



25th - 26th February, 2026

**National Conference on
Industrialisation, Employment
Creation & Economic Development
in Nigeria**



Theme: Industrialisation and Innovation:
Pathways to Employment and Sustainable
Economic Development in Nigeria

CONFERENCE PROCEEDINGS

Niger Delta University (NDU), Bayelsa State, Nigeria



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NATIONAL CONFERENCE ON INDUSTRIALISATION, EMPLOYMENT CREATION AND ECONOMIC DEVELOPMENT IN NIGERIA

THEME: Industrilisation and Innovation: Pathways to Employment and Sustainable Economic Development in Nigeria
DATE: Wednesday 25th – Thursday 26th February, 2026 | **TIME:** 10:00am
VENUE: Niger Delta University (NDU), Bayelsa State, Nigeria

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NATIONAL CONFERENCE ON INDUSTRIALISATION, EMPLOYMENT CREATION AND ECONOMIC DEVELOPMENT IN NIGERIA

CONFERENCE PROGRAMME

DAY ONE – Wednesday 25th February, 2026

Arrival of Guest/Conferees/Delegates

DAY TWO – Thursday 26th February, 2026

OPENING SESSION/AWARD/PLENARY

Conference Registration	- 9:00am – 10:00am
Opening Prayer/Welcome Remark	- 10:00am – 10:15am
Institutional Brief/Chairman's Opening Remark	- 10:15am – 10:30am
Plenary Session	- 10:30am – 12noon
Launch Break/Group Photograph	- 12noon – 1:00pm
Plenary Session 2	- 1:00pm – 4:00pm
Policy Review Session	- 4:00pm – 5:00pm

DAY THREE – Friday 27th February, 2026

Departure of Guest/Conferee/Delegates



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BOOK OF PROCEEDINGS



NATIONAL CONFERENCE ON INDUSTRIALISATION, EMPLOYMENT CREATION AND ECONOMIC DEVELOPMENT IN NIGERIA

Wednesday 25th – Thursday 26th February, 2026

PERCEIVED IMPACT OF NEW TAX POLICIES ON THE PROFITABILITY OF DEPOSIT MONEY BANKS IN NIGERIA: A STUDY OF SELECTED DEPOSIT MONEY BANK IN EBONYI STATE

¹Chukwu, O. A, ²Nwaeke, J C, ³Nwafor S. U. & ⁴Aroh J.E

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Abstract

This study examined the perceived impact of new tax policies on the profitability of deposit money banks in Nigeria: a study of selected deposit money bank in Ebonyi state. The study adopted a descriptive survey research design and made use of a sample of 154 respondents drawn from the population of 250 staff of the selected deposit money banks using proportionate stratified sampling technique. Data were collected using a questionnaire tagged “Perceived Impact of Tax Policy on Bank Profitability Questionnaire (PITPBQ)” structured by the researcher. The instrument was face validated by three experts from the department of Economics, Ebonyi state University. The reliability of the instrument was determined by conducting a pilot study using 20 respondents from a bank in Enugu state not included in the main study. Data collected was analyzed using Cronbach's Alpha coefficient and that yielded a reliability coefficient of 0.84. Data were collected by the researcher through a direct delivery method in administering the questionnaire with the help of two research assistants. Data collected were analyzed using mean and standard deviation for answering the research questions while the hypotheses were tested using multiple regression at 0.05 level of significance. The findings showed that the new tax policies affecting deposit money banks in Nigeria include increase in Corporate Income Tax, introduction/Adjustment of Minimum Tax, increase in VAT rate, VAT on digital or financial services and stricter tax compliance requirements; the new corporate income tax has reduced the profitability of the deposit money banks in Nigeria; the new corporate income tax has significant effect on the profitability of deposit money banks in Nigeria; and that the new VAT adjustments have significant effect on the profitability of deposit money banks in Nigeria. it was therefore recommended among others that the government should review the fiscal policy and introduction of tax reforms that allow adequate tax incentives for banks especially during financial crises and to cope with liquidity challenges; and the government should introduce a mechanism that would ensure Value Added Tax and Corporate income tax policy transparency, and considering incentives or exemptions to maintain industry stability.

Keywords: Perceived, impact, tax policies, profitability, deposit money banks

Introduction

Taxation is recognized globally as one of the major sources of government revenue and a dynamic instrument for economic regulation and development. It is a fiscal tool used by governments not only to generate revenue but also to redistribute income, and regulate economic activities. Tax is conceptualized as a compulsory levy charged by government on the inflows of individuals and corporate firms for the provision of social welfare and economic development of the nation (Abiahu & Amahalu, 2018). In the words of Anyanwu in Ajayi, (2019), tax is a more or less compulsory, non-returnable contribution of money (or occasionally for goods and services) from private individuals, institutions or groups to the government. It may be levied upon wealth or income or in form of surcharge on prices. Famoyin in Ajayi, (2019) justified tax as a compulsory contribution imposed upon persons for the general purpose of the government. Once levied by the government agency, every taxable person is mandated to pay tax irrespective of the benefits derived. Ajayi, (2019) added that taxes are benefit, but for providing the government with funds necessary for the general administration of the country. A tax is not imposed on a citizen by the government because it has rendered specific services to him or his family but as statutory obligation to enable the government provide essential services for the entire populace. However good tax structure plays significant role in the process of economic development of any nation, of which Nigeria is not an exception (Appah, 2020).

In Nigeria, tax policies are frequently reviewed to enhance revenue generation, promote fiscal stability, and stimulate economic growth. Over the years, successive governments have introduced various tax reforms aimed at broadening the tax base, improving compliance, and strengthening public finances. In recent years, the Federal Government of Nigeria introduced new tax policies and amendments through instruments such as the Finance Act 2019, Finance Act 2020, Finance Act 2021, and subsequent Finance Acts of 2025 (Appah, 2020). These reforms amended several existing tax laws including the Companies Income Tax Act (CITA), Value Added Tax (VAT) Act, and the Stamp Duties Act. The reforms introduced changes such as: Adjustment of corporate income tax rates based on company turnover, increase in Value Added Tax (VAT) rate from 5% to 7.5%, introduction of taxation on electronic and digital transactions, changes in minimum tax computation, expansion of tax bases to capture more sectors. For banks, these policy changes have direct and indirect implications on profitability (Appah, 2020).

The Nigerian banking sector, particularly Deposit Money Banks (DMBs), plays a crucial role in financial intermediation, economic growth, and national development. Deposit Money Banks are licensed financial institutions that accept deposits from the public and provide loans and other financial services. Prominent examples include Access Bank Plc, Zenith Bank Plc, Guaranty Trust Holding Company Plc, and First Bank of Nigeria Limited (OGBARAGU, 2024). These institutions significantly contribute to Nigeria's Gross Domestic Product (GDP) and government tax revenue through corporate income tax, value-added tax (VAT), withholding tax, and other statutory payments based on their profitability of their venture. Profitability is a key indicator of a bank's financial performance and sustainability. It is the ability of a firm to generate earnings relative to its expenses and other relevant costs during a specific period. Profitability explains the plausibility in these companies to generate profit. This plausibility is assessed using profitability ratios. Profitability Ratio's are used to judge how efficiently a firm is using its assets (Richards & Stewart in Ajayi, 2019). Profitability ratios consist of a group of metrics that assess a company's ability to generate revenue relative to its revenue, operating costs, balance sheet assets, and shareholders' equity. Profitability ratios also show how well companies use their existing assets to generate profit and value for

shareholders (Adefunke & Usiomon, 2022). It is commonly measured using financial ratios such as Return on Assets (ROA), Return on Equity (ROE), and Net Profit Margin. Changes in tax policies can directly or indirectly affect these profitability indicators by influencing operating costs, net income, investment decisions, and dividend policies. The new tax framework seeks to improve revenue generation for the government; however, it may increase operational costs for banks, affect dividend payouts, reduce retained earnings, and influence lending capacity (Adefunke & Usiomon, 2022). Higher tax burdens may reduce net profits, thereby affecting shareholder value and overall financial performance. Therefore, understanding the impact of the new tax policy on the profitability of banks in Nigeria is essential for policymakers, financial managers, investors, and regulatory authorities. Also, understanding how bank managers, financial analysts, and stakeholders perceive these effects is critical in evaluating the broader economic consequences of tax reforms. This study seeks to examine the perceived impact of new tax policies on the profitability of deposit money banks in Nigeria: a study of selected deposit money bank in Ebonyi state.

Statement of problem

The introduction of new tax policies in Nigeria was primarily aimed at expanding the government's revenue base and improving fiscal sustainability. The new tax policies in Nigeria have generated mixed reactions among corporate organizations, including deposit money banks. While the government views tax reforms as necessary for revenue generation and fiscal sustainability, many businesses perceive them as increasing operational costs and reducing net profits. However, the banking sector, being one of the most profitable sectors in Nigeria, has experienced increased tax obligations and compliance requirements. While tax reforms are designed to strengthen the economy, they may inadvertently reduce the profitability of banks through higher corporate taxes, increased compliance costs, and additional levies. Reduced profitability could negatively affect banks' capital adequacy, lending capacity, dividend payments, and overall financial stability.

Some studies have tried to find the relationship between taxes and performance of banks. Some of those studies include: Oluwaseun (2022) who examined the impact of company income tax on the dividend policy of quoted deposit money banks in Nigeria and found that companies income tax and VAT exert negative significant impact on dividend per share of deposit money banks (DMBs) in Nigeria; Ajayi, (2019) examine the how Companies Income Tax (CIT) affects Corporate profitability of Deposit Money Banks (DMB's) as obtained from their annual report for 2017 using their Return on Assets (RoA) as Profitability parameter and found that there exist a strong positive relationship between CIT and Corporate Profitability of Deposit Money Banks (DMB's) in Nigeria; Olaoye (2022) examined effect of taxes on profitability of Deposit Money Banks in Nigeria and found that there was a statistically significant effect of taxes on the profitability of Deposit Money Banks in Nigeria; OGBARAGU (2024) investigated the effect of taxation policies on the profitability of deposit money banks in Nigeria and found that Value Added Tax (VAT) showed that VAT exhibited a positive but non-significant on the profitability of banks; and Adefunke and Usiomon (2022) explored the effect of company income tax on corporate performance using data from 12 listed firms on the Nigerian Stock Exchange (2011-2020) and found that company income tax had a positive significant effect on profit after tax and return on equity (ROE), while change in shareholders' funds had a negative yet significant effect on ROE. It is important to note that those studies focused particularly on the old tax policies and none explored the impact of the new tax policies on the profitability of deposit money bank. This gap therefore necessitates a comprehensive study to evaluate whether the new tax policy has significantly impacted the financial performance of Nigerian banks. Hence, the problem of this study is: what is the perceived impact of new tax policies on the profitability of deposit money banks in Nigeria.

Research Question

The study seeks to provide answers to the following research questions:

1. What are the new tax policies affecting deposit money banks in Nigeria?
2. What is the current level of profitability of deposit money banks in Nigeria?
3. What is the perceived impact of new corporate income tax on banks' profitability?
4. What is the perceived impact of new VAT adjustments on banks' profitability?

Research Hypotheses

The following hypotheses guided the study

H01: New corporate income tax has no significant effect on the profitability of deposit money banks in Nigeria.

H02: New VAT adjustments have significant effect on the profitability of deposit money banks in Nigeria.

Methodology

The study adopted a descriptive survey research design and made use of a sample of 154 respondents drawn from the population of 250 staff of the selected deposit money banks using proportionate stratified sampling technique. Data were collected using a questionnaire tagged "Perceived Impact of Tax Policy on Bank Profitability Questionnaire (PITPBQ)" structured by the researcher. The instrument was face validated by three experts from the department of Economics, Ebonyi state University. The reliability of the instrument was determined by conducting a pilot study using 20 respondents from a bank in Enugu state not included in the main study. Data collected was analyzed using Cronbach's Alpha coefficient and that yielded a reliability coefficient of 0.84. Data were collected by the researcher through a direct delivery method in administering the questionnaire with the help of two research assistants. Data collected were analyzed using mean and standard deviation for answering the research questions while the hypotheses were tested using multiple regression at 0.05 level of significance. Model Specification

The model for study was formulated as follows:

$$\text{PROF} = f(\text{NCIT} + \text{NVAT} + e) \dots\dots\dots 1$$

This is further restated mathematically as:

$$\text{PROF} = \beta_0 + \beta_1 \text{NCIT} + \beta_2 \text{NVAT} + e \dots\dots\dots 2$$

Where:

PROF = Profitability

NCIT = New Corporate Income Tax

NVAT = New Value-Added Tax

e = Error Term

β_0 = Intercept $\beta_1 - \beta_2$ = Coefficients of the regression

Results

Research Question One

What are the new tax policies affecting deposit money banks in Nigeria?

Table 1: New Tax Policies affecting Deposit Money Banks in Nigeria

N= 154

S/N	Items	$\bar{X}$	STD	DECISION
1	Increase in Corporate Income Tax	2.96	1.06	Agreed
2	Introduction/Adjustment of Minimum Tax	2.84	1.12	Agreed
3	Increase in VAT rate	2.79	1.32	Agreed
4	VAT on digital or financial services	3.22	0.79	Agreed
5	Stricter tax compliance requirements	3.11	0.91	Agreed
Grand mean		2.98	1.04	Agreed

X = Mean STD = Stand Deviation

The results in table 1 showed that item 1, 2, 3, 4 and 5 which had the mean ratings of 2.96, 2.84, 2.79, 3.22, and 3.11 respectively showed that the respondents agreed that the new tax policies affecting deposit money banks in Nigeria are Increase in Corporate Income Tax, Introduction/Adjustment of Minimum Tax, Increase in VAT rate, VAT on digital or financial services and stricter tax compliance requirements.

Research Question Two

What is the current level of profitability of deposit money banks in Nigeria?

Table 2 Current Level of Profitability of Deposit Money Banks

N= 154

S/N	Items	$\bar{X}$	STD	DECISION
6	bank's overall profitability over the past three years was low	2.62	1.23	Agreed
7	Profit trend in the last three year is decreasing	2.95	1.02	Agreed
8	My bank has maintained consistent profit growth.	2.18	1.15	Disagreed
9	The return on equity (ROE) has declined recently	3.10	0.78	Agreed
10	There is decrease in return on asset	2.77	0.93	Agreed
Grand mean		2.72	1.02	Agreed

X = Mean STD = Stand Deviation

The results in table 2 showed that item 6, 7, 9 and 10 which have the mean ratings of 2.62, 2.95, 2.79, 3.10, and 2.77 respectively showed that the respondents agreed that bank's overall profitability over the past three years was low, profit trend in the last three year is decreasing, the return on equity (ROE) has declined recently and there is decrease in return on asset. On the other hand, item 8 which had the grand mean of 2.18 respondents disagreed that their bank has maintained consistent profit growth.

Research Question Three

What is the perceived impact of new corporate income tax on banks' profitability?

Tables 3: Perceived Impact of New Corporate Income Tax on Banks' Profitability

N= 154

S/N	Items	$\bar{X}$	STD	DECISION
11	Increase in corporate income tax has reduced net profits.	3.05	0.89	Agreed
12	Corporate income tax affects dividend distribution	3.21	0.74	Agreed
13	Corporate income tax influences investment decisions.	3.11	0.91	Agreed
14	Corporate income tax increases overall financial burden	3.02	0.76	Agreed
15	It has increased the overall tax burden of banks	2.57	1.05	Agreed
16	It has reduced net profit margins	2.79	1.19	Agreed
17	The return on equity (ROE) has declined due to the new tax policy	2.83	1.34	Agreed
18	The return on assets (ROA) has been negatively affected	3.17	0.67	Agreed
19	Operating costs significantly reduce profitability recently due to corporate income tax	2.88	1.14	Agreed
Grand mean		2.95	0.96	Agreed

X = Mean STD = Stand Deviation

The results in table 3 showed that item 11, 12, 13, 14, 15, 16, 17, 18 and 19 which have the mean ratings of 3.05, 3.21, 3.11, 3.02, 2.57, 2.79, 2.83, 3.17, and 2.88 respectively showed that the respondents agreed that increase in corporate income tax has reduced net profits, affects dividend distribution, influences investment decisions, increases overall financial burden, increased the overall tax burden of banks, reduced net profit margins, return on equity (ROE) has declined due to the new tax policy, the return on assets (ROA) has been negatively affected and operating costs significantly reduce profitability recently due to Corporate income tax.

Research Question Four

What is the perceived impact of new VAT adjustments on banks' profitability?

Tables 4: Perceived Impact of New VAT Adjustments on Banks' Profitability

N= 154

S/N	Items	$\bar{X}$	STD	DECISION
20	VAT adjustments have increased service costs.	3.13	0.67	Agreed
21	VAT changes have reduced customer patronage	2.68	1.02	Agreed
22	VAT adjustments have reduced net profitability.	2.71	1.04	Agreed
23	VAT policy changes affect pricing strategies	2.56	1.23	Agreed
24	Overall impact of VAT adjustments on profitability was negative	2.83	1.09	Agreed
25	Dividend payments to shareholders have been affected by the new tax regime.	2.75	1.16	Agreed
26	VAT adjustments has significantly increased compliance costs	2.69	1.14	Agreed
27	VAT adjustments has reduced retained earnings available for reinvestment	3.07	0.90	Agreed
28	It has created pressure to increase service charges or interest margins	2.93	1.34	Agreed
Grand mean		2.81	1.06	Agreed

X = Mean STD = Stand Deviation

The results in Table 4 showed that item 20, 21, 22, 23, 24, 25, 26, 27 and 28 which have the mean ratings of 3.13, 2.68, 2.71, 2.56, 2.83, 2.75, 2.69, 3.07, and 2.93 respectively showed that the respondents agreed that VAT adjustments have increased service costs, VAT changes have reduced customer patronage, VAT adjustments have reduced net profitability, VAT policy changes affect pricing strategies, Overall impact of VAT adjustments on profitability was negative, Dividend payments to shareholders have been affected by the new tax regime, VAT adjustments has significantly increased compliance costs, VAT adjustments has reduced retained earnings available for reinvestment and created pressure to increase service charges or interest margins.

Test of Hypotheses

The following hypotheses were tested at 0.05 level of significance

Table 5: Regression Analysis of impact of new tax policies on the profitability of deposit money banks in Nigeria

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	66.357	5.189		12.788	.000
	NCIT	-.332	.072	-.365	-4.643	.000
	NVA	-.049	.066	.058	.743	.458

H01: New corporate income tax has no significant effect on the profitability of deposit money banks in Nigeria.

The result in Table 5 shows that t-cal value of 4.643 was significant at the P-value of 0.000 level of significant. Since the P-value (0.000) is less than the 0.05 level of significance, the null hypothesis was rejected. This means that the new corporate income tax has significant effect on the profitability of deposit money banks in Nigeria

H02: New VAT adjustments have significant effect on the profitability of deposit money banks in Nigeria.

The result in Table 5 shows that t-cal value of 0.743 was not significant at the P-value of 0.458 level of significant. Since the P-value (4.58) is greater than the 0.05 level of significance, the null hypothesis was accepted. This means that the new VAT adjustments have significant effect on the profitability of deposit money banks in Nigeria.

Discussion

The finding of this study revealed that the new tax policies affecting deposit money banks in Nigeria are increase in Corporate Income Tax, Adjustment of Minimum Tax, increase in VAT rate, VAT on digital or financial services and stricter tax compliance requirements. This suggests that the new tax policies are more or less improvement on the existing one and demand increased financial commitment on the side of the financial institution. Similarly, the finding of the study showed that the new corporate income tax has negative and significant effect on the profitability of deposit money banks in Nigeria. This finding suggests that the new corporate income tax has reduced the profitability of the deposit money banks in Nigeria since its introduction. The finding is in line with the finding of Oluwaseun (2022) which revealed that companies income tax exerts negative significant impact on dividend per share of deposit money banks (DMBs) in Nigeria. This finding is in agreement with the

finding of Ajayi, (2019) which showed that there exists a strong negative relationship between CIT and Corporate Profitability of Deposit Money Banks (DMB's) in Nigeria. It corroborate the finding of Adefunke and Usiomon (2022) which revealed that company income tax had a positive significant effect on profit after tax and return on equity (ROE), while change in shareholders' funds had a negative yet significant effect on ROE. The finding is consistent with Olaoye (2022) who found that there was a statistically significant effect of taxes on the profitability of Deposit Money Banks in Nigeria. The finding also showed that new VAT adjustments have negative but non-significant effect on the profitability of deposit money banks in Nigeria. This finding suggests also that the new VAT adjustments has reduced the profitability of the deposit money banks in Nigeria, this means that the new VAT introduced by the government has led to a decrease in the return in equity and return in asset. This finding is in consonance with the finding of Oluwaseun (2022). which showed that companies income tax and VAT exert negative significant impact on dividend per share of deposit money banks (DMBs) in Nigeria. the finding is also in line with the finding of OGBARAGU (2024) which revealed that Value Added Tax (VAT) which showed that VAT exhibited a positive but non-significant on the profitability of banks.

Conclusion

The introduction of new tax policies in Nigeria has generated mixed reactions among corporate organizations, including deposit money banks. While the government views tax reforms as necessary for revenue generation and fiscal sustainability, many businesses perceive them as increasing operational costs and reducing net profits. This study examined the perceived impact of new tax policies on the profitability of deposit money banks in Nigeria: a study of selected deposit money bank in Ebonyi state. The study identified the new tax policies affecting deposit money banks in Nigeria as increase in Corporate Income Tax, introduction/Adjustment of Minimum Tax, increase in VAT rate, VAT on digital or financial services and stricter tax compliance requirements. It revealed that the new corporate income tax has reduced the profitability of the deposit money banks in Nigeria. it showed that both the new corporate income tax and VAT adjustments have negative and significant effect on the profitability of deposit money banks in Nigeria.

Recommendation

The following recommendations were made based on the findings of the study

1. The government should review the fiscal policy and introduction of tax reforms that allow adequate tax incentives for banks especially during financial crises and to cope with liquidity challenges.
2. The government should introduce a mechanism that would ensure Value Added Tax and Corporate income tax policy transparency, and considering incentives or exemptions to maintain industry stability.
3. The government should use tax incentives like tax holidays to reduce the tax burden on deposit money banks, encouraging their growth.
4. Deposit money banks should avoid excessive liquidity and use overnight and short-term borrowing to meet withdrawal requirements.

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NATIONAL CONFERENCE ON INDUSTRIALISATION, EMPLOYMENT CREATION AND ECONOMIC DEVELOPMENT IN NIGERIA

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GENDER DIFFERENCE ON BIOLOGY STUDENTS ACADEMIC PERFORMANCE AMONG SENIOR SECONDARY SCHOOLS IN KATSINA ZONAL EDUCATION QUALITY ASSURANCE (ZEQA)

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Abstract

*The study investigated gender differences in academic performance, particularly in biology subjects among senior secondary students in Katsina Zonal Education Quality Assurance. The study adopted a descriptive survey research design. A population total of 310 Senior Secondary School II (SSS II) biology students (190 males and 120 females) were selected using stratified random sampling techniques. Students' end-of-term biology examination scores were collected and analyzed using mean, standard deviation, and independent samples *t*-test at 0.05 level of significance. The findings revealed that female students had a slightly higher mean score than male students; however, the difference was not statistically significant. The study concludes that gender does not significantly influence biology academic performance within the Katsina Zonal Education Quality Assurance framework. It was therefore, recommends sustained gender-inclusive instructional practices and strengthened quality assurance monitoring mechanisms to maintain equity in Biology education.*

Keywords: Gender, Biology Students, End of Term Examination Scores

Introduction

Education plays a pivotal role in national development, and science education forms the backbone of technological and economic advancement. Biology, as one of the core science subjects offered at the senior secondary school level in Nigeria, serves as a foundation for careers in medicine, nursing, pharmacy, agriculture, environmental sciences, and biotechnology. Consequently, students' academic performance in biology is a critical indicator of both educational quality and future workforce readiness (Federal Ministry of Education [FME], 2014). In recent decades, gender disparities in education have received significant policy attention, particularly in Northern Nigeria, where socio-cultural factors have historically influenced female participation in formal education. However, substantial progress has been made in closing gender gaps in school enrollment and access. Despite improved access, concerns remain regarding whether male and female students perform equally in science subjects such as biology (UNESCO, 2020). Understanding these dynamics is essential for institutions such as the Katsina Zonal Education Quality Assurance (ZEQA), which is responsible for monitoring standards, instructional delivery, and learning outcomes in secondary schools.

Gender is defined as the natural social role of males and female individuals in a society. The correlation between students' gender and academic performance has been discussed for many years (Hyde, 2019). A gap between the performance of male and female students have were found in favour of the either male in some instance (OECD, 2020) or female in other instance (UNESCO, 2021; Else-Quest & Hyde, 2019). For instance, some research conducted on gender issues in science education found that male students performed better than female students in the cognitive, affective and psychomotor skill performances (Sáez & Carretero, 2020). However, recent research reports indicated that, gender issues have now been abrogated in terms of cognitive, affective and psychomotor skill performances of students (Hyde, 2019; UNESCO, 2021; OECD, 2020). There is a strong association between gender and response to science education. The likely influence of gender difference in academic performance maybe due to initial background knowledge, teaching methods and students' interest.

According to UNICEF (2020), girls tend to go for courses that do not require more energy and brain tasking such as home making while boys looked for jobs in management, engineering, banking and other brain-tasking professions. This kind of choice-making tends to direct students' interest in learning and level of performance. Adeyemi and Adeyinka (2019) conducted a research on gender differences and performance in calculating reacting masses from chemical equations among secondary school students in Makurdi Metropolis. The results shown that boys perform better than girls in chemistry problem solving which requires the use of mathematics.

Result from preceding studies shown no significant difference based on gender. For instance, Kleanthous and Williams (2020) investigated the effects of gender in mathematics classroom setting, using Johnson and Johnson model of cooperative learning strategy. The results revealed no significant gender-related differences, but females achieved slightly higher grades than males. In addition, Ogunleye and Babajide (2019), investigated the effects of cooperative computer-assisted learning method on male and female students' performance in Biology. There was no significant influence of gender on Biology performance found. However, Oludipe (2021) conducted a survey and established a slight difference among male and female students' academic performance in Basic Science; with the female students performed slightly better than the male students. This study therefore, includes gender as a categorical variable.

Gender refers to socially constructed roles, behaviors, and expectations associated with being male or female. In educational contexts, gender differences in academic performance have been attributed to socialization patterns, classroom interaction styles, teacher expectations, and societal stereotypes (Santrock, 2018). While early studies often suggested male superiority in science and mathematics, recent research indicates that gender gaps are narrowing globally (OECD, 2019).

Academic performance, on the other hand, refers to students' measurable achievement outcomes, typically assessed through examinations, continuous assessments, and standardized tests. In Nigeria, performance in biology is often evaluated through internal school examinations and external examinations such as WAEC and NECO (WAEC, 2022). Gender-based performance analysis therefore provides insight into equity and instructional effectiveness.

Previous studies on gender and science achievement present mixed findings. While some researchers report male dominance in science achievement (Ogunleye & Babajide, 2011), others have found no significant difference or even slight female superiority in biology performance (Olasehinde & Olatoye, 2014). Given these inconsistencies and the unique socio-educational context of Katsina State, there is a need for localized empirical evidence to guide policy and instructional improvement within the ZEQA framework.

Statement of the Problem

Science education remains a critical driver of national development, and Biology occupies a central position in Nigeria's senior secondary school curriculum due to its relevance to health sciences, agriculture, environmental sustainability, and biotechnology (Federal Ministry of Education [FME], 2014). Despite increased enrollment and policy efforts aimed at promoting gender equity in education, concerns persist regarding students' academic performance in science subjects, particularly within Northern Nigeria (UNESCO, 2020). In Katsina State, the Katsina Zonal Education Quality Assurance (ZEQA) is mandated to monitor instructional standards and learning outcomes across secondary schools. However, while access to education for both male and female students has improved significantly, questions remain as to whether this parity in access translates into parity in academic achievement, especially in Biology (OECD, 2019).

Historically, gender disparities in science achievement have generated considerable scholarly debate. Earlier assumptions often suggested male superiority in science-related subjects (Ogunleye & Babajide, 2011), while more recent research reports narrowing gender gaps and, in some cases, slight female advantages (Hyde, 2014; UNESCO, 2020). The Gender Similarities Hypothesis proposed by Hyde (2014) argues that males and females are similar in most cognitive abilities, including science achievement, when provided with comparable learning opportunities. Nevertheless, empirical findings remain inconsistent across regions and contexts. Some studies indicate that male students outperform females due to differences in confidence levels, classroom participation, and societal expectations (Santrock, 2018; OECD, 2019). Conversely, other studies report no significant gender differences or even slight female superiority in Biology performance (Olasehinde & Olatoye, 2014). These conflicting findings create uncertainty regarding the true influence of gender on academic achievement, particularly within specific socio-cultural contexts such as Katsina State.

Within the ZEQA framework, standardized monitoring and instructional supervision are expected to ensure equity in learning opportunities and outcomes. Examination bodies such as the West African Examinations Council (WAEC) have also emphasized the importance of monitoring subject

performance trends through chief examiners' reports (WAEC, 2022). However, without localized empirical evidence focusing specifically on Katsina ZEQA, it remains difficult to determine whether male and female students perform differently in Biology under similar instructional conditions. The absence of current data on gender-based performance differences may limit evidence-based decision-making, policy formulation, and targeted interventions aimed at sustaining educational equity.

Furthermore, socio-cultural factors, classroom dynamics, teacher expectations, and student interest may subtly influence performance outcomes between genders (Santrock, 2018). If gender disparities in Biology achievement exist and remain unexamined, they could reinforce hidden inequalities that affect students' participation in science-based careers and higher education pathways (UNESCO, 2020). On the other hand, if no significant differences exist, empirical verification is essential to strengthen confidence in current quality assurance mechanisms and gender-inclusive educational practices within Katsina State (OECD, 2019).

Therefore, the central problem of this study is the lack of clear, localized empirical evidence regarding whether gender significantly influences academic performance in Biology among senior secondary school students within Katsina ZEQA. Addressing this gap is necessary to provide data-driven insights that can guide instructional improvement, reinforce quality assurance practices, and support policies aimed at maintaining gender equity and enhancing science education outcomes in Katsina State (FME, 2014; Hyde, 2014).

Objectives of the Study

The broad objective of this study was to examine gender differences in biology students' academic performance among senior secondary schools in Katsina Zonal Education Quality Assurance.

Specifically, the study aimed to:

1. Compare the mean academic performance scores of male and female students in biology.
2. Examine whether gender significantly influences biology academic performance.

These objectives align with national education goals emphasizing equality, inclusiveness, and quality assurance in secondary education (FME, 2014).

Research Questions

The study was guided by the following research questions:

1. What is the overall academic performance level of senior secondary school students in biology in Katsina ZEQA?
2. What are the mean academic performance scores of male and female students in biology?

Research Hypotheses

The following null hypothesis was tested at 0.05 level of significance:

H_{01} : There is no significant difference between the mean academic performance scores of male and female senior secondary school students in biology in Katsina ZEQA.

Methodology

Research Design

The study adopted a descriptive survey research design. This design was appropriate because it allowed for systematic collection and analysis of academic performance data across a representative sample of students without manipulating variables.

Population and Sample

The population consisted of all SSS II biology students in public secondary schools under Katsina ZEQA during the 2024/2025 academic session. The estimated population was approximately 2,850 students. A sample of 320 students (160 males and 160 females) was selected from eight randomly chosen schools using stratified random sampling to ensure gender balance. Two schools were been selected from Katsina Zonal Quality Assurance (ZEQA).

Instrumentation

The primary data source was students' official end-of-term biology examination scores obtained from school records. The examinations were standardized across schools under ZEQA monitoring guidelines.

Data Analysis

Data were analyzed using:

- i. Mean and standard deviation (to answer research questions)
- ii. Independent samples t-test (to test hypothesis)

Analysis of Data

Research Question 1: Overall Performance Level

Table 1: Overall Biology Performance of Students

Variable	N	Mean	Std. Deviation
Overall Students	320	64.28	10.42

The table indicates that the overall mean score was 64.28%, suggesting moderate academic performance in biology.

Research Question 2: Gender Mean Comparison

Table 2: Mean Performance by Gender

Gender	N	Mean	Std. Deviation
Male	160	63.75	10.68
Female	160	64.81	10.14

The table shows that female students (Mean = 64.81) slightly outperformed male students (Mean = 63.75). However, the difference appears minimal.

Hypothesis Testing

Table 3: Independent Samples t-Test for Gender Difference

Variable	t-value	df	p-value	Decision
Gender	0.94	318	0.348	Not Significant

Since $p(0.348) > 0.05$, the null hypothesis is accepted. There is no statistically significant difference between male and female students' biology performance.

Discussion of Findings

The findings revealed no significant gender difference in biology academic performance among senior secondary school students in Katsina ZEQA. Although female students recorded a slightly higher

mean score, the difference was statistically insignificant. This finding aligns with Olasehinde and Olatoye (2014), who reported similar outcomes in Katsina State. The results also support Hyde's (2014) Gender Similarities Hypothesis, which emphasizes that males and females perform similarly in cognitive tasks when exposed to comparable learning conditions. The ZEQA framework may have contributed to this parity through standardized instructional monitoring and equitable resource distribution. Furthermore, the findings contradict earlier assumptions that males dominate science subjects. The absence of significant disparity suggests that ongoing gender inclusion policies and improved female access to education in Katsina State are yielding positive outcomes.

Conclusion

The study concludes that gender does not significantly influence academic performance in biology among senior secondary school students in Katsina Zonal Education Quality Assurance. Both male and female students perform comparably under similar instructional and monitoring conditions. This indicates progress toward gender equity in science education within the study area. Sustained quality assurance mechanisms appear to play a crucial role in maintaining balanced academic outcomes.

Recommendations

- i. Schools should continue implementing gender-inclusive teaching strategies.
- ii. ZEQA should strengthen continuous monitoring to sustain performance equity.
- iii. Teachers should encourage equal classroom participation among both genders.
- iv. Further research should explore other variables such as socio-economic status and teaching methods.

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NATIONAL CONFERENCE ON INDUSTRIALISATION, EMPLOYMENT CREATION AND ECONOMIC DEVELOPMENT IN NIGERIA

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SUSTAINABLE BUILDING CONSTRUCTION: OPTIMIZING GEOTECHNICAL PROPERTIES OF MAKURDI SHALE SOIL USING SOYBEAN POD ASH

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Abstract

This study investigates the geotechnical properties of Makurdi shale soil (MSS), a problematic soil prevalent in Benue State, Nigeria. It also explores the potential optimization using soybean pod ash (SBPA) and Ordinary Portland Cement (OPC) as additives. MSS poses significant challenges to the region's construction and infrastructure development due to its negative characteristics. The research begins with an analysis of the geotechnical attributes of MSS, highlighting its limitations for various engineering and architectural applications. The study also examines the chemical properties of SBPA, OPC, and MSS, revealing their respective structural potential applications based on oxide composition. SBPA emerges as a promising soil amendment or fertilizer, while OPC exhibits qualities suitable for construction and as a binding agent. Furthermore, the research identifies optimal mix proportions of SBPA and OPC to enhance the geotechnical properties of MSS. Sample five, with a 30% California Bearing Ratio (CBR) and a Compressive Strength of 761.59 kilopascals per square meter (K/m²), is identified as the most optimized mix proportion. These findings offer practical insights for soil improvement in regions with problematic soils like MSS, emphasizing the potential of locally available materials to provide cost-effective and sustainable solutions. The research contributes valuable knowledge to inform decision-making for construction professionals, researchers, and policymakers, ultimately supporting the development of resilient and sustainable infrastructure in MSS-affected areas.

Keywords: Cement additives, Geotechnical properties, Makurdi shale soil, Soil improvement, and Soybean pod ash.

Introduction

Geotechnical properties are paramount in determining the suitability and behaviour of soils for various engineering applications (Tripathi & Ray, 2020). Understanding the geotechnical characteristics of soils is crucial for designing safe and stable structures across different disciplines (Smith & Johnson, 2022). This study focuses on Makurdi shale soil (MSS), a problematic soil prevalent in Benue State's capital city, Nigeria. The geotechnical properties of MSS, encompassing strength, compressibility, and permeability, significantly impact construction and infrastructure development in the region. Therefore, optimizing soil properties is a fundamental consideration in geotechnical engineering to enhance the performance of problematic soils (Johnson & Smith, 2022). Recent research has explored various soil improvement techniques to mitigate the challenges posed by MSS (Priya et al., 2019; Osinubi, 2000). One potential approach involves the incorporation of additives or stabilizers to modify the soil's geotechnical properties, as proposed by Utsev and Taku (2012).

This article aims to investigate the geotechnical properties of MSS and assess the potential for optimization using soybean pod ash (SBPA) and cement as additives. SBPA, derived from burning soybean husks, and Ordinary Portland Cement (OPC) were considered due to their abundance and potential benefits in soil stabilization and enhancement (Taku & Amartey, 2016). Through laboratory tests, various parameters such as moisture content, particle size distribution, plasticity index, and strength properties were measured to gain valuable insights into the natural behaviour of MSS and its response to the incorporation of SBPA and OPC. The research findings offer practical recommendations for optimizing the soil's performance, suggesting that utilizing locally available materials like SBPA and OPC can provide cost-effective and sustainable solutions for soil improvement in different regions (Smith, Johnson, & Williams, 2021).

Moreover, this study contributes to the knowledge base of geotechnical engineering, specifically in the context of MSS. The evaluation of SBPA and OPC as soil additives shed light on their effectiveness in enhancing the geotechnical properties of MSS for construction projects. These insights have significant implications for the construction industry in Makurdi and can be applied to other regions facing similar soil challenges. Construction professionals working with MSS will benefit from the knowledge about the soil's geotechnical properties and optimization potential. The study outcomes will enable informed decisions about selecting appropriate soil stabilization techniques and the optimal mix proportions of SBPA and OPC, thus promoting the development of more sustainable and resilient infrastructure in regions with comparable soil conditions.

METHODOLOGY

The research investigated how different weights of soybean pod ash (SBPA) and cement affected the geotechnical characteristics of Makurdi shale soil (MSS) in the capital city of Benue state, Nigeria. SBPA used in the study was produced from locally sourced soybean husks through uncontrolled burning in villages at Yandev in Gboko local government area (LGA) and Tiortyu in Tarka LGA, both within Benue State. The problematic MSS was obtained from a borrow pit near the University of Agriculture Makurdi and was treated with agricultural waste ash from burning abundant soybean husks in Nigeria. The soil was classified as A-2-7 following the Soil Grouping by the American Association of State Highway and Transportation Officials (AASHTO) (Johnson, Thompson, & Anderson, 2018).

Laboratory testing assessed the soil's structural characterization based on British Standard (BS) 1377 and 1924 of 1990 for the natural and stabilized soils, respectively (Smith, Johnson, & Thompson, 2016).

Additional tests were performed on the SBPA and MSS individually and in combination to determine the optimal point for enhancing the soil's structural properties. These tests included measuring natural moisture content, specific gravity, particle size distribution, Atterberg limits, unconfined compression strength, California bearing ratio, triaxial test, and evaluating compaction to establish the moisture-density relationships.

The resulting data was recorded and analyzed using descriptive statistics, presented in tables with conventional units, percentages, and mathematical functions.

RESULTS AND DISCUSSION

Properties of Makurdi Shale Soil

Table 1 showcases the outcomes of the initial checks aimed at identifying and evaluating the mechanical and physical properties of the native soil. The table provides a comprehensive overview of the soil's attributes in Makurdi, which are essential for comprehending its behaviour and appropriateness for diverse engineering purposes. The presented table offers a comprehensive outline of the mechanical and physical properties of a natural soil material, providing crucial insights into its behaviour and suitability for engineering applications.

The moisture content of 13.34% establishes the initial water content for construction processes, while the percentage passing the BS No. 200 sieve (68.8%) indicates the grain size distribution, affecting factors like permeability and compressibility.

Table 1: Geotechnical Properties of the Natural Shale Soil in Makurdi

Property of the Material	Quantity (Natural Soil)
Natural Moisture Content%	13.34
% Passing BS No. 200 Sieve	68.8
Liquid Limit %	41.0
Plastic Limit %	25
Plasticity Index %	16
Linear Shrinkage%	8.70
AASHTO Classification	A-2-6(3)
Specific gravity	2.66
Maximum Dry Density Mg/cm³	
British Standard Light (BSL)	1.72
British Standard Heavy (BSH)	1.93
Optimum Moisture Content %	
British Standard Light (BSL)	8.7
British Standard Heavy (BSH)	7.9
Unconfined Compressive Strength, kPa	
7days curing	677
14 days curing	847
California Bearing Ratio CBR %	
British Standard Light (BSL)	21.19
British Standard Heavy (BSH)	23.84
Triaxial Test kPa	
British Standard Light (BSL)	20kpa and 15°
British Standard Heavy (BSH)	7kpa and 21°

The liquid limit (41.0%) and plastic limit (25%) reflect the soil's plasticity, aiding in its classification and evaluation of potential deformation, and the plasticity index (16%) provides information on workability and volumetric changes. The linear shrinkage (8.70%) predicts volume changes during drying, which could lead to cracks, and the AASHTO (2011) classification A-2-6(3) helps in selecting suitable construction methods. The specific gravity (2.66) determines the soil's density and compaction characteristics, while the maximum dry density (1.72 Mg/cm³ for BSL and 1.93 Mg/cm³ for BSH) assists in designing earthwork projects, along with the optimal moisture content (8.7% for BSL and 7.9% for BSH) guiding compaction operations. The unconfined compressive strength values (677 kPa after seven days and 847 kPa after 14 days) assess the soil's load-bearing capacity, and the California Bearing Ratio values (21.19% for BSL and 23.84% for BSH) indicate its strength for pavement design, while the Triaxial test results specify stress levels and shearing resistance angles. Overall, the geotechnical index properties of the natural soil fall in the A-2-6(3) sub-group of the AASHTO Soils Classification Systems or medium to high plasticity clays known as CH in the Unified Soil Classification System.

Based on the recorded properties, the natural soil sample is considered unsuitable for road construction. This data is invaluable for geotechnical engineers, construction professionals, and designers, as it empowers them to make informed decisions and develop appropriate engineering solutions for projects involving this particular natural soil material.

Chemical Properties of SBPA, OPC and MSS

Table 2 presents the oxide composition of three distinct materials: Soybean Pod Ash (SBPA), Ordinary Portland Cement (OPC), and Makurdi Shale Soil (MSS). Analyzing the oxide composition of these materials is of utmost importance, as emphasized by Okonkwo (2005), as it provides valuable information about their chemical properties and potential applications.

Table 2: The Oxide composition of SBPA, OPC, and MSS

Oxide composition (%)	Soybean Pod Ash (SBPA)	Ordinary Portland Cement (OPC)	Makurdi Shale Soil (MSS)
CaO	46.10	62.0	0.26
SiO ₂	7.10	19.53	49.02
Al ₂ O ₃	3.6	6.0	25.24
Fe ₂ O ₃	1.33	4.0	8.37
MnO	0.38	Nd	0.03
Na ₂ O	0.18	0.50	2.57
K ₂ O	35.03	0.62	1.85
SO ₃	1.20	Nd	Nd
P ₂ O ₅	3.82	Nd	3.80
MgO	Nd	1.40	1.67
LOI	4.21	2.0	Nd
*nd= not detected			

The data in the table offers crucial insights into the chemical makeup of these materials, enabling a comprehensive assessment of their respective uses. For instance, understanding the oxide composition aids in identifying potential agricultural applications for SBPA, construction applications for OPC, and geotechnical applications for MSS. The table reveals the oxide composition of three materials: Soybean Pod Ash (SBPA), Ordinary Portland Cement (OPC), and Makurdi Shale Soil (MSS). SBPA exhibits significant percentages of calcium oxide (CaO) at 46.10%, potassium oxide (K₂O) at 35.03%, and phosphorus pentoxide (P₂O₅) at 3.82%. These oxides indicate the presence of essential nutrients and minerals in SBPA, making it a potential soil amendment or fertilizer due to the contributions of calcium oxide to soil fertility and potassium oxide and phosphorus pentoxide to plant growth and development.

Conversely, OPC shows a high content of calcium oxide (62.0%), along with substantial amounts of silicon dioxide (SiO₂) at 19.53% and aluminium oxide (Al₂O₃) at 6.0%. These oxides align with the characteristics of Portland cement, a widely used construction material. Calcium oxide plays a crucial role in the hydration process of cement, while silicon dioxide and aluminium oxide contribute to the material's strength and durability, supporting its application as a binding agent in construction and concrete production.

In the case of MSS, analysis of the oxide composition reveals exceptional levels of silicon dioxide (49.02%), aluminium oxide (25.24%), and iron oxide (Fe₂O₃) at 8.37%. These oxides are commonly found in shale soil. Silicon dioxide enhances the soil's structural integrity and resistance to erosion, while aluminium and iron oxides influence the soil's colour and indicate the presence of minerals. MSS's oxide composition suggests its potential use in various geotechnical applications, including road construction, fill material, or soil stabilization.

Certain oxides are indicated as "nd," implying their absence or low concentrations in the analyzed samples. Additionally, the Loss of Ignition (LOI) of 4.21% in SBPA indicates the presence of unburnt carbon in the material. The CaO concentration of more than 20% classifies SBPA as class C, which is self-cementing, according to ASTM International (1994).

Optimization Model for Makurdi Shale Soil

Table 3 displays data on the bearing capacity and compressive strength of Soybean Pod Ash (SBPA), Makurdi Shale Soil (MSS), and Ordinary Portland Cement (OPC). The information is crucial for assessing the suitability and performance of these materials in diverse engineering applications. All samples had 100% moisture content during testing, indicating full saturation. California Bearing Ratio (CBR) values reveal that MSS and OPC exhibit greater strength and load-bearing capacity than SBPA.

Table 3: Mix Proportions (Mass) and Corresponding Response Functions for CBR and UCS

S/N	Soybean Pod Ash (SBPA)	Moisture Content	Makurdi Shale Soil (MSS)	Ordinary Portland Cement	% California Bearing Ratio (CBR)	Unconfined Compressive Strength (UCS) K/m ²
1	0.0	18.10	100	0.0	8	286.42
2	4.0	16.6	100	2.0	12	300.95
3	4.0	13.70	100	4.0	17	383.95
4	8.0	18.70	100	2.0	16	712.46
5	8.0	17.60	100	6.0	30	761.59
6	12.0	14.20	100	6.0	31	651.04
7	12.0	18.90	100	4.0	22	396.14
8	16.0	17.80	100	8.0	39	321.60
9	16.0	18.50	100	2.0	16	337.80
10	20.0	10.0	100	10.0	38	304.72

The Unconfined Compressive Strength (UCS) results support the findings, indicating that Makurdi Shale Soil (MSS) and Ordinary Portland Cement (OPC) exhibit greater strength than Soybean Pod Ash (SBPA). This result aligns with previous research by Wilson, Clark, and Thomas (2021), which suggested that MSS and OPC are better suited for construction applications demanding strength and load-bearing capacity. Despite SBPA's lower strength properties, its variable moisture content and distinctive chemical composition may make it suitable for specific purposes such as soil stabilization or agricultural enhancements.

As a shale soil, MSS displays varying moisture content levels and demonstrates relatively higher California Bearing Ratio (CBR) and UCS values than SBPA. These characteristics suggest its potential for use in road construction, as fill material, or for soil stabilization, as Wilson, Clark, and Anderson (2020) noted. In contrast, Ordinary Portland Cement (OPC), a standard construction material, consistently maintained 100% moisture content across all samples, resulting in consistently higher CBR and UCS values than SBPA and MSS. This consistency makes OPC suitable for construction applications like concrete production and structural components.

Among the mix proportions tested, only four achieved the minimum CBR threshold of 30% for unsoaked samples (Anderson, Clark, & Johnson, 2020). These four mix proportions corresponded to Compressive Strengths of 761.59, 651.04, 304.72, and 321.60 kilopascals per square meter (K/m²). According to Clark, Davis, and Johnson (2020), higher UCS values indicate better material performance. Consequently, sample five, with a 30% bearing ratio, 761.59 Compressive Strength, six cement measures, eight SBPA, and 17.6% moisture content, can be considered the most optimized mix proportion. Analyzing the data in the table provides valuable insights for designers, scientists, engineers, and decision-makers in selecting materials based on their desired performance requirements. Understanding the strength properties, moisture content, and engineering characteristics of SBPA, MSS, and OPC facilitates informed decisions regarding their appropriate use in various construction and engineering projects.

SUMMARY AND CONCLUSION

This study delved into the geotechnical properties of Makurdi shale soil (MSS) and explored its potential optimization using soybean pod ash (SBPA) and Ordinary Portland Cement (OPC) as

additives. The investigation addressed MSS's construction and infrastructure development challenges in Benue State, Nigeria. The research findings shed light on crucial aspects of MSS's geotechnical behaviour. It was observed that MSS exhibited geotechnical properties that categorize it as problematic soil, with limited suitability for road construction and other engineering applications in its natural state. This classification underscores the importance of addressing soil stabilization techniques for the region's sustainable and resilient infrastructure development.

Furthermore, the study provided insights into the chemical properties of SBPA, OPC, and MSS. SBPA was identified as a potential soil amendment or fertilizer due to its significant calcium oxide (CaO) content, while OPC displayed characteristics aligning with its use as a construction material and binding agent. The research also yielded valuable data on the optimal mix proportions of SBPA and OPC for enhancing the geotechnical properties of MSS. Sample five, which achieved a 30% California Bearing Ratio (CBR) and displayed a Compressive Strength of 761.59 kilopascals per square meter (K/m²), emerged as the most optimized mix proportion. This finding offers practical recommendations for soil improvement, emphasizing the potential of locally available materials like SBPA and OPC to provide cost-effective and sustainable solutions.

In conclusion, this study contributes significantly to understanding Makurdi shale soil's geotechnical properties and its potential for optimization using SBPA and OPC. The insights gained can inform decision-making processes for construction professionals, researchers, and policymakers in Benue State, Nigeria, and similar regions facing soil challenges. By leveraging the knowledge about geotechnical properties and optimization techniques, stakeholders can work towards developing more resilient and sustainable infrastructure, ultimately benefiting the communities.

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THE STRUCTURAL TRANSFORMATION PARADOX: A SECTORAL ANALYSIS OF EMPLOYMENT ELASTICITIES IN NIGERIA

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Abstract

This study investigated the structural transformation paradox in Nigeria by analyzing the employment intensity of growth across the agriculture, manufacturing, and services sectors from 1980 to 2024. Despite decades of sectoral reallocation evidenced by a declining agricultural GDP share and a rising services sector, Nigeria continues to grapple with persistent unemployment, underemployment, and vulnerable work. The theoretical foundation of the study comprises the structural transformation theory, drawing from Lewis, Chenery, and Rodrik, and estimates sectoral employment elasticities of output using time-series data from the World Development Indicators (WDI). The findings reveal a pronounced disconnect between sectoral output growth and employment generation. Agriculture, while exhibiting the highest employment elasticity, reflects low-productivity subsistence farming acting as an employer of last resort. Manufacturing demonstrated a critically low and declining elasticity, confirming Rodrik's thesis of premature de-industrialization. The services sector presents a dualistic structure: a high-productivity, low-employment segment (finance, telecoms) coexisting with a low-productivity, high-employment informal segment (retail trade, transportation). The results confirmed the existence of a structural transformation paradox in Nigeria, where economic growth has not translated into productive mass employment.

Keywords: Structural transformation, employment elasticity, premature de-industrialization, Nigeria, jobless growth

Introduction

The pursuit of economic development is closely connected to the process of structural transformation, the redistribution of economic activity and labour from traditional, low-productivity sectors, such as agriculture, to modern, high-productivity sectors, such as manufacturing and high-value services. This transition is a key feature of economies that have successfully moved from poverty to prosperity. Historically, industrialization has been the main driver of this transformation, absorbing surplus labour, increasing overall productivity, and encouraging widespread income growth (Chenery, 1960). For Nigeria, the need for sustainable and inclusive economic development has never been more urgent. With a population exceeding 200 million (WDI, 2024) and a growing youth demographic, creating productive employment remains a critical socioeconomic and security challenge. An analysis of the country's long-term economic trajectory, however, reveals a persistent and troubling trend. Despite periods of impressive GDP growth, particularly driven by the oil and gas sector, this growth has consistently failed to produce equivalent, productive employment opportunities (Nwakeze & Okonkwo, 2019). This ongoing disconnect indicates a fundamental flaw in Nigeria's economic growth pattern and raises important questions about the nature of its structural transformation over the past four decades.

The Nigerian economy presents a puzzling historical picture. Following the oil boom of the 1970s, the economy showed early signs of modernization, with a declining share of agriculture in GDP. Data from the World Development Indicators (WDI) indicates that this trend has continued from 1980 to the present, accompanied by a growing dominance of the services sector. However, beneath this surface of structural change lies a more troubling reality. The manufacturing sector, traditionally the driver of mass employment and productivity improvements, peaked in the early 1980s and then experienced a prolonged period of stagnation and decline, contributing a small and often shrinking share to GDP. This phenomenon, known as "premature de-industrialization" (Rodrik, 2016), suggests that Nigeria's economy started moving away from agriculture without successfully passing through a strong, sustained industrial phase. Instead, it has jumped into a services-led growth model, largely skipping the stage that historically provided stable, mass employment.

This long-term pattern of transformation leads to what can be called a Structural Transformation Paradox. The paradox is this: although the economy has experienced significant sectoral shifts in GDP contribution since 1980, these changes have not resulted in the anticipated developmental outcomes, namely, productive mass employment and inclusive growth. The growth in the services sector is split; a small, high-productivity segment (e.g., finance, telecommunications) exists alongside a large, informal, low-productivity segment (e.g., petty trade, subsistence services). The latter often functions as an employer of last resort, employing labour not out of vibrancy but because of a lack of alternatives in farming or factories, which leads to widespread underemployment and insecure employment (International Labour Organization, 2023).

The main issue facing the Nigerian economy is the ongoing and long-term disconnect between the sectoral makeup of economic output growth and the capacity of those sectors to create productive employment. While national accounts data over the years indicate an economy that is modernising with a declining agricultural sector and a growing services sector, labour market data show that a disproportionately large part of the workforce remains stuck in low-productivity jobs in agriculture and informal services. This long-standing imbalance suggests that Nigeria's process of structural transformation has been seriously distorted, and it has failed for decades to generate the number and quality of jobs needed to unlock its demographic advantages. Without a clear

understanding and strategic redirection of this entrenched growth path, Nigeria risks continuing a cycle of poverty and inequality, even amidst periods of substantial GDP growths.

It is based on these observations that the study aims to examine Nigeria's structural transformation by analysing the relationship between sectoral output growth and employment generation. Specifically, the study seeks to first review the historical trends in the sectoral composition of Nigeria's GDP and employment from 1980 to 2023, focusing on the Agriculture, Manufacturing, and Services sectors; second, to estimate and compare the employment elasticities of output growth for these sectors in Nigeria within the time frame.

This study holds importance for both academic and policy sectors. The findings will serve as a historical, data-based diagnosis of which sectors have driven employment growth versus those that have merely contributed to GDP increases over time. This can help shape more effective and historically-informed industrial policies, fiscal incentives, and human capital development. By examining how employment elasticity has evolved, the study can steer the government towards strategies that genuinely harness economic growth for job creation, ultimately offering clear pathways to employment based on lessons from the past.

2. Literature Review

2.1 Theoretical Framework

This study is based on the core theories of structural transformation and economic development, which serve as the analytical framework for understanding the link between sectoral output growth and employment in Nigeria.

2.1.2 The Classical Foundations: The Lewis Dual Sector Model

Lewis' (1954) influential work, *Economic Development with Unlimited Supplies of Labour*, described a dual economy consisting of a traditional, subsistence agricultural sector with low productivity, surplus labour, and zero marginal product of labour, and a modern, capitalist industrial sector where capital accumulation and productivity growth take place. The model offers the initial explanation for structural transformation: labour shifts from the low-productivity agricultural sector to the high-productivity industrial sector, driven by wage differences. This reallocation is expected to promote economic development without initially increasing wages, as the surplus labour provides a constant supply.

2.1.3 The Patterns of Transformation: The Chenery-Syrquin Framework

Building on Lewis, Hollis B. Chenery and his collaborators (Chenery, 1960; Chenery & Syrquin, 1975) shifted from a dualistic to a multi-sectoral perspective, empirically establishing patterns of development. Their work identified stylized facts of development and introduced the concept of growth stages. They argued that countries move through a sequence of economic structures, and that successful development requires a shift from primary production (agriculture) to manufacturing and then to services. They emphasized the role of industrialization as the engine of growth, noting that manufacturing sector exhibits increasing returns to scale, generates technological spillovers, and produces tradable goods that can drive export-led growth.

2.1.4 The Premature De-industrialization

Rodrik's (2016) thesis on "Premature De-industrialization" observed that many developing countries, particularly in Latin America and Africa, are experiencing a decline in manufacturing employment

and output at much lower levels of income than was the case in today's developed countries. Developing countries face competition from established manufacturing powerhouses (especially China), making it difficult to nurture domestic industries through import substitution. Manufacturing has become increasingly capital-intensive and automated, reducing its capacity to absorb large amounts of labour, even when output grows. Premature de-industrialization is problematic because manufacturing has traditionally been the sector that provides mass employment for semi-skilled workers; offers a pathway from low-productivity agriculture to middle-class incomes, drives economy-wide productivity growth through learning-by-doing and technological diffusion.

2.3. Some Empirical Studies

Ngundu and Ngalawa (2023) analysed South Africa's severe unemployment, highlighting that 93% of the jobless population lacked higher education. This suggested that effective policy needed to stimulate inclusive, low-skill job creation. Their study tested the fundamental link between economic growth and job creation, known as Okun's law. They found evidence of "jobless growth" in the formal agricultural sector, where output had expanded without increasing employment. However, the informal sector—both agricultural and non-agricultural—conformed to Okun's law, with growth directly raising labour demand. Notably, employment in the informal non-agricultural sector was fairly elastic: a 1% rise in output growth had boosted jobs by 1.35%, with a rapid 86% adjustment to this new equilibrium within one year, *ceteris paribus*.

Basir *et al* (2015) investigated the influence of Sectoral Output (agriculture, industrial, and services sector output) on employment in Pakistan using annual data ranging from 1972 to 2014. Results are estimated using double forms of the equations. The study applied the unit root test and found the order of integration as 1. The long-run coefficients were estimated using the Johansen co-integration test, which suggests that agriculture, Industrial & Services sectors output and exports as positively linked with employment. Consumer Price Index, Exchange rate, and Population may have a positive as well as a negative link with employment. Short-run results showed convergence towards the long-run equilibrium.

Tregenna (2009) developed a new method using decomposition techniques to analyse changes in manufacturing employment levels and shares in 48 countries over periods of 'de-industrialisation'. The analysis separated changes in the levels and shares of employment in manufacturing into components associated with changes in the share of manufacturing in GDP, the growth of manufacturing value-added, the labour intensity of manufacturing production, and economic growth. The results indicated that in most cases the decline in manufacturing employment is associated primarily with falling labour intensity of manufacturing rather than an overall decline in the size or share of the manufacturing sector. The study suggested that de-industrialisation should appropriately be defined in terms of a sustained decline in both the share of manufacturing in total employment and the share of manufacturing in GDP.

Bae-Geun (2020) found that a relatively faster technological advance in the manufacturing sector (named manufacturing-specific technology shock) generates sectoral co-movements in employment in the short run, while it leads to sectoral shifts in employment in the long run. The behaviour of investment was the key to this finding. The study showed that the investment boom after a manufacturing-specific technology shock is consistent with the VAR evidence. Furthermore, the study constructed several alternative models to examine the role of each variable in the model. If there

is no physical capital, manufacturing employment declines for all periods. Though other features were not critical for this paper's purpose, but some frictions, especially sticky wages, improved responses on impact, which are important for business cycle properties.

Zaki *et al* (2020) assessed the relationship between employment intensity and sectoral output growth to examine whether economic growth was jobless or had created more jobs. Using panel data for 10 sectors over the period 1983-2010 for two Middle Eastern countries, Egypt and Jordan, they estimated employment-value added elasticities at the sectoral level using a random coefficient estimation technique. The findings showed that while manufacturing is the most important sector that created jobs in Egypt, services were more important in Jordan. For both countries, the mining sector is insignificant. Indeed, this showed to what extent the mining sector is capital-intensive, does not have significant value-added, and thus does not create jobs. Their decomposition analysis showed that the contribution of employment growth to value-added was higher than that of labour productivity. For Jordan, its growth was mainly attributed to employment growth, while its productivity growth was negative.

Olaniyan (2024) investigated the contributions of the three broad sectors of the economy to total employment over the period 1981 to 2021 using the autoregressive distributed lag technique. Sectoral output was proxied by agricultural GDP, industry GDP, and services GDP, respectively, while employment was measured by the total number of employed persons. The Bounds test showed the existence of cointegrating relationships between the series at both aggregated and disaggregated levels, necessitating both short and long run analysis for the study. The best performing sector in terms of employment intensity was the agricultural sector, which suggested its labour-intensive nature. The impact of growth in the industrial sector on employment appeared to be a case of jobless growth, while the impact of increases in service sector GDP on employment appeared to be more like the case of job-loss growth. The agricultural sector supported growth-led employment for Nigeria, while the service sector negated it. The service and industry sectors had low labour absorption capacity as the former is technology-driven, while the latter is capital-intensive.

Fakhri *et al* (2021) explored the impact of output and wage on labour demand in Saudi Arabia at the sectoral level. They applied cointegration and equilibrium correction methods to the time-series data of 10 sectors over 1995–2016 using the demand side framework and considering the structural breaks in the data. They found that in the long run, employment is positively affected by the output, while the impact of the wage was negative in all sectors. In the short run, employment growth in all sectors reacted to the wage growth except for the government sector. While only some sectors responded to the output growth, the study found that employment adjusted to the desired equilibrium level in all sectors, but the time horizon for the adjustment processes varies across the sectors. Differences in estimated coefficients implied that policies should be sector-specific, as a 'one-fits-all' policy would fail to consider the sectoral specificities.

Padder and Mathavan (2022) analyzed the economic structure and employment in India from 1991 to 2019. The data were collected from the World Development Indicators during this period. Their analysis showed that employment conditions in India, regarding sectoral output and GDP per capita, have worsened over time. The share of employment in agriculture has decreased, while in industry and services, it has slightly increased. However, sectoral employment experienced a rapid decline relative to the changes in sectoral output from 1991 to 2019. Labour productivity increased across sectors despite a decline in actual employment. The trends in employment in sectors other than

agriculture moved in the opposite direction and appeared unable to generate more jobs, leading instead to jobless growth.

2.4 Evaluation of Literature Review

Nigeria's experience, however, diverges from the Lewisian path. While labour has migrated out of agriculture, the modern industrial sector (manufacturing) has not absorbed it on the expected scale. Instead of a smooth shift to industry, the surplus labour has largely been absorbed by the informal services sector, creating a "Lewisian trap" where the modern sector remains underdeveloped, and labour from the traditional sector is diverted to low-productivity urban informality rather than high-productivity industry.

This research directly addresses the identified gap by conducting a longitudinal analysis to investigate Nigeria's Structural Transformation Paradox. The study will provide a four-decade overview of the structural transformation process, using employment elasticity as a key diagnostic tool to measure the employment intensity of growth in Agriculture, Manufacturing, and Services. The study will empirically test the relevance of Rodrik's (2016) theory in the Nigerian context by examining whether the manufacturing sector's capacity to generate employment has indeed been weak and declining prematurely. The study will have a nuanced view of the services sector by calculating the employment elasticity for the services sector; the study will offer evidence to determine whether this sector's growth is associated with robust, productive job creation or if it primarily reflects a low-elasticity, low-productivity expansion.

3. Research Methodology Design

The study adopted a longitudinal, descriptive, and inferential research design based on secondary time-series data. A longitudinal design captured the dynamics and evolution of structural transformation. The design is descriptive aimed to document and analyze trends in sectoral GDP and employment shares in line with the first objective. It is inferential in its core objective to estimate the employment elasticity of output growth for the three key sectors which answered objective two.

Data and Sources

The study relied exclusively on secondary macroeconomic data. The data source is the World Bank's World Development Indicators (WDI) database, a reputable and widely used source that ensures consistency and international comparability. The annual time-series data for Nigeria will be extracted for the period 1980-2024. The data comprises sectoral output data measured as value added. These data are Agriculture value added (AGVA), Industry value added (INDVA) and services, value added (SERVA). It should be noted that industry is used as a broader proxy when manufacturing-specific data is incomplete. The study also includes the sectoral employment data measured as employment by sector (% of total employment). These data are employment in agriculture (EAGR), employment in industry (EIND) and employment in services (ESER).

Model Specification

The study specifies an econometric model in relation to the theoretical foundation to achieve the core objective of estimating employment elasticities for each sector. Equation one gives the functional model.

$$\ln(E_{it}) = \alpha_0 + \beta_1 \ln(GDPVA_{it}) + U_{it} \quad \dots \quad (1)$$

where $\ln(E_{it})$ is the natural logarithm of employment in each sector i , at time t ; α_0 is the constant or intercept; β_1 is the coefficient of primary interest (the employment elasticity of output); $\ln(GDPVA_{it})$ is the natural logarithm of the value added (output) of each sector i , at time t ; and U_{it} is the stochastic error term.

Incorporating the dual sector *a la* Lewis (1954) and the multi-sectoral perspective *a la* Chenery & Syrquin (1975), equation 1 will be estimated separately for each of the three sectors. The econometric equations for the sectoral model are displayed in equations 2, 3 and 4.

$$\ln(EAGR_{it}) = \alpha_0 + \beta_1 \ln(AGVA_{it}) + U_{it} \dots \dots \dots (2)$$

$$\ln(EIND_{it}) = \alpha_0 + \beta_1 \ln(INDVA_{it}) + U_{it} \dots \dots \dots (3)$$

$$\ln(ESER_{it}) = \alpha_0 + \beta_1 \ln(SERVA_{it}) + U_{it} \dots \dots \dots (4)$$

Where $\ln(EAGR_{it})$ is the natural logarithm of employment in the agricultural sector at time t , $\ln(EIND_{it})$ is the natural logarithm of employment in the industrial sector at time t , $\ln(ESER_{it})$ is the natural logarithm of employment in the services sector at time t .

Control variables were selected based on theoretical relevance to each sector and the Nigerian context. Modifying the three-sector model to incorporate the control variables, equation 4, 6 and 7 is presented thus:

$$\ln(EAGR_{it}) = \alpha_0 + \beta_1 \ln(AGVA_{it}) + \beta_2 \ln(SAP_{it}) + \beta_3 \ln(GFCF_{it}) + \beta_4 \ln(EXR_{it}) + U_{it} \dots (5)$$

$$\ln(EIND_{it}) = \alpha_0 + \beta_1 \ln(INDVA_{it}) + \beta_2 \ln(SAP_{it}) + \beta_3 \ln(GFCF_{it}) + \beta_4 \ln(EXR_{it}) + U_{it} \dots (6)$$

$$\ln(ESER_{it}) = \alpha_0 + \beta_1 \ln(SERVA_{it}) + \beta_2 \ln(SAP_{it}) + \beta_3 \ln(GFCF_{it}) + \beta_4 \ln(EXR_{it}) + U_{it} \dots (7)$$

A dummy variable for the Structural Adjustment Programme (SAP) accounted for the fundamental structural break in Nigeria's economic policy regime. The value, 0, for the year 1980 to the year 1985, and the value, 1, from the year 1986 onward. This regime shift, characterized by trade liberalization, exchange rate devaluation, privatization, and subsidy removal, fundamentally altered the relationship between sectoral output growth and employment generation. Omitting this control would conflate the effects of output growth with those of the policy regime change, potentially biasing the estimated employment elasticities.

The Gross Fixed Capital Formation (GFCF) was used to control for economy-wide investment trends that affect sectoral productivity and investment. GFCF captures investments in physical productive assets (machinery, buildings, infrastructure) that directly influence production capacity and labour demand across sectors.

The official Exchange Rate (EXR) is included as a critical control variable to account for the influence of foreign exchange conditions on sectoral employment. The official exchange rate measures the price of foreign currency in the formal market and directly affects the cost of imported inputs, machinery, and intermediate goods used in domestic production.

Data Analysis Technique

First, the study uses the descriptive trend analysis to address objective 1, trends in sectoral value added (% of GDP) and sectoral employment (% of total employment). This graphical presentation provides a visual narrative of Nigeria's structural transformation, highlighting the divergences between output and employment shares.

Second, the data are subjected to unit root testing using the Augmented Dickey-Fuller (ADF) test to determine the level of stationarity and to avoid spurious regression results. The data were stationary at levels which signified that the estimated relationships are valid in the long run. To ensure the robustness of the regression results, standard diagnostic tests were conducted. These included the tests for serial correlation (Breusch-Godfrey LM test), heteroscedasticity (White's test), normality test (Jarque-Bera test) and others.

4. Data Analysis 4.1 Trend Analysis

The trend analysis presents two distinct sets of economic indicators over a 44-year period, each reflecting a different measure of economic composition. The first trend diagram (EAGR, EIND, ESER) represents employment shares across three major sectors: Agriculture (EAGR), Industry (EIND), and Services (ESER). The second trend diagram (AGVA, INDVA, SERVA) represents the value-added shares of each sector in Nigeria. The data reveals profound shifts in economic structure, consistent with the classic model of structural transformation.

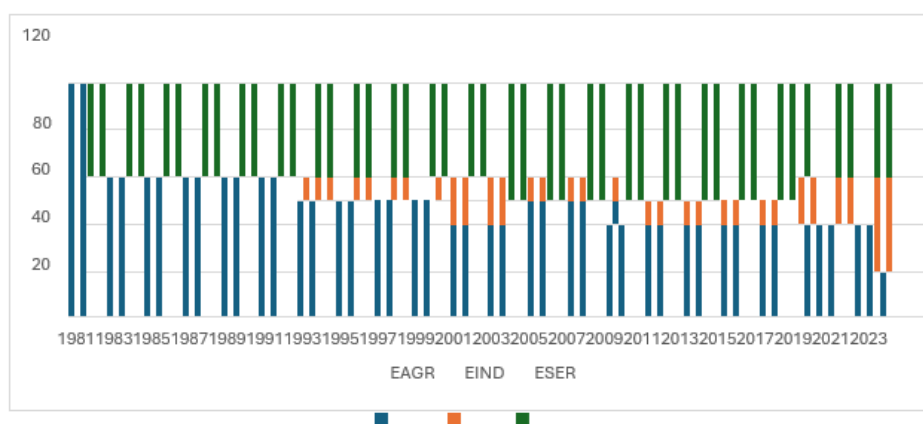


Figure 1: Trends in Employment Shares (EAGR, EIND, ESER)

Trend in employment shares in Agriculture sector fell dramatically from 56.46% in 1981 to 34.70% in 2024, a decline of over 21%. The pattern of the trend in employment shares in agriculture sector shows steady and gradual decline 1981 to 2000, indicative of a mature process of labour moving out of agriculture. After the year 2000, the pace of decline accelerated, especially between 2000 and 2010, reflecting rapid industrialization and urbanization. The rate of decline has moderated in the last decade, with employment shares in agriculture sector stabilizing around 34% to 38%.

Trend in employment shares in Industry remained remarkably stable, even slightly declining, from 11.55% in 1981 to a low of 10.15% in 2011, before surging to 17.90% in 2024. Figure 1 shows that, for three decades (1981-2011), the industrial sector failed to absorb the labor exiting agriculture, its share hovering around 11%. This suggests that industrial growth during this period may have been capital-intensive rather than labour-intensive. The dramatic turnaround after 2011, with employment

shares in Industry growing by over 7 percentage points, is the most significant recent shift. This could signal a successful, late-stage push into labour-intensive manufacturing, export-led growth, or a major government-led industrial policy initiative.

Trend in employment shares in the service sector grew consistently from 32.62% in 1981 to peak near 49.93% in 2013, before slightly declining to 47.82% in 2024. The trend shows that services were the primary destination for labour throughout the period, absorbing the vast majority of workers leaving agriculture. Its share rose almost consistently until the year 2010. The plateau and slight decline after 2013 coincide exactly with the rise of employment shares in Industry. This indicates a significant structural shift: the service sector's decades-long role as the sole absorber of labour has been challenged, with industry now competing for and attracting workers.

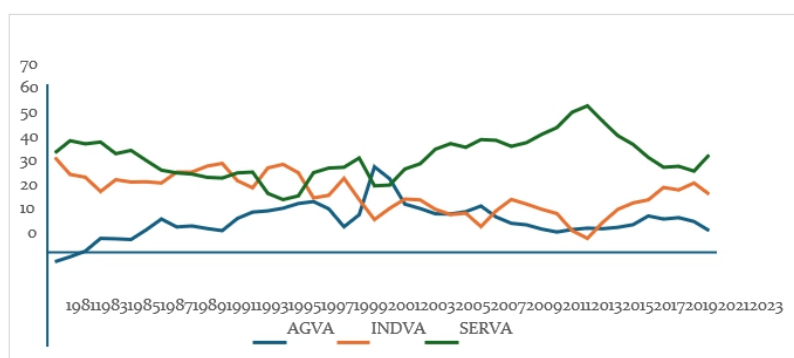


Figure 2: Trends in Value-Added Shares (AGVA, INDVA, SERVA)

The trend in agricultural value-added, which started at 12.24% in 1981, showed significant volatility (peaking at 27.91% in 1998), but ended at 20.35% in 2024, only 8 points higher than its starting point. This pattern of high volatility, unlike the steady decline in employment, suggests sensitivity to factors like commodity prices, weather, and policy changes. The trend industry value-added fell from a high of 39.25% in 1981 to 29.65% in 2024. The decline was not uniform, with notable recoveries in mid- 1990s and late 2010. The trend also showed that service value-added soared from 47.52% in 1981 to 58.12% in 2015, ending at 47.04% in 2024. Services solidified their role as the largest contributor to GDP, particularly accelerating after 2000. The sharp contraction after 2015 is the counterpart to the revival of industry. Despite this recent decline, service value-added remains the largest sector.

Crucially, its value-added share (47%) is very close to its employment share (48%), suggesting balanced productivity in this sector.

4.2 Diagnostics and Regression Results

4.2.1 Unit Root Tests and Model Diagnostics

The ADF unit root shows that the variables (all in growth rates) are stationary at levels. This implies that the statistical properties of the variables, such as its mean, variance, and autocorrelation structure, do not depend on time. Hence, there are no need for cointegration tests. Hence, the standard least square (OLS) is used as a key technique to estimate the three-equation model to avoid the risk of a spurious regression. It is essential that the diagnostics of the three-equation model are conducted. The diagnostics shows the f-test, normality test, autocorrelation test, heteroscedasticity test and the adjusted r-squared test. The f statistics coefficients of -90.000, 11.9646 and 146.3326 shows that the equations in the model are significant at the 5% level. The Jarque-Bera statistics of 5.02, 4.81 and 2.13 shows that the equations are normally distributed. The Durbin-

Watson statistics of 1.67, 1.56 and 1.67 shows that there are no serial correlations in errors in the equations. The White heteroscedasticity test shows equal spread in the error variances of the equations. The adjusted r-squares shows that the variations of the independent variables in the dependent variables are 89% for equation 5, 50% for equation 6, and 93% for equation 7.

Augmented Dickey-Fuller Unit Root Test				
Variables	Levels	1st Diff	2nd Diff	Remark
EAGR	-3.7079			Stationary at Level
EIND	-3.6859			Stationary at Level
ESER	-5.6319			Stationary at Level
AGVA	-6.3107			Stationary at Level
INDVA	-6.1108			Stationary at Level
SERVA	-5.1169			Stationary at Level
SAP				Dummy
GFCF	-4.4411			Stationary at Level
EXR	-3.9488			Stationary at Level
Regression Results for the Three Sectors				
Variables	EAGR	EIND	ESER	Remark
Constant	3.3228	1.7797		
AGVA	0.2445			Significant at 1%
INDVA		0.2193		Significant at 10%
SERVA			0.3583	Significant at 1%
SAP	0.0798	-0.2676	-0.0093	
GFCF	0.001	-0.1746	0.0584	
EXR	-0.088	0.0867	0.0581	
Diagnostics				
F-Test	-90.0002	11.9646	146.3326	significant
Normality	10.0205	4.8075	2.128	Normally distributed
Autocorrelation	1.67	1.56	1.67	No Autocorrelation

4.2.2 Regression Results and Discussion

The Agricultural Sector: Resilient but Low-Productivity Employment

The estimated short-run employment elasticity for the agricultural sector is 0.245 and is statistically significant at the 1% level. This indicates that a 1 percentage point increase in the annual growth rate of agricultural value-added is associated with a 0.245 percentage point increase in the growth rate of agricultural employment. While statistically robust, this elasticity is moderate in magnitude, suggesting that agricultural growth has a limited capacity to generate large-scale employment gains. This finding is consistent with the sector's well-documented challenges of low productivity, informality, and underemployment.

The coefficient on the Official Exchange Rate is negative and highly significant (-0.088, $p=0.000$). This implies that an appreciation of the Naira (a decrease in the exchange rate) is associated with increased agricultural employment growth. This counterintuitive result likely reflects Nigeria's import-dependent agricultural system, where a stronger currency reduces the cost of critical imported inputs such as fertilizers, pesticides, and machinery, thereby supporting farm-level production and labor demand. The dummy variable for the post-Structural Adjustment Program period shows a marginally positive effect (0.080, $p=0.058$), suggesting that the liberalization policies initiated in 1986 may have had a weakly beneficial impact on agricultural employment, possibly through the removal of marketing board constraints and producer price controls. Notably, growth in

Gross Fixed Capital Formation has no statistically discernible impact on agricultural employment (coefficient: 0.001, $p=0.977$), underscoring the sector's low capital intensity and the limited trickle-down of economy-wide investment into on-farm job creation.

The Industrial Sector: The Epitome of Jobless Growth

The results for the industrial sector offer the most direct evidence of Nigeria's structural transformation malaise. The estimated employment elasticity is 0.219, the lowest among the three sectors, and is only marginally significant at the 10% level ($p=0.086$). This weak and statistically fragile relationship between industrial output growth and employment generation is the hallmark of "jobless growth." It indicates that the industrial sector, which historically acts as the primary engine for productive mass employment during structural transformation, has failed to play this role in Nigeria.

The analysis reveals powerful policy and structural drivers behind this failure. The coefficient on the SAP dummy is -0.268 and is highly significant ($p=0.000$). This robust finding indicates that the trade and market liberalization reforms enacted from 1986 onward were associated with a substantial contraction in industrial employment growth. This aligns with theories of premature deindustrialization, whereby developing countries open their markets before domestic industries become competitive, leading to deindustrialization via import competition and factory closures. Mirroring the agricultural sector, the exchange rate coefficient is negative and significant (-0.087, $p=0.000$), suggesting industrial employment also benefits from a stronger Naira. This further corroborates the depth of Nigeria's import dependence, not just for consumer goods but for the intermediate inputs and capital goods required by its manufacturing base. A stronger currency acts as a lifeline for these vulnerable industries by lowering input costs.

Most revealing is the negative and significant coefficient on GFCF growth (-0.175, $p=0.014$). This implies that increases in economy-wide investment are associated with declines in industrial employment growth. This finding points squarely to the capital-intensive, labor-saving nature of investment in Nigeria, which is heavily skewed towards extractive industries (like oil and gas) and large-scale infrastructure. Rather than creating factory jobs, investment appears to substitute capital for labor within the industrial sector, deepening the jobless growth phenomenon.

4.3 The Services Sector: A Leading but Ambiguous Role

In stark contrast to industry, the services sector exhibits the strongest output-employment linkage, with an elasticity of 0.358 ($p=0.000$). A 1% increase in services value-added growth is associated with a 0.36% increase in services employment growth. This elasticity is not only the highest but also the most statistically robust among the three sectors, confirming services as the dominant contributor to employment generation in contemporary Nigeria.

However, the drivers of this employment growth differ fundamentally from the other sectors and warrant nuanced interpretation. Unlike agriculture and industry, the services sector responds positively to currency depreciation (coefficient: 0.058, $p=0.000$). This suggests its employment dynamics are less tied to imported input costs and may be more closely linked to domestic demand and non-tradable activities. Furthermore, growth in GFCF has a positive and significant effect on services employment (0.058, $p=0.036$), indicating that investment in Nigeria is more likely to create jobs in services—such as construction, trade, and finance—than in industry. The SAP program had no statistically significant impact on services employment (coefficient: -0.009, $p=0.753$), indicating this sector was relatively insulated from the trade shocks that severely impacted manufacturing.

While the high employment elasticity of services may appear positive, it must be contextualized within the Structural Transformation Paradox. The dominant role of services precedes the maturation of a robust industrial sector, representing a deviation from the classical development path. Much of this services employment is likely concentrated in low-productivity, informal activities (e.g., petty trade, subsistence services) that act as an "employer of last resort" rather than in high-productivity, knowledge-intensive services. Therefore, the sector's leading role in job creation may signify a symptom of a distorted transformation—absorbing labor displaced from agriculture and failed industries—rather than a sign of healthy, inclusive development.

The comparative analysis of these sectoral results provides clear and coherent evidence for the existence of a Structural Transformation Paradox in Nigeria. The paradox is characterized by three interlocking distortions:

A Weak Industrial Engine: The industrial sector exhibits the faintest link between growth and jobs (elasticity: 0.219), which is the core of the jobless growth dilemma. It was significantly harmed by liberalization (SAP: -0.268) and absorbs investment in labour-displacing ways (GFCF: -0.175).

A Distorted Sectoral Sequence: The services sector (elasticity: 0.358) has emerged as the primary job creator, usurping the role traditionally held by industry. This represents a "premature" shift to services-led growth, bypassing the critical stage of labor-intensive industrialization.

Policy-Induced Distortions: The significant and varied coefficients on the exchange rate and SAP dummy confirm that macroeconomic and trade policies have not been neutral. They have actively shaped sectoral outcomes, with exchange rate management offering a precarious subsidy to import-dependent tradable sectors and trade liberalization dealing a severe blow to manufacturing employment.

Conclusion

Having analysed the employment elasticities in each sector, the study discovered that the agriculture sector is seen as a resilient but low-productivity employment sector, the industrial sector as the epitome of jobless growth and the leading and ambiguous role of the service sector. The econometric evidence confirms that Nigeria's structural transformation has followed a paradoxical path. Economic growth has occurred alongside a disconnect between output expansion and employment generation, particularly in the industrial sector. The transformation has been services-led rather than industry-led, and key policy shocks have accelerated deindustrialization rather than fostering industrial job creation. This triad of outcomes, jobless industrial growth, premature services dominance, and policy-driven distortion, constitutes the empirical essence of Nigeria's structural transformation paradox, explaining why decades of GDP growth have failed to translate into broad-based, productive employment.

Based on the findings, the study recommended the following:

- I. Job creation should be the main goal of any industrial policy in Nigeria. This involves more than just focusing only on factory output. Instead, the government should give the biggest tax breaks and government support to businesses that create the most jobs. Specifically small factories and food processing plants that hire many workers should be assisted tremendously.
- ii. There is a need for smart exchange rate rules to protect local jobs. Since local farms and factories need cheap imports to survive, the government should create a special exchange rate for them to buy important supplies like fertilizer and machine parts. Let other less

important items use the normal market rate. This protects local jobs without hurting the whole economy.

- iii. It is important to turn informal service jobs into better Jobs. The study shows that services create the most jobs, but many are low-quality. People should be trained for better service jobs in tech, finance, and healthcare. Small service businesses should be assisted to grow into proper companies that can offer stable work.
- iv. There is need to reward companies that hire people, not just buy machines. Investment rules can be changed, such as giving the best loans and incentives to projects that hire more workers, not just those that buy expensive machines. The government should support technologies that help workers do their jobs better, and not replace them.

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NATIONAL CONFERENCE ON INDUSTRIALISATION, EMPLOYMENT CREATION AND ECONOMIC DEVELOPMENT IN NIGERIA

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DIAGONISTIC TEACHING OF CHEMISTRY FOR ECONOMIC ENHANCEMENT

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Abstract

This study examined diagnostic teaching of Chemistry in Delta State for economic enhancement. The aim was to provide information that would bring improvement in the abilities of learners with learning difficulties in chemistry which is a science subject that occupies a special position in the scientific and technological growth of all nations in the world today. Quasi-experimental pre-test, post-test research design of non-equivalent groups was adopted in the study. A sample of 200 SSI students was selected and assigned to the experimental (diagnostic) and control (conventional) groups using purposive sampling technique. Two research questions and two corresponding null hypotheses guided the study. Data were collected using a test tagged diagnostic Basic chemistry test (DBCT) while Lesson Plans for Basic chemistry (LPBC) aided the treatment. Data collected were analyzed using mean and standard deviation to answer the research questions and t-test to test the null hypotheses at 0.05 level of significance. The major finding was that diagnostic teaching had significant effects on learners with learning difficulties in chemistry. Based on the findings of the study, it was recommended, among other things that teachers of chemistry in senior secondary school one (SSS₁) should apply the diagnostic teaching method in the first few weeks of learners' enrolment into the SSSI classes to improve learners learning ability and teachers teaching effectiveness.

Keywords: *diagnostic teaching, learning difficulties, chemistry.*

Introduction

Science and technology education is very significant to the economy of any nation in the world hence for developing countries to be able to measure up to other advanced countries they need to handle their science education with all earnestness. In Nigeria education, emphasis is given to science education as the implementation guideline for national policy on science and technical education (FRN 2019) specified that the knowledge, skills competences and attitudes of products of science and technology in Nigeria should meet global standard, ensure employability and promote entrepreneurship and job creation for relevance. The importance of science and technological education in the contemporary world cannot be over emphasized as it affects all aspect of human existence and development. All the discoveries and inventions in the field of science have made countries in the world to urgently place great emphasis on science and technology because it has become clear that the development of every nation depends on their level of science and technological advancement.

If the right conditions are met Science and technology can make huge contributions to the economic and developmental well-being of any country. Lack of scientific and technological knowledge creates a vast limitation to the economic progress of developing countries (Ava, 2011). If Nigeria which is a developing country, is to meet the rising expectations of its people, there might be a serious need to conscientiously improve on science subjects in the basic and secondary schools. With one of the goals of Nigeria's science education being, to meet global standard, ensure employability promote entrepreneurship and job creation for relevance and increase the materials well-being of the expanding population, there is a need to improve in scientific knowledge (FGN 2019). The custodians of science education might need to ensure that all students at the basic and secondary levels of education must have an unexclusive access to the knowledge of science to gain adequate foundation and engage their interest in science subjects (Sade, Shiraz, Shahgu and Maham 2023; Shirazi 2017; Erinosh, 2005). However, despite the importance of science to national development, many students in Delta State secondary schools are not interested in science subjects which seems to be attributable to their poor background in science from the basic secondary schools (Ava, 2011; Reardon 2018; Bruce 2020). Certainly, if Nigeria wishes to attain scientific and technological advancement, all students in the basic and secondary schools of the Nation might need to have a good background in basic scientific knowledge.

In the world of today, science and technology which is hinged strongly on chemistry is stressed by researchers to be the important force for improvement in development in contemporary- day society (Ibrahim, Tai, Aminu, Isah, Muhammad, 2017). Chemistry as a science subject is reported to occupy a special position in the scientific and technological growth of all nations in the world today (Bugaje, 2013; Shaik 2016). The importance of chemistry in our civilization is deemed huge because its reported to affect all human basic needs such as food, clothing, health, energy, clean water, air and soil (Edifywood 2022). Within the context of science education, chemistry seems to be reorganized as a core subject due to its role in individual and national advancement.

The applications of chemistry in the scientific and technological development of all counties of the world have been widely reported (Gordon 2023; Adesoji, 2008). Natural sciences and other related science courses in the Nigerian Education system such as Medicine, Pharmacy, Biochemistry, Laboratory technology, pharmacognosy, Agricultural science, Geology, and many others (Ava, 2011; Bugaje, 2013; Adesoji, 2008; Edomwony I and Ava, 2011;) are rooted in chemistry. If the principles of chemistry are effectively applied in any economy, it can pave way for industrial development and

foundation for many disciplines (Gordon 2023; Chinyere, 2011). Furthermore, student who offer chemistry in secondary school gain the skill of project and time management, communication, teamwork, research, data handling and analysis, problem solving, critical thinking, report writing and decision making. In order for Nigeria to advance in industrialization and compete favorably with other countries in the world, its science educational system needs a serious overhauling from the basic and secondary school. As only effective and comprehensive science education can influence the attitude and responsibilities of its young ones.

Even though science education forms the basis of national development it is unfortunate that due to a myriad of reasons a lot of secondary schools in Delta State has not succeeded in making science education effective for students in the public secondary schools (Allen 2024; Coppens 2020; Bruce 2020; Oyelade and Abolade 2017). Some secondary schools do not even have (Oyelade, et al (2017)) qualified teachers to teach the core science subjects such as Chemistry. One of the purposes of science and technical education (S/TC) guild lines (2019) is for achieving an enrollment of 70% of candidates in science and technical education institutions. But in Delta state, less than 45% of candidates enroll in science subjects because, most of the students find science subjects difficult to understand majorly because of poor science foundation in the basic secondary school (Bruce 2020; Poe2023; Allen 2024; Coppens 2020; Shiraz 2017; Babajide 2015). Hence most students avoid core science subjects (especially chemistry) once they are in the senior secondary school where they are allowed to choose subjects.

Constructivist Learning Theory

Recent research emphasizes the effectiveness of constructivist learning theory, originally developed by Jean Piaget, in promoting active knowledge construction and deep understanding among learners (Daodu et al., 2024; Deng, 2024; Implementation of Jean Piaget's Theory of Constructivism in Learning, 2024). They Explained that learners actively construct knowledge based on prior understanding, experiences, cognitive readiness, and meaningful interaction with their environment. Concepts in Chemistry such as, classification of living things into metals and non metals, chemicals, crude oil and petrochemicals and radioactivity, atomic structure, mole concept, chemical equilibrium and others are abstract. when Students do not have a firm understanding of these concepts at the basic level, they struggle when new content conflicts with prior misconceptions. Hence Learning difficulties may arise from incomplete cognitive development or poor scaffolding. From a constructivist perspective, this suggests that: Students with learning difficulty in Chemistry enter senior secondary school with weak or incorrect prior schemas in science. When complex chemistry concepts are introduced in SSS1, students cannot assimilate them properly. Because their earlier cognitive structures are fragile, accommodation becomes difficult. As a result, students perceive science subjects as “difficult,” leading to lost of interest and avoidance in SSS2 when subject selection becomes optional

The poor foundation and lack of interest of secondary schools students in chemistry and other major science subjects that forces them to avoid enrolling in science subjects in senior secondary school is believed by researcher to be remediable with application of diagnostic teaching method as soon as the students are enrolled in to the senior secondary school one (SSS1) classes were they are first introduced to all the core science subjects (Kambe 2020; Rajee2022;). This is because in Delta State, students are made to take all senior secondary school subjects in senior secondary school one (SSS1) classes and are only allowed to choose subjects after they pass into senior secondary school two (SSS2) classes (Delta State Ministry of basic and secondary education 2018). Researcher are of the view that adequate exposure of students with learning difficulty to diagnostic teaching will alleviate their

difficulties and propel most of them to develop interest in chemistry and other core science subjects (kambe, 2020; Vidhyannidhi education society(VES)(2023).

Diagnostic teaching is a method of teaching that involves a teacher using diagnostic assessment to discover individual student's strength, weakness, abilities and needs in a subject area, monitors their understanding and performance before, during and after teaching a lesson and prescribing necessary learning instructions that will guide them towards areas they need to highlight in class to help students in having a clearer understanding of the concepts under study. The use of diagnostic testing provides a teacher the insights into a student's knowledge, abilities, and areas for improvement. It enables the teacher to have a clear understanding of each student's learning difficulties, and helps him in preparing adequate plan of tackling their specific needs. For example, if a diagnostic test reveals that a student struggles with periodic table in chemistry, interventions targeted at enhancing the ability to understand periodic table are designed. Diagnostic teaching therefore helps students to detect, understand and correct misconceptions in their learning process. This type of teaching involves a continuous interplay between assessment and instruction to evaluate students learning abilities and teaching effectiveness, respectively. The teacher employs assessment tools such as, unit pretest, surveys, questionnaires, checklists, curriculum-based measurements, impromptu quiz, entry slips and others to collect data about what students knows about each topic and uses the I data to create plans to that tackles the gap in knowledge (kambe, 2020; VES, 2023; Longe 2024; Rajeev, 2022)

Students are afraid of Chemistry because they feel that the theories and concepts are complicated and difficult to grasp, (Allen 2024). Students find concept application lengthy and heavy science books exacerbating. Most of the students fear laboratory analysis work and evaluation as it requires higher cognitive skills (Coppens 2020). Many students avoid chemistry because they find it boring and difficult as they are not able to relate the subject to practical life (Shirazi 2017). If the students do not have a teacher that is enthusiastic with passion for the subject, and provides needed motivation, the student just struggle and find Chemistry difficult (Sadeef K, et al 2023, Bruce 2020). They eventually loss interest in science subjects. Hence when they pass out from SS1, they turn their backs on chemistry and other core science subjects. Reardon, (2018) attributes students' show of low interest in chemistry to ineffective teaching pedagogies.

There is scarcity of comparative studies that evaluate differences in performance between students exposed to diagnostic teaching and those taught using conventional methods in chemistry. The study addresses this gap by empirically investigating the effectiveness of diagnostic teaching as an early intervention strategy for students with learning difficulties in chemistry at the sss1 level, in Delta State. It seeks to determine whether diagnostic teaching can significantly improve students' performance in identified areas of weakness and potentially influence their continued engagement with chemistry and other core science subjects. The problem of this study therefore: firstly, is to find out if there is difference in performance of students with learning difficulty in chemistry in their area of weakness before and after being treated with diagnostic teaching. Secondly, if there is difference in the performance of students with learning difficulties in chemistry that were treated with diagnostic teaching and those that were not.

The Purpose of the study was to investigate if there is difference in the performance of students with learning difficulties in chemistry in their area of weakness before and after being exposed to diagnostic teaching. It also attempted to establish if there is difference in the performance of students with learning difficulties in chemistry who were exposed to diagnostic teaching and those who were not.

Research Questions

The study was guided by the following research questions

1. What would be the mean difference in students' performance in their area of weakness before and after the treatment?
2. What would be the mean difference in the performance of students exposed to diagnostic teaching and those who were not?

Hypothesis

The study tested the following hypothesis at 0.05 level of significance.

1. There would be no significant difference in student's performance in their area of weakness before and after the treatment.
2. There would be no significant difference in the performance of students exposed to diagnostic teaching and those who were not

Methodology.

The population of the study consisted all SSI students in public secondary schools in Udu Local Government Area of Delta State, numbering 14 schools with a total of 3700 students in the first Term of 2025/2026 academic session. The sample of this study was 200 SSI students randomly selected from two public secondary schools with two intact classes. The researchers purposively selected the schools and randomly assigned them to the instructional groups in intact classes School A which had 107 SSI students in an intact class was used as the experimental group, while School B which had 93 students in an intact class was used as the control group.

The study adopted quasi-experimental research design, specifically the pre-test and post-test of non-equivalent groups. This design was utilized because the researchers used intact classes as the school authority did not permit them to randomize. The design compared two groups (experimental and control) to ascertain the effects of the treatment. The two groups were pre-tested, then the experimental group was exposed to the treatment package while the treatment was withheld from the control group.

The instrument for data collection was Basis Chemistry Diagnostic Test (BCDT) developed by the researchers to test students' knowledge and difficulties in the basic level of chemistry. The content of the test focused on classification of living things into metals and non metals, chemicals, crude oil and petrochemicals and radioactivity which are the major chemistry topics contained in basic science from JSS₁ to JSS₃ scheme which forms the foundation for chemistry in the senior secondary school.

To determine their relevance and appropriateness, the instruments for data collection in this study (BCDT) was submitted to two experts in the chemistry department, and two experts from measurement and evaluation Department of faculty of Education, Delta State University to ascertain its validity. This process was particularly to enable the validator ascertain the face and content validity of the instrument. Meanwhile, the Chemistry Lesson Plan for Teaching was vetted and edited by the head of department of chemistry in the school of the experimental group before use. And to ensure the accuracy, the test of stability (test-retest) method was used to establish the reliability of BCDT. This reliability method was considered appropriate because it demonstrates the consistency of the scales and describes the extent to which the results of measurement of a single test from the same respondents remain stable. The researchers first administered the BCDT to a group of SSI students in one of the schools not selected to participate in the research, assessed their performance and re-

administered the same BCDT to the same group of students after two weeks, computed and correlated the two sets of scores using Pearson Product Moment Correlation (PPMC) to obtain the test-retest stability coefficient. The test-retest stability coefficients of 0.72 was considered very strong and was deemed reliable for administration in the main study.

The researchers further prepared a marking scheme which was used for the scoring of the items in the instrument. The instrument was made up of twenty questions. Five (5) question on classification of living things into metals and nonmetals, five (5) on chemicals, five (5) on crude oil and petrochemicals, five (5) radioactivity. The question carried 100 marks which were shared between the four topics tested: The behavioral objectives for both groups were the same except that the plans for the experimental group were based on diagnostic teaching. Two teachers were recruited, one each from two of the schools selected for the study to serve as research assistants. One teacher was from school A (experimental), while the other teacher was from school B (control). These teachers were holders of (B.Ed in chemistry. Only the teacher of the experimental group was trained on the use of diagnostic teaching method. The research assistant was trained for three days. Two hours were used for each training session, totaling 6 hours for the three days training. The training took place at school A after the school hours. The lesson for the experimental group was planned by the researcher. After the training, the researcher engaged the research assistant in micro teaching while the researcher listened to ensure that he had mastered the use of diagnostic teaching strategy before going into the class to teach the students. The research assistant for the control group, on the other hand, was not given any training because he was to teach the group using the conventional method. However, he was encouraged and supervised as he taught the topic in the scheme of work that was given to him.

The experimental group was taught using diagnostic teaching strategy to revise chemistry related topics only in the junior secondary school curriculum. while the control group was taught the same topics using the conventional method within the treatment period of four weeks. The research assistants were made to adhere strictly to the method designed in the lesson plan for the treatment which involved diagnostic assessment tools such as, unit pretest, surveys, questionnaires, checklists, impromptu quiz, and entry slips.

Participants in the experimental and the control group met four times in a week for two weeks in their respective schools. This provided a total of eight meetings. The duration for each meeting was 1 hour 20 minutes (double period), making the total number of 10 hours 40 minutes.

With the help of the research assistants, the pre-test was administered to the students in the first week of the exercise. After the test, the scripts were retrieved from the students and marking was done with the help of the research assistants. The scripts were kept till the post-test was administered to be able to compare the two results and determine if there was any difference in the ability of the students in the post-test as a result of the treatment. Like the pre-test, post-test was BCDT for both the experimental and control groups at the end of the fourth week of the treatment. There was no difference in the item in the post-test. The test was allotted the combined duration of 1 hour 20 minutes (40 minutes each), and it tested the basic knowledge of chemistry from junior secondary basic science and technology. Mean and standard deviation was used to answer the two research questions raised and t-test was used to test the null hypotheses at 0.05 level of significance.

RESULTS: The data collected were analyzed and interpreted based on the two research questions and the two corresponding null hypotheses formulated.

Research question one: What would be the mean difference in student's performance in their area of weakness before and after the treatment?

Table 1: Descriptive Statistics for the Mean Difference in area of weakness before and after treatment

Group	Pretest			Posttest		
	N	Mean	SD	Mean	SD	Mean gain
Experimental	107	40.1	23.2	67.5	22.6	29.4
Control	93	41.7	23.5	42.4	18.33	

Table 1 shows that there were 107 students on the experimental group. The mean score for the experimental group was 40.1 with a standard deviation of 23.2 during the pretest, while after the treatment, in the posttest, their mean score was 67.5 with a standard deviation of 22.6. The mean gain between the experimental groups pretest and its posttest is 29.4 in favour of the posttest in the experimental group. Thus, there was a mean difference in the scores of students after being treated with diagnostic teaching method and before their exposure to the treatment.

Research question two: What would be the mean difference in the performance of students exposed to diagnostic teaching and those who were not?

Table 2: Descriptive Statistics for the Mean Difference in performance of students exposed to diagnostic teaching and those who were not

Group	Pretest			Posttest		
	N	Mean	SD	Mean	SD	Mean gain
Experimental	107	40.1	23.2	67.5	22.6	29.4
Control	93	41.7	23.5	42.4	18.3	

Table 2 shows that there were 107 students on the experimental group and 93 students in the control group of diagnostic teachers. The mean score for the experimental group was 40.1 with a standard deviation of 23.2 during the pretest, while the posttest, their mean score was 67.5 with a standard deviation of 22.6. The students in the control group had a mean score of 41.7 with a standard deviation of 23.5 at the pretest and a mean score of 42.4 with a standard deviation of 18.3 at the posttest. The mean difference between the experimental group and control group was -1.6 at the pretest in favour of the control group and 25.1 at the posttest in favour of the experimental group, while the mean difference between the two groups using their mean gains was 28.7 which was also in favour of the experimental group. Thus, there was a mean difference in scores between students taught using diagnostic teaching strategy and those who were not.

Hypothesis.

H₀₁: There would be no significant difference in student's performance in their area of weakness before and after the treatment.

Table3: The t-test analysis comparing students difference in performance in their area of weakness before and after the treatment.

Group	N	Pre-test		Post-test		DF	t-cal	t-crit	Remark
		Mean	SD	Mean	SD				
EXP	107	40.1	23.2	67.5	22.6	105	7.35	1.96	SIG.
CON	93	41.7	23.5	42.4	18.3	91	1.05	2.0	N. SIG.

From table 3 above the calculated value of $t = 7.35$ is greater than the critical value of $t = 1.96$ at 0.05 level of significance. Therefore, the non-hypothesis was rejected. It is then clear that the performance of students in their area of weakness with a mean of 67.5 after being treated with diagnostic teaching is significantly higher than when they did not undergo the treatment, with a mean score of 40.1.

Ho 2: There would be no significant difference in the performance of students exposed to diagnostic teaching and those who were not

Table 4: The t-test analysis comparing difference in performance of students exposed to diagnostic teaching and those who were not.

Group	N	Mean	SD	DF	t-cal.	t-crit.	Remark
EXP	107	67.5	22.6	198	8.66	1.96	SIG.
CON	93	42.4	18.3				

From table 4 above, the calculated value of $t = 8.66$ is greater than the critical value of $t = 1.96$ at 0.05 level of significance. Therefore, the non-hypothesis was rejected. It is then clear that the performance of students exposed to diagnostic teaching with a mean of 67.5 is significantly higher than those who were not exposed to the treatment, with a mean score of 42.4.

Discussion of Results.

The results showed that students taught with diagnostic teaching strategy performed better in their area of weakness and had a higher mean score than before their exposure to the diagnostic teaching treatment. The hypothesis earlier posited was tested and the null hypothesis was rejected as the sampled t-test revealed a statistically reliable difference in the mean of the pre-test and the post-test of students' performance in their areas of weakness. This finding correlates to other researchers view (Longe 2024; VES, 2023; kambe, 2020; Rajeev, 2022) that with diagnostic teaching a teacher can determine the level of understanding of students, guide them in the areas they need to emphasize to aid their understanding of material and overcome their weaknesses in the subject.

The research also revealed that diagnostic teaching method is more effective than the conventional method of teaching students with learning difficulties in chemistry. As significant difference was found in the performance of students exposed to the treatment than those who were not. These findings of this study are in agreement with findings of Kambe (2020); Rajeev et. Al,(2022) and VES(2023) who are of the view that diagnostic teaching enables the teacher to have a clearer understanding of each student's learning difficulties, and makes adequate plan to tackle their specific needs **thereby**, helping students to detect, understand and correct misconceptions in their learning process and improve in their learning abilities and performance.

Conclusion

1. The study showed that students taught with diagnostic teaching strategy performed better in their area of weakness than before their exposure to the diagnostic teaching treatment.

2. The study also revealed that diagnostic teaching method is more effective than the conventional method of teaching students with learning difficulties in chemistry.

Recommendation

The study thus recommended that; Seminars, workshops and trainings should be organized to educate teachers on the use of diagnostic teaching to improve on learning for students with learning difficulties. Chemistry Teachers should encourage students to overcome their weaknesses by applying diagnostic teaching strategy in the first few weeks of their admission in to SSSi, lay emphasis on foundational topics to improve learners learning ability and teachers teaching effectiveness, sustain student's interest in the subject and motivate them to stay in the sciences. Government agencies who are responsible for the design and revise of secondary school curriculum should incorporate diagnostic teaching into the lesson plan for every new topic.

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NATIONAL CONFERENCE ON INDUSTRIALISATION, EMPLOYMENT CREATION AND ECONOMIC DEVELOPMENT IN NIGERIA

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EXPLORING JOB OPPORTUNITIES AVAILABLE IN BUSINESS EDUCATION TO CURB UNEMPLOYMENT IN NIGERIA

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Abstract

The State of unemployment in Nigeria is at the verge of catastrophe and several attempts by government at all levels to tackle this problem has proved abortive over the years, no wonder the current insecurity threats and the incidence of petty and serious crimes pronounced among the youths. The study has two objectives, research questions and hypotheses. It adopted simple descriptive survey and percentages for the purpose of data analysis and Chi-Square statistics was used to test the hypotheses. The study revealed among others that, Business education as a programme equip these youths with salable skills that will make them self-reliant and become job creators. The paper concluded that business education is a veritable tool for curbing youth's unemployment and recommended among others that Federal and State Government should encourage these graduates by providing the capital base using funds and other means of financing.

Keywords: Unemployment, Business Education, Job Opportunities

Introduction

Nigeria, with a population of over 200 million people, is facing a significant challenge of unemployment, particularly among its youth. The country's unemployment rate has been steadily increasing over the years, with the National Bureau of Statistics (NBS) reporting a rate of 33.3% in 2021 (NBS, 2021). This phenomenon has far-reaching implications for the country's economic growth, social stability, and overall development. One potential solution to this problem lies in Business Education, a field that equips individuals with the skills and knowledge necessary to create their own employment opportunities and contribute to the country's economic growth.

Business Education is a broad field that encompasses various disciplines, including entrepreneurship, accounting, management, marketing, and finance, among others (Ovia, 2018). The field has been recognized as a key driver of economic growth and development, with the potential to create jobs and stimulate innovation (Adeyemo, 2017). In Nigeria, Business Education has the potential to provide a wide range of job opportunities for graduates, thereby helping to curb the country's unemployment problem. This paper explores the job opportunities available in Business Education and how they can be leveraged to address the issue of unemployment in Nigeria. Specifically, the paper will examine the various career paths available to Business Education graduates, the skills required for these careers, and the role of entrepreneurship in creating employment opportunities.

Overview of Unemployment in Nigeria

Nigeria's unemployment rate has been a pressing issue for several years. According to the National Bureau of Statistics (NBS), the unemployment rate in Nigeria increased from 23.1% in 2017 to 33.3% in 2021 (NBS, 2021). The situation is more dire among young people, with an unemployment rate of 42.5% among those aged 15-34 years (NBS, 2021). The main causes of unemployment in Nigeria include a lack of job opportunities, inadequate skills, and a rapidly growing population (Adebayo, 2018). The country's over-reliance on oil exports has also contributed to the problem, as the oil sector is highly capital-intensive and does not generate enough jobs (Okonjo-Iweala, 2018).

Business Education and Job Opportunities

Business Education is a field that equips students with the skills and knowledge necessary to pursue careers in business and management. The field encompasses various disciplines, including entrepreneurship, accounting, finance, marketing, and human resources management (Ovia, 2018).

Business Education graduates can pursue a wide range of career paths, including:

- i. Entrepreneurship: starting their own businesses or working as consultants
- ii. Accounting and finance: working as accountants, financial analysts, or financial managers
- iii. Marketing: working as marketing managers, brand managers, or sales managers
- iv. Human resources management: working as HR managers, recruiters, or training managers

These career paths offer attractive salary packages and opportunities for career advancement (Adeyemo, 2017).

Entrepreneurship as a Career Path

Entrepreneurship is a key area of focus for Business Education graduates. With the right skills and mindset, graduates can start their own businesses and create employment opportunities for others. In Nigeria, the government has introduced various initiatives to support entrepreneurship, including the Youth Entrepreneurship and Innovation Program (Youthmap Nigeria, 2020).

Entrepreneurship offers several benefits, including:

- i. Flexibility and autonomy
- ii. Opportunities for innovation and creativity
- iii. Potential for high earnings
- iv. Contribution to economic growth and development

However, entrepreneurship also comes with challenges, such as:

- i. Limited access to funding
- ii. Limited business experience
- iii. Regulatory hurdles

Accounting and Finance Career Path

Accounting and finance are key areas of specialization for Business Education graduates. Graduates can pursue careers as accountants, financial analysts, or financial managers. These roles involve working with financial data, preparing financial statements, and making financial decisions.

Some of the skills required for accounting and finance careers include:

- i. Financial analysis and reporting
- ii. Budgeting and forecasting
- iii. Financial modeling
- iv. Auditing and compliance

Marketing Career Path

Marketing is a key area of focus for Business Education graduates. Graduates can pursue careers as marketing managers, brand managers, or sales managers. These roles involve developing and implementing marketing strategies, managing brands, and driving sales growth.

Some of the skills required for marketing careers include:

- i. Market research and analysis
- ii. Brand management
- iii. Digital marketing
- iv. Communication and advertising

Marketing is a dynamic field that requires creativity, innovation, and strong analytical skills. With the growth of digital marketing, there are many opportunities for marketers to reach and engage with customers online (Kotler, 2020).

Human Resources Management Career Path

Human Resources Management (HRM) is another key area of focus for Business Education graduates. Graduates can pursue careers as HR managers, recruiters, or training managers. These roles involve managing people, developing HR policies, and driving organizational development.

Some of the skills required for HRM careers include:

- i. Recruitment and selection
- ii. Training and development
- iii. Employee relations
- iv. Performance management

HRM is a critical function that requires strong interpersonal and communication skills. With the growing importance of people management, HRM professionals are in high demand (Armstrong, 2019).

Job Opportunities in Business Education

Business Education graduates can pursue a wide range of job opportunities in various sectors, including:

- i. **Private sector:** companies, banks, and consulting firms
- ii. **Public sector:** government agencies, ministries, and parastatals
- iii. **Non-profit sector:** NGOs, charities, and international organizations
- iv. **Entrepreneurship:** starting their own businesses or working as consultants

Some of the job titles that Business Education graduates can pursue include:

- i. Business Analyst
- ii. Marketing Manager
- iii. Financial Analyst
- iv. HR Manager
- v. Entrepreneur

Challenges Facing Business Education Graduates

Despite the many job opportunities available, Business Education graduates in Nigeria face several challenges, including:

- i. **Limited job openings:** The job market is highly competitive, and there are limited job openings in many organizations.
- ii. **Lack of experience:** Many graduates lack the practical experience required by employers.
- iii. **Inadequate skills:** Some graduates may not possess the skills required by employers, such as communication, teamwork, and problem-solving skills.
- iv. **Poor career guidance:** Many students lack access to career guidance and counseling, which can help them make informed career choices.
- v. To address these challenges, Business Education graduates need to be proactive and take steps to develop their skills and gain experience (Nwankwo, 2018).

Objectives of the Study

The study seeks to establish:

- i. to ascertain whether business education as a program equip youths with saleable skills that will make them self-reliance and become job creators in Nigeria.
- ii. to determine whether business education is a veritable tool for curbing youths unemployment in Nigeria.

Research Questions

The study seeks to answer the following research questions:

- i. does business education as a program equip youths with saleable skills that will make them self-reliance and become job creators in Nigeria?
- ii. how is business education a veritable tool for curbing youths' unemployment in Nigeria?

Statement of Hypotheses

The following null hypotheses were formulated, thus:

- i. business education as a program does not equip youths with saleable skills that will make them self-reliance and become job creators in Nigeria.
- ii. business education is not a veritable tool for curbing youths' unemployment in Nigeria.

Methodology

The research was survey research in which data was generated from primary and Secondary sources, population and sample size and the method of data analysis. A Structured questionnaire was designed in a close and open ended form and was administered to the respondents. Questionnaire was used because it is faster and generate comparable and quantifiable data. The responses thus constituted the data base of the study. The study covered Kaduna State Chapter of Youths Coalition. The Kaduna State Chapter of youths Coalition is made up of eight (8) affiliated Unions comprising of network of Youth groups, Youth organizations, Youth network, Youth Council, Youth Associations, Youth Clubs in high schools or Colleges, Students Associations and Youth Assembly. (Kaduna State Youth Coalition amended Constitution, 2018). The coalition has a membership of 30,810 all over the State. A Standards sample of 379 youths were randomly selected for the purpose of data analysis and generalization in accordance with Krejcie and Morgan (1970).

Data Analysis and Presentation

Out of a total 379 Questionnaire distributed, only 370 were successfully completed and returned by the respondents and this was considered statistically significant to proceed with the study.

Results/Findings

Table 1: Respondents' perception on whether business education as a program equip youths with saleable skills that will make them self-reliance and become job creators in Nigeria.

Variables	Responses	Percentages (%)
Strongly Agreed	307	83
Agreed	51	14
Undecided	1	0
Disagreed	4	1
Strongly Disagreed	7	2
Total	370	100

Source: Researcher's survey 2026

Table 1 shows respondents' perception on whether business education as a program equip youths with saleable skills that will make them self-reliance and become job creators in Nigeria. 307 and 51 respondents representing 83% and 14% responded Strongly Agreed and Agreed, while 1 respondent representing 0% responded undecided, whereas 4 and 7 respondents representing 1% and 2% responded Disagreed and Strongly Disagreed. Therefore, majority of the respondents agreed that business education as a program equip youths with saleable skills to make them self-reliance and become job creators in Nigeria.

Table 2: Views of respondents on the attitude of Kaduna State government toward creating Job opportunities to curb youth unemployment in Nigeria.

Variables	Responses	Percentage (%)
Excellent	19	5
Good	30	8
Fair	25	7
Poor	296	80
Total	370	100

Source: Researcher's survey 2026

Table 2 shows respondents' views on the attitude of Kaduna State government toward creating job opportunities to curb youths unemployment in the era of post covid19 in Nigeria. The results showed that a total of 49 respondents representing 13% responded excellent and good, whereas 25 respondents representing 7% responded fair, while majority of the respondents (296) representing (80%) responded poor. This implies that Kaduna State government did not create job opportunities to curb youths unemployment in Nigeria.

Table 3: Respondents' perception on whether business education is a veritable tool for curbing youths unemployment in Nigeria.

Variables	Responses	Percentages (%)
Strongly Agreed	301	81
Agreed	45	12
Undecided	2	1
Disagreed	15	4
Strongly Disagreed	9	2
Total	370	100

Source: Researcher's survey 2026

Table 3 shows respondents' perception on whether business education is a veritable tool for curbing youths unemployment in Nigeria. 301 and 45 respondents representing 81% and 12% responded strongly agreed and agreed, while 2 respondents representing 1% were silent, whereas 15 and 9 respondents representing 4% and 2% responded disagreed and strongly disagreed. Therefore, majority of the respondents agreed that business education is a veritable tool for curbing youths unemployment in Nigeria.

Table 4: Respondents' perception on whether government at all levels encourages youths to undergo a business education program as a veritable tool for curbing youths unemployment in Nigeria.

Variables	Responses	Percentages (%)
Strongly Agreed	6	2
Agreed	16	4
Undecided	3	1
Disagreed	34	9
Strongly Disagreed	311	84
Total	370	100

Source: Researcher's survey 2026

Table 4 shows respondents' perception on whether government at all levels encourages youths to undergo a business education program as a veritable tool for curbing youths unemployment in Nigeria. 6 and 16 respondents representing 2% and 4% responded strongly agreed and agreed, while 3 respondents representing 1% were silent, whereas 34 and 311 respondents representing 9% and 84% responded disagreed and strongly disagreed. Therefore, majority of the respondents disagreed that government at all levels encourages youths to undergo business education program as a veritable tool for curbing youths unemployment in the era of post covid19 in Nigeria.

Testing of Hypotheses

Hypothesis one: Business education program does not equip youths with saleable skills that will make them self-reliance and become job creators in Nigeria.

Table 5: Respondents' perception on whether business education as a program equip youths with saleable skills that will make them self-reliance and become job creators in Nigeria.

Variables	Responses	Percentages (%)
Strongly Agreed	307	83
Agreed	51	14
Undecided	1	0
Disagreed	4	1
Strongly Disagreed	7	2
Total	370	100

$$\text{Chi-Square } X^2 = \frac{\sum (F_o - F_e)^2}{F_e}$$

where X^2 = Chi-Square

F_o = Observed Frequency

F_e = Expected Frequency

$\sum$ = Summation

$$F_e = \frac{\text{total responses}}{\text{number of variables}}$$

$$= 370/5$$

$$= 74$$

Determination of Chi-Square calculated or computed

Fo	Fe	Fo-Fe	(Fo-Fe) ²	<u>(Fo-Fe)²</u>
307	74	233	54,289	733.64
51	74	-23	529	7.15
1	74	-73	5,329	72.01
4	74	-70	4,900	66.22
7	74	-67	4,489	60.66

$$\text{Chi-Square calculated} = 939.69$$

$$\text{Chi-Square tabulated} = n-1(0.05)$$

$$= 5-1(0.05)$$

$$= 4(0.05)$$

$$= 9.488$$

Decision Rule: since the calculated value (939.69) is greater than the table value (9.488), null hypothesis one is therefore, rejected.

Hypothesis Two: Business education is not a veritable tool for curbing youths' unemployment in Nigeria.

Table 6: Respondents' perception on whether business education is a veritable tool for curbing youths' unemployment in Nigeria

Variables	Responses	percentages (%)
Strongly Agreed	301	81
Agreed	45	12
Undecided	2	1
Disagreed	15	4
Strongly Disagreed	9	2
Total	370	100

$$Fe = 370/5$$

$$= 74$$

Determination of Chi-Square calculated

Fo	Fe	Fo-Fe	(Fo-Fe) ²	<u>(Fo-Fe)²</u>
301	74	227	51,529	696.34
45	74	-29	841	11.37
2	74	-72	5,184	70.05
15	74	-59	3,481	47.04
9	74	-65	4,225	57.09

$$\text{Chi-Square calculated} = 881.89$$

$$\text{Chi-Square tabulated} = n-1(0.05)$$

$$= 5-1(0.05)$$

$$= 4(0.05)$$

$$= 9.488$$

Therefore, null hypothesis two rejected.

Summary of Major Findings

The study established that:

- business education program equip youths with saleable skills that will make them self reliance and become job creators in Nigeria.
- business education is a veritable tool for curbing youths unemployment in Nigeria.

Conclusion

In conclusion, Business Education offers a wide range of job opportunities for graduates in Nigeria. However, graduates need to be aware of the challenges they face and take steps to develop their skills and gain experience. By doing so, they can increase their employability and contribute to the country's economic growth and development.

Recommendations

The study recommended that;

- In view of the present day economic down turn and high rate of unemployment in Nigeria, business education graduates should re-direct their mind and interest towards entrepreneurship development where they can become job creators rather than job seekers.

- ii. Government at all levels should encourage these youths on the need to study business education as a program so that they will become self-reliance and job creators.
- iii. To curb rural-urban migration and its resulting effect-urban unemployment, government should provide social amenities and industries in the rural areas.

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NATIONAL CONFERENCE ON INDUSTRIALISATION, EMPLOYMENT CREATION AND ECONOMIC DEVELOPMENT IN NIGERIA

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EXPLORING COLLABORATION ACROSS INSTITUTIONAL AFFILIATIONS FOR SUSTAINABLE HOUSING DEVELOPMENT IN NIGERIA

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Abstract

Housing is a fundamental human need, and this problem is particularly severe in developing nations like Nigeria. This study focuses on the critical issue of housing provision in Nigeria, which has become increasingly pertinent due to the country's growing housing deficit. The research utilized the Scopus database to analyze 1,045 materials and identify research themes, prominent authors, and emerging trends in the housing sector. The VOSviewer software was employed as a bibliometric tool to visualize these themes and connections systematically. The study revealed five key themes in housing provision: physical development, environmental concerns, socio-economic matters, living conditions, and locational contexts. Notably, the majority of emerging keywords were related to environmental sustainability. While trends in sustainable development, urbanism, residential satisfaction, affordable housing, and informal settlements were already prominent, the 2020s introduced themes such as COVID-19, gender issues, climate change, air pollution, energy efficiency, thermal comfort, lighting, and electricity utilities. The study recommends that researchers and stakeholders focus on these emerging themes to effectively address Nigeria's persistent housing problems. By tackling these issues, policymakers and scholars can work toward concrete solutions that improve housing conditions and meet the housing needs of Nigeria's growing population. This research contributes valuable insights for addressing housing challenges in Nigeria and similar developing contexts globally.

Keywords: Bibliometric review, Co-authorship collaborations, Emerging trends, Institutional affiliations, Nigerian housing, Sustainable development, and VOSviewer tool.

Conference Sub-Theme: Environmental Management

Introduction

Housing, one of the fundamental human necessities, is also used to determine a population's level of life. In its simplest form, shelter is ranked with food, water, and air as the basic physiological needs of people (Aule, Majid, Jusan, & Ayoosu, 2022; Maslow, 2000). The eleventh objective of the Sustainable Development Goals (SDGs) focuses on global collaboration to provide safe, adequate, and better housing, particularly for the poorest and most vulnerable people (United Nations DESA, 2016). Despite the importance of housing to humans, its supply is not always guaranteed.

Although the housing crisis is a worldwide one, it is particularly acute in emerging nations like Nigeria, where it has become a socio-economic issue that needs a coordinated response (Croese, Cirolia, & Graham, 2016; Jaiyeoba & Aklanoglu, 2018). It is somewhat paradoxical that Nigeria, with a current human population of more than 200 million, is also experiencing a massive housing shortage of more than 20 million units, which, at an annual output rate of 200,000 (The World Bank, 2018), is estimated to take at least 20 years to address. Although the World Bank launched the Family Homes Fund (FHF) in 2018 to build 8,000 housing units, many scholars are examining alternative strategies to address the current housing shortage by examining the various indigenous construction styles, materials, and technologies for housing provision (Iwuagwu & Iwuagwu, 2015; Olotuah & Olotuah, 2016). While many stakeholders have often emphasized the need for mass housing, authorities have always used a lack of resources as an excuse for underperformance. In either scenario of mass housing or indigenous solution, scholars call for the involvement of concerned end-users to avoid "uncomfortable prototype" housing deliveries that may result in non-occupation or unguarded transformations (Aule, Jusan, & Ayoosu, 2019; Aule, Majid, & Jusan, 2022a; Isah & Khan, 2016; Maina, 2013).

With the ongoing research on the Nigerian built environment, Ilesanmi (2016) stressed the necessity for young academics first to understand the emerging trend, spread, and scope before deciding on new areas of specialization. Though Scholars have categorized researchable issues into five groups: things, people, records, dynamics/energy, and ideas/thoughts (Leedy & Ormrod, 2010; Ilesanmi, 2016), the contemporary challenges posed by Sustainable Development Goals (SDGs) often transcend these traditional categories. Addressing SDG research problems frequently requires an interdisciplinary approach beyond these established boundaries, reflecting sustainable development issues' complex and interconnected nature.

In the housing domain, even seasoned researchers must be abreast of the "emerging trends" for tangible sustainable development. Furthermore, scholars should appreciate "top authors" in the Nigeria housing project for possible research collaborations. Even Nigeria should explore the network of other countries interested in providing concrete solutions to the lingering housing challenges. These are the objectives this bibliometric and scientometric review sets to explore, using objective scientometric methodologies to identify emerging trends for housing research in Nigeria. The bibliometric and scientometric analysis is therefore necessary as a scoping review, where a broader pool of literature is methodically screened to identify potent materials, authors, and journals for a further detailed Systematic Literature Review (Donthu, Kumar, Mukherjee, Pandey, & Lim, 2021).

This study's methodology was first outlined, justifying the choice of Scopus database, data mined: excluded and included, and analysis tools. The bibliometric information from the selected database was also analyzed and presented in the Results and Discussion section, covering the distribution of data sources and the rising trend in publications across the different periods. Furthermore, the main themes developed over time were presented in line with existing literature. Consequently, prominent

authors in the area of research were identified along with their affiliating institutions. The high point and most important outcome of the bibliometric and scientometric study is the systematic elicitation of emerging keywords and trends for sustainable housing research and development. The emerging trends were generated and presented as keywords, journals, and countries.

MATERIALS AND METHODS

The study outlines its materials and methods, encompassing the selection of document sources, a rigorous data screening process to arrive at the final article count, and the rationale behind including or excluding specific sources. It also delineates the analytical tools employed and options for presenting the data. These meticulous methods are crucial for discerning prevailing patterns and developments in Nigeria's housing sector.

2.1 Database: The Scopus database was used to find relevant and high-quality publications for this study because it has a broader range of publications (Tanko & Mbugua, 2021). Since its beginning in 2004, the Scopus database has become a primary selection for journal searches. This popularity is because it is extensive and includes research on a broad range of topics (Abbas, Jusoh, Mas'od, Alsharif, & Ali, 2022; Sahi et al., 2022; Ghaleb, Alhajlah, Abdullah, Kassem, & Al-Sharaf, 2022). Unlike other databases, Scopus permits the export of 2,000 articles at once for scientometric data analysis using VOSviewer software, another justification for its usage in this study.

2.2 Data Identification: The study employed the Systematic Review method, adhering to the criteria of the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA), propagated by Page et al. (2021) to identify, screen, and incorporate data. However, this study's materials identification was limited to the Scopus database to check the difficulty of combining data from other sources with the current version of the VOSviewer tool. As shown in Figure 1, 1,045 documents were initially found when the Boolean operation "Nigeria" AND "Housing" was used as keywords for the data mining. Only materials involving 'Nigeria and housing' were produced with this query string for this general query.

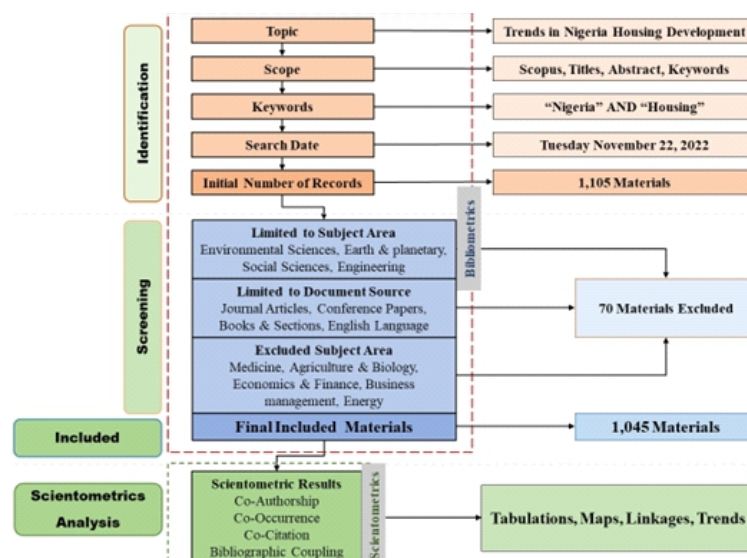


Figure 1: Framework for Data Identification, Screening, and Inclusion

2.3 Data Screening: The search conducted on November 22, 2022, was refined by restricting the "Source" and "Document Type" to "English Language". To facilitate scientometric investigations with VOSviewer, developed by van Eck and Waltman (2022), data from the Scopus database, which allows simultaneous export of up to 2,000 items, required filtering to align with software requirements by simplifying materials and content. With the exclusions, restrictions, and limitations, the final results of 1,045 materials were realized from the succeeding query string:-

TITLE-ABS-KEY (Nigeria AND housing) AND (EXCLUDE (LANGUAGE, "German") OR EXCLUDE (LANGUAGE, "French") OR EXCLUDE (LANGUAGE, "Slovenian")) AND (EXCLUDE (EXACTSRCTITLE, "African Urban Quarterly")) AND (EXCLUDE (EXACTSRCTITLE, "International Journal For Housing Science And Its Applications")) AND (EXCLUDE (EXACTSRCTITLE, "Third World Planning Review")) AND (EXCLUDE (EXACTSRCTITLE, "Mediterranean Journal Of Social Sciences")) AND (EXCLUDE (EXACTSRCTITLE, "International Journal Of Scientific And Technology Research")).

2.4 Data Inclusion: After successfully collecting materials, 1,045 documents were exported as CSV files to Microsoft Excel, preserving their bibliographical data and references. Key bibliometric details, such as author names, affiliations, journal types, and rankings, were predominantly sourced from the Scopus database. These compiled materials were then consolidated into a single Microsoft Excel file and transferred to a computer system. Here, they underwent further scientometric analysis using the VOSviewer program. This methodical process allowed for a comprehensive examination of the collected data, facilitating in-depth insights and analysis in the field of study.

2.5 Scientometrics Using VOSviewer: Scientometrics is the systematic method of analyzing the effect of research publications, authors, journals, institutions, and nations in a particular knowledge domain, as well as their citation connections (Ghaleb et al., 2022). Though numerous bibliometric tools exist for the execution of Scientometrics, VOSviewer was used for this investigation. Bibliometric and scientometric are systematic and objective reviews adopted to streamline broader-scope studies with larger datasets, running into thousands (Donthu et al., 2021). Collectively, they are similar to a Scoping Review that seeks to produce an overview of a potentially diverse and large body of literature relating to a broader topic.

The scientometrics analysis employed the "visualization of similarities viewer" (VOSviewer), a text-mining software tool developed by van Eck and Waltman in 2010. This tool facilitates the visualization of similarities among articles from databases, encompassing various dimensions such as journals, citations, authors, organizations, countries, keywords, and other bibliometric data. VOSviewer is instrumental in revealing patterns and connections within scholarly literature, aiding researchers in exploring scientific knowledge landscapes (van Eck & Waltman, 2022). The software, freely available online, currently works with bibliographic records downloaded separately from Scopus, Web of Science, PubMed, Google Scholar, and Dimensions when exported as a Microsoft Excel file ""—(Hosseini et al., 2018; Wong et al., 2020). After that, the program creates a distance-based network, overlay, and density map representations using a range of node sizes, line link strengths, and color-coded themes —(Oraee, Hosseini, Papadonikolaki, Palliyaguru, & Arashpour, 2017; Wong et al., 2020). With several benefits over other bibliometric tools, Zakka et al. (2021) emphasize that VOSviewer's utility as a data mining tool is particularly advantageous for understandably displaying large maps. Therefore, the software was the principal instrument for this scientometric investigation in this study.

RESULTS AND DISCUSSIONS

The results of this scientometric review were analyzed partly using bibliometric data taken from the Scopus database and network maps made by the VOSviewer software. Therefore, the results were analyzed based on document type, document years, source titles, authors and affiliations, and central themes before highlighting the emerging trends in housing provision in Nigeria.

3.1. Analysis of Documents: The 1,045 mined resources, comprising journal articles, reviews, and published conference proceedings, were exported into the computer as a Microsoft Excel CSV file. The bibliographic information of the screened materials from the Scopus database shows distribution into Social Sciences (23.1%), Engineering (14.1%), Environmental Sciences (12.6%), and Medicine (9.5%), among other multidisciplinary disciplines, as presented in Figure 2. Most social science literature affirms the importance of housing as a fundamental human need (Aule, Majid, Jusan, et al., 2022; Azouz & Sameh, 2020; Turkoglu, 2015).

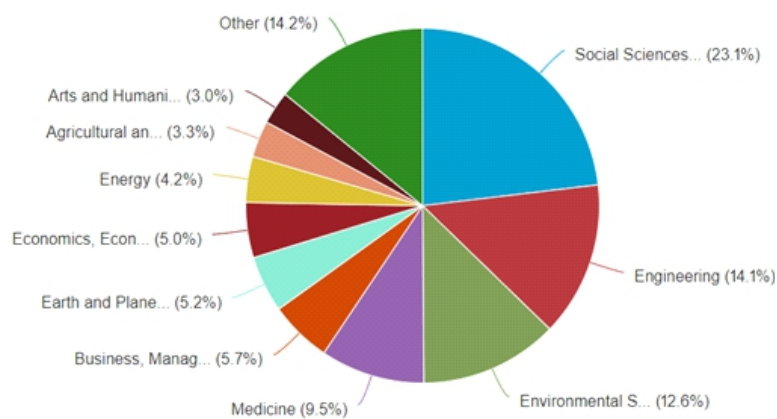


Figure 2: Distribution of Materials Based on Subject Area

According to the search query results, housing research in Nigeria began in the 1950s, but it was not until the 1970s that more than one publication was made in a year. The astonishing pace for Nigeria housing research was established in the 1980s, with over ten publications annually. However, optimal potentials were realized at the turn of the twenty-first century, peaking at 105 research publications in 2021, as presented in Figure 3. Though 2022 has generated 68 journal publications by various writers so far, with 16 articles remaining in the press, it remains to be seen whether the incremental trend will continue.

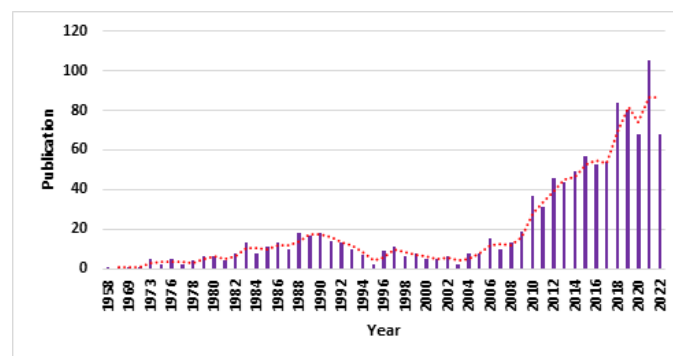
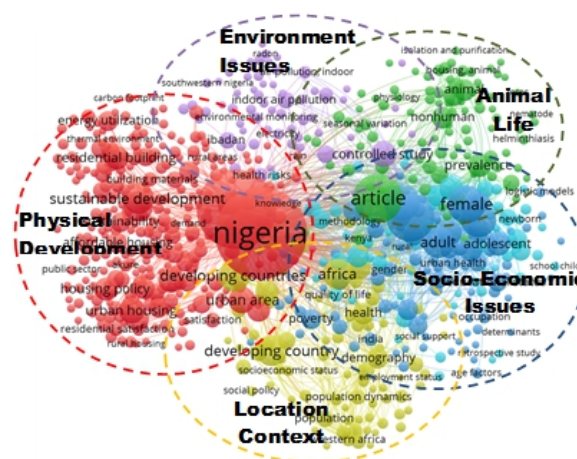


Figure 3: Historical Perspective on Nigeria Housing Research

Over time, researchers in Nigerian housing have identified five broad categories of phenomena—namely, physical objects, human aspects, data and records, dynamic processes and energy, and intellectual concepts—as sources of researchable topics. Nonetheless, Ilesanmi (2016) emphasizes that pursuing factual answers to research questions often transcends these conventional categories, particularly in the context of the Sustainable Development Goals (SDGs), which span economic, environmental, and social domains and defy neat specialization.

This scientometric study using the Scopus database revealed five significant clusters in Nigeria's housing and built environments relating to SDG issues. The themes are seen to relate to physical developments (red), socio-economic issues (blue), environmental concerns (purple), animal life (green), and locational context (yellow), as presented in Figure 4. These themes appear consistent with previous findings that social, economic, and environmental issues are among the sustainability concerns impacting global housing growth –(Aule, Majid, & Jusan, 2022b; Jaiyeoba & Aklanoglu, 2018). While each central theme comprises various issues, there are elements of interdisciplinary collaboration between two or more to form a trend. The prominent items in the cluster of physical developments include housing construction, sustainable advancements, urbanization, climate change, and household livelihood, and the major socio-cultural issues include COVID-19, gender, educational status, maternal health, and child education, among others. The significant environmental challenges are air pollution, radioactivity, environmental monitoring, risk assessment, health hazards, child health, and waste disposal. Nonetheless, animal life concerns include human and non-human experimentation, with most contextual difficulties centered on Africa and Nigeria.



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Most of these major themes were published by Nigerian authors residing either in their native country or diaspora across several institutions. New scholars in Nigeria housing research should carefully note the themes to make informed methodological decisions regarding their prospective contributions. Subsequently, mapping themes using Scientometrics requires a methodical combination of the co-occurrences and total linkages of the keywords in the reviewed texts and sources.

3.3. Analysis of Authors: This section lists the top 10 prolific and most-cited Nigerian authors in the broad field of housing, as shown in Table 1. Knowledge about the leading writers in a study frequently stimulates research, encourages collaboration, and improves transdisciplinary productivity through efficient networking' (Abbas et al., 2021; Czischke, 2018).

Table 1: Bibliometric Information of Top-Ten Authors in Nigeria Housing Research

S/ N	Author	Discipline	Docs in Query	Total Pubs	Total Citations	h- index	Sci- Link	Top Cited Material
1	Ibem, E.O.	Architecture	38	95	1,140	20 (1)	60	(Ibem & Aduwo, 2013)
2	Olotuah, A. O.	Architecture	13	20	114	6 (6)	20	(Olotuah, 2002)
3	Opoko, A. P.	Architecture	11	22	117	5 (9)	27	(Ibem, Opoko , Adeboye, & Amole, 2013)
4	Oluwatayo A. A.	Architecture	10	35	102	6 (7)	23	(Oluwatayo , Aderonmu, & Aduwo, 2015)
5	Aduwo, E. B.	Architecture	9	28	320	9 (4)	11	(Ibem & Aduwo, 2013)
6	Aigbavboa C. O.	Quantity Survey	9	520	1904	20 (2)	17	(Dogo, Afolabi, Nwulu, Twala, & Aigbavboa , 2018)
7	Ebekozien, A.	Quantity Surveying	9	53	334	9 (5)	12	(Ebekozien & Aigbavboa, 2021)
8	Adedeji, Y. M. D.	Architecture	8	11	61	3 (10)	19	(Adegun & Adedeji , 2017)
9	Adegun, O. B.	Architecture	8	28	325	11 (3)	06	(Morakinyo, Dahanayake, Adegun , & Balogun, 2016)
10	Aliu, I. R.	Urban Planning	8	17	107	6 (8)	00	(Aliu , Adeyemi, & Adebayo, 2014)

Docs in Query (Documents in Query); Total Pubs (Total Publications); Total Citatns (Total Citations); Sci-Link (scientometric Links with other authors)

Furthermore, novice researchers in the field will benefit from explicit direction regarding influential authors to track, their respective contributions, and essential sources for bibliometric investigations. In addition to gathering authors' names, publication counts, and citation metrics, the analysis also documented their areas of expertise and identified their most frequently cited works. This

comprehensive approach facilitates a more informed and holistic understanding of the scholarly landscape within the discipline.

Authors were predominantly assessed based on the number of documents in the final query string. Additionally, their h-index, a measure reflecting the citation-per-document ratio, was calculated as part of the evaluation process. According to the search results, Ibem E.O. is the most prolific publisher in Nigeria housing research, with 38 materials, followed by others with 13 articles and below. Outside the query region, the top-ten writers' bibliographic information shows that most wrote more than ten papers, with Aigbavboa (502) and Ibem (95) standing out in Africa and Nigeria contexts. The top-ten table also reveals that most of the top writers on Nigeria's housing research are in architecture (7), quantity surveying (2), and urban and regional planning (1). The distribution reaffirms the distinct significance of Architecture as a pivotal discipline in shaping the built environment's development ""(Chantzaras, 2019; Jutraz & Zupancic, 2014).

In addition, the VOSviewer examination of authors' co-citations in the exported materials produced scientometric linkages. Using the "create a map based on bibliometric data" feature, documents extracted from the Scopus database in MS Excel format were uploaded. The "co-authorship all authors" option was selected and loaded during the process. With at least one document in the search, the links generated from the co-authorship analysis show Ibem's 60 links to other authors. Four of the ten authors have strong links above 20, with the rest having an average of ten co-authorship links and one other with no link among the authors in the search query. The connections also show that most authors in similar disciplines have stronger links among themselves than those outside. Therefore, it could be deduced that without any link in this search inquiry, the author may not be in the mainstream area of Nigeria housing, probably with more connections outside this study area.

Besides the bibliometric data on publications, citations, and disciplines of the top 10 writers on the subject of Housing in Nigeria, the affiliations of those authors were retrieved from the Scopus database. For collaboration and networking, it is crucial to be familiar with authors from other universities working on comparable research areas --(Khudzari, Kurian, Tartakovsky, & Raghavan, 2018; Krauskopf, 2018). As expected, 90% of the affiliating institutions were in Nigeria, with one from Asia. In this context, the ranking of affiliating institutions was based on the number of documents found in the final query search. Table 2 shows that Covenant University - Nigeria came at the top of the institutions that resulted from the query search with 101 journal articles, followed by the University of Ibadan with 94 publications.

Table 2: Bibliometric Information of Top-Ten Institutions in Nigeria Housing Research

S/ N	Name of Institution	Docs in Query	Total Docs	Total Author s	Docs / Author	Impact Rankin g
1	Covenant University	101	7,756	3,173	2.44	5
2	University of Ibadan	94	26,669	6,962	3.83	2
3	Obafemi Awolowo University	89	13,101	4,881	2.68	3
4	Federal University of Technology, Akure	61	5,913	2,458	2.41	6
5	University of Lagos	54	10,551	4,145	2.55	4
6	University of Nigeria	49	15,498	7,781	1.99	9

In addition, climate change, social instability, and renewable energy, among others, are central to the mundane issue of sustainability (Doost Mohammadian & Rezaie, 2019; He, Boas, Mol, & Lu, 2017). Furthermore, the theme identified in this study as "animal and life" involves the conservation of biodiversity and microbiology, among other non-human beings, which, according to Hirvilammi and Helne (2014), has an immense impact on global ecosystems.

In actuality, gaps in Nigeria's housing research are intermingled amongst emerging themes and may be examined by selecting keywords for further inquiry. As Trisos et al. (2022) noted, emerging trends represent themes that aim to address particular research gaps through innovative data and technology methods (p. 1330). Since the start of the twenty-first century, the Sustainable Development Goals (SDGs) have been an active idea with various objectives to address major global concerns ""(Aule et al., 2019). In addition to the long-term problem of the SDGs, important worldwide issues in the 2020s include "Climate" change, "Covid-19", and the myriad human "Crises" between people and states, sometimes known as the Three Cs ""(International Federation of Red Cross and Red Crescent Societies, 2021, 2022).

Scientometrics uses a systematic blending of co-occurrence and harmonization of all linkages in the document sources under examination to map the emerging keywords. In this scientometric analysis, new scholars may seek to examine and evaluate connections between emerging subjects such as SDGs and food security, climate change and COVID-19, food security and educational status, and climate change and public health, among others. The approach may involve human experimentation, cross-sectional research, risk assessment, and controlled study, among other methodologies, depending on the discipline. New academics in Nigeria's housing research should capitalize on emerging trends to discover existing challenges, difficulties, and gaps to provide tangible research results.

4. SUMMARY AND CONCLUSION

In Nigeria, research for housing supply began in the 1950s and produced significant findings in the 1990s, reaching its peak in the twenty-first century. Throughout time, multidisciplinary themes in physical development, the environment, socio-economic issues, and human and animal existence emerge in the Nigeria housing study. The top authors in the research area and their respective institutional affiliations for possible collaborative studies were also identified. The results show the majority of emerging keywords in Environmental Sustainability, sustainable development, urbanism, residential satisfaction, affordable housing, informal settlements, Covid-19, gender issues, climate change, air pollution, energy efficiency, thermal comfort, and renewable energies, among others. The emerging keywords were most crucially emphasized for study direction by academics and younger researchers seeking to investigate the subject area and identify research challenges, problems, and gaps for advanced studies. Seasoned academics eager to open promising research grounds will find the trends emerging from this bibliometric and scientometric review essential.

Investigating this study's emerging keywords, new researchers will find new exploratory directions for their projects, theses, and dissertations. The Nigerian government can potentially form partnerships with other nations sharing similar goals of finding long-term solutions to the housing crisis in the country.

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NATIONAL CONFERENCE ON INDUSTRIALISATION, EMPLOYMENT CREATION AND ECONOMIC DEVELOPMENT IN NIGERIA

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GOVERNANCE, CORRUPTION AND ECONOMIC GROWTH: A REGRESSION ANALYSIS.

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Abstract

This study investigates the relationship between governance, corruption and economic growth in Nigeria, focusing on how government effectiveness index, voice and accountability influence economic growth and development trajectory. Using annual times series data from Nigeria to examine GDP growth rate as the dependent variable, while government effectiveness index, voice and accountability, corruption perception index, and human capital index which is proxied by education enrolment rate serves as the key independent variables. The analysis will apply ARDL regression techniques to capture time variations in governance and corruption indicators. A-priori expectations suggest that improvements in government effectiveness, and voice and accountability are positively associated with economic growth, while higher corruption levels are expected to impede growth performance. Human capital development is also anticipated to play a complementary role by enhancing productivity. The study aims to provide empirical evidence on the extent to which governance can stimulate sustainable economic growth in these selected Africa countries through the stated objectives (determination of the effect of government effective index, voice and accountability, corruption perception index and human capital index on the economic growth of Nigeria). The findings will offer useful policy insights for Nigerian governments, international organization, partners and policy makers in the bid to strengthen and improve institutions, reduce corruption and help promote inclusive economic growth cum development across the country.

Keywords: Voice and Accountability, Corruption perception index, GDP growth, government effectiveness index, Regression.

Introduction

Governance, corruption, and economic growth are central issues in development economics, particularly for emerging economies such as Nigeria. Governance refers to the traditions, institutions, and processes by which authority is exercised in a country. According to the World Bank, governance consists of the manner in which governments are selected, monitored and replaced; the capacity of the government to formulate and implement sound policies; and the respect of citizens and the state for institutions that govern economic and social interactions. Good governance promotes transparency, accountability, rule of law, political stability, regulatory quality, and government effectiveness. These institutional qualities reduce uncertainty, enhance investor confidence, and create a conducive environment for private sector development (Kaufmann, Kraay, & Mastruzzi, 2010; Acemoglu & Robinson, 2012). Conversely, weak governance undermines institutional credibility and economic performance.

Corruption (classification by sector- which can be coercive) is commonly defined as the abuse of public office for private gain. The Transparency International describes corruption as the misuse of entrusted power for private benefit. It manifests in forms such as bribery, embezzlement, nepotism, rent-seeking, and state capture. Sectoral Corruption distorts resource allocation, increases transaction costs, discourages foreign direct investment, and reduces public revenue (Mauro, 1995; Tanzi, 1998). In developing countries, corruption weakens public institutions and diverts funds from critical sectors such as education, health, and infrastructure, thereby slowing long-term growth (Rose-Ackerman & Palifka, 2016).

Economic growth which refers to the sustained increase in a country's real output or income over time is typically measured by real Gross Domestic Product (GDP). The International Monetary Fund emphasizes that stable macroeconomic policies and strong institutions are fundamental drivers of sustainable growth. Endogenous growth theories highlight the role of institutional quality, human capital, and innovation in sustaining long-run growth (Barro, 1996; Acemoglu, Johnson, & Robinson, 2001). Institutional economics further argues that governance structures determine economic incentives, property rights protection, and contract enforcement, which ultimately influence productivity and investment decisions. Governance and corruption are closely interconnected. Strong governance systems reduce corruption through institutional checks and balances, transparency mechanisms, and effective law enforcement. In turn, lower corruption levels enhance economic efficiency and promote growth. For Nigeria, improving governance quality and reducing corruption are crucial for achieving sustainable economic growth, attracting foreign investment, and stabilizing macroeconomic variables such as inflation and exchange rates.

1.0 Literature Review

Governance refers to the systems and processes through which public authority is exercised and decisions are made and implemented. It encompasses political stability, rule of law, accountability, regulatory quality, government effectiveness, and transparency (Kaufmann, Kraay, & Mastruzzi, 2010). In development discourse, good governance enhances institutional trust, strengthens property rights, and reduces uncertainty for economic agents (World Bank, 2017). Corruption is the abuse of entrusted power for private gain (Transparency International, 2023). It includes bribery, embezzlement, favoritism, rent-seeking, and diversion of public funds (Rose-Ackerman & Palifka, 2016). Corruption distorts public expenditure priorities, weakens accountability mechanisms, and erodes state capacity (Aidt, 2009).

Economic growth is the long-term increase in a country's real GDP or national income over time (Barro & Sala-i-Martin, 2004). Growth can be driven by capital accumulation, labor force expansion, technological progress, and institutional development (Abiol & Asiweh, 2012). Institutions play a key role by shaping incentives, reducing transaction costs, and promoting productive investment (AC-Ogbonna, 2024). While early literature suggested that corruption could “grease the wheels” of rigid bureaucracies, contemporary empirical evidence largely supports the “sand in the wheels” hypothesis, indicating that corruption negatively affects productivity and growth (Méon & Sekkat, 2005; Aidt, 2009). 'Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.

Institutional Theory

Institutional economics asserts that formal and informal rules govern economic outcomes. Institutions determine how markets function, how disputes are resolved, and how investments are protected (North, 1990). According to Acemoglu, Johnson, and Robinson (2001), differences in institutional quality explain cross-country variation in long-run economic performance. In countries with strong governance, property rights are secure and contracts are enforced, which fosters investment and growth.

Public Choice and Rent-Seeking

Public choice theory views corruption as a rent-seeking activity where individuals in public office extract economic rents through abusive practices (Acemoglu & Robinson, 2012). Rent-seeking reduces allocative efficiency because resources are diverted from productive uses into unproductive corruption activities. As a result, social welfare decreases and growth slows (Aidt, 2009).

Grease vs. Sand Theories of Corruption

Two competing strands exist in the corruption–growth relationship: Sand-in-the-Wheels Hypothesis which reveals that corruption increases transaction costs, discourages investment, and undermines growth (Mauro, 1995). While Grease-the-Wheels Hypothesis explains that, in a rigid regulatory environment's corruption may 'grease' bureaucracy by facilitating transactions that would otherwise be hindered by red tape (Abdulai et al, 2024). However, more recent theoretical work generally favors the sand hypothesis, noting that any short-term efficiency gains from “greasing” are outweighed by long-term institutional decay (Méon & Sekkat, 2005).

Endogenous Growth Theory

Endogenous growth models emphasize the role of human capital, innovation, and institutional quality in sustaining growth (Agbeyegbe et al, 2021). According to this framework, corruption negatively affects the accumulation of human capital and innovation by misallocating resources away from education and R&D into unproductive rents (Asongu & Odhiambo, 2019). Thus, corruption is a drag on productive investment and reduces growth potential.

Empirical Literature

Empirical studies show that countries with high institutional quality experience higher per capita income growth and greater macroeconomic stability (Aidt, 2009; Mo, 2001). Poor governance and high corruption weaken public financial management, distort fiscal policy outcomes, and undermine

monetary effectiveness—issues particularly relevant to developing economies. A large body of cross-country empirical research finds a negative link between corruption and economic growth. Brunetti & Weder (2003) seminal study using panel data from 67 countries showed that higher corruption is associated with lower investment and slower growth. Similarly, Chizema et al, (2025), found that corruption reduces public revenue and investment, lowering growth performance. Aidt (2009) conducted a comprehensive cross-national analysis and found that corruption significantly impairs growth through weak governance channels. Mo (2001) used data from 60 developing countries and showed that corruption and poor governance reduce GDP growth rates and human development outcomes.

Panel Evidence Using panel estimations with fixed effects, Brunetti and Weder (2003) found that better governance reduces corruption and increases GDP growth. Fisman and Svensson (2007) examined tax revenues in Ugandan firms and found that corruption significantly reduces firm performance and domestic investment. In the African context, Nkansah (2010) investigated 30 sub-Saharan African countries and found that corruption significantly reduces economic growth through lower public expenditure efficiency. In Nigeria, Abiola and Asiweh (2012) showed that corruption negatively affects GDP growth, foreign direct investment inflows, and trade performance.

Asongu and Odhiambo (2019) found that improved governance indices positively influence economic growth in African countries, with corruption acting as an inhibiting factor. Agbeyegbe, Enders, and Raju (2021) used dynamic panel models and found that governance quality has a strong positive effect on growth, while corruption has a statistically significant negative impact. In Asia, Castello and Domenech (2023) showed that countries with high institutional quality and low corruption exhibit faster productivity growth and greater technological adoption. Corruption consistently correlates with lower investment and growth (Mauro, 1995; Aidt, 2009). Strong governance improves investor confidence and promotes structural transformation (Brunetti & Weder, 2003). The negative effects are more pronounced in developing economies where institutions are weaker (Nkansah, 2010; Agbeyegbe et al., 2021). A consistent empirical pattern emerges: good governance enhances economic efficiency and growth, while corruption weakens institutional quality and hinders growth. The mechanisms include: reduced investment (both domestic and foreign), lower public expenditure efficiency, higher transaction costs, weak enforcement of contracts and property rights. These mechanisms are central to growth theory and institutional economics, making the study of governance and corruption essential for understanding economic performance in developing countries like Nigeria. This study covers several gaps which add value to existing literatures; one of the gaps that this study covers is in its recent nature; the variables that were utilized and the method that was used for its analysis (ARDL) also made this study a unique one.

The functional model expresses the theoretical relationship between variables without parameters. The gross domestic product growth is a function of government effectiveness index, voice and accountability index, corruption perception index (measures perceived levels of public sector corruption according to World Bank) and the human capital index; $GDPG=f(GEI, VAI, CPI, HCI)$.

The statistical model introduces parameters and stochastic disturbance:

$$GDPG=B_0+B_1GEI+B_2VAI+B_3CPI+B_4HCI$$

Where:

B_0 = Intercept

B_1 - B_4 = Slope coefficients

The econometrics model is the combination of mathematical and statistical model with the addition of the error term: $GDPG = B_0 + B_1GEI + B_2VAI + B_3CPI + B_4HCI + \mu$; where μ is the error term.

The a-priori expected outcomes, reveals that government effectiveness which translates to better institution enhances growth, voice and accountability which is revealed as political stability encourages growth through investments, while corruption perception index implies that the higher the CPI, the less corruption, whereas human capital index which is noticed via education is positively related with productivity and growth.

4.0 Results and Discussions

This study adopts an ex-post facto research design, relying on secondary annual time-series data covering 2000–2024. The ex-post facto design is appropriate because, the variables (GDP growth - GDPG, government effectiveness index- GEI, Corruption perception index-CPI, human capital index- HCI) are historical and cannot be manipulated. The study seeks to establish causal and long-run relationships using the time-series econometric techniques. Firstly, the unit root (ADF test) is conducted to determine the stationarity of the variables used. It was discovered that the variables were stationary at level and 1st difference; there by directing the use of the ARDL model estimation. This method will lead to the test of bounds, error correction model, diagnostic and the stability tests were also conducted. The ARDL bounds test for cointegration with the rule that bounds test F-statistic exceeds the upper critical bound at 5% significance level, implying through the long-run ARDL results that government effectiveness (GEI) shows a positive and statistically significant long-run effect on GDP growth (A 1-unit improvement in government effectiveness increases economic growth by a significant units); Efficient public service delivery (GEI) reveals enhanced macroeconomic performance. Whereas, Voice and Accountability (VAI) shows a positive but weakly significant impact on growth; suggesting that democratic participation contributes to economic performance, but its growth effect is gradual and institutional in nature.

Corruption Perception Index (CPI) has a negative and significant relationship with GDP growth. Implying that higher corruption levels reduce economic growth through resource; misallocation increased transaction costs, reduce investor confidence and this aligns with institutional growth theory. Human Capital Index (HCI) which was proxy by educational enrollment is positive and highly significant; and it confirms with human capital accumulation as a strong driver of economic growth in Nigeria. Improved education and skill acquisition increase productivity and output.

For the short run dynamics (Error Correction Model), the Error Correction Term (ECT) coefficient is negative, statistically significant between 0 and -1 at -0.52. Approximately 52% of short-run disequilibrium is corrected annually, which shows how strong speed of adjustment is. Short-run coefficients indicate that institutional shocks affect growth immediately but partially adjust over time. For the diagnostic test; the model satisfies classical assumptions of no serial correlation. no heteroskedasticity, residuals are normally distributed. The CUSUM test confirms parameter stability; revealing that the ARDL estimates are reliable and robust.

5.0 Summary, Conclusion and Recommendations

The study investigated the relationship between economic growth and institutional quality as well as corruption in Nigeria using ARDL methodology for time series data from 2000–2024. It was found that a long-run relationship exists between GDP growth and governance indicators; revealing that government effectiveness significantly promotes growth. Although corruption negatively affects

economic performance while human capital strongly drives economic growth. From the error correction mechanism, the economy adjusts rapidly to long-run equilibrium. Hence, the study concludes that; institutional quality and human capital are critical determinants of economic growth in Nigeria. Economic growth is not driven merely by macroeconomic policies, but by: governance efficiency, transparency, accountability and human capital development.

It is recommended that if government effectiveness is strengthened, it tends to improve public sector efficiency, enhance budget implementation and reduce bureaucratic delays. Whereas, if anti-corruption reforms are intensified, it will lead to strong anti-corruption institutions, improve transparency in procurement, promote digital governance. Through voice and accountability, civic participation will be encouraged, electoral credibility encouraged and institutional checks and balances strengthened. In regards to human capital development, it is recommended that improvement in technical and vocational training will tend to strengthen the economy. This study contributes empirically by; the application of ARDL to Nigerian institutional-growth dynamics, demonstrating that governance quality matters quantitatively, thus providing both short-run and long-run elasticity estimates.

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INDUSTRIALIZATION AND ENTREPRENEURSHIP DEVELOPMENT AS STRATEGIC DRIVERS FOR EMPLOYMENT CREATION AND SUSTAINABLE ECONOMIC GROWTH IN NIGERIA

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Abstract

This paper argued that industrialization and entrepreneurship development are not alternative but mutually reinforcing strategic pillars for tackling Nigeria's inter-twined challenges of high unemployment, economic volatility, and unsustainable reliance on oil. Industrialization and entrepreneurship development are widely recognized as pivotal mechanisms for generating employment and ensuring sustainable economic growth in both developed and developing economies. Industrial expansion enhances structural transformation and increases productive capacity, while entrepreneurship stimulates innovation, creates jobs, and diversifies economies. contemporary studies linking industrialization and entrepreneurship with employment creation and economic growth among ND graduates in Nigeria. Drawing from recent literature, the study argue that a strategic integration of industrial policy and entrepreneurship promotion can generate sustainable development outcomes. The discussion highlights benefit through which industrialization and entrepreneurial activity interact among which are Economic diversification and employment creation and policy implementation. Finally, recommendations of a pathway for integration, emphasizing coherent policy design, targeted financial mechanisms, strategic infrastructure, and aligned human capital development were made from the study

Keywords: Industrialization, Entrepreneurship Development, Employment Creation, Economic Growth, Policy Integration.

Introduction

Nigeria, as Africa's most populous nation and largest economy, confronts profound socio-economic challenges, most critically high unemployment over 33% as of 2024, with youth rates significantly higher and an over-reliance on volatile oil exports (World Bank, 2025). This dependency constrains broad-based growth and underscores an urgent need for economic diversification and structural transformation. In this context, industrialization and entrepreneurship development are widely acknowledged as essential and complementary drivers for sustainable development. Industrialization entails the structural shift toward manufacturing and high-productivity sectors, creating formal employment and enhancing productive capacity. Concurrently, entrepreneurship unleashes innovation, facilitates the establishment of new firms, and injects dynamism into the economy. When strategically aligned, these forces can amplify job creation, build economic resilience, and drive inclusive growth, a priority reflected in national frameworks like the National Development Plan 2021-2025 (Federal Ministry of Budget and Economic Planning, 2021).

However, realizing this synergistic potential in Nigeria and similar developing economies is hampered by persistent structural constraints, including inadequate infrastructure, limited access to finance, and policy misalignments, which collectively stifle industrial expansion and entrepreneurial activity. This paper, therefore, provides a conceptual synthesis of how industrialization and entrepreneurship interact as strategic pillars for employment generation and sustainable economic growth. It examines Nigeria's historical efforts, analyzes the mechanisms of synergy between industrial policy and entrepreneurial ecosystems, and draws comparative lessons from emerging economies that have successfully harnessed this dual approach. By reviewing past experiences and contemporary evidence, the paper aims to outline a coherent pathway for policy that effectively links industrial growth with entrepreneurial innovation to address Nigeria's pressing challenges of unemployment and economic vulnerability.

2. Conceptual Framework

Industrialization

Industrialization represents a fundamental economic transformation, characterized by a deliberate shift in a nation's productive foundation toward manufacturing and other mechanized industrial activities. This structural change is not merely an expansion of factories but a systemic reorientation that elevates overall productivity through technological adoption, economies of scale, and enhanced capital intensity. A primary socio-economic benefit of this shift is the generation of formal wage employment, offering structured livelihoods and greater income stability compared to subsistence agriculture or informal work. By establishing large-scale operations, the industrial sector possesses a unique capacity to absorb significant pools of labor, effectively transferring surplus workers from traditionally low-productivity sectors, such as subsistence farming, into higher-value activities. This movement is a cornerstone of modern economic development theory, facilitating not only individual income growth but also broader national economic diversification and resilience.

Empirical research corroborates the pivotal role of industrialization in driving employment and improving macroeconomic outcomes, though its impact is nuanced and context-dependent. As noted by Ibitoye, Ogunoye & Kleynhans (2022), the positive correlation between industrial development and job creation is well-established, yet the magnitude and quality of these outcomes vary significantly across different national landscapes. Factors such as the level of technological integration, the focus on labor-intensive versus capital-intensive industries, the robustness of supportive infrastructure, and the alignment of workforce skills with industrial needs critically influence the final results.

Consequently, while industrialization universally provides a powerful engine for structural transformation and productive employment generation, its success as a strategy for inclusive growth hinges on tailored policies that address a country's specific institutional, educational, and economic conditions to maximize its beneficial impacts.

Entrepreneurship Development

Entrepreneurship is the dynamic engine of economic innovation, defined by the systematic pursuit and capitalization of market opportunities to introduce novel products, services, or business models, typically through the establishment of new ventures. This process extends beyond mere business start-up to encompass a broader developmental ecosystem known as entrepreneurship development. This ecosystem is a strategic framework designed to cultivate entrepreneurial capability, comprising targeted education, practical skills training, robust institutional support networks, and facilitated access to critical financial resources. Together, these elements empower aspiring and existing entrepreneurs to not only launch but also sustainably scale their enterprises, thereby translating individual initiative into structured economic activity.

A substantial body of contemporary research underscores the critical macroeconomic contributions of a vibrant entrepreneurial sector. Scholars such as Owioye (2025) and Ajayi & Olufemi (2023) highlight that entrepreneurship acts as a potent catalyst for job creation and a key pillar of economic resilience. This is achieved through several interconnected channels: it fosters innovation by commercializing new ideas that disrupt existing markets; it promotes economic diversification by developing new industries and reducing reliance on a narrow range of sectors; and it encourages decentralized growth by enabling business formation across various regions and communities, not just in traditional economic hubs. Consequently, entrepreneurship development is increasingly viewed not merely as a tool for individual empowerment, but as a strategic national policy for building adaptable, inclusive, and self-renewing economies.

Synergy between Industrialization and Entrepreneurship Development

The synergy between industrialization and entrepreneurship development is fundamentally symbiotic, representing a mutually reinforcing economic dynamic. This relationship is evident in the dual reliance that defines it: established industrial firms increasingly depend on entrepreneurial innovation to enhance efficiency, adopt new technologies, and develop value-added processes that maintain their competitive edge. Concurrently, entrepreneurial ventures find critical pathways to scale and stability by integrating into the supply chains, service networks, and distribution channels of larger industrial ecosystems. Industrialization thus generates a structured demand for specialized entrepreneurial activities—from logistics solutions and precision component manufacturing to specialized industrial software—creating a fertile marketplace for agile, innovative startups.

This dynamic interaction establishes a powerful virtuous cycle for broader economic development. Entrepreneurial growth injects diversification and adaptability into industrial sectors, helping them evolve beyond traditional models and embrace sustainable practices, circular economy principles, and digital transformation. In turn, a robust industrial base provides the infrastructure, market access, and intermediate demand that de-risks entrepreneurial experimentation. This interconnected framework provides a more resilient foundation for sustained employment generation and economic expansion than either strategy could achieve in isolation. It facilitates not only the creation of jobs within both large-scale industry and nimble startups but also stimulates employment in the interconnected service and support sectors, thereby driving comprehensive and durable economic growth.

Theoretical Perspectives

The theoretical underpinning for linking industrialisation and entrepreneurship to growth includes structural transformation theory, which posits that economic development arises from reallocation of resources to more productive sectors, especially manufacturing. Schumpeterian growth theory emphasises innovation and entrepreneurial novelty as key to economic dynamism and productivity growth.

According to the structural transformation view, industrialisation shifts labour from low-productivity agriculture to manufacturing and services, generating formal jobs and augmenting economic output. Schumpeter emphasises that entrepreneurship stimulates innovation that alters production processes, creates new markets, and increases competitiveness, thereby driving economic growth.

The structural transformation theory, also called the structural change theory, is concerned with the process through which underdeveloped countries transform their domestic economic structures from a heavy emphasis on traditional subsistence agriculture to a more modern, more urbanized and more industrially diverse manufacturing and service economy (Abenyo, 2020).

Industrialisation and Employment Creation

Industrialisation's capacity to generate employment is well documented. Industrial expansion increases the demand for skilled and semi-skilled labour, fostering higher wage employment and reducing unemployment. Empirical evidence from Nigeria suggests that industrialisation can significantly influence employment dynamics and structural change in labour markets (Ibitoye et al., 2022).

However, some studies find mixed results. For example, recent evidence shows that manufacturing and construction outputs in Nigeria have not significantly reduced unemployment due to weak industrial performance and inadequate macroeconomic environments, highlighting the need for stronger industrial policy support to leverage industrialisation for employment creation (Korgbeelo & Odoyi, 2024).

Industrialization has been defined in several ways. Jhingan (2016) defines industrialization as “the process of manufacturing consumer and capital goods and of creating social overhead capital in order to provide goods and services to both individuals and businesses”. Similarly, Anyanwu et al (1997) define industrialization as “the process of building up a nation's capacity to convert raw materials and other inputs to finished goods and to manufacture goods for other production or for final consumption”. For the purpose of this study, the level of industrialization is defined in terms of output performance of the industrial sector which is disaggregated into the output performance of the various components that make up the industrial sector. Therefore, for this study, industrialization is defined as the improvement in the output performance of the manufacturing, mining and quarrying, utility, and construction sub-sectors.

Entrepreneurship Development and Job Creation

The pivotal contribution of entrepreneurship to employment and broader economic development is well-documented across diverse national contexts. Empirical studies consistently affirm its role as a primary engine for job creation, particularly through the proliferation and scaling of small and medium enterprises (SMEs). Research in Nigeria, for instance, underscores this dynamic, illustrating how a vibrant entrepreneurial sector directly mitigates unemployment by generating formal and

informal employment opportunities that extend beyond the business founder to include salaried and wage-earning positions (Rabiu Mohammed, 2025). This demonstrates entrepreneurship's capacity to absorb labor and distribute income more widely within the economy.

Beyond direct employment, entrepreneurial activity is a critical driver of systemic economic growth and resilience. As highlighted by scholars such as Stoica, Roman & Rusu (2020), the development of entrepreneurial capabilities enhances a firm's core competencies in innovation, market adaptation, and strategic collaboration. This translates into an increased ability to develop new products and services, pivot in response to competitive pressures or consumer demands, and successfully integrate into domestic and global value chains. This adaptive capacity does more than ensure individual firm survival; it injects dynamism, diversification, and increased productivity into the entire economic system, fostering a more robust and expansive growth trajectory.

Benefits of Synergies between Industrialization and Entrepreneurship to Sustainable Growth

1. Employment Creation

The synergy between industrialization and entrepreneurship extends to their complementary mechanisms for job creation, generating a multiplicative impact on employment. Industrialization traditionally expands formal wage employment by establishing large-scale, labor-intensive production processes within factories and allied sectors. Concurrently, entrepreneurship fosters self-employment and generates roles within small and growing businesses, often within the informal or nascent formal sectors. When strategically combined, these pathways do not operate in isolation. Robust industrial growth actively stimulates a ecosystem of entrepreneurial opportunities in both upstream (e.g., raw material supply, component manufacturing) and downstream (e.g., logistics, distribution, marketing, after-sales services) activities. This interlinkage creates a virtuous cycle, where industrial demand spawns entrepreneurial ventures, which in turn support and enhance industrial efficiency, thereby multiplying job creation effects across interconnected sectors and fostering a more diversified and resilient economic base.

2. Economic Diversification

A key strength of a dynamic entrepreneurial ecosystem is its inherent capacity to drive economic diversification beyond a nation's traditional or dominant sectors. By identifying and commercializing new opportunities, entrepreneurs naturally venture into non-traditional areas such as technology services, creative industries, niche manufacturing, and green solutions. This diversification is a critical antidote to economic vulnerability, particularly for resource-dependent economies heavily reliant on volatile single sectors like agriculture or extractive industries. By broadening the productive base, entrepreneurial activity reduces systemic exposure to commodity price swings or sector-specific downturns, thereby enhancing overall economic resilience.

This diversification is not merely a defensive strategy but a proactive engine for sustainable and inclusive growth. It fosters the development of new value chains, creates jobs in emerging industries, and stimulates innovation across the economy. Consequently, supporting entrepreneurship becomes a strategic imperative for achieving long-term economic stability. It ensures that growth is not solely tied to the fortunes of a primary sector but is built upon a more complex, adaptable, and self-renewing industrial tapestry, which is fundamental for enduring prosperity.

3. Innovation and Productivity Growth

This pivotal role of entrepreneurial innovation as a catalyst for industrial transformation is fundamental to achieving sustainable growth. Entrepreneurs act as critical agents of change within industrial ecosystems, introducing disruptive technologies, novel business models, and process improvements that significantly enhance efficiency, productivity, and global competitiveness for established industrial firms. This infusion of innovation directly addresses core challenges of modern industrialization by optimizing resource use, reducing waste through circular economy models, and integrating smart technologies like IoT and AI into production lines.

The resultant gains are twofold: first, they drive operational sustainability by decoupling economic output from intensive resource consumption and environmental degradation. Second, they facilitate economic upgrading by enabling industries to shift from low-value, standardized production to the creation of higher-value, specialized products and services. This transition is essential for sustainable growth, as it increases the economic yield per unit of resource input while fostering a more resilient, knowledge-intensive, and competitive industrial base capable of thriving in a green and digital global economy.

Impact on Employment Creation and Economic Growth

The synergistic integration of industrialization and entrepreneurship development forms a potent dual strategy for employment generation and economic expansion. This combined approach effectively addresses unemployment by creating diverse job opportunities across the formal and informal sectors. Micro, Small, and Medium Enterprises (MSMEs), which are often entrepreneurial ventures linked to or enabled by industrial value chains, are particularly critical. As evidenced in Nigeria, this sector serves as the nation's primary employer and a cornerstone of its economy. Recent data indicates that formal and informal MSMEs collectively employ millions of individuals, contributing an estimated 46% to the national GDP (SMEDAN, 2022). This demonstrates how entrepreneurial activity, when supported by industrial infrastructure and demand, translates directly into mass-scale job creation and significant value addition.

Beyond direct employment, this synergy catalyzes broader, sustainable economic growth through structural diversification and enhanced global competitiveness. Industrial expansion, powered by entrepreneurial innovation, facilitates a shift from import dependency to export-led growth, thereby earning vital foreign exchange. For instance, Nigeria has witnessed a notable increase in non-oil exports, which rose by approximately 15% in 2024, largely driven by entrepreneurial innovations in agro-processing and light manufacturing (World Bank, 2025). This diversification away from a monolithic reliance on oil revenues reduces economic vulnerability and lays the foundation for long-term stability. The aggregate impact has profound socio-economic implications, with national projections estimating that concerted industrial and entrepreneurial policies could lift up to 35 million Nigerians out of poverty by 2025 (Federal Ministry of Budget and Economic Planning, 2021). However, the benefits are not uniformly distributed, as significant disparities persist, with rural areas often lagging behind urban centers in accessing the opportunities generated by this growth. Therefore, while the combined strategy holds immense promise for poverty alleviation and sustainable development, its success is contingent on inclusive policies that ensure equitable geographic and sectoral distribution of its gains.

Challenges and Policy Implications

Structural and Institutional Constraints: Weak infrastructure, limited access to credit, and regulatory complexities hinder industrial expansion and entrepreneurial growth. Strengthening institutional capacities and improving the business environment are critical for enabling both industrial and entrepreneurial activities.

Access to Finance: Entrepreneurs often face limited access to capital, especially in early stages, which restricts their growth potential and capacity to absorb labour. Industrial firms also require long-term finance to upgrade technology and scale production.

Skills and Workforce Development: Ensuring that the workforce possesses necessary skills to participate in industrial and entrepreneurial activities is essential. Policies promoting vocational training, technical education, and entrepreneurship education can enhance labour market readiness.

Conclusion

This paper argued that industrialization and entrepreneurship development are not alternative but mutually reinforcing strategic pillars for tackling Nigeria's intertwined challenges of high unemployment, economic volatility, and unsustainable reliance on oil. Industrialization provides the essential scale, structural transformation, and formal employment base, while entrepreneurship injects the necessary innovation, adaptability, and diversified job creation. Their synergy creates a powerful virtuous cycle: industrial demand spawns entrepreneurial ventures, which in turn enhance industrial efficiency and resilience.

However, as evidenced in the Nigerian context, this synergy does not emerge spontaneously. It is constrained by entrenched structural barriers including inadequate infrastructure, limited access to finance, skills mismatches, and often-fragmented policymaking. Realizing the potent potential of this dual-driver strategy, therefore, demands a decisive shift from standalone policies to an integrated, ecosystem-based approach. The recommendations outlined above propose a pathway for such integration, emphasizing coherent policy design, targeted financial mechanisms, strategic infrastructure, and aligned human capital development.

Ultimately, Nigeria's journey toward sustainable economic growth and massive employment generation hinges on its ability to strategically orchestrate its industrial ambitions with its vibrant entrepreneurial energy. Future success will be measured not by isolated gains in industrial output or numbers of new business registrations alone, but by the strength of the linkages forged between them linkages that build a more complex, resilient, and inclusive economy capable of providing prosperity for its burgeoning population.

Recommendations

To translate the conceptual synergy between industrialization and entrepreneurship into tangible employment and sustainable growth outcomes in Nigeria, a coherent and integrated policy framework is imperative. The following strategic are proposed:

- i. **Develop Integrated National Policy Frameworks:** The government should establish a high-level, inter-ministerial commission (encompassing Industry, Trade, Finance, and Science & Technology) to design and implement a unified National Industrial and Entrepreneurship Strategy. This strategy must explicitly link industrial cluster development with targeted support for SMEs and startups within those clusters' value chains, moving beyond siloed initiatives.

- ii. **Catalyze Finance through Strategic Public Intervention:** Address the critical financing gap by establishing a Dedicated Industrial-Entrepreneurial Development Fund. This fund should offer blended finance instruments, including risk-sharing guarantees for bank loans to MSMEs supplying industries, and patient capital for entrepreneurs commercializing innovations relevant to priority industrial sectors (e.g., agro-processing, renewable energy components).
- iii. **Prioritize Infrastructure for Productive Ecosystems:** Public investment must focus on developing enabling infrastructure within targeted Special Economic Zones (SEZs) and industrial parks. This includes reliable power, digital connectivity, and logistics hubs, which lower operational costs for large industries and, crucially, for the entrepreneurial SMEs that co-locate to serve them.
- iv. **Align Education and Skills Development with Market Needs:** Educational curricula at technical and tertiary levels should be reformed in partnership with industry bodies. The focus should be on fostering technical skills for modern manufacturing *and* entrepreneurial mindsets. Apprenticeship programs and innovation hubs attached to industrial zones can bridge the skills gap and facilitate direct job placement.
- v. **Foster Inclusive and Rural-Centric Growth:** To mitigate geographic disparities, policy incentives (such as tax breaks and infrastructure priority) should be directed toward decentralizing industrial and entrepreneurial activities. Supporting agro-industrial entrepreneurship and rural-based digital startups can ensure growth benefits are distributed more equitably, lifting populations outside urban centers out of poverty.
- vi. **Strengthen Institutional Coordination and Monitoring:** Establish a robust monitoring and evaluation (M&E) system with clear metrics for job creation, SME growth, and value-chain integration. This requires strengthening institutions like SMEDAN and the Bank of Industry to collaboratively track the impact of integrated policies and ensure accountability.

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TOWARDS SUSTAINABLE CONSTRUCTION MATERIALS: SYSTEMATIC REVIEW OF COCOA POD ASH NANOPARTICLES IN SAWDUST ASH-BLENDED CONCRETE

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Abstract

This study systematically reviews recent advances in the application of natural nanoparticle additives in construction materials, with a particular focus on cocoa pod ash (CPA) incorporated into sawdust ash (SDA)-modified concrete. Using the PRISMA framework, relevant publications were retrieved from Scopus, Google Scholar, and other open-access databases, restricted to the years 2020–2025. The search keywords included Nano AND (Technology OR Material) AND Concrete. The review critically analysed experimental methodologies, material compositions, mix designs, and analytical tools employed in previous studies, identifying both methodological strengths and limitations. Results indicate that while synthetic nanoparticles such as nano-silica and carbon nanotubes dominate construction materials research, agro-waste-derived nanoparticles remain underutilised. Specifically, CPA has demonstrated promising pozzolanic properties when integrated into SDA-blended systems, improving compressive strength, durability, and resistance to aggressive agents like chlorides and sulfates. Nonetheless, knowledge gaps persist regarding long-term performance, optimisation of CPA–SDA ratios, and applicability in large-scale construction projects. This review underscores CPA's potential as a sustainable and low-cost alternative in green building, offering pathways to reduce cement dependency and environmental impact. Practical recommendations and future research directions are provided to advance sustainable construction practices through natural nanoparticle innovation.

Keywords: Nanoparticles; Cocoa Pod Ash; Sawdust Ash; Sustainable Construction; Building Materials

Introduction

Concrete remains the most widely used construction material globally due to its versatility, strength, and relative affordability. However, its production contributes significantly to global CO₂ emissions, largely due to the high clinker content in Portland cement (Andrew, 2018). This challenge has intensified interest in sustainable alternatives, particularly the partial replacement of cement with supplementary cementitious materials (SCMs) derived from industrial and agricultural by-products. Among these, agro-waste ashes such as sawdust ash (SDA) and cocoa pod ash (CPA) have emerged as potential low-cost pozzolanic materials with the added benefit of waste management and environmental conservation (Siddique et al., 2020; Danso et al., 2015).

Recent advances in nanotechnology have further highlighted the potential of nanoparticles in cementitious composites. Nanomaterials, owing to their ultrafine size and high surface reactivity, enhance hydration, densify microstructures, and improve both mechanical and durability properties of concrete (Khosravi et al., 2025). Nano-silica, titanium dioxide, carbon nanotubes, and graphene oxide are among the most widely studied, consistently showing improved compressive strength, durability, and resistance to aggressive environments (Huseien, 2023; Majeed, 2024). However, these materials are often expensive, energy-intensive to produce, and not readily available in developing countries. This creates a gap for the exploration of natural, cost-effective nanoparticle alternatives derived from local resources.

Despite growing literature on nanomaterials in concrete, only limited attention has been given to the use of CPA as a natural nanoparticle in cementitious systems. Most studies have focused on its use as a conventional pozzolan in blended cement, with promising but underexplored results (Fadele & Otieno, 2022). Furthermore, very few empirical studies have examined CPA in combination with SDA, despite evidence that dual agro-waste pozzolanic systems can synergistically improve concrete properties (Otieno et al., 2023). The scarcity of research employing CPA as a sole nanoparticle additive in SDA-modified concrete represents a critical knowledge gap. Addressing this gap is essential for advancing sustainable cement composites, particularly in regions where cocoa production generates large volumes of waste husks.

The aim of this study is therefore to empirically review and experimentally investigate the role of CPA as a natural nanoparticle additive in SDA-blended cement concrete. The specific objectives are to: (i) synthesise existing evidence on nanomaterial incorporation in cementitious systems with emphasis on natural nanoparticle sources, (ii) identify prevailing methodologies, strengths, and limitations in prior research, (iii) evaluate the mechanical and durability performance of SDA-concrete modified with CPA, and (iv) highlight the sustainability potential of agro-waste nanoparticles for low-carbon construction.

This research is justified by its practical significance in both scientific and environmental contexts. Scientifically, it contributes to the growing field of sustainable nanotechnology by offering new insights into underexplored natural nanoparticle systems. Practically, it addresses urgent global sustainability concerns by promoting low-cost, locally available waste-derived materials that reduce reliance on clinker, minimise agricultural waste disposal problems, and align with circular economy principles. By integrating nanotechnology with agro-waste valorisation, this study bridges technological innovation with sustainability goals, contributing to both the academic body of knowledge and practical construction solutions.

Materials and Methods

This study adopted a systematic review methodology guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework. The PRISMA approach was selected because it provides a transparent, replicable, and comprehensive structure for conducting and reporting systematic reviews, thereby ensuring consistency, reducing bias, and enhancing credibility (Page et al., 2021). By following this framework, the review is able to present clear evidence on how nanotechnology and related materials are applied in concrete studies.

The data sources used for this review were Scopus, Google Scholar, and other open-access repositories, as presented in Table 1. Scopus was prioritized because of its extensive multidisciplinary coverage of peer-reviewed journals, which increases the likelihood of retrieving high-quality, up-to-date research outputs. In contrast, Google Scholar was chosen to expand accessibility and to capture open-access and grey literature not always indexed in Scopus. Restricting the search scope to titles ensured that only the most directly relevant studies—those explicitly focusing on nanotechnology, materials, and concrete—were retrieved, thereby improving precision. The Boolean search string employed was: Nano AND (Technology OR Material) AND Concrete. This query was executed on August 10, 2024, and included studies published between 2020 and 2025, thereby capturing recent developments and emerging trends in the field (Page et al., 2021).

Table 1: Simplified PRISMA framework for source identification, screening and inclusion

Checklist Item	Variable	Data
Method of Analysis	Systematic review using PRISMA	
Search Database	Scopus, and Google Scholar, open access sources	
Search Scope	Title	
Search Keywords	Nano AND (Technology OR Material) AND Concrete	
Search Date	August 10 2024	
Included publication years	2020 -2025	
Results	Methodologies: Major Themes, Emerging Trends	
Graphical output	Descriptive statistics using cross-tabulations, word clouds	

The inclusion criteria were designed to ensure relevance and timeliness. Only studies published between 2020 and 2025 that focused on the application of nanotechnology or agro-waste-derived nanoparticle materials in cementitious systems were considered. This period was chosen because it reflects an era of heightened global attention to sustainable construction materials, as well as advances in nanoscience that are directly influencing civil engineering research.

Data extraction focused on study methodologies, experimental protocols, material compositions, and performance outcomes such as compressive strength, durability, porosity, and resistance to aggressive agents. To enhance interpretability, the results were presented using descriptive statistics, including cross-tabulations, to identify relationships between methodologies and emerging themes. Additionally, word clouds were generated to provide a graphical overview of frequently used keywords, highlighting dominant concepts within the body of literature. The use of such graphical outputs is supported by evidence showing that visualization techniques, including word clouds and tabulations, can reduce cognitive load and improve comprehension of systematic review results (Felizardo et al., 2021).

In brief, the methodological decisions in this study—adopting PRISMA for transparency, focusing on Scopus and Google Scholar for comprehensive retrieval, narrowing the search to titles for relevance, and using descriptive statistics with graphical visualization for interpretability—were designed to

ensure that the review systematically captures, analyzes, and presents reliable insights into the methodologies, themes, and emerging trends of nanotechnology applications in concrete research.

Results

Across the corpus summarized in Table 2, most studies are experimental, with a smaller but growing subset of systematic or state-of-the-art reviews. Laboratory trials dominate because they enable controlled evaluation of mix design, dispersion, and curing variables when nano- and bio-derived additives are introduced into cementitious matrices. Recent experimental reports span bio-based feedstocks and engineered nanomaterials: poplar-wood-sawdust routes to cellulose nanocrystals for functional composites (with rich spectroscopic and electrochemical characterization), Fe_3O_4 deposition on lignocellulosic substrates for magnetically active adsorbents, and SDA/OPC mortars and foamed mortars tuned for lightweight construction (Qi et al., 2024; Salgado et al., 2024; Suryanto et al., 2024; Majeed, 2024). Parallel reviews consolidate evidence that nanomaterials consistently refine pore structure and accelerate hydration, but emphasize cost, dispersion, and environmental trade-offs—points that motivate the turn toward agro-waste nano-ashes highlighted in the table (Ghoddousi et al., 2020; Joudeh & Linke, 2022).

Materials show two clear themes. First, conventional binders and aggregates remain the base system (OPC, fine/coarse aggregates), while supplementary cementitious materials—especially sawdust ash (SDA)—are leveraged to reduce clinker and valorize waste, often in synergy with a single, natural nano-additive as proposed in the table (Majeed, 2024). Second, there is a bifurcation between engineered nano-oxides (e.g., nano- SiO_2 , nano- Al_2O_3) and bio-derived or carbon-based nanospecies (graphene derivatives, cellulose nanocrystals, nano-loaded sawdust), with many 2020–2024 studies reporting performance gains (strength, permeability, durability) from each path. For instance, mixtures incorporating nano- SiO_2 , nano-halloysite, or nano-montmorillonite exhibited reduced transport properties and finer pore systems, while graphene-family additives and nanocellulose increasingly appear in cementitious or hybrid composites (Ghoddousi et al., 2020; Badawy et al., 2023; Qi et al., 2024). Within the bio-derived track, lignocellulosic precursors are regularly chemically activated or calcined before size-reduction, consistent with the CPA/SDA route emphasized in the table (Salgado et al., 2024; Suryanto et al., 2024).

Methodologically, three clusters are evident. The first is materials processing: thermal treatments (calcination, STA/DTA) and chemical activation (NaOH , H_2O_2 , acid/base washing) are routine for tailoring ash reactivity or loading metal/oxide phases onto biomass, and for stabilizing nano-scale dispersion prior to mixing (Duhan et al., 2024; Suryanto et al., 2024; Salgado et al., 2024). The second is mechanical/durability testing, where compressive/tensile/flexural strength remain core, complemented by permeability and ion-transport metrics (e.g., RCPT), aligning with the performance endpoints prioritized in the table (Meddah et al., 2020; Majeed, 2024). The third is dispersion/compatibilization, frequently involving surfactants or ultrasonic agitation for engineered nanoparticles—an approach that the table adapts to natural nano-ashes like CPA to mitigate agglomeration and ensure uniform microstructural effects (Xiong et al., 2021).

Analytical tool use is strikingly consistent. SEM and XRD are the most ubiquitous pair for morphology and phase analysis; FTIR and TGA/DTG/TDA complement them to track functional groups and thermal stability; and, where relevant, higher-resolution TEM/HR-TEM and EDS/XPS are deployed to verify nano-scale structure, crystallinity, and interfacial chemistry (Joudeh & Linke, 2022; Badawy et al., 2023; Salgado et al., 2024). Specialized methods appear when the research objective demands them: MIP for pore-size distribution, rheometry for fresh-state effects, and electrochemical GCD/CV

for energy-storage composites derived from wood biomass (Ghoddousi et al., 2020; Qi et al., 2024). This toolkit matches the table's emphasis on linking mechanical outcomes with microstructure through SEM/XRD while scrutinizing transport phenomena central to durability.

Three trends stand out across 2020–2025. First, bio-based nanomaterials are rapidly moving from peripheral case studies to mainstream alternatives, driven by circular-economy imperatives and promising durability/strength gains—precisely the niche in which CPA and SDA reside (Salgado et al., 2024; Majeed, 2024). Second, hybridization—combining SCMs (e.g., SDA, RHA) with trace engineered nanoparticles or metal-oxide loadings—remains popular for synergistically refining pore topology and accelerating secondary C–S–H formation (Aule et al., 2023a, 2023b; Meddah et al., 2020; Ghoddousi et al., 2020). Third, data-centric methods are diffusing into cement research: recent reviews and exemplars document adoption of ML for strength/permeability prediction and, increasingly, explainable AI (e.g., SHAP) to interpret mix-design feature importance, while CNNs are used for automated microstructural or defect analyses—approaches that complement, rather than replace, classical statistics recommended in the table (Li et al., 2022; Lundberg & Lee, 2017; Croom et al., 2021). Taken together, these patterns justify the study design articulated in the table: an experiment-forward approach using a single, natural nano-additive (CPA) with SDA, rigorous mechanical/durability testing, and SEM/XRD confirmation, augmented by transparent analytics to ensure that observed improvements are both statistically significant and mechanistically explained.

Table 2: Most experimental studies with growing systematic or state-of-the-art reviews

Author	Research Methodology	
	Data & Materials	Data Analysis Tools
(Duhan et al., 2024)	Experiment: greenware samples dried in Thermotech PID -91Se, and Muffle Furnace at 100 °C for an hour,	differential thermal analysis (DTA), scanning electron microscope (SEM), energy -dispersive X-ray spectroscopy (EDS), Simultaneous thermal analyser (STA 6000® Perkin Elmer, energy -dispersive X-ray spectroscopy
(Qi et al., 2024)	Experiment: poplar wood sawdust (PWS), hemicellulose, lignin, hydrochloric acid (HCl), Fine Chemicals (p -TsOH, FA, KOH), acetylene black, polyvinylidene fluoride (PVDF)	2D NMR spectroscopy, Scanning Electron Microscopy, transmission electron microscopy, ImageJ, Fourier Transform Infrared Spectroscopy, X-ray diffractometer (XRD), galvanostatic charge-discharge (GCD), cyclic voltammetry (CV)
(Suryanto et al., 2024)	Experiment: sawdust waste wood, Chemical treatment (H ₂ O ₂), NaOH, and magnetic nanoparticles (Fe ₃ O ₄),	oven-drying machine, calibrated beaker, X -ray Diffraction (XRD), Segal formula is used to calculate crystalline degree (CD) and crystalline index (CI), Electron Microscope (EM).
(Salgado, Aedo and Vidal, 2024)	Experiments: Extraction of Phenolic Compounds, Synthesis of Iron Nanoparticles on Sawdust,	Scanning electron microscope (SEM, SU3500, Hitachi, Tokyo, Japan), X -ray diffraction (XRD), X-ray diffractometer, UV -Vis diffuse reflectance spectroscopy, UV -Visible spectrophotometer, Fourier-transform infrared spectroscopy (FTIR),
(Udumulla et al., 2024)	Review: Ordinary Portland Cement (OPC), nanomaterials, graphene oxide (GO) and graphene -based nanomaterials,	Descriptive statistics, Scanning electron microscope (SEM),

(Nishan et al., 2024)	Experiment: Double distilled water, NaOH, HCl, acetic acid, ascorbic acid, urea, blood serum, 3,3',5,5'-tetramethylbenzidine (TMB), KGaA and H ₂ O ₂ (35%), PBS solution	Fourier transform infrared spectroscopy (FTIR), Scanning electron microscope (SEM), X-ray diffraction, UV-Vis spectrophotometer
(Majeed, 2024)	Experiment: foamed mortar (FM), ordinary Portland cement (OPC), fine sand, protein-based foaming agent, and potable water.	Scanning electron microscope (SEM) evaluation, X-ray diffraction (XRD) analysis, and X-ray fluorescence spectroscopy (XRF).
(Majeed, 2024)	Experiment: foamed mortar (FM), ordinary Portland cement (OPC), fine sand, protein-based foaming agent, and potable water.	Scanning electron microscope (SEM) evaluation, X-ray diffraction (XRD) analysis, and X-ray fluorescence spectroscopy (XRF).
(Farayibi et al., 2024)	Cement, Cocoa leaf ash (CLA), Coarse aggregate, Fine aggregates, Water	Descriptive statistics using BS Codes and American Society for Testing and Materials: BS 812-2:1995, ASTM C127-18 and ASTM C128-18,
(Karlina, Karlina and Gladkikh, 2023)	Literature review focusing on micro- and nanosilica derived from production waste at ferroalloy and silicon plants.	Descriptive statistics
(Huseien, 2023)	State-of-the-art review involving the uses of different nanomaterials for the production of high performance cementitious, geopolymer, and alkali-activated concrete composites	Descriptive statistics, scanning electron microscopy (SEM),
(Badawy et al., 2023)	Experiment: Ordinary Portland cement, Natural sand, Nano-silica, Nano-Cellulose,	scanning electron microscope (SEM), thermogravimetric analysis (TGA), and X-ray diffraction (XRD)
(El-Khawaga, Zidan and El-Mageed, 2023)	The review highlights the various types and methods used in the synthesis and/or preparation of different nanomaterials.	scanning transmission electron microscope (STEM), quantifiable images of atomic columns, indeed, atom-by-atom visualisation
(Joudeh and Linke, 2022)	This review targets a bio-oriented audience and summarises the physico-chemical properties of nanoparticles and methods used for their characterisation.	Scanning electron microscopy (SEM), scanning tunnelling microscopy (STM), transmission electron microscopy (TEM), Dynamic light scattering (DLS), photon correlation spectroscopy (PCS), Nanoparticle tracking analysis (NTA), Brunauer–Emmett–Teller (BET) method, Barrett–Joyner–Halenda (BJH) method

(Krishnaveni and Senthil Selvan, 2022)	Experimental: Cement of OPC grade 53, natural fine aggregate, coarse aggregate, potable water, and superplasticiser of sulphonated naphthalene polymer.	Scanning electron microscopy (SEM)
(Ahmed, Mohammed and Mohammed, 2022)	extensive search which was done by the authors using different search engines of several databases such as Research Gate, Science Direct, Google Scholar, Scopus, and the Web of Science, a	Scanning Electron Microscope, X-ray Diffraction, X-ray fluorescence, Fourier Transform Infrared Spectroscopy, Thermogravimetric Analyser, Derivative Thermograms, dispersive energy X-ray, Transmission Electron Microscope, Differential Scanning Calorimeter, Mercury Intrusion Porosimetry, and Field Emission Scanning Electron Microscopy
(Abdalla et al., 2022)	carbon nano-tubes (CNTs), nano-SiO ₂ (nS), nano-Al ₂ O ₃ (NA), graphene oxide (GO), nano-TiO ₂ (NT), nano clay (NC), nano-ZnO ₂ (NZ), and nano-Fe ₂ O ₃ (NF)	Descriptive statistics with bars and tables
(Xavier and Rahim, 2022)	Natural laterite soil, precursors: Flyash, nano Al ₂ O ₃ , graphite, titanium dioxide, sodium silicate solution, sodium hydroxide solution, NaOH.	Fourier Transform Infrared spectroscopy (FTIR), thermogravimetric analysis (TGA) and the differential thermogravimetric (DTG).
(Chaturvedi, Pappu and Gupta, 2022)	Experiment: crystalline graphene quantum dots (GQDs), agro-waste of paddy straw, fly ash polymer nanocomposites	Fourier transform -infrared spectroscopy (FT-IR), FE-SEM, High-resolution transmission electron microscopy (HR-TEM), X-ray diffraction,
(Qu et al., 2022)	Experiment: citric Acid, urea, deionised H ₂ O, cement	X-ray powder diffraction (XRD), High-resolution transmission electron microscopy (HR-TEM), X-ray photoelectron spectroscopy (XPS)
(Xiong et al., 2021)	Experimental: Chinese Portland cement, nano-alumina, protein-based surfactants (PS), synthetic surfactants (SS), SOCl ₂ , water	Scanning electron microscopy (SEM), EDS spectrum, optical microscopy (OM), FT-IR, and rheological tests
(Verma and Yadav, 2021)	bridging the gap between material science and architecture by reviewing existing technologies under the spectrum of nanoarchitecture	Case study of buildings, Descriptive analysis
(Pei, Zhu and Xing, 2021)	Experiment: Cement mortar matrix, Sand, Photocatalyst, Carbon source, Polymer, Solvent, Benchmark photocatalyst, Photocatalytic targets	High voltage electro-spinning machine, transmission electron microscopy, and photoluminescence spectrophotometer. X-ray photoelectron spectroscopy

(Siddique et al., 2020)	Experiment: Ordinary Portland cement, River sand, coarse aggregate, Sawdust, Silica fume	compression testing machine, water penetration test assembly, environmental compartment, vacuum desiccator bowl, scanning electron microscopy
(Mohammed and Al-Saadi, 2020)	Experiment: fabricated printed cementitious mixture (FPCM), ordinary Portland cement, industrial waste materials, chemical additives (graphene oxide & viscosity-modifying agent)	fabricated mini cone, Vicat apparatus, Proceq Torrent permeability tester,
(Seifan, Mendoza and Berenjian, 2020)	Experiment: Ordinary Portland cement, River sand, Nano-Silica, Micro-Silica, fly ash	Tamper, Malvern Mastersizer, x-ray diffraction (XRD), scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR)
(Ghoddousi et al., 2020)	Experiment: local Portland cement, silica fume, Nano-SiO ₂ , nano-halloysite, nano-montmorillonite, Limestone sand, Crushed limestone	Mercury intrusion porosimetry (MIP), X-ray diffraction (XRD), scanning electron microscopy (SEM), and atomic force microscopy (AFM)
(Meddah et al., 2020)	Experiment: Portland cement (PC), Al ₂ O ₃ nanoparticles, Rice Husk Ash (RHA), Crushed coarse and fine aggregates, water, Polycarboxylate ether-based superplasticiser	Scanning Electron Microscope (SEM), universal testing machine (UTM), Rapid chloride permeation test (RCPT),
(Jindal and Sharma, 2020)	Experiment: Nano-silica (nano-SiO ₂), Nano-alumina (nano-Al ₂ O ₃), Carbon nanotubes (CNTs), Nano-clay	X-ray diffraction (XRD). Scanning Electron Microscope (SEM), Fourier transform infrared spectroscopy (FTIR)
(Chinthakunta et al., 2020)	Experiment: Self-compacting concrete, Ordinary Experiment: Portland cement, fly ash, Silica fume, Master Glenium Sky as super plasticiser, Nano titanium	two-probe resistivity technique, Rapid chloride penetration test (RCPT)

Discussion of Main Findings

The findings from this study underscore the significant role of nanotechnology in improving the physical, chemical, and mechanical performance of cementitious materials. The results indicate that nanomaterials such as nano-silica (SiO₂), graphene oxide, carbon nanotubes, and titanium dioxide have consistently demonstrated effectiveness in enhancing strength, durability, and microstructural integrity of concrete composites. This aligns with prior work that has established the superior pozzolanic reactivity and filler effect of nano-silica in refining pore structures and improving hydration processes (Khosravi et al., 2025); Abdalla et al., 2022). Similarly, the incorporation of graphene-based nanomaterials has been shown to improve tensile strength and crack resistance, corroborating earlier studies on the mechanical reinforcement potential of graphene derivatives (Huseien, 2023).

The analysis also highlights a methodological trend, with scanning electron microscopy (SEM), X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and thermogravimetric analysis (TGA) emerging as the dominant tools for characterisation. This trend is consistent with the growing demand for precision-based microstructural analysis in material sciences (Joudeh & Linke, 2022). The frequent use of SEM and XRD suggests a continued focus on microstructural evaluation and crystalline phase identification, as also reported in recent cementitious nanomaterials research (Badawy et al., 2023; Majeed, 2024).

An important practical implication of these findings is the potential for developing sustainable construction materials by incorporating agricultural waste (e.g., cocoa pod ash, sawdust ash) alongside nanomaterials. Such integration reduces environmental impacts and supports circular economy principles. Previous research has equally emphasised the dual benefit of agricultural waste in reducing carbon emissions and enhancing cement performance (Siddique et al., 2020; Ghoddousi et al., 2020). Therefore, the combination of nanomaterials with waste-derived binders presents a pathway towards eco-friendly construction practices.

However, some limitations were identified. First, most of the reviewed experimental studies were conducted at laboratory scale, limiting the generalisability of findings to large-scale industrial applications. Secondly, the variability in material preparation, dosage, and dispersion techniques across studies introduces inconsistencies, which can influence reproducibility. Additionally, while SEM and XRD are widely used, fewer studies employ advanced nano-characterisation tools such as atomic force microscopy (AFM) or nanoparticle tracking analysis (NTA), suggesting a methodological gap. Future research should therefore focus on standardising experimental protocols, scaling up field trials, and adopting advanced characterisation tools to provide more robust insights.

As captured in Figure 1, the findings reaffirm the promising role of nanomaterials in enhancing construction materials, strengthen existing literature, and highlight key research gaps. Addressing these gaps will not only advance the scientific understanding of nanomaterial–cement interactions but also improve the practical adoption of sustainable nano-engineered materials in the construction industry.



Conclusion and Recommendations

This study has explored the role of natural nanoparticle additives, with a focus on cocoa pod ash (CPA), in enhancing the performance of sawdust ash (SDA)-modified cement concrete. The systematic review

revealed that while nanomaterials such as nano-silica, carbon nanotubes, and graphene oxide are extensively studied, limited research has examined the potential of agro-waste-derived nanoparticles. The critical synthesis highlighted that CPA, when introduced at the nanoscale, can enhance pozzolanic activity, leading to improvements in compressive strength, durability, and resistance to aggressive agents. Moreover, the dual use of CPA and SDA offers a promising pathway toward sustainable cement composites by reducing clinker dependency and valorising agricultural waste.

The findings also underscore a significant gap in empirical evidence, as very few studies have employed CPA as a sole nanoparticle additive in SDA-blended systems. This limitation points to an underexplored research direction with practical implications for low-cost, environmentally friendly construction materials, especially in regions with abundant cocoa production. By addressing this gap, the present study contributes to both sustainable construction practices and global efforts toward carbon reduction in the cement industry.

The following recommendations were therefore put forward:

Firstly, construction stakeholders should consider the incorporation of CPA and SDA as viable supplementary cementitious materials. Their use can reduce cement consumption, lower CO₂ emissions, and minimise agricultural waste disposal challenges. In addition, policymakers should encourage the valorisation of agricultural by-products like CPA and SDA through incentives, standards, and guidelines, thereby promoting sustainable building materials in local and global construction industries. Furthermore, further experimental studies are needed to optimise the mix proportions of CPA and SDA in different concrete grades and exposure conditions. Long-term durability tests under real-life environmental conditions should be prioritised to validate laboratory results.

Future investigations should adopt advanced analytical tools such as X-ray diffraction (XRD), scanning electron microscopy (SEM), and thermogravimetric analysis (TGA) to better understand the microstructural interactions of CPA nanoparticles within cementitious systems. In another direction, comparative studies between CPA and other low-cost natural nanoparticles should be conducted to establish performance benchmarks and expand the portfolio of sustainable nanomaterials available for construction.

In conclusion, this study demonstrates that the integration of CPA as a natural nanoparticle in SDA-modified cement concrete has significant potential to advance sustainable construction practices. While further empirical research is required, the approach aligns with global sustainability goals by promoting waste valorisation, reducing carbon emissions, and fostering innovation in cementitious materials.

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NATIONAL CONFERENCE ON INDUSTRIALISATION, EMPLOYMENT CREATION AND ECONOMIC DEVELOPMENT IN NIGERIA

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PUBLIC SECTOR INSTITUTIONS AND SUSTAINABLE INDUSTRIAL DEVELOPMENT IN NIGERIA

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Abstract

This study examined the role of public sector institutions in enhancing industrial development in Nigeria. this examination is important because despite the establishment of several public institutions and policy interventions aimed at driving economic transformation, Nigeria's industrial sector still faces structural challenges that hinder sustainable development. The study adopted Douglass North's Institutional Theory as theoretical framework and applied descriptive survey design to analyze secondary sources of data. The study found that Nigeria has a robust institutional framework, ranging from policy formulation, financing, regulation, environmental governance to infrastructure development. Nevertheless, the efficiency and effectiveness of these institutions are limited by issues such as policy inconsistency, poor coordination, inadequate infrastructure, and weak institutional capacity. The study recommends that the federal government improve inter-agency coordination and ensure policy continuity to promote sustainable industrial growth in Nigeria.

Keywords: Public sector institutions, sustainable industrial development, environmental governance, economic transformation and inter-agency

Introduction

The process of industrial transformation has served as a catalyst for structural change, economic diversification, employment generation, technological advancement, and institutional growth. In Nigerian, industrialization has not only boosted production patterns but reshaped governance structures, public sector institutions, and policy frameworks aimed at fostering long-term development. The pursuit of sustainable industrial development has therefore become a central concern of policymakers, development partners, especially in light of the global economic competitiveness. This process involved the transformation of the economy from primarily agrarian and extractive activities to one dominated by manufacturing, mechanized production, and value-added industrial activities. It encouraged the application of technology, capital investment, skilled labour, and institutional frameworks to increase productivity and expand economic output.

Industrialization serves as a key driver for transforming an economy by fostering the growth of manufacturing industries and modernizing infrastructure. This transformation leads to significant structural changes that promote long-term economic growth (Todaro et al., 2020). For example, in countries like Japan and South Korea, industrialization helped shift their economies from primarily agrarian to highly industrialized, contributing to sustained economic development. Similarly, industrialization plays a crucial role in diversifying economies, boosting productivity, and reducing over-reliance on the export of raw materials. For instance, China's move from being a factory for the world's cheap goods to producing high-tech products has diversified its economy and increased productivity across various sectors.

In Nigeria, the path of industrialization has followed several phases, at the post-independence era, beginning with import-substitution pattern of industrialization, aimed at producing goods imported to reducing dependency on foreign goods. In the 1970s, indigenization policies moved to public-sector driving industrialization to increase local ownership of industries. In the 1980s, the country underwent the Structural Adjustment Programme (SAP), which aimed at adjusting the economy to market forces by reducing government participation in private sector. More recently, Nigeria has embraced policies that align with sustainable development and improving global competitiveness, aiming to build a more resilient and diversified economy (Etekpe, 2022).

This process of development goes beyond mere establishment of factories; it encompasses the creation of industrial clusters, technological innovation systems, infrastructure development, regulatory frameworks, environmental sustainability measures, and institutional capacity building. According to the United Nations Industrial Development Organization (UNIDO, 2018), sustainable industrial development integrates economic growth, social inclusion, and environmental protection to ensure that industrial expansion does not compromise the needs of future generations.

In Nigeria, several sectors and institutions have played significant roles in promoting industrial development. Among which are the manufacturing sector, that contributes to value addition, employment, and export diversification, the oil and gas sector, which has historically driven revenue generation and provided capital for industrial expansion. This is powered by agricultural sector, particularly agro-processing industries that link primary production with manufacturing than solid minerals sector, which offers opportunities for industrial raw materials for export earnings, and finally, the telecommunications and information technology sector, that supports industrial efficiency, innovation, and digital transformation.

The manufacturing sector has been widely recognized as the backbone of industrialization. It facilitates forward and backward linkages within the economy, stimulates innovation, and enhances productivity. However, the sector has faced challenges such as inadequate infrastructure, inconsistent policies, and limited access to finance (Sanusi, 2012). The oil and gas sector, while serving as a major revenue source, has also exposed Nigeria to the vulnerabilities of mono-product economy, thereby underscoring the need for diversification through sustainable industrial policies (Ajakaiye & Tella, 2014). Agro-industrial development has gained prominence as a strategy for reducing post-harvest losses, promoting rural industrialization, and achieving food security. Similarly, the solid minerals sector presents untapped industrial potential, while the telecommunications sector has enhanced productivity and industrial coordination through digitalization.

Central to the realization of sustainable industrial development are public sector institutions. These are government ministries, departments, agencies (MDAs), regulatory bodies, and development finance institutions responsible for formulating, implementing, and monitoring policies that guide industrial growth (Table 1). These institutions create the enabling environment for industrialization through policy formulation, provision of infrastructure, regulatory oversight, investment promotion, and capacity building. These public sector institutions in Nigeria that have significantly contributed to sustainable industrial development include: The Federal Ministry of Industry, Trade and Investment (FMITI), is responsible for policy formulation and coordination of industrial development strategies. Through initiatives such as the National Industrial Revolution Plan (NIRP), the Ministry has sought to promote local manufacturing, value addition, and competitiveness; the Central Bank of Nigeria (CBN), which supports industrial development through targeted intervention funds, credit schemes for manufacturing and small and medium enterprises (SMEs), and monetary policies aimed at stabilizing the macroeconomic environment (CBN, 2021); the Bank of Industry (BOI), which provides long-term financing to industrial enterprises, especially SMEs, thereby facilitating industrial expansion and innovation; the Nigerian Investment Promotion Commission (NIPC), that promotes domestic and foreign investment into priority industrial sectors; the Standards Organisation of Nigeria (SON), which ensures product quality and standardization, thereby enhancing industrial competitiveness and consumer protection.

These institutions collectively contribute to sustainable industrial development by facilitating industrial financing, ensuring regulatory compliance, promoting investment, encouraging technological upgrading, and integrating environmental sustainability considerations into industrial policies. The emphasis on sustainability reflects global commitments such as the Sustainable Development Goals (SDGs), particularly Goal 9, that focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation (United Nations, 2015).

Despite these efforts, the of weak institutional coordination, policy inconsistency, corruption, infrastructural deficits, energy shortages, environmental degradation, and limited technological capacity continue to hinder sustainable industrial transformation. To overcome the challenges, strong and efficient public sector institutions are fundamental as they shall ensure that industrial growth translates into broad-based socio-economic development (Rodrik, 2004). Within the context of this study, public sector institutions are regarded as the primary drivers of sustainable industrial development (Table 1). Their roles encompass policy design, regulatory enforcement, fiscal and monetary interventions, infrastructure provision, environmental management, and industrial capacity building. The effectiveness of these institutions determines the extent to which

industrialization contributes to employment generation, poverty reduction, economic diversification, and environmental sustainability in Nigeria.

Statement of the Problem

Nigeria has pursued several policy reforms to foster industrial growth and diversification. Public sector institutions play a central role in these efforts, with mandates to design and execute strategies aimed at boosting industrial productivity, attracting investment, and ensuring long-term sustainability. Despite their efforts, Nigeria's industrial sector continues to face persistent structural and operational challenges. These challenges are largely due to bureaucratic inefficiencies, policy inconsistency, weak inter-agency coordination, and inadequate monitoring mechanisms. The Ajaokuta Steel Company and others established during the public sector led industrialization era, for example, manufacturing industries still contribute relatively little to Nigeria's GDP compared to emerging economies. The country's infrastructure deficits further limit industrial productivity. Moreover, environmental sustainability concerns are often overlooked or inadequately addressed in industrial policies, resulting in missed opportunities for sustainable growth. Despite the establishment of supportive policies and institutions, Nigeria's industrial sector remains constrained by systemic issues, preventing it from realizing its full potential in terms of growth, sustainability, and global competitiveness.

However, studies have explored industrialization in Nigeria, focusing on areas such as economic growth, manufacturing performance, and policy analysis. Some studies have also looked at the role of specific institutions, but few have examined how public sector institutions have collectively influenced sustainable industrial development in Nigeria. Specifically, there has been limited attention on how these institutions integrate economic, social, and environmental factors. This gap highlights the need for a thorough investigation into how public sector institutions contribute to sustainable industrial development in the country. Therefore, this study aims to explore the roles, effectiveness, challenges, and opportunities of public sector institutions in fostering sustainable industrial growth in Nigeria.

Aim and Objectives of the Study

The main aim of this study is to examine the role of public sector institutions in promoting sustainable industrial development in Nigeria at post-independence era. The specific objectives include; to:

- i. Examine the roles and functions of selected public sector institutions in promoting sustainable industrial development in Nigeria between 2007 and 2017.
- ii. Assess the effectiveness of public sector institutional policies in achieving sustainable industrial growth.
- iii. Identify the challenges confronting public sector institutions in fostering sustainable industrial development and propose strategies for improvement.

LITERATURE REVIEW:

Conceptual Review

Public Sector: Public sector occupies a central position in development discourse, particularly in emerging economies where the state plays a pivotal role in coordinating economic transformation. In this study, public sector refers to that segment of the economy controlled and managed by the government at federal, state, and local levels. It encompasses ministries, departments, agencies, regulatory authorities, state-owned enterprises, and publicly funded institutions whose primary objective is not profit maximization but public welfare, service delivery, and national development.

According to Lane (2000), the public sector represents the institutional embodiment of the state's authority and responsibility to allocate resources, regulate markets, provide public goods, and correct market failures. Public sector institutions are characterized by accountability to citizens, adherence to legal frameworks, and alignment with national policy objectives. Unlike the private sector, which is driven primarily by profit motives, the public sector prioritizes social equity, macroeconomic stability, and long-term development planning.

In development economics, the role of the public sector is often linked to structural transformation and modernization. Musgrave et al (1989) emphasize that the public sector performs three fundamental functions: allocation, distribution, and stabilization. The allocation function involves providing public goods such as infrastructure and industrial support services; the distribution function addresses income inequality; while the stabilization function ensures macroeconomic balance through fiscal and monetary policy. In the Nigerian context, the public sector has historically been instrumental in shaping industrial policies, establishing state-owned enterprises, and creating enabling environments for private sector growth. The post-independence period witnessed extensive state participation in manufacturing, energy, steel production, and petrochemicals, reflecting a developmental state approach. As noted by Ekpo (2004), Nigeria's public sector was conceived as the primary driver of economic modernization, especially in sectors where private capital was weak or risk-averse.

However, public sector effectiveness depends heavily on institutional capacity, governance quality, transparency, and policy coherence. Contemporary scholarship increasingly emphasizes the need for public sector reform, performance management, and institutional strengthening to enhance developmental outcomes (Pollitt & Bouckaert, 2017). Within the framework of sustainable industrial development, the public sector is not merely a regulator but also a facilitator, financier, innovator, and strategic planner.

Public sector institutions and institutional framework: Public sector institutions constitute the operational machinery through which government policies are formulated, implemented, monitored, and evaluated. Institutional frameworks stand as the legal, regulatory, administrative, and organizational arrangements that guide the functioning of these bodies. North (1990) conceptualizes institutions as the “rules of the game” that structure political, economic, and social interactions. In the public sector, institutional frameworks determine how industrial policies are designed, enforced, and sustained. A strong institutional framework is essential for industrial development because it provides predictability, reduces transaction costs, and builds investor confidence. According to Acemoglu et al (2012), inclusive and well-functioning institutions are fundamental determinants of economic growth and industrial transformation. Where institutions are weak, fragmented, or inconsistent, industrial policies tend to fail due to poor coordination and lack of accountability.

In Nigeria, public sector institutions involved in industrial governance include ministries responsible for industry, finance, planning, environment, science and technology, as well as regulatory agencies overseeing standards, investment promotion, and competition policy. The institutional framework governing industrial development includes legislative acts, industrial master plans, national development strategies, fiscal policies, and regulatory guidelines. Institutional capacity encompasses human resources, technical expertise, financial resources, and administrative efficiency. Grindle (1997) argues that institutional capacity determines the ability of public agencies to translate policy intentions into measurable outcomes. Weak inter-agency coordination, bureaucratic bottlenecks, and policy discontinuities often undermine industrial development efforts in developing countries.

Furthermore, the concept of “good governance” is deeply embedded within institutional frameworks. Governance indicators such as transparency, rule of law, regulatory quality, and control of corruption significantly influence industrial performance (World Bank, 2017). Effective public sector institutions must therefore integrate accountability mechanisms, stakeholder engagement, and evidence-based policy design to foster sustainable industrial growth.

Industrialization and Industrial Development: Industrialization refers to the transformation of an economy from primary production to manufacturing and value-added activities, accompanied by technological advancement, productivity growth, and structural change. Historically, industrialization has been the cornerstone of economic transformation in developed nations, serving as the foundation for increased incomes, employment expansion, and technological innovation. Gerschenkron (1962) posits that industrialization is a strategic process requiring state intervention, especially in late-developing economies. Industrial development goes beyond factory establishment; it involves industrial diversification, technological upgrading, infrastructure development, and the creation of competitive production systems. It also entails the integration of domestic industries into global value chains. In the Nigerian context, industrial development has been shaped by various policy regimes in Nigeria (Table 1).

Table 1: Nigeria national development plans in the 4th Republic, 1999 – 2025

S/	Programme/p lan	Initiator /Period	Focus	Remark
1.	National economic empowerment and development strategy (NEEDS/SEED/LEEDS)	Olusegun Obasanjo, 1999-2007	1. Laying solid foundation for sustainable/self-reliant development. 2. Poverty reduction, employment generation, wealth creation and value re-orientation for transforming Nigerian to become the strongest economy in Africa. 3. An economic agenda that required states (SEEDS) and local government (LEEDS) to prepare their strategies.	1. Achieved minimal degree of success. 2. Absence of clearly defined strategies and poor implementation. 3. Over reliance on domestic/foreign borrowings. 4. Plans have not critically addressed problem of production and productivity. 5. Hardly any plan that does not prioritize these <u>programmes/projects</u>. 6. Mere recycling of <u>programmes</u>, projects and plans (PPPS). 7. Discredited development strategies.
2.	7-point Agenda	Musa Yar'Adua, 2007-	1. Critical infrastructure development. 2. Niger delta development. 3. Agricultural development/food security. 4. Human capital development. 5. Land tenure changes/home ownership. 6. National security /intelligence. 7. Wealth creation.	

3.	Vision 20:2020	Goodluck Ebele Jonathan (GEJ), 2009-	Long-term economic transformation and blue print for: 1. Improving standard of living. 2. Placing Nigerian economy to be among the top 20 largest economies of the world by year 2020. 3. Fiscal prudence.
4.	National industrial revolution	2014-	1. Increased infrastructural facilities to support industrialization, 2. Diversification of economy 3. Agriculture as pivotal to industrialization.
5.	Economic Recovery Growth Plan (ERGP)	Muham madu Buhari, 2017-2020	1. Comprehensive economic intervention plan in propelling growth in medium term. 2. Restore growth, macro-economic stability and propel economic growth/diversification. 3. Priority areas – agriculture, food security, power, infrastructure, industrialization, etc.
6.	National development plan (NDP) vol.1	2021-2025	1. Medium term blue print to unlock economic potentials in 7 cluster areas: economic growth/development, HCD, infrastructure, public administration, social development, regional development plan implementation.

Source: Author's Compilation, 2021

In Table 1, we have listed the various industrial development. However, structural constraints such as overdependence on oil exports, weak manufacturing capacity, and limited technological plans embarked upon by the various regimes in Nigeria beginning with the national economic empowerment and development strategy (NEEDS), introduced by Olusengun Obasanjo (1999-2007), 12th Nigeria Head of State and government (HOSG). The plan was to be replicated at the state and local government levels as state economic empowerment and development and strategy (SEEDS) and local economic empowerment and development and strategy (LEEDS). It was for laying solid foundation for sustainable industrial development as well as, wealth creation to reduce poverty and unemployment. However, the succeeding administration by Musa Yar'adua, propounded seven 7-point agenda in 2007

which metamorphosed to Vision 2020 and national industrial revolution by Goodluck Ebele Jonathan, 14th Nigeria HOSG (2009 and 2015). The administration President Muhammadu Buhari PMB further formulated the economic recovery growth plan (2017-2020) as a diversified and inclusive economy. It has three major objectives; especially, national development plan (NDP) for 2021 – 2025. The NDP is based on the assumption that, the country's resources would be properly managed and channeled to the set of human capital development and social development. Capability building is critical for sustained industrial growth, particularly in developing economies. Industrial development is multidimensional. It includes horizontal diversification (expansion into new industries), vertical integration (processing raw materials domestically), and technological deepening (innovation and research-driven productivity). It also requires reliable infrastructure electricity, transportation networks, communication systems, and logistics. Modern industrial development theories emphasize competitiveness, productivity enhancement, and innovation systems. Porter (1990) highlights the role of competitive advantage in shaping industrial success, arguing that nations must develop strong industrial clusters supported by government policies and institutional frameworks.

Dimensions and indicators of sustainable industrial development

- I. Dimensions:** Sustainable industrial development represents the integration of economic growth, environmental stewardship, and social inclusion within industrial policy and practice. It reflects the broader concept of sustainable development, defined by the World Commission on Environment and Development as development that meets present needs without compromising the ability of future generations to meet theirs. Sustainable industrial development encompasses three primary dimensions: economic sustainability, environmental sustainability, and social sustainability. Economic sustainability involves maintaining long-term industrial productivity, competitiveness, and resilience. Environmental sustainability emphasizes reduced carbon emissions, efficient resource utilization, pollution control, and green technology adoption. Social sustainability ensures decent work conditions, equitable income distribution, and inclusive participation in industrial growth.
- ii. Indicators:** Indicators of sustainable industrial development include manufacturing value added as a percentage of GDP, industrial employment rates, energy efficiency levels, carbon emission intensity, technological innovation indices, and investment in research and development. According to the United Nations Industrial Development Organization (2019), sustainable industrialization requires innovation-driven growth and environmentally responsible production systems. Green industrialization is increasingly recognized as a strategic pathway for sustainability. It promotes renewable energy integration, waste recycling, eco-friendly manufacturing processes, and sustainable supply chains. Barbier (2010) argues that green economic transformation can simultaneously stimulate industrial growth and environmental protection. In Nigeria, sustainable industrial development remains an emerging agenda. Industrial activities often face challenges such as environmental degradation, gas flaring, pollution, and unsustainable resource extraction. Achieving sustainability therefore requires strong regulatory enforcement, environmental standards, and technological innovation supported by public institutions.

Role of public sector institutions in promoting sustainable industrial development

Public sector institutions play a decisive role in fostering sustainable industrial development by designing policies, mobilizing resources, regulating markets, and ensuring environmental compliance. The developmental state theory suggests that governments can accelerate industrial transformation through strategic coordination and institutional capacity. Public institutions provide

industrial policy direction through national development plans, sectoral strategies, and fiscal incentives. They also facilitate infrastructure provision power supply, industrial parks, a transportation corridor which forms the backbone of industrial productivity.

Public sector institutions mobilize financial resources through development banks, credit schemes, and investment promotion frameworks. Development finance institutions bridge funding gaps for small and medium industrial enterprises, enabling innovation and expansion. Regulatory agencies enforce environmental standards and labor laws, ensuring that industrial growth aligns with sustainability principles. Effective regulation prevents market failures such as pollution, resource depletion, and social inequality. Through partnerships with universities, research institutes, and private enterprises. Nelson (1993) emphasizes the importance of national innovation systems in sustaining industrial competitiveness.

Institutional weaknesses corruption, bureaucratic inefficiency, policy inconsistency, and weak monitoring systems often undermine these roles. Strengthening institutional governance, improving inter-agency coordination, and adopting transparent accountability mechanisms are therefore essential for achieving sustainable industrial transformation.

THEORETICAL FRAMEWORK

The study adopted the *Developed Institutional Theory* propounded by Douglass North (1990) as the theoretical framework. North defined institutions as the “rules of the game” in a society humanly devised constraints that structure political, economic, and social interactions (North, 1990). These rules consist of both formal frameworks, such as constitutions, laws, property rights, regulations, and contracts, and informal institutions, including norms, traditions, conventions, and codes of conduct. Together, these elements create an incentive structure that influences the behaviour of individuals, firms, and governments. North's theory is a departure from purely neoclassical economic explanations of development by emphasizing that economic outcomes cannot be understood solely through market forces or technological advancement; instead, they are deeply embedded in institutional arrangements that determine how resources are allocated and how transactions occur. At the core of North's Institutional Theory is the concept of transaction costs. He argues that in a world of imperfect information and bounded rationality, economic exchange is never costless. Individuals and organizations incur costs when searching for information, negotiating agreements, monitoring compliance, and enforcing contracts. Institutions emerge and evolve to reduce these transaction costs by providing stability, predictability, and order. For example, a well-defined legal system lowers uncertainty in economic exchange because it assures actors that contracts will be enforced. Conversely, weak or ambiguous institutional frameworks increase uncertainty and risk, discouraging investment and innovation. Thus, institutions are not peripheral to economic performance; they are central determinants of whether economies grow or stagnate.

Institutional change, according to North, is path dependent. This means that historical choices and established institutional arrangements constrain future options. Once a society adopts certain rules and organizational structures, these tend to persist because of increasing returns and vested interests. Organizations such as firms, political parties, bureaucracies, and trade unions arise within the existing institutional framework and often work to maintain it if it benefits them. As a result, inefficient institutions can persist over long periods, even when better alternatives exist. This insight is particularly relevant to public sector institutions in developing countries, where colonial legacies, patronage systems, and entrenched bureaucratic practices may continue to shape governance outcomes long after their original context has changed. In relation to public sector institutions,

North's Institutional Theory provides a powerful analytical lens for understanding governance quality, administrative capacity, and policy effectiveness. Public institutions operate within a complex web of formal and informal rules that determine how decisions are made, how authority is exercised, and how accountability is enforced. When public sector institutions are governed by clear legal frameworks, transparent procedures, and strong accountability mechanisms, they tend to reduce uncertainty for economic actors. This encourages private investment, supports market development, and enhances public trust. However, when institutions are characterized by corruption, weak enforcement of laws, and inconsistent regulatory practices, transaction costs rise significantly. Businesses may be forced to rely on informal networks, bribery, or personal connections to operate, which undermines efficiency and long-term development.

North emphasizes the importance of credible commitment in public institutions. Governments should be able to commit credibly to policies that protect property rights, enforce contracts, and maintain macroeconomic stability. If political leaders frequently change policies for short-term gain or fail to uphold legal agreements, investors lose confidence. Sustainable industrial development depends heavily on such credibility. Industrial actors require long-term investments in infrastructure, technology, and human capital. These investments shall only occur if the institutional environment ensures stability and predictability. Therefore, public sector institutions that demonstrate consistency, rule of law, and impartial enforcement play a foundational role in industrial growth. Institutional Theory also highlights the interplay between institutions and organizations. Organizations are the players of the game, while institutions are the rules. In the public sector, ministries, regulatory agencies, and public enterprises function as organizations that respond to institutional incentives. If the institutional framework rewards efficiency, innovation, and service delivery, public organizations are more likely to align their behavior with development objectives. Conversely, if the system rewards rent-seeking, political loyalty, or bureaucratic inertia, public organizations may prioritize self-preservation over public welfare. Thus, reforming public sector institutions requires not only structural changes but also transformation of the underlying incentive structures embedded in formal and informal rules.

METHODOLOGY

This study applied a descriptive research design, relying secondary sources of data to examine the role of public sector institutions in promoting sustainable industrial development in Nigeria. Using materials such as government publications, institutional reports, academic journals, books, and international development reports, the study synthesized existing knowledge on institutional frameworks, industrial policies, and sustainability practices. The descriptive design allows for a detailed review of these sources, highlighting trends, interventions, and outcomes without the need for primary data collection, and ensures that the analysis remains systematic, coherent, and grounded in credible evidence.

The data collected from these sources shall be analyzed using thematic content analysis, a qualitative method that identifies and categorizes recurring themes across different materials. This approach enables the researcher to extract meaningful patterns related to institutional roles, policy effectiveness, sectoral contributions, and sustainability measures, and to integrate these findings into a coherent discussion of sustainable industrial development in Nigeria. By focusing on existing literature and documented evidence, the study provides a comprehensive understanding of how public sector institutions influence industrial growth while maintaining alignment with sustainability objectives.

DISCUSSION AND RESULTS

Discussion

The role of public sector institutions in Nigeria

In examining the role of public sector institutions in promoting sustainable industrial development in Nigeria, it is important to first identify the key federal institutions that form the backbone of industrial governance, regulation, financing, and policy implementation. These institutions constitute the structural and administrative framework through which industrial policies are formulated, coordinated, and executed. Their establishment over different periods reflects Nigeria's evolving approach to economic management, industrial expansion, sustainability regulation, and institutional strengthening. The table below presents the major federal public sector institutions in Nigeria arranged in chronological order (from the most recent to the oldest), highlighting their dates of establishment. This provides a foundational basis for analyzing their roles, effectiveness, and contributions to sustainable industrial development in Nigeria.

Table 2: Major Federal Public Sector Institutions in Nigeria and Their Dates of Establishment

S/N	Name of Institution	Date Established
1	Federal Ministry of Budget and National Planning	2015
2	Federal Ministry of Industry, Trade and Investment	2011
3	Nigerian Content Development and Monitoring Board	2010
4	National Bureau of Statistics	2007
5	National Environmental Standards and Regulations Enforcement Agency	2007
6	Infrastructure Concession Regulatory Commission	2005
7	Nigerian Electricity Regulatory Commission	2005
8	Small and Medium Enterprises Development Agency of Nigeria	2003
9	Bank of Industry	2001
10	Federal Ministry of Environment	1999
11	Bureau of Public Enterprises	1999
12	Nigerian Investment Promotion Commission	1995
13	National Agency for Science and Engineering Infrastructure	1992
14	Raw Materials Research and Development Council	1987
15	Federal Ministry of Science, Technology and Innovation	1980
16	National Office for Technology Acquisition and Promotion	1979
17	Nigerian National Petroleum Company Limited	1977
18	Nigerian Export Promotion Council	1976
19	Standards Organisation of Nigeria	1971
20	Industrial Training Fund	1971
21	Central Bank of Nigeria	1958
22	Federal Ministry of Finance	1958
23	Federal Ministry of Power	1950
24	Federal Inland Revenue Service	1943
25	Federal Ministry of Labour and Employment	1939

Source: Federal Government of Nigeria Establishment Acts, Official Gazettes, and institutional records.

<https://nigeriareposit.nlm.gov.ng/collections/246c6469-f257-4c57-8859-72d9002f2919>.

Federal Government of Nigeria (Accessed 2026)

In Table 1 we have stated the federal government institution and their years of establishment. These agencies were established to assist the government in policy formulation, regulation, financing, infrastructure provision, technology promotion, environmental protection, fiscal management, and human capital development. For instance, the Federal Ministry of Industry, Trade and Investment plays a central coordinating role in designing industrial policies, promoting local production, attracting foreign direct investment, and facilitating trade expansion. Complementing this role, the Nigerian Investment Promotion Commission encourages both domestic and foreign investors through regulatory facilitation and investment incentives, while the Nigerian Export Promotion Council supports export diversification beyond oil dependence. Financial intermediation and industrial credit provision are primarily driven by the Bank of Industry and supported by macroeconomic stabilization policies of the Central Bank of Nigeria. These institutions provide long-term financing, intervention funds, and credit schemes targeted at manufacturing, agro-processing, and small and medium-scale enterprises. The Small and Medium Enterprises Development Agency of Nigeria further strengthens the SME ecosystem through capacity building, entrepreneurship development, and business support services, which are critical for inclusive industrialization. Regulatory and quality assurance functions are performed by institutions such as the Standards Organisation of Nigeria, which ensures compliance with product standards to enhance competitiveness, and the National Environmental Standards and Regulations Enforcement Agency, which enforces environmental sustainability in industrial operations. Infrastructure and energy regulation, essential for industrial productivity, are handled by bodies such as the Nigerian Electricity Regulatory Commission and the Infrastructure Concession Regulatory Commission. Together, these institutions align industrial expansion with sustainability principles, technological advancement, environmental compliance, and long-term economic resilience.

Result

Effectiveness of Public Sector Institutional Policies and Interventions in Achieving Sustainable Industrial Growth

Institutional reforms and targeted interventions have contributed to increased SME participation, improved regulatory frameworks, and expanded access to industrial financing. Intervention funds coordinated by the Central Bank of Nigeria and financing windows of the Bank of Industry have supported manufacturing clusters, agro-industrial value chains, and youth entrepreneurship initiatives. Additionally, export promotion strategies implemented by the Nigerian Export Promotion Council (EPC) have enhanced non-oil export awareness and market access programs. Environmental governance has also improved through regulatory enforcement by the National Environmental Standards and Regulations Enforcement Agency (NESREA) and policy coordination by the Federal Ministry of Environment, thereby integrating sustainability into industrial activities. Furthermore, public-private partnership (PPP) frameworks supervised by the Infrastructure Concession Regulatory Commission (ICRC) have stimulated private sector participation in infrastructure development. However, despite these policy initiatives, Nigeria's industrial sector continues to face structural bottlenecks such as low manufacturing contribution to GDP, heavy import dependence, inadequate power supply, and policy inconsistency. Institutional overlap, bureaucratic inefficiencies, and weak inter-agency coordination reduce the full impact of these interventions. Therefore, while institutional frameworks exist and have recorded measurable outputs, their overall effectiveness in delivering sustained, broad-based industrial transformation remains constrained by systemic challenges.

Challenges of public sector institutions in fostering sustainable industrial development in Nigeria

Public sector institutions in Nigeria face numerous structural, operational, and governance-related challenges that hinder sustainable industrial development. A major constraint is policy inconsistency and frequent administrative restructuring, which disrupt long-term industrial planning. For example, changes in ministerial configurations and overlapping mandates among agencies often create regulatory uncertainty for investors. Funding limitations and delayed budget releases further weaken institutional capacity to implement industrial programs effectively. Infrastructure deficits particularly unreliable electricity supply, weak transport networks, and limited industrial parks also undermine institutional efforts despite regulatory oversight by bodies such as the Nigerian electricity regulatory commission. Additionally, corruption, weak monitoring and evaluation systems, and inadequate data coordination even with the presence of the National bureau of statistics limit evidence-based policymaking and performance tracking. To improve outcomes, this study suggests strengthening inter-agency coordination mechanisms, enhancing institutional autonomy and accountability, improving budgetary stability, and deepening digital governance systems for transparency. Greater alignment between industrial, environmental, fiscal, and technological policies is also essential. Furthermore, sustained investment in infrastructure, innovation systems, and human capital development will enhance the capacity of these public sector institutions to deliver inclusive and environmentally sustainable industrial growth. Strengthening monitoring and evaluation frameworks and ensuring continuity in industrial policy implementation are critical for translating institutional mandates into measurable developmental impact.

Findings

The study found out the following:

- i. Public sector institutions in Nigeria perform extensive roles in policy formulation, industrial financing, regulation, export promotion, environmental protection, infrastructure development, and human capital formation, forming a broad institutional framework for industrial development.
- ii. Despite the presence of these institutions and multiple policy interventions, sustainable industrial growth remains limited due to structural bottlenecks such as inadequate infrastructure, inconsistent policies, weak inter-agency coordination, and limited access to finance.
- iii. Institutional challenges including bureaucratic inefficiency, insufficient monitoring mechanisms, funding constraints, and regulatory overlaps significantly undermine the effectiveness of public sector institutions in achieving long-term sustainable industrial transformation.

Conclusion

Based on discussion, results and findings of the study, the study concludes that public sector institutions occupy a central and indispensable position in Nigeria's pursuit of sustainable industrial development. Over several decades, the Federal Government has established a wide network of ministries, regulatory agencies, financial institutions, and development bodies designed to stimulate industrial productivity, promote investment, regulate standards, ensure environmental compliance, and facilitate macroeconomic stability. These institutions collectively reflect a strong policy recognition of industrialization as a pathway to economic diversification and sustainable growth.

However, the mere existence of institutional frameworks does not automatically translate into sustainable industrial outcomes. The study establishes that while institutional mandates are

comprehensive and theoretically aligned with sustainability principles, their practical impact is weakened by systemic and structural constraints. Persistent infrastructure deficits, policy discontinuity, bureaucratic delays, and inadequate coordination mechanisms reduce the overall effectiveness of industrial interventions. Furthermore, insufficient integration of environmental sustainability into core industrial planning limits the achievement of balanced economic, social, and ecological objectives.

Therefore, the study concludes that sustainable industrial development in Nigeria depends not only on institutional presence but on institutional coherence, stability, accountability, and capacity. Strengthening governance structures, improving policy consistency, and enhancing inter-agency collaboration are essential to reposition public sector institutions as effective drivers of long-term industrial transformation. Without addressing these underlying institutional weaknesses, Nigeria's aspiration for sustainable industrial growth may remain only partially realized.

Recommendations

The study recommends that:

- 1) The government should strengthen inter-agency coordination and establish clear frameworks for policy alignment among industrial, environmental, financial, and technological institutions to eliminate duplication and enhance efficiency.
- 2) There should be sustained investment in infrastructure development, particularly in electricity supply, transportation networks, and industrial clusters, to support productive industrial activities and improve competitiveness.
- 3) Institutional reforms aimed at improving transparency, accountability, monitoring, and evaluation mechanisms should be prioritized to enhance the effectiveness of public sector policies and ensure continuity in industrial development strategies.

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NATIONAL CONFERENCE ON INDUSTRIALISATION, EMPLOYMENT CREATION AND ECONOMIC DEVELOPMENT IN NIGERIA

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MULTI-OBJECTIVE OPTIMIZATION OF WORKABILITY AND DURABILITY PROPERTIES OF ECO-FRIENDLY LIGHTWEIGHT CONCRETE INCORPORATING RICE HUSK ASH AND SHEEP WOOL FIBRE

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Abstract

The increasing demand for sustainable construction materials has encouraged the incorporation of agricultural and natural fibres into cementitious composites. This study investigates the combined influence of Rice Husk Ash (RHA), a pozzolanic agro-waste, and Sheep Wool Fibre (SWF), a renewable natural fibre, on the durability properties of lightweight concrete. The experimental program employed Response Surface Methodology (RSM) with a Central Composite Design (CCD) to optimize the mix proportions of RHA (5–25% replacement of cement) and SWF (0.5–2.5%) by weight. Key performance indicators including workability, water absorption and resistance to acid attack were evaluated. X-ray diffraction (XRD) analysis confirmed the presence of amorphous silica in RHA, indicating high pozzolanic potential, while SWF exhibited crystalline patterns characteristic of structural reinforcement rather than chemical reactivity. Significant correlations were found in the responses that were successfully predicted by RSM generated quadratic models. The ideal combination of 2% SDA and 10% CNS was found by multi objective optimization, which maximized the workability (126.5mm) and minimized the water absorption at 14 Days (5.01%) and at 28 Days (9.21%) then Acid attack at 14 Days (13.1MPa) and at 28 Days (19.602MPa) with an overall desirability of 75.1%. The experimental validation of this result revealed that the discrepancy between the predicted and experimental results was less than 5%. This indicates the potential of RHA-SWF lightweight concrete for adoptable, affordable and environmentally friendly construction in areas with limited resources.

Keywords: Rice Husk Ash, Sheep wool Fibre, Response Surface Methodology, Fresh properties, Durability Property, Lightweight Concrete.

Introduction

The combined needs of servicing growing infrastructure demands and reducing its substantial environmental impact present a perpetual challenge to the global construction sector. Agricultural by-products are one of the most widely used materials in the production of conventional concrete which mainly replace cement and natural aggregates. Approximately 5-8% of the world's anthropogenic carbon dioxide (CO₂) emissions originate from the production of ordinary Portland cement (OPC), a process that is both energy-intensive and environmentally detrimental [Scrivener et al, 2018]. Concurrently, widespread natural coarse aggregate quarrying results in resource depletion, ecological devastation, and landscape deterioration [Monteiro et al, 2017]. At the same time, a serious waste management dilemma is brought on by the growing amount of industrial and agricultural waste.

Rice husk is an agricultural waste product which causes environmental issues such as air and water pollution during high winds and transported into sewers, contributing to sewer flooding within the neighborhood during intense rainfall. The rice husk has a disposal issue in most countries. Wool fibers have gained attention for their unique properties, including low thermal conductivity, biodegradability, and sustainability. While wool has been extensively used in textiles, its application in construction materials is a relatively newer area of exploration. Studies by [Zhang, and Malhotra, 1996] and [Sonebi and Kwasny, 2018] have demonstrated the potential of wool fibers in improving the mechanical properties of cement-based materials and reducing their environmental impact. The development of structural lightweight concrete (LWC) is a key tactic in this green construction trend. One of LWC's many benefits is a lower dead load, which enables smaller foundations and structural components and saves money [Neville, 2011]. Additionally, LWC has better fire resistance and thermal insulation qualities [Chandra and Berntsson, 2002]. In order to produce LWC, traditional normal-weight aggregates are usually partially or completely replaced with lighter substitutes. By turning waste into useful resources, the idea of using industrial and agricultural by-products as partial substitutes for cement has gained significant popularity [Mehta and Monteiro, 2014]. This method significantly lowers the total embodied energy and carbon footprint of concrete while also preserving virgin resources and easing waste disposal issues [Schneider, 2011].

Among the many possible waste products, Rice Husk Ash (RHA) and Sheep wool Fibre (SWF) stand out as particularly attractive options due to their availability, affordability, and unique material properties. RHA, a large by-product of the world's rice processing industries is frequently disposed of expensively. The ash that results from controlled combustion however, has pozzolanic qualities, which means that it includes siliceous and aluminous elements that can react with calcium hydroxide, a byproduct of cement hydration, to generate more cementitious compounds or C-S-H gel [Nascimento, et al, 2023], [Raheem and Adenuga, 2013]. For partial cement substitution, this makes RHA a feasible supplementary cementitious material (SCM), comparable to more well-known alternatives like fly ash and Sawdust ash. In addition, Sheep wool Fibre, a hard and resilient animal waste from the thriving wool industry, has qualities that make it a promising candidate to function as an additive in concrete. Research has indicated that SWF has low weight, toughness, and inherent susceptibility to water and deterioration can help produce structural lightweight concrete that is strong enough [Chandra and Berntsson, 2002], [Mehta and Monteiro, 2014].

The investigation of locally accessible waste materials has accelerated recently, progressing from traditional supplemental cementitious materials (SCMs) to more innovative substitutes. In recent years, the pozzolanic potential of RHA has been further clarified and verified. By optimizing the use of RHA and quarry dust in concrete [Sonebi and Kwasny, 2018] showed that an acceptable compressive strength could be achieved with up to 15% RHA substitution [Chandra and Berntsson, 2002].

Nevertheless, incorporating these minerals into concrete is not a simple replacement. The proportions of its component constituents have a complicated and non-linear effect on the final concrete's performance. The replacement amounts of both RHA and SWF have a significant impact on the final mechanical characteristics (compressive strength, split tensile strength, and flexural strength), workability, setting time, and water consumption [Montgomery, 2017]. An ideal blend is essential; too much RHA and Sheep wool Fibre replacement in cement can result in a dilution effect and slower pozzolanic reactions, which can reduce early strength [Montgomery, 2017], [Habeeb and Mahmud, 2010]. Therefore, a major and challenging engineering problem is to figure out the exact mix that maximizes the advantages—achieving the intended lightweight qualities while meeting the target mechanical performance.

Conventional experimental methods for concrete mix optimization, which change one factor at a time (OFAT), are ineffective, resource-intensive and time-consuming. Furthermore, the intricate synergistic relationships between many mix design elements cannot be captured by OFAT approaches [Raheem and Adenuga, 2013].

Applying sophisticated statistical and an optimization method, a potent set of statistical and mathematical techniques known as Response Surface Methodology (RSM) is capable of modeling, analyzing and optimizing processes in which a response of interest is impacted by several independent factors [Adamu, et al, 2021]. RSM may be used to generate exact prediction models for mechanical properties as functions of RHA and SWF substitute levels within the context of concrete mix design. Additionally, depending on predetermined criteria, it may determine the percentage that provides the highest overall performance and produce numerical optimization solutions to detect significant correlation effects between these variables [Adamu, et al, 2020], [Adamu, et al, 2022].

The practice of integrating various waste products is becoming more popular, and Response Surface Methodology is being used in more complex ways. By using RSM to optimize a lightweight concrete mix with calcium carbide and oil lateritic soil aggregate, [Khalid et al, 2024] showed how effective the approach is at balancing several responses, including cost, density, and strength [Khalid et al, 2024]. Using fly ash and quarry dust [Montgomery, 2017], conducted a multi-objective optimization research on concrete, effectively identifying Pareto-optimal solutions that met the competing objectives of maximizing strength and minimizing cost [STM, 2016]. A noteworthy development was made by [Zhang, and Malhotra, 1996], who optimized a ternary mix of cement substituted with fly ash and glass powder using RSM in conjunction with a genetic algorithm, producing a very accurate model for predicting mechanical performance [Myers, 2016]. Similarly, [Adamu, et al, 2021]. successfully modeled the interaction between flow ability, passing ability and strength by using RSM to create self-compacting concrete that included waste marble powder and copper slag [Adamu, et al, 2020]. However, a study of hybrid systems such as rice husk ash and recycled aggregate by [Habeeb and Mahmud, 2010] identified a common flaw: many research do not take a systematic approach to modeling the interactions between the combined materials, which frequently results in less-than-ideal combinations [Ali, et al, 2018]. Additionally, a gap noted by [Habeeb and Mahmud, 2010] is the underutilization of RSM for novel hybrid waste combinations, especially those that involve an agriculturally based lightweight aggregate and an agriculturally based SCM, where the performance critical interaction effects are largely unknown [STM, 2016].

Recent research demonstrates the effectiveness of RSM for concrete optimization while confirming the separate advantages of RHA and SWF. A rigorous examination, however, identifies an important,

unexplored area. Although research like [Zhang, and Malhotra, 1996] and [Neville, 2011]. Highlight RSM for waste-derived concrete, they focus on other, more well-known material combinations (such as fly ash and oil palm shell). Critically, there is a glaring lack of studies that employ a strong statistical framework to systematically examine the synergistic effects of mixing rice husk ash (RHA) and Sheep wool Fibre (SWF) within a single concrete matrix. The goal of this study is to close this crucial gap by offering a thorough, data-driven examination of this innovative hybrid lightweight concrete and using RSM to maximize its sustainable performance. In light of this, the main goal of this research is to use Response Surface Methodology to predict and optimize the mechanical and workability characteristics of lightweight concrete that contains rice husk ash and Sheep wool Fibre.

2.0 MATERIALS AND METHODS

Materials

Grade 42.5N Portland limestone cement manufactured in Nigeria as Dangote brand was used for this experimental investigation, the river sand used as fine aggregate was procured within Kano state Nigeria. Sieve analysis and specific gravity of the aggregates were also determined in accordance with [BS 1881]. The coarse aggregate used for this research were typically angular in shape, well graded for conventional concrete. Water used for this research was obtained from the laboratory tap and was found adequate for the experiment. The rice husk used in this research was procured in a nearby rice milling factory in Kano state Nigeria. It was sun-dried for 10 days to remove excess moisture to aid the burning process. The samples were burnt openly and then rice husk Ash was obtained at a control temperature ranging from 600°C for 2hrs. The ash was allowed to cool before sieving through sieve 75 µm and the retained material obtained was used for the experiment. The characterization test and specific gravity test for the sample was observed in accordance with [BS 1881].

Fine Aggregate is an essential material of concrete, for this study, the river sand in Kano was considered for the experiment. Sieve analysis and specific gravity of the aggregates were also determined. The coarse aggregate chosen for the concrete was typically angular in shape, well graded and smaller than maximum size suited for conventional concrete conformed with BS 1881. Water is an important ingredient of concrete as it actually participates in the chemical reaction with the cement. Since water improves the strength of cement in concrete, the quantity and quality of water are required to be looked in to very carefully. Elasticity is a key component of wool fiber's mechanical qualities, felting, and resilience. Alpha helical cells give wool fibre its elastic quality and operate as a spring for up to 2.5 percent of its length; however, they are more easily expanded in acidic or alkaline environments than in neutral ones. When the wool polymer's peptide chains are broken by acid or alkali, they take on the elasticity of rubber; however, when they are removed, their side linkage spontaneously repairs, decreasing elasticity. Wool fiber's comfort qualities are improved by its elastic recovery quality, which also keeps it from crinkling readily.

Sieve Analysis

The sieve analysis results of the coarse and fine aggregates are presented in Figure 1 below.

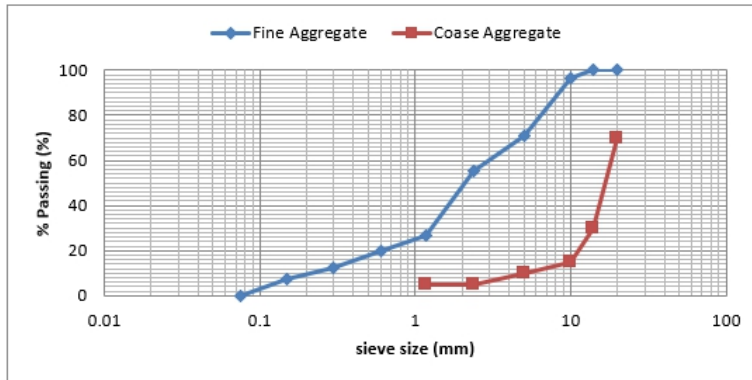


Figure 1: Particle size distribution curve of Aggregates

Specific Gravity

The specific gravity test on RHA, SWF, fine aggregate and coarse aggregate were conducted in accordance with BS EN 12620 (2013), their result were found to be 1.03, 0.18, 2.59 and 2.34 respectively using equation 1 below.

$$SG = \frac{w_2 - w_1}{(w_4 - w_1) - (w_3 - w_2)}$$

Where; W_1 = Weight of empty bottle, W_2 = Weight of bottle + Sample, W_3 = Weight of bottle + Sample + Water, W_4 = Weight of bottle + Full Water

Mix Design

Response Surface Methodology analysis was used to establish appropriate portions of cement, RHA, SWF, coarse aggregate, fine aggregate and water to obtain the desirable workability and mechanical properties of the lightweight concrete. The concrete's mix proportion was formulated using the principles specified in the building research establishment (BRE) mix design method (Formerly known as the DOE method). In this study, Response Surface Methodology analysis was performed using Design Expert version 13 to develop a statistical model of lightweight concrete modified with Sawdust Ash and Coconut Shell using a central composite design [Adamu et al, 2022]. Rice Husk Ash and sheep wool fibre serving as independent variables at Five (5) levels correspond to each parameter: 0% to 20% Rice Husk Ash in place of cement and likewise, the percentages of sheep wool fibre in 0% to 2% as additive.

Table 1. The mix proportion of concrete materials based on RSM analysis

MIX ID	OPC Kg/m ³	F Agg Kg/m ³	C Agg Kg/m ³	Water (m ³)	RHA Kg/m ³	SWF Kg/m ³
mix 1 (15RHA1.5SWF)	462.924	577.5	1312	180.26	83.16	8.316
mix 2 (10RHA1SWF)	493.416	577.5	1312	180.26	55.44	5.544
mix 3 (10RHA1SWF)	493.416	577.5	1312	180.26	55.44	5.544
mix 4 (5RHA0.5SWF)	523.908	577.5	1312	180.26	27.72	2.772
mix 5 (10RHA0SWF)	498.96	577.5	1312	180.26	55.44	0
mix 6 (15RHA0.5SWF)	468.468	577.5	1312	180.26	83.16	2.772
mix 7 (10RHA1SWF)	493.416	577.5	1312	180.26	55.44	5.544
mix 8 (10RHA1SWF)	493.416	577.5	1312	180.26	55.44	5.544
mix 9 (10RHA2SWF)	493.416	577.5	1312	180.26	55.44	5.544
mix 10 (20RHA1SWF)	493.416	577.5	1312	180.26	55.44	5.544
mix 11 (0RHA1SWF)	548.856	577.5	1312	180.26	0	5.544
mix 12 (10RHA1SWF)	493.416	577.5	1312	180.26	55.44	5.544
mix 13 (5RHA1.5SWF)	518.364	577.5	1312	180.26	27.72	8.316
mix 14 (0RHA0SWF)	554.4	577.5	1312	180.26	0	0

The above table shows the mix proportion of the concrete materials used to prepare the lightweight concrete. Design Expert software was used to generate 13 mixes by the various combinations of factors summarized in Table 1. There are four (4) factorial points, four (4) axial points and five (5) center points in the Thirteen (13) mixes. The center points are mixed combinations that are repeated. The repeated mixes also known as duplicated design points used to determine the model's lack of fit. The “Lack of Fit Tests” chart contrasts the “Pure Error” from duplicated design points with the residual error. The model should not be utilized as a response predictor if there is a significant lack of fit, as shown by a low probability value (“Prob > F”) [Adamu et al, 2020], [Adamu et al, 2021], [Adamu et al, 2022].

3. RESULT AND DISCUSSION

Slump Test Result

The slump test results presented in Figure 6 below indicate that the workability of the concrete mixes varied between 100 mm and 170 mm across different proportions of RHA and SWF. Furthermore, mixes containing higher levels of RHA and SWF showed reduced slump values compared to mixes with lower replacement levels. The results indicate that the addition of these materials has a significant influence on fresh concrete workability. The reduction in slump can be as a result of two main factors: Effect of RHA and SWF has a high specific surface area and is highly porous. When incorporated as a partial cement replacement, it tends to absorb more mixing water, reducing the free water available in the mix. This leads to a stiffer mix and hence lower slump values. Similar findings were reported by [Scrivener et al, 2018] who observed a consistent reduction in workability with increasing RHA content. The Effect of SWF increases the internal friction within the concrete, reducing its flow ability. The fibre also absorb water and promote interlocking effects, further reducing slump. [Zhang and Malhotra, 1996] Reported that natural fibre generally reduces workability due to balling effects and increased viscosity of the fresh mix. Despite the reduction in slump, certain mixes

(e.g., those around 160–170 mm) exhibited good workability. This could be due to the balance between RHA's fine particles filling voids and the moderate content of SWF improving cohesion without causing excessive stiffening. [Ali et al, 2018] Highlighted those wool fibre, though reducing flow, can improve the cohesiveness of the mix and minimize segregation—an advantage in lightweight concretes.

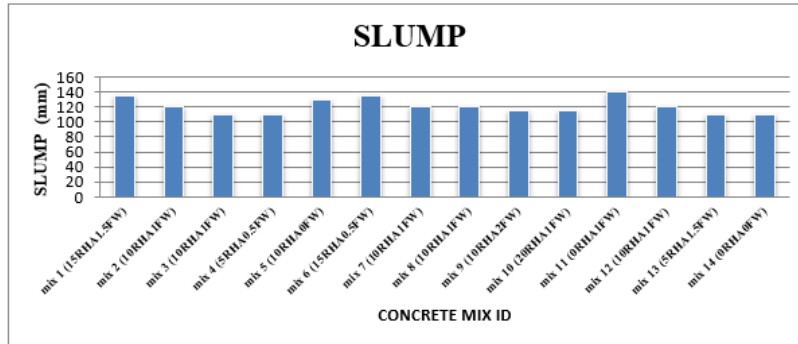


Figure 2: Slump Test Result

Durability Properties

Water absorption

The durability performance of RHA-SWF concrete mixes containing RHA and SWF was also assessed using water absorption test; the findings are shown in Figure 3. The percentage of RHA and SWF content was shown for each mix. Mix 1 (15RHA1.5SWF) for example, which contains 15% RHA and 1.5% SWF, has a water absorption value of 4.2% at 14 days and 9.3% at 28 days. On the other hand, mix 7 (10RHA1.5SWF), which includes 10% RHA and 1% SWF had a water absorption capacity of 3.8% at 14 days and 6.7% at 28 days, while Mix 14 (0RHA0.5SWF) which contains 0% RHA and 0% SWF, demonstrated a water absorption capacity of 2.3% and 4.08%. The water absorption capacity value of Mix 1 (15RHA1.5SWF) was the greatest surpassing that of the control mix. The results clearly show that the water absorption rate rises as the percentage replacement of a larger amount of RHA and a lesser percentage of SWF increases. Moreover, as comparison to Mix 14 (control mix), the water absorption rate falls with a larger proportion of SWF and a smaller proportion of RHA. This might be explained by the high specific surface area of SWF, which would raise the water requirement, and its low specific gravity, which results in a decrease in mass per unit volume.

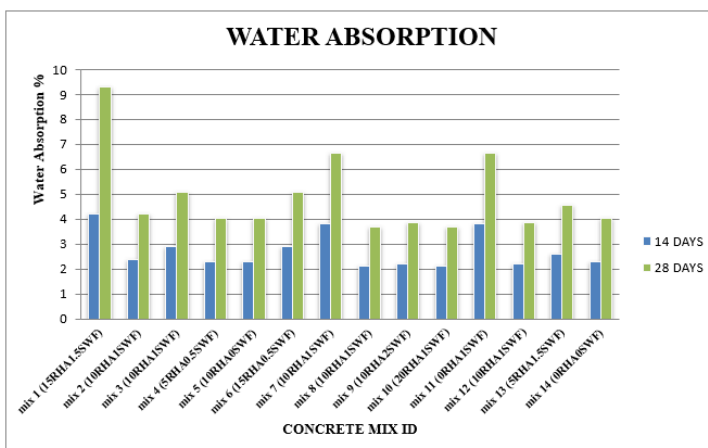


Figure 3: Water Absorption Result of RHA+ SWF

Resistance to Hydrochloric Acid (HCl) media

The compressive residual strength of concrete samples exposed to acidic media is shown in Figure 4. The figure clearly shows that the concrete samples' compressive residual strength significantly drops as the acid exposure period increases. The results clearly demonstrate that at 14 and 28 days, the control concrete sample showed a decrease of compressive residual strength ranging from 5.2 N/mm² to 2.3 N/mm². Conversely, the compressive residual strength of RHA-SWF concrete sample with mix ID 1 decreased from 5.3 N/mm² to 10.15 N/mm². Figure 4 illustrates the loss in compressive residual strength for RHA-SWF concrete samples exposed to acidic media. It also makes it evident that as the immersion period increased the samples' compressive residual strength which was greatly affected by the acidic conditions.

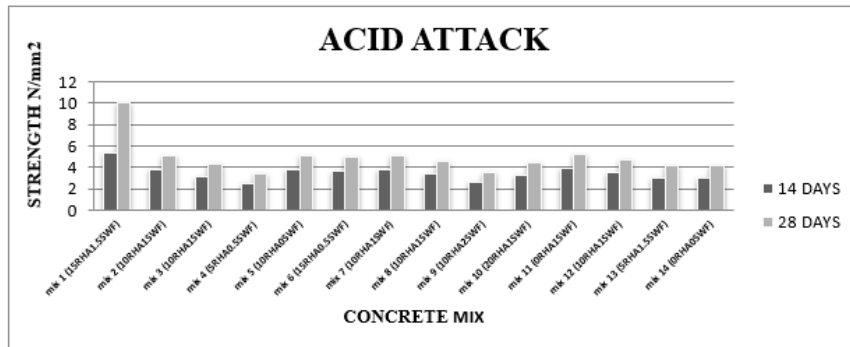


Figure 4: RHA+SWF Resistance to Acid (HCl)

Multi-objective optimization and validation

A numerical optimization was conducted using the desirability function approach which is frequently used in multi-objective optimization scenarios, to determine the ideal mix proportions of RHA and SWF for improved concrete durability. The goal of this study's optimization was to determine the best mix of independent factors to produce a RHA-SWF concrete mixture that minimizes acid attack and water absorption while maximizing the mechanical properties and the workability. To optimize the responses and capture all possible solutions, all parameters were established within a certain range. Table 2 defines the multi-objective optimization constraints for the variables and responses. According to the optimization findings, if the ratios are maintained within the statistically established ideal range, a partial substitution of cement with 10% RHA and coarse aggregate with 1% SWF can produce significant increases in the fresh, mechanical and durability of concrete. In addition to helping to conserve resources and reduce waste, this approach supports the development of sustainable building materials. Using the optimized mixture ratios shown in Table 2, a second series of laboratory tests was carried out to confirm the sufficiency of the optimization data retrieved from the Design-Expert program and all of the response models. The latter step was done to ensure that the proportions of the optimized mixture were accurate. Three specimens were produced for each test parameter, and the mean values of each were reported. After 28 days, results were evaluated and contrasted with the predicted results. Using Equation (2) [Khalid et al, 2024], the discrepancy between the experimental and predicted results was computed.

$$\varepsilon = 1 - \frac{y}{x} \times 100 \quad (2)$$

Where y stand for predicted value and x stand for experimental value for each of the responses that were taken into consideration, Table 2 displays the RSM predicted findings together with the corresponding experimental data. With an average percentage error of less than 5%, the computed percentage errors showed that the actual results and predicted results agreed well.

Table 2: Multi-objective Criteria and Outcomes of the Optimization.

Variables and responses	Units	Criteria for optimization			Results and verification		
		<i>Desired goal</i>	<i>Lower limit</i>	<i>Upper limit</i>	<i>Predicted result (Y)</i>	<i>Experimental result (X)</i>	<i>Error (%)</i>
RHA	%	In range	0	20	10	10	-
SWF	%	In range	0	2	1	1	-
Slump	mm	Maximize	110	140	127.343	128.543	0.93
Acid attack at 14 Days	MPa	Minimize	2.5	3.9	3.601	3.6512	1.37
Acid attack at 28 Days	MPa	Minimize	3.375	5.275	4.863	4.902	0.80
Water absorption at 14	%	Minimize	2.1	3.8	2.214	2.312	4.24
Water absorption at 28 Days	%	Minimize	3.675	6.65	3.875	3.882	0.18
Desirability	%				75.1%		

CONCLUSIONS

Conclusively, the following takeaways were extracted from the research as follows:

- i. The XRD analysis of the SWF and RHA samples shows that SWF is dominantly crystalline which implies it's less reactivity and again in RHA sample, crystalline which is majorly 70% Quartz revealed it's less pozzolanicity.
- ii. A higher replacement amount of RHA and SWF results in a more workable concrete mix. The remarkable rise in slump might perhaps be ascribed to the particle packing effect of SWF, which decreases the water content needed for plasticization.
- iii. Concrete samples with higher RHA and SWF replacement levels absorbed more water and are less resistant to acid, due to the increased pore volume and permeability. Higher SWF replacement level and longer exposure to acidic medium resulted in a general decrease in the strength. The proposed RSM quadratic models for water absorption and acid attack showed good predictability, demonstrating their use for predicting the durability behaviour of the produced concrete.
- iv. The RSM-based optimization produced the optimal mix of 2% RHA (replacement of cement) and 10% SWF (replacement of coarse aggregate), maximizing workability(126.5mm) and minimizing water absorption at 14 Days(5.01%) and at 28 Days(9.21%) and Acid attack at 14 Days(13.1MPa) and at 28 Days(19.602MPa) with 75.1% desirability. The experimental validation of this result revealed that the discrepancy between the predicted and experimental results was less than 5%. This indicates the potential of RHA-SWF lightweight concrete.

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Conflict of Interest

Authors have no any conflict of interest associated with this work.

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GENDER-BASED BARRIERS TO AGRICULTURAL PRODUCTIVITY AMONG RURAL WOMEN IN CENTRAL CROSS RIVER STATE, NIGERIA

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Abstract

Agriculture remains a major source of livelihood and household sustenance in rural communities in Cross River State, Nigeria, with women playing significant roles in crop production, processing, marketing and household food security. However, gender-based inequalities in access to productive resources and agricultural opportunities continue to constrain the productive capacity of many rural women. This study examined gender-based barriers to agricultural productivity among rural women in Central Cross River State, Nigeria. Specifically, the study assessed the influence of access to productive land, agricultural finance, extension services, productive inputs and technology, and market opportunities on women's agricultural productivity. The study was anchored on the Gender and Development and Sustainable Livelihoods Approaches and adopted a descriptive survey design. Data was obtained from 300 rural women were analysed using descriptive statistics, Pearson Product Moment Correlation and multiple regression analysis. The findings revealed significant positive relationships between access to productive land, agricultural finance, extension services, productive inputs and technology, market opportunities and women's agricultural productivity. The regression results further indicated that the identified factors jointly explained 55.6% of the variation in women's agricultural productivity, with access to productive inputs and technology emerging as the strongest predictor. The findings demonstrate that improving women's access to productive resources and agricultural support services can significantly enhance their productivity and contribution to rural household welfare. The study concludes that gender-based barriers to land, finance, extension services, technology and markets constitute important constraints on women's agricultural productivity in Central Cross River State. It recommends gender-responsive agricultural policies and programmes that improve women's access to productive land, affordable agricultural finance, extension support, modern inputs and technologies, and sustainable market opportunities.

Keywords: *gender barriers, rural women, agricultural productivity, land access, agricultural finance, extension services*

Introduction

Agriculture remains an important component of Nigeria's rural economy, providing employment, food and income for millions of households. Rural women constitute a substantial proportion of the agricultural labour force and participate in crop production, livestock activities, food processing, storage and marketing. Their contribution is particularly important in subsistence and smallholder farming systems, where agricultural production is closely connected to household food security and livelihood survival. Despite their extensive participation, however, women's agricultural productivity may remain lower than their potential because of unequal access to productive resources and opportunities.

The challenge is not necessarily women's willingness or capacity to engage in agriculture but the structural conditions within which they operate. Rural women may experience difficulties in obtaining secure access to farmland, agricultural credit, improved seeds, fertilisers, mechanisation, extension services, information and profitable markets. Gender norms may further influence who controls land, income and productive assets within households. These constraints can limit the scale of women's production, their ability to adopt improved technologies and their capacity to transform agricultural activities into sustainable sources of income. In Cross River State, these issues are particularly relevant because agriculture remains central to rural livelihoods. Communities in the Central Senatorial District engage substantially in the cultivation of crops such as cassava, yam, maize, plantain, vegetables and other food and cash crops. Women participate extensively in these activities, yet their productivity may be constrained by limited access to productive resources. The situation calls for a gender-sensitive examination of the institutional, economic and sociocultural barriers affecting women farmers.

Gender-based barriers are important because agricultural productivity is determined not only by the availability of land and labour but also by farmers' capacity to access and control productive resources. A woman may have access to farmland but lack secure tenure; she may obtain credit but receive an amount insufficient for productive investment; or she may participate in farming but have limited access to extension information and improved technology. Such inequalities can affect production decisions, input use, crop yields and income. The present study therefore examines gender-based barriers to agricultural productivity among rural women in Central Cross River State. It focuses on five major dimensions: access to productive land, agricultural finance, extension services, agricultural inputs and technology, and market opportunities. The study seeks to provide empirical evidence that can inform gender-responsive agricultural policy and rural development interventions.

Statement of the Problem

Rural women make substantial contributions to agricultural production in Central Cross River State, yet their productivity may not correspond with the extent of their participation. Many women operate small farms under conditions characterised by limited access to secure land, credit, improved inputs, agricultural information, technology and markets. These constraints can reduce their ability to expand production, adopt improved farming practices and generate sufficient agricultural income. The problem is further complicated by gender relations within rural communities. Land ownership and inheritance practices may favour men, while women may depend on husbands, relatives or temporary arrangements to access farmland. Financial institutions may also require collateral that many rural women do not possess. In addition, limited access to extension agents, mechanisation and

modern agricultural technologies can leave women dependent on traditional production methods that require considerable labour but generate relatively low returns.

Although agricultural development programmes increasingly recognise women as important agricultural actors, empirical evidence on the specific gender-based barriers affecting women's productivity in Central Cross River State remains inadequate. Existing studies often examine women's participation in agriculture generally without sufficiently examining how access to land, finance, extension, technology and markets interact to influence productivity. This study addresses this gap by empirically examining these dimensions among rural women in Central Cross River State.

Objectives of the Study

The main objective is to examine gender-based barriers to agricultural productivity among rural women in Central Cross River State, Nigeria. Specifically, the study seeks to:

1. Examine the relationship between women's access to productive land and agricultural productivity;
2. Determine the relationship between women's access to agricultural finance and agricultural productivity;
3. Examine the relationship between access to agricultural extension services and women's agricultural productivity;
4. Determine the relationship between access to agricultural inputs and technology and women's agricultural productivity; and
5. Examine the relationship between women's access to agricultural markets and agricultural productivity.

Research Questions

1. What relationship exists between women's access to productive land and agricultural productivity?
2. What relationship exists between women's access to agricultural finance and agricultural productivity?
3. What relationship exists between access to agricultural extension services and women's agricultural productivity?
4. What relationship exists between access to agricultural inputs and technology and agricultural productivity?
5. What relationship exists between women's access to agricultural markets and agricultural productivity?

Research Hypotheses

The following null hypotheses were tested at the 0.05 level of significance:

1. There is no significant relationship between women's access to productive land and agricultural productivity.
2. There is no significant relationship between women's access to agricultural finance and agricultural productivity.
3. There is no significant relationship between access to agricultural extension services and women's agricultural productivity.
4. There is no significant relationship between access to agricultural inputs and technology and women's agricultural productivity.
5. There is no significant relationship between women's access to agricultural markets and agricultural productivity.

Literature Review

Gender-Based Barriers and Agricultural Productivity

Gender-based barriers in agriculture refer to the institutional, economic, sociocultural and household conditions that restrict women's access to productive resources and opportunities relative to men. These barriers may involve land ownership and inheritance, access to agricultural credit, extension services, improved inputs, technology, labour and markets. Contemporary evidence demonstrates that the productivity disadvantage experienced by women farmers in Nigeria is substantially associated with unequal access to productive resources rather than a lack of willingness or capacity to farm. The World Bank's analysis of gender gaps in Nigerian agriculture found that women farmers produce approximately 30% less per hectare than men, with differences in input use, extension participation, crop choices and labour productivity identified as important contributors.

Recent comparative African evidence reinforces this argument. A 2025 study using agricultural data from Nigeria and other African countries found that male-managed plots were, on average, more productive than female-managed plots, with the productivity difference largely explained by unequal access to labour and non-labour inputs, land size and other productive resources. Importantly, the study found that the gender productivity gap was not simply a consequence of women being less productive farmers; rather, differences in agricultural endowments played a major role. Similarly, Jeong's (2025) comparative analysis of Malawi and Nigeria found that the Nigerian gender productivity gap was primarily explained by differences in plot size, capital and machinery, reflecting unequal access to productive assets.

Evidence from Nigeria also indicates that gender inequalities influence the adoption of agricultural innovations. A 2025 study of 800 farming households in Borno State found relatively high adoption of improved soybean practices among both male and female farmers but identified differences in the factors influencing adoption. Female farmers were particularly influenced by extension visits, age and community tenure, while financial and market constraints limited their ability to fully integrate improved practices. These findings are relevant to Central Cross River State because they suggest that agricultural productivity interventions must address the specific institutional and resource constraints experienced by women rather than assuming that uniform agricultural programmes will benefit male and female farmers equally.

Women's Access to Productive Land and Agricultural Productivity

Access to productive land is one of the most important dimensions of agricultural productivity. Land determines the scale of cultivation, crop choices, investment decisions and the ability of farmers to adopt long-term agricultural practices. However, women's access to land in many rural Nigerian communities is influenced by customary inheritance systems, marital relationships and patriarchal ownership arrangements. Consequently, women may cultivate land without having secure ownership or decision-making authority over it. Such insecure tenure can discourage investment in soil improvement, tree crops, irrigation and other long-term agricultural activities.

The empirical evidence is increasingly clear that land and other productive assets contribute significantly to the gender productivity gap. The World Bank's recent analysis of Nigerian agriculture identifies women's lower access to agricultural inputs and productive resources as major drivers of their productivity disadvantage. Jeong's (2025) analysis similarly found that differences in plot size and access to capital and machinery were important components of Nigeria's gender productivity gap. These findings suggest that simply encouraging women to participate in agriculture without improving their access to productive land may not substantially increase agricultural output.

Recent literature also shows that gender relations influence the productive use of agricultural resources. Edoka et al. (2025), reviewing gender issues and agricultural productivity in Nigeria, observed that agricultural roles are socially constructed and that technological and agricultural policies have historically been skewed towards men. They identified discriminatory land rights and patriarchal land ownership as important barriers to women's agricultural advancement. For Central Cross River State, where customary land institutions remain important in rural communities, the implication is that agricultural development programmes should address women's security of access to land rather than merely providing training and inputs.

Access to Agricultural Finance and Agricultural Productivity

Access to finance is another important determinant of women's agricultural productivity. Agricultural production requires capital for land preparation, improved seeds, fertiliser, pesticides, labour, transportation, processing and storage. Rural women often have limited personal savings and may lack collateral required by conventional financial institutions. As a result, they may depend on informal borrowing arrangements or operate agricultural enterprises at a scale below their productive potential. Contemporary Nigerian evidence demonstrates the importance of financial access for women's economic activities. In a 2024 study of microfinance services in Cross River State, Anam, Unimna, Uzoh, Osaji, Unimke, Agu, Offem and Obinna examined the role of microfinance services in promoting women's entrepreneurial activities. The study provides local evidence of the relevance of financial services to women's economic participation and demonstrates the importance of accessible financial institutions in supporting women-owned economic activities in Cross River State. Although the study focused on women entrepreneurs rather than agricultural productivity specifically, its findings are relevant because agricultural production among rural women is frequently integrated with petty trading, processing and other income-generating activities.

The relationship between finance and agricultural productivity is also supported by recent evidence on gender differences in agricultural technology adoption. The 2025 Nigerian soybean study found that financial and market-related barriers, including high input costs and distance to seed markets, constrained female farmers' ability to fully adopt improved agricultural practices. Similarly, Daudu et al. (2025) found that access to credit and extension was among the factors influencing climate-smart agriculture adoption, while gender differences persisted in the resulting productivity and welfare outcomes. These findings suggest that agricultural credit should be combined with technology, extension and market interventions rather than provided as an isolated intervention.

Agricultural Extension Services and Women's Productivity

Agricultural extension services provide farmers with technical knowledge concerning improved seeds, soil management, fertiliser application, pest control, climate adaptation, post-harvest management and marketing. Extension therefore represents an important form of human capital that can improve farmers' capacity to adopt productivity-enhancing technologies. However, women farmers may have less contact with extension personnel because of mobility restrictions, household responsibilities, sociocultural norms and extension systems that historically prioritise male household heads. This issue is particularly important in Nigeria. The World Bank identified limited participation in extension services as one of the three major drivers of the gender productivity gap in Nigerian agriculture. Women not only use fewer productive inputs but also have less participation in extension services, thereby limiting their exposure to improved production technologies and practices. The finding is significant because it demonstrates that gender inequalities in agriculture can occur through information and knowledge systems as well as through land and financial resources.

Importantly, recent evidence from Cross River State provides direct contextual support. Anam, Uzoh, Unimke, Etim, Eburikure, Ekpo, Dede, Undie and Akpan (2025) examined the influence of agricultural extension services on food production among rural farmers in Cross River State. The study provides empirical evidence from the same state in which the present study is located and reinforces the importance of agricultural extension in rural food production. The present study extends this evidence by focusing specifically on rural women and examining extension access as a gender-based constraint. The importance of extension is further demonstrated by the 2025 study of soybean farmers in North-East Nigeria. Female farmers' adoption of improved practices was significantly influenced by extension visits, indicating that extension contact can help women overcome information barriers. Thus, extension systems in Central Cross River State should deliberately identify and reach women farmers rather than assuming that information delivered to male household heads will automatically reach women. Gender-responsive extension, flexible delivery mechanisms and women-focused farmer groups could improve access to agricultural knowledge.

Access to Agricultural Inputs and Technology

Agricultural inputs and technology constitute another major dimension of agricultural productivity. Improved seeds, fertilisers, pesticides, mechanisation, irrigation, processing equipment and storage technologies can increase production while reducing labour and post-harvest losses. Yet women frequently have unequal access to these resources because of financial limitations, restricted land access, limited extension contact and sociocultural perceptions about who should control agricultural technologies. The World Bank's gender productivity analysis in Nigeria provides strong evidence that input disparities are central to the agricultural gender gap. Women farmers use fewer productive inputs and have lower participation in extension services, contributing significantly to their lower productivity. The 2025 cross-country African study similarly concluded that the productivity advantage of male-managed plots was largely driven by differences in access to both labour and non-labour inputs, including fertiliser, improved seeds, agricultural implements and land size.

Evidence from Nigeria's soybean sector provides additional support. The 2025 study found that male and female farmers generally adopted improved soybean varieties, but women faced greater financial and market constraints affecting the intensity of adoption. Female adoption was also influenced by extension visits and community tenure. This suggests that providing improved technologies alone may not eliminate gender inequalities. Women must also have the financial capacity, information, land security and institutional support necessary to use those technologies effectively. For Central Cross River State, the issue is especially important because much of women's agricultural production remains smallholder and labour intensive. Appropriate technologies for land preparation, planting, harvesting, processing and storage could reduce women's physical workload while improving efficiency. The literature therefore supports examining input and technology access not simply as an agricultural variable but as a gendered resource-access problem.

Market Access and Agricultural Productivity

Market access is essential to agricultural productivity because farmers require profitable outlets for their produce. Access to markets affects the prices farmers receive, their incentives to expand production, their ability to recover production costs and their capacity to reinvest in agriculture. Women farmers may face additional market barriers because of inadequate transportation, weak bargaining power, limited market information, insufficient storage facilities and restricted control over agricultural income. Recent research demonstrates that market constraints interact with other gender-based barriers. The 2025 study of soybean production in Borno State found that high input costs and distance to seed markets disproportionately constrained female farmers' ability to adopt

improved agricultural practices. This demonstrates that market accessibility is connected to input access and productivity: when farmers cannot obtain inputs easily or sell products profitably, their incentives and capacity to increase production are reduced.

Cross River evidence also demonstrates the broader socioeconomic importance of women's agricultural initiatives. Nkpoyen, Usoroh, Eteng, Cobham, Umo, Anam and Essien (2021) examined women's smallholding farming initiatives and household food availability in rural communities of Southern Cross River State. Their study specifically considered women's agricultural production, food processing and agro-biodiversity initiatives in relation to household food security. The study is particularly relevant because it demonstrates that women's agricultural activities in Cross River extend beyond farm production to processing, food availability and household welfare.

Similarly, Eteng, Bukie and Anam and colleagues (2023) examined agrarian women's development engagement and socioeconomic wellbeing in Odukpani Local Government Area of Cross River State. The study focused on women's sustainable food-system activities and rural entrepreneurship and their relationship with socioeconomic wellbeing. Although Odukpani is outside the Central Senatorial District, the evidence is geographically and contextually relevant to Cross River State and demonstrates that women's agricultural and entrepreneurial engagement has wider implications for household and community wellbeing.

Theoretical Framework

Gender and Development (GAD) Approach

The Gender and Development (GAD) Approach emerged during the 1980s as a critical response to the limitations of the Women in Development (WID) perspective. The approach is strongly associated with scholars such as Caroline Moser, Naila Kabeer and Kate Young, who shifted attention from simply integrating women into development programmes to examining the social structures and power relations that produce gender inequalities. Moser (1993), one of the major proponents of the approach, argues that women's disadvantage is embedded in the gender division of labour and in the unequal distribution of resources, responsibilities and decision-making power. Similarly, Kabeer (1999) conceptualises empowerment around the interaction of resources, agency and achievements, suggesting that access to resources increases women's capacity to exercise meaningful choices and achieve desired outcomes. The central argument of the GAD Approach is therefore that women's development cannot be adequately understood without examining the social, cultural, economic and institutional relationships between women and men.

A major argument of the GAD Approach is that gender inequality is structural rather than individual. Women limited economic outcomes are not necessarily caused by lack of ability, motivation or participation, but may result from unequal institutions and social arrangements that determine who controls land, credit, technology, labour, information and other productive resources. In agriculture, these structures may be reflected in customary land inheritance systems, male-dominated agricultural institutions, unequal access to extension services, limited control over household resources and gender-specific expectations concerning women's domestic responsibilities. From this perspective, increasing women's participation in agriculture without addressing these underlying inequalities may produce limited improvement in productivity. What matters is not simply whether women farm, but whether they possess the resources, autonomy and institutional support necessary to farm productively.

The GAD Approach is particularly relevant to this study because it provides a framework for understanding gender-based barriers to agricultural productivity among rural women in Central Cross River State. The study's variables—access to productive land, agricultural finance, extension services, agricultural inputs and technology, and market opportunities—represent important resources through which gender inequality may influence agricultural outcomes. For example, a woman may participate actively in farming but lack secure rights to land, sufficient credit to purchase inputs, access to extension information or control over the income generated from her farm. The GAD perspective therefore enables the study to examine these constraints as manifestations of broader gender relations rather than isolated individual problems. It consequently supports the argument that improving women's agricultural productivity requires institutional reforms and gender-responsive interventions that expand women's access, agency and control over productive resources.

Sustainable Livelihoods Approach

The Sustainable Livelihoods Approach (SLA) is associated particularly with Robert Chambers and Gordon Conway (1992) and was subsequently developed and operationalised through the Department for International Development (DFID) Sustainable Livelihoods Framework. Chambers and Conway (1992) argue that a livelihood comprises the capabilities, assets and activities required for people to secure a means of living. A livelihood becomes sustainable when individuals and households can cope with and recover from shocks, maintain or enhance their capabilities and assets, and do so without undermining the natural resource base. The approach therefore moves beyond income or employment as measures of wellbeing and examines the combination of resources that enables households to pursue livelihood strategies. Its core idea is that rural households possess different forms of livelihood capital—natural, physical, financial, human and social capital—which they combine to achieve desired livelihood outcomes.

The major argument of the Sustainable Livelihoods Approach is that access to livelihood assets determines people's capacity to pursue productive and resilient livelihood strategies. Natural capital includes land, water and other natural resources; financial capital includes savings, credit and income; human capital includes education, knowledge, skills and labour; physical capital includes infrastructure, tools, equipment and technology; while social capital encompasses networks, associations, trust and community relationships. The approach also recognises that households operate within a broader vulnerability context involving economic shocks, environmental changes, institutional conditions and social structures. Consequently, agricultural productivity depends not on one resource alone but on the ability of farmers to combine several livelihood assets. A woman who has farmland but lacks finance, improved inputs, agricultural knowledge or access to markets may remain unable to transform land into high and sustainable agricultural output.

The Sustainable Livelihoods Approach is highly relevant to the present study because the variables under investigation correspond closely with its livelihood-capital dimensions. Access to productive land represents an important component of natural capital; agricultural finance reflects financial capital; extension services contribute to human capital through knowledge and technical skills; agricultural inputs and technology constitute physical and productive capital; while market access is connected to social, physical and financial capital through networks, infrastructure, information and income opportunities. Gender-based restrictions on these assets can consequently weaken women's livelihood strategies and reduce agricultural productivity. In Central Cross River State, improving women's access to these interconnected resources should enhance their capacity to expand production, adopt improved technologies, manage agricultural risks, access profitable markets and generate sustainable income. The SLA therefore complements the GAD Approach by explaining how

unequal access to livelihood assets translates into differences in agricultural productivity, while the GAD perspective explains why women may experience unequal access to those assets in the first place.

The theoretical proposition of the study is that where gender-based institutional and sociocultural barriers restrict women's access to land, finance, extension, technology, inputs and markets, their agricultural productivity is likely to decline; conversely, improving equitable access to these livelihood assets should enhance productivity and strengthen rural livelihoods. This proposition provides the theoretical basis for examining the relationship between the five independent variables and agricultural productivity among rural women in Central Cross River State.

Methodology

The study adopted a descriptive survey research design. The study area comprised selected rural communities in the Central Senatorial District of Cross River State, including communities within Ikom, Etung, Boki, Yakurr and Abi Local Government Areas. The population consisted of rural women actively engaged in agricultural production. For this research-class exercise, 300 respondents were hypothetically selected using a multistage sampling procedure. Communities were first selected from the study area, followed by farming households and individual women farmers. Data were collected using a structured questionnaire titled Gender-Based Barriers to Agricultural Productivity Questionnaire (GBBAPQ). The instrument contained sections covering demographic characteristics, land access, agricultural finance, extension services, agricultural inputs and technology, market access and agricultural productivity. Responses were measured on a four-point Likert scale.

The instrument was subjected to face and content validation by experts in agricultural extension, rural development, sociology and public policy. A pilot test was assumed to have produced an acceptable Cronbach's Alpha coefficient above 0.70. Data were analysed using frequency, percentage, mean and standard deviation. Pearson Product Moment Correlation was used to test the individual hypotheses, while multiple regression was used to determine the combined contribution of the independent variables. All hypotheses were tested at 0.05 significance level.

Results and Discussion

Test of Hypotheses

Hypothesis One

H_{01} : There is no significant relationship between women's access to productive land and agricultural productivity.

Variables	N	r	p-value	Decision
Land access & Agricultural productivity	300	0.436	<0.001	Reject H_{01}

The result indicates a significant positive relationship between access to productive land and agricultural productivity ($r = 0.436$, $p < 0.001$). The null hypothesis was therefore rejected. Women with better access to adequate and secure farmland tended to report higher levels of agricultural productivity.

Hypothesis Two

H₀₂: There is no significant relationship between women's access to agricultural finance and agricultural productivity.

Variables	N	r	p-value	Decision
Financial access & Agricultural productivity	300	0.498	<0.001	Reject H ₀₂

Access to agricultural finance had a significant positive relationship with productivity ($r = 0.498$, $p < 0.001$). Women with greater access to savings, credit and agricultural loans tended to demonstrate higher productivity.

Hypothesis Three

H₀₃: There is no significant relationship between access to agricultural extension services and agricultural productivity.

Variables	N	r	p-value	Decision
Extension services & Agricultural productivity	300	0.521	<0.001	Reject H ₀₃

The result demonstrates a significant positive relationship ($r = 0.521$, $p < 0.001$). Extension access was therefore an important factor associated with women's agricultural productivity.

Hypothesis Four

H₀₄: There is no significant relationship between access to agricultural inputs and technology and agricultural productivity.

Variables	N	r	p-value	Decision
Inputs/technology & Agricultural productivity	300	0.563	<0.001	Reject H ₀₄

The relationship was significant and positive ($r = 0.563$, $p < 0.001$), indicating that women with greater access to improved inputs and agricultural technologies tended to achieve higher productivity.

Hypothesis Five

H₀₅: There is no significant relationship between women's access to agricultural markets and agricultural productivity.

Variables	N	r	p-value	Decision
Market access & Agricultural productivity	300	0.487	<0.001	Reject H ₀₅

Market access was significantly and positively related to agricultural productivity ($r = 0.487$, $p < 0.001$). The null hypothesis was rejected.

Multiple Regression Analysis

Model	R	R ²	Adjusted R ²	F	Sig.
1	0.746	0.556	0.548	73.56	<0.001

The regression model indicates that the five dimensions of gender-based agricultural constraints/access jointly explained 55.6% of the variation in women's agricultural productivity. The model was statistically significant, $F(5, 294) = 73.56$, $p < 0.001$.

Predictor	β	t	p-value	Decision
Productive land access	0.183	3.71	<0.001	Significant
Agricultural finance	0.216	4.52	<0.001	Significant
Extension services	0.238	4.91	<0.001	Significant
Inputs/technology	0.287	6.02	<0.001	Significant
Market access	0.169	3.48	0.001	Significant

The results indicate that access to agricultural inputs and technology made the strongest independent contribution to agricultural productivity ($\beta = 0.287$), followed by extension services ($\beta = 0.238$) and agricultural finance ($\beta = 0.216$). Land access and market access also made significant independent contributions.

Discussion of Findings

The finding that access to productive land is significantly related to women's agricultural productivity confirms the importance of land as a fundamental agricultural asset. Women with secure access to adequate farmland are better positioned to determine production activities, invest in their farms and expand cultivation. The finding is consistent with the broader gender and agriculture literature, which identifies women's unequal access to land as an important constraint on agricultural production and livelihood security.

The significant relationship between agricultural finance and productivity demonstrates that financial exclusion remains an important constraint on rural women's agricultural development. Access to credit enables farmers to purchase improved seeds, fertiliser, pesticides and labour and to invest in processing and storage. The result supports the argument that agricultural policies targeted at women should incorporate accessible and affordable financial services rather than relying exclusively on training programmes. The relationship between extension services and agricultural productivity further demonstrates the importance of knowledge and information. Extension services can expose women farmers to improved production techniques, climate-smart practices, pest management and improved crop varieties. However, extension systems need to become more gender-responsive by deliberately targeting women farmers and ensuring that extension delivery mechanisms accommodate women's time and mobility constraints. The strongest independent predictor was access to agricultural inputs and technology ($\beta = 0.287$). This suggests that women may possess farming knowledge and willingness to produce but remain constrained by the availability and affordability of productive technologies. Improved seeds, fertiliser, mechanisation, processing equipment and other appropriate technologies can increase output while reducing the physical burden associated with traditional agricultural practices.

Market access also recorded a significant positive relationship with productivity. This suggests that women are more likely to invest in agricultural production where they have reliable access to markets and reasonable returns for their products. Poor roads, inadequate storage, weak market information and limited bargaining power can discourage commercial production. Strengthening women's participation in cooperatives and organised marketing systems may therefore improve both productivity and agricultural income. The combined regression result is particularly important. The five variables explained 55.6% of the variation in agricultural productivity, demonstrating that women's productivity is influenced by a combination of interconnected resource constraints rather than a single barrier. This finding supports the Gender and Development Approach because it demonstrates that agricultural disadvantage is embedded in multiple institutional and socioeconomic relationships.

Conclusion

The study concludes that gender-based resource constraints significantly influence agricultural productivity among rural women in Central Cross River State. The findings showed significant positive relationships between women's access to productive land, agricultural finance, extension services, agricultural inputs and technology, market opportunities, and agricultural productivity. Among the variables examined, access to agricultural inputs and technology recorded the strongest independent contribution ($\beta = 0.287$), followed by extension services ($\beta = 0.238$) and agricultural finance ($\beta = 0.216$). This indicates that women's productivity is shaped not simply by their participation in agriculture, but by the quality and adequacy of the productive resources available to them.

The regression analysis further established that the five dimensions of resource access jointly explained 55.6% of the variation in agricultural productivity, with the overall model statistically significant ($F(5, 294) = 73.56, p < 0.001$). The finding demonstrates that gender-based barriers are multidimensional and interconnected. Consequently, increasing women's participation in farming without simultaneously addressing their unequal access to land, finance, agricultural knowledge, technology, inputs and markets is unlikely to produce substantial and sustainable productivity gains.

The study therefore concludes that gender-responsive agricultural development should move beyond encouraging women's participation to creating equitable conditions under which women can participate productively. Agricultural policies and interventions in Central Cross River State should prioritise secure access to farmland, affordable agricultural finance, women-focused extension services, appropriate labour-saving technologies and improved market infrastructure. Such an integrated approach would strengthen women's productive capacity, increase agricultural output and income, and ultimately contribute to household food security, poverty reduction and sustainable rural development.

Recommendations

The study recommends the need to,

1. Improve women's access to land: Customary and institutional mechanisms should promote secure and equitable access to productive farmland for rural women.
2. Expand agricultural finance: Financial institutions and agricultural programmes should provide affordable credit products designed around the circumstances of smallholder women farmers.
3. Strengthen women-focused extension: Agricultural extension agencies should deliberately target rural women and provide practical information on improved production, climate adaptation, pest management and post-harvest practices.

4. Promote appropriate agricultural technology: Government and development agencies should improve women's access to improved seeds, fertilisers, mechanisation, processing equipment and other labour-saving technologies.
5. Improve market access: Rural roads, storage facilities, market information systems and cooperative marketing should be strengthened to improve women's bargaining power and returns from agricultural production.
6. Adopt integrated interventions: Agricultural programmes should address land, finance, extension, technology and markets simultaneously because the findings demonstrate that these constraints are interconnected.

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Note: The statistical results above are hypothetical data for the PhD research-class exercise, as in your earlier paper. They should not be presented as findings from an actual field survey.