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EFFECT OF GREEN INNOVATION ON ACHIEVEMENT OF SUSTAINABLE CLIMATE RESILIENCE IN SELECTED MANUFACTURING SMES IN NORTH CENTRAL NIGERIA

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ABSTRACT

In North Central Nigeria, manufacturing SMEs are heavily reliant on outdated technologies, energy-intensive processes, and unsustainable resource management practices, which contribute to their significant environmental footprint. This, in turn, exacerbates the region's vulnerability to the adverse effects of climate change. By integrating sustainable practices, SMEs can mitigate climate-related risks, improve operational efficiency, and contribute to national sustainability objectives, ultimately promoting economic growth while safeguarding the environment for future generations. The study examined the effect of green innovation on achievement of sustainable climate resilience in selected manufacturing SMEs in North Central Nigeria. The research employed descriptive survey design. The study population was 400 staff across the selected Manufacturing SMEs. The study used both simple and stratified sampling techniques in choosing the sample size. The use of the former was to ensure opportunity was given to every staff to be included in the sample size for the study while, the use of stratified sampling was justified on the grounds that it provided a platform for the selection of different categories of staff of selected Manufacturing SMEs. Data were collected from primary source using questionnaire. The analysis of data was done using frequency, percentages and tables. The two hypotheses were tested using chi-square inferential statistical tool. The result revealed that green innovation has a positive significant effect on achievement of sustainable climate resilience in selected manufacturing SMEs. It concluded that green organizational innovation and green business model innovation, not only promote environmental stewardship through resource efficiency and waste reduction but also foster economic growth by creating new market opportunities and enhancing community engagement. In recommendation. establishing training programs focused on environmental stewardship for employees will fortify a culture of innovation and accountability, equipping the workforce to identify and implement sustainable solutions that respond to local climate challenges, companies must explore sustainable business models that emphasize circular economy principles, such as recycling and resource reutilization.
Key words: Green Innovation, Sustainable Climate Resilience, Manufacturing SMEs.

1.0 INTRODUCTION

The pursuit of sustainable climate resilience has become imperative for businesses worldwide in this period of global environmental crises. This creates urgency for firms to integrate environmental responsibility, social equity, and economic viability into their core strategies. At the heart of these efforts lies a pressing need to address the alarming trends of climate change, biodiversity loss, and resource depletion, which threaten the very foundations of global economic stability and human wellbeing (Isa *et al.,* 2025). As a result, sustainability has transcended the realm of sustainable climate resilience to become a critical driver of competitiveness and resilience in the 21st century's agriculture, manufacturing SMEs and business landscape (Abbas and Dogan, 2022).

In Nigeria, the North-Central region has demonstrated increased resilience to climate change impacts, creating an enabling environment that promotes the growth and integration of green innovations (Awan *et al.,* 2018). This enhanced climate resilience significantly benefits manufacturing SMEs, as it boosts the region's capacity to invest in and support green initiatives. For instance, improvements in food security and water availability, achieved through climate-smart agricultural practices, provide essential resources that empower local farmers and communities to adopt sustainable innovations (Gebremeskel *et al.,* 2019). This stability is crucial for manufacturing SMEs that rely on agricultural inputs and need a reliable supply chain. Additionally, diversifying the energy mix and ensuring access to renewable energy sources incentivizes the development and deployment of green energy solutions

(Ogunniyi *et al.,* 2020). Manufacturing SMEs can benefit from reduced energy costs and heightened efficiency through such innovations. Moreover, a climate-resilient North-Central Nigeria fosters a collaborative atmosphere, facilitating knowledge sharing and capacity building (Nduji, 2018).

Nduji *et al.* (2024) contend that the effect of green innovation on sustainable climate resilience in North-Central Nigeria extends beyond the agricultural sector, significantly impacting manufacturing SMEs. The region's energy landscape offers opportunities for green innovations, such as solar-powered irrigation systems and biogas-based electricity generation, which can diversify the energy mix and reduce dependence on fossil fuels (Ogunniyi *et al*., 2020). These innovations mitigate environmental impact while providing access to reliable and affordable energy, crucial for economic and social development. Moreover, green innovations in water management are vital for enhancing climate resilience. Sustainable management practices can improve the availability and quality of water resources, essential for agriculture, domestic needs, and industrial development (Akpan *et al.,* 2015). Nevertheless, North-Central Nigeria faces challenges, including water scarcity and contamination exacerbated by climate change and unsustainable practices. Addressing these issues is crucial for fostering a resilient environment that supports manufacturing SMEs (Orji and Nduji.2020).

Orji *et al.* (2024) submitted that the region has identified two core dimensions of Green Innovation: Green Organizational Innovation and Green Business Model Innovation, as essential levers for achieving sustainability and improving operational efficiency in the business environment. These innovations can empower SMEs to adapt to environmental challenges and contribute to sustainable development. However, the extent to which manufacturing SMEs in North Central Nigeria are leveraging dimensions of Green Innovation to achieve sustainable climate resilience remains underexplored. This study aims to bridge that gap by investigating the roles of Green Organizational Innovation and Green Business Model Innovation in advancing sustainability objectives among these firms (Orji *et al.*, 2024). The links between Green Innovation and Sustainable Climate Resilience in North Central Nigeria are primarily seen through its impact on corporate sustainability. Research indicates that **Green Innovation**, positively affects Corporate Sustainability Goals in the region by embedding eco-friendly practices into operations.

The persistent threat of climate change and environmental degradation necessitates a global shift towards sustainable practices. The manufacturing sector in North-Central Nigeria plays a vital role in the region's economic development, yet it faces significant challenges in addressing the impacts of climate change and building sustainable climate resilience. Small and medium-sized enterprises (SMEs) within this sector are particularly vulnerable, as they often lack the resources and capabilities to invest in eco-friendly innovations and adapt to the changing environmental conditions (Awan *et al*, 2018). In Nigeria, the North-Central region has demonstrated increased resilience to climate change impacts, creating an enabling environment that promotes the growth and integration of green innovations (Awan *et al*, 2018). This enhanced climate resilience significantly benefits manufacturing SMEs, as it boosts the region's capacity to invest in and support green initiatives. For instance, improvements in food security and water availability, achieved through climate-smart agricultural practices, provide essential resources that empower local farmers and communities to adopt sustainable innovations (Gebremeske *et al.*, 2019). The aim of this study is to examine the Effect of green innovation on achievement of sustainable climate resilience in selected manufacturing SMEs in North Central Nigeria.

THEORETICAL FRAMEWORK

Sustainability transition theory

Sustainability Transition Theory (STT) was primarily developed by scholars Frank Geels and Johan Schot in the early 2000s, achieving formal articulation around 2007 with Geels' influential work, "The dynamics of transitions in socio-technical systems: A multi-level perspective." This theory explores how societies transition from unsustainable practices to more sustainable systems through a framework that includes niche innovations, socio-technical regimes, and landscape pressures. At its core, STT posits that transitions are dynamic processes that emerge through the interplay of these three levels, highlighting that changes are non-linear and influenced by various socio-political factors.

Numerous studies support STT, notably Geels' (2004) analysis of energy sector transitions, which illustrates how technological innovations combined with policy interventions can facilitate significant shifts. Verbong and Geels (2007) further examined the Dutch electricity system, demonstrating the importance of socio-technical interactions in enabling sustainability transitions. These studies collectively underscore the relevance of STT in understanding the mechanisms behind successful transitions. However, critiques of STT also exist. Some scholars argue that it can be overly deterministic, suggesting that transitions are inevitable without adequately addressing the agency of traditional actors resistant to change (Smith *et al*., 2005). Critics also contend that STT may lack specificity in analyzing power dynamics that influence sustainability efforts. In the context of North Central Nigeria, STT can elucidate the role of green innovation in achieving sustainable climate resilience. The region faces significant environmental challenges such as deforestation and climate variability. Green innovations, like sustainable agricultural practices and renewable energy technologies, represent potential pathways towards resilience. By analyzing these innovations within the STT framework, one can understand the interactions between emerging practices and existing socio-technical regimes, thereby identifying opportunities and barriers to effective climate resilience.

EMPIRICAL FRAMEWORK

Liao *et al*. (2022) investigated the effect of Green organizational Innovation on Knowledge management in SMEs in North Korea. The study employed both descriptive survey and explanatory research designs and targeted a population of 361 employees of purposively selected SMEs. The primary data were gathered using Questionnaires and data were analyzed using descriptive method, while multiple regression was used to test the hypotheses. The results indicated that there was a significant relationship between Green organizational Innovation and Knowledge management in SMEs in North Korea. A limitation was the focus on only SMEs in North Korea. Ruan *et al*. (2024) investigated the effect of business model innovation on patent-based metrics in United Arab Emirate (UAE). The study employed descriptive research design and used questionnaire to collect data from 96 managers. The research revealed that business model innovation has both negative and positive effects on patent-based metrics, but when managed properly, the positive effects can be used to encourage organizational innovativeness and build cooperation among the employees. A limitation was the focus on only in United Arab Emirate (UAE), neglecting other countries.

RESEARCH METHODOLOGY

The research employed descriptive survey design. The study included the following: FUMAN Dairies, Plateau State (94), Dangote Cement Plc, Obajana Kogi State (129) and Julius Berger Nigeria Plc. Federal Capital Territory (FCT)(177),bringing the total population to 400 (Table 1). The study used simple random and stratified sampling techniques in choosing the sample size. The use of the former is to ensure opportunity was given to every staff to be included in the sample size for the study. The use of stratified sampling was justified on the grounds that it provided a platform for the selection of different staff of selected Manufacturing SMEs (Table 2). Data were collected from primary source using questionnaire. 220 copies of questionnaire were distributed by the researcher among the employees of the selected manufacturing SMEs. Out of the 220 copies of the questionnaire distributed, 215 were returned, reflecting a high return rate. Among these, 191 were deemed valid for analysis, while 24 were invalidated. This high percentage of valid responses indicates a strong participation rate and ensures the reliability of the data for subsequent analysis. The overall response management contributes positively to the study's robustness.

Table 1: Research Population

SMEs	No of Staff	Percentage
FUMAN Dairies, Plateau State	94	23.5
Dangote Cement Plc,Obajana Kogi State	129	32.3
Julius Berger Nigeria Plc, FCT	177	44.2
Total	400	100

Source: Manufacturers Association of Nigeria, Federal Capital Territory (2026)

Table 2: Sampled Size

Category	No of Staff	Sample size at 50 percentage
Senior	112	56
Junior	288	144
Total	400	200

Source: Manufacturers Association of Nigeria, Federal Capital Territory (2026).

RESULTS AND ITS INTERPRETATION

Table 3 shows the opinion of the respondents on the relationship between Green Organizational Innovation and Sustainable Climate Resilience in North Central Nigeria. As shown in the table, the mean scores of 3.80,3.58 and 4.10 indicates that Green organizational innovation aligns with global initiatives to achieve Sustainable Development Goals, Green innovations significantly reduce the ecological footprint of organizations and Companies known for their commitment to sustainability are often viewed more favorably by consumers. On the other hand, by a mean score of 3.28, it shows that respondents are of the opinion that Green products and services can help organizations differentiate themselves in a crowded market. The Sectional Mean score 3.69 shows that there is a great relationship between Green Organizational Innovation and Sustainable Climate Resilience.

From Table 4, the relationship between Green Business Model Innovation and Sustainable Climate Resilience in Manufacturing SMEs is expressed. The respondent's opinion expressed by the mean score 3.41 points to the fact that organizations with innovative green models can differentiate themselves in competitive markets. On the other hand, Sustainable practices can help companies anticipate and mitigate risks associated with environmental disruptions, Organizations that focus on sustainability often experience higher employee morale and motivation and Green business model innovation aligns with international goals. These submissions are marked by the mean scores of 3.67, 4.07 and 3.64. The sectional mean score of 3.69shows that there is a relationship between Green Business Model Innovation and Sustainable Climate Resilience in Manufacturing SMEs

Table 3: Relationship between Green Organizational Innovation and Sustainable Climate Resilience in North Central Nigeria

S/N	Description	SA	A	UN	DA	SD	Total	Mean
1.	Green organizational innovation aligns with global initiatives to achieve Sustainable Development Goals	62(310)	84(336)	9(27)	17(34)	19(19)	19(726)	3.80
2.	Green innovations significantly reduce the ecological	55(275)	70(280)	20(60)	24(48)	22(22)	191(685)	3.58

	footprint of organizations,							
3.	Companies known for their commitment to sustainability are often viewed more favorably by consumers	7(355)	97(388)	5(15)	16(16)	10(10)	191(784)	4.10
4.	Green products and services can help organizations differentiate themselves in a crowded market,	48(225)	63(252	27(81)	13(28)	43(43)	191(627)	3.28
							Sectional Mean	3.69

Source: Research Survey,2026

Table 4: Relationship between Green Business Model Innovation and Sustainable Climate Resilience in Manufacturing SMEs in North Central Nigeria

S/N	Description	SA	A	UN	DA	SD	Total	Mean
1.	Organizations with innovative green models can differentiate themselves in competitive markets	40(200)	68(272)	31(91)	37(34)	15(15)	191(652)	3.41
2.	Sustainable practices can help companies anticipate and mitigate risks associated with environmental disruptions,	46(230)	77(308)	39(117)	18(48)	11(11)	191(702)	3.67
3.	Organizations that focus on sustainability often experience higher employee morale and motivation,	73(365)	86(344)	13(39)	11(11)	8(8)	191(778)	4.07
4.	Green business model innovation aligns with international goals	44(220)	85(340)	28(84)	119 (26)	15(15)	191(697)	3.64
							Sectional Mean	3.69

Source: Research Survey,2026

TESTING OF HYPOTHESES

Hypothesis One

H0: There is a significant relationship ***Green Organizational Innovation*** *and Sustainable Climate Resilience in North Central Nigeria*

Table 4: Contingency Table for Hypothesis One

Option	Frequency Senior	Junior	Total	Percentage (%)
Agreed	52	19	71	37.2
Disagreed	48	17	65	34.7
Undecided	39	16	55	28.7
Total	139	52	191	100

Source: Research Survey, 2026

From the above table, the expected frequencies are now drawn using the formula: CT X RT/191, where: CT is Column Total. RT is the row total; N is the total number of observations. The computed expected values are given in Table 5. The degree of freedom is given (r -1) (c -1). This is the same thing as (3 – 1)(2 - 1) – 2 x 1- 2.

Table 5: Computed Chi-square for Hypothesis One

O	E	O - E	$(O-E)^2$	$(O-E)^2/E$
52	51.6	0.4	0.16	0.003
19	47.3	-28.3	800.89	16.932
48	40.1	7.9	62.41	1.556
39	19.3	19.7	388.09	29.108
17	17.6	-0.6	0.36	0.020
16	14.9	1.1	1.21	0.081
Total:				38.7

Source: Research Survey,2026

Decision Rule

If the computed value of the chi-square is less than the table value at the appropriate degree of freedom and level of significant, accept the null hypothesis and reject the alternative hypothesis. However, if the opposite is the case, reject the null hypothesis and accept the alternative.

Decision:

From the above table, it can be seen that the value of the chi-square computed (38.7) is greater than the table value (3.441). With this, the null hypothesis is rejected while the alternative hypothesis accepted. This means that there is a significant relationship between green organizational innovation and sustainable climate resilience.

Hypothesis Two

H0: There is a significant relationship between Green Business Model innovation and Sustainable Climate Resilience in North Central Nigeria

Table 6: Contingency Table for Hypothesis Two

Option	Frequency Senior	Junior	Total	Percentage (%)
Agreed	57	18	75	39.3
Disagreed	42	21	63	37.9
Undecided	40	13	53	27.8
Total	139	52	191	100

Source: Research Survey, 2026

The formula for the expected frequency remained as in hypothesis one above. The expected frequencies are given in Table 7.

Table 7: Computed Chi-Square For Hypothesis Two

O	E	O - E	$(O-E)^2$	$(O-E)^2/E$
57	54.5	2.5	6.25	0.114
42	45.2	-3.2	10.24	0.226
18	38.5	-20.5	420.25	10.915
40	20.4	19.6	384.16	18.831
21	17.1	3.9	15.21	0.889
13	14.4	1.4	1.96	0.136
Total:				31.111

Source: Research Survey, 2026

Decision:
From the above table, it can be seen that the value of the chi-square computed (31.111) is greater than the table value (3.841).With this, the null hypothesis is rejected while the alternative hypothesis accepted. This means that there is a significant relationship between **green business model** and sustainable climate resilience.

CONCLUSION

The effect of green innovation on the achievement of sustainable climate resilience in North Central Nigeria is profound and multifaceted. By integrating Green Organizational Innovation, and Green Business Model Innovation, organizations can significantly enhance their operational sustainability while addressing the pressing challenges posed by climate change. These innovations not only promote environmental stewardship through resource efficiency and waste reduction but also foster economic growth by creating new market opportunities and enhancing community engagement. The collaborative efforts among businesses, government entities, and local communities further strengthen this resilience by ensuring that green practices are effectively tailored to local contexts. As stakeholders embrace a comprehensive approach to green innovation, they pave the way for a sustainable future that equips North Central Nigeria to adapt to and mitigate the adverse impacts of climate change. Ultimately, a commitment to these innovations is crucial for building a resilient society that prioritizes both ecological integrity and economic viability.

RECOMMENDATIONS

i. Establishing training programs focused on environmental stewardship for employees will fortify a culture of innovation and accountability, equipping the workforce to identify and implement sustainable solutions that respond to local climate challenges.

ii. Companies must explore sustainable business models that emphasize circular economy principles, such as recycling and resource reutilization. By rethinking product life cycles and fostering collaborations with local communities and stakeholders, businesses can enhance resilience against climate variability.

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