^2}{t^\beta \Gamma(1-\beta)} + 2\gamma_1 f_1(t, \gamma_1)$$

$${}^c D_+^\beta \Omega_1(t, \gamma_1) \leq \frac{\gamma_1^2}{t^\beta \Gamma(1-\beta)} + 2\gamma_1 \left(-15\gamma_1 - \frac{\gamma_2^2 \operatorname{cosec} \gamma_1}{2\gamma_1} + \gamma_1 \sin \gamma_2 + \frac{3\gamma_2^2 \sin \gamma_1}{\gamma_1} \right)$$

$${}^c D_+^\beta \Omega_1(t, \gamma_1) \leq \frac{\gamma_1^2}{t^\beta \Gamma(1-\beta)} - 30\gamma_1^2 - \gamma_2^2 \operatorname{cosec} \gamma_1 + 2\gamma_1^2 \sin \gamma_2 + 6\gamma_2^2 \sin \gamma_1$$

As $t \rightarrow \infty$, $\frac{\gamma_1^2}{t^\beta \Gamma(1-\beta)} \rightarrow 0$, so we now have that

$${}^c D_+^\beta \Omega_1(t, \gamma_1) \leq -30\gamma_1^2 - \gamma_2^2 \operatorname{cosec} \gamma_1 + 2\gamma_1^2 \sin \gamma_2 + 6\gamma_2^2 \sin \gamma_1$$

$$= 2\gamma_1^2(-15 + \sin \gamma_2) + \gamma_2^2(6 \sin \gamma_1 - \operatorname{cosec} \gamma_1)$$

$$\leq 2\gamma_1^2(-15 + |\sin \gamma_2|) + \gamma_2^2(6 |\sin \gamma_1| - \frac{1}{|\sin \gamma_1|})$$

$$\leq 2\gamma_1^2(-15 + 1) + \gamma_2^2(6 - 1)$$

$$= \gamma_1^2(-14) + \gamma_2^2(5)$$

Therefore,

$${}^C D_+^\beta \Omega_1(t, \gamma_1) \leq -14\Omega_1 + 5\Omega_2 \quad (6.4)$$

Also for $\gamma_0 \in S_\psi$, for $t = t_k$, $k = 1, 2, \dots$ we have, $\Omega_1(t, \gamma(t) + \xi_k) = |\xi_k + \gamma(t)| \leq \Omega_1(t, \gamma(t))$

Similarly, we compute for the Dini derivative for $\Omega_2(t, \gamma_2) = \gamma_2^2$ and follow through the same argument by substituting for $f_2(t, \gamma_2) = {}^C D^\beta \gamma_2(t) = \frac{3\gamma_1^2}{\gamma_2} - \gamma_2 \sin \gamma_1 - 5\gamma_2 \operatorname{cosec} \gamma_1 - \gamma_1^2 \cos \gamma_2$ in equation (3.4) to have that,

$${}^C D_+^\beta \Omega_2(t, \gamma_2) \leq 4\Omega_1 - 12\Omega_2 \quad (6.5)$$

Also for $\gamma_0 \in S_\psi$, for $t = t_k$, $k = 1, 2, \dots$ we have, $\Omega_2(t, \gamma(t) + \tau_k) = |\tau_k + \gamma(t)| \leq \Omega_2(t, \gamma(t))$

By combining equations (6.4) and (6.5), we have

$${}^C D_+^\beta \Omega \leq \begin{pmatrix} -14 & 5 \\ 4 & -12 \end{pmatrix} \begin{pmatrix} \Omega_1 \\ \Omega_2 \end{pmatrix} = g(t, \Omega) \quad (6.6)$$

Now, consider the comparison system ${}^C D^\beta u = g(t, \Omega) = Au$, where $A = \begin{pmatrix} -14 & 5 \\ 4 & -12 \end{pmatrix}$.

The vectorial inequality (6.6) and all other conditions of Theorem 5.2 are satisfied since the eigenvalues of A are all negative real parts. Hence, the system (6.1) is uniformly practically stable. Therefore, the trivial solution $\gamma_0 = 0$ of the IFRDE (6.1) is uniformly practically stable.

7 Conclusion

In this paper, we examined the uniform practical stability of nonlinear impulsive Caputo fractional differential equations with fixed moment of impulse, using an auxiliary Lyapunov functions which are analogues of vector Lyapunov functions, and is generalized by a class of

piecewise continuous Lyapunov functions. By splitting the vector Lyapunov functions $V(t, \gamma)$ into several components of $V_1, V_2, \dots$, each of the state variable or solution state $x_1, x_2, \dots, x_m$ can be inserted into each of the components rather than into one Lyapunov function, so that the arguments to obtain the desired practical stability result becomes less complicated, and the imposed conditions would be less restrictive. Together with the comparison results, sufficient conditions for the uniform practical stability of the impulsive Caputo fractional order system (3.3) is established with an illustrative example.

Conflicts of Interest: The authors declare that there is no conflict of interest.

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