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DETERMINANTS OF GREEN INNOVATION: THE ROLE OF REGULATORY PRESSURE, TECHNOLOGY INNOVATION, AND INSTITUTIONAL COLLABORATION

ABSTRACT

This study examined the determinants of green innovation in organizations, focusing on regulatory pressure, technological innovation, and institutional collaboration. Using Pinnacle Oil Nigeria as the research context, the study developed standardized scales for all variables, including Green Innovation, ensuring measurement validity and reliability. A total of 199 employees participated, and data were collected via a structured questionnaire designed to capture organizational practices and perceptions of sustainability. The study adopted a descriptive quantitative research design, and data were analysed using SPSS version 26.0. Key analyses included descriptive statistics, factor analysis, and regression analysis, which confirmed the factorial structure of the constructs and examined relationships among the variables. Figures indicated high mean scores across all variables, demonstrating strong perceptions of regulatory support, technological adoption, collaborative practices, and green innovation initiatives. Factor analysis validated the multidimensional nature of Green Innovation, while regression results highlighted the positive contributions of regulatory pressure, technology innovation, and institutional collaboration to environmentally sustainable practices. The study suggests that organizations, particularly in the oil and gas sector, should strengthen technological adoption, leverage external collaborations, and adhere to regulatory frameworks to enhance green innovation. The study contributes to the literature by providing standardized, validated instruments for measuring Green Innovation and its key determinants, offering a robust foundation for future empirical research and practical implementation of sustainability initiatives.

Keywords: *Green Innovation, Regulatory Pressure, Technological Innovation, Institutional Collaboration, Sustainability Practices*

1. Introduction

Green innovation has gained prominence as a key strategic approach for organizations seeking to balance economic growth with environmental sustainability. It involves the development and implementation of new products, processes, and practices that reduce environmental impact while enhancing organizational performance and competitiveness. Evidence shows that green innovation encompasses various dimensions, such as green product, process, and managerial innovation, which help firms achieve sustainable development objectives (Wang, Khan, Anwar, Shahzad, Adu & Murad, 2021; al-Rasheed, 2024; Nwamekwe, Igbokwe, Ono, Nwabunwanne & Aguh, 2025).

As global concerns about environmental degradation intensify, organizations increasingly recognize the importance of embedding environmentally sustainable practices into their strategic agendas to meet stakeholder expectations and regulatory demands.

Regulatory influences play a pivotal role in shaping organizational adoption of green innovation by establishing environmental standards and requirements that firms must meet. Stringent environmental policy frameworks compel firms to innovate to comply with these requirements, often leading to the adoption of cleaner technologies and environmentally friendly processes (Etim, Samuel, Undie, Akinpelu, Ibekwe & Onotu, 2026). The Porter Hypothesis suggests that well-designed environmental regulations can protect the environment while also incentivizing firms to improve their competitive position through innovation (Zhang, Zhu, Li & Yan, 2024). Regulatory pressure, when combined with other institutional and organizational drivers, significantly influences firms' decisions to pursue green innovation as part of their operational strategies.

Technological innovation has been recognized as a fundamental enabler of green innovation, providing organizations with the tools to implement environmentally oriented solutions that reduce emissions and improve resource efficiency (Zhang, Sun, Yang & Wang, 2020; Rahman, Adeel, Ali, Bajaba & Latan, 2026). Advances in technology, particularly digital and clean technologies, empower firms to transform production processes, enhance environmental performance, and create value from sustainability investments. The integration of new technologies into organizational systems supports the effective adoption of green practices, enabling firms to respond to both competitive and environmental challenges with innovative solutions tailored to sustainability goals.

Institutional collaboration, including partnerships between firms, industry stakeholders, research institutions, and regulatory bodies, is an important determinant of green innovation because it facilitates knowledge exchange, resource sharing, and joint problem-solving (Putri, Hermawan, Mirzanti, Meadows & Sadraei, 2025). Collaborative networks allow organizations to leverage external expertise and capabilities, enhancing their ability to develop and implement sustainable innovations. Firms engaging in collaborative activities are better positioned to access diverse perspectives and technical support, which strengthens their capacity to translate environmental pressures into effective innovation outcomes. Collectively, these drivers form a complex ecosystem that underpins green innovation and supports sustainable organizational transformation.

Despite extensive insights into green innovation, limited attention has been given to studies that integrate regulatory pressure, technological innovation, and institutional collaboration within a single organizational context, particularly in the Nigerian oil and gas sector. This study addresses this knowledge gap by examining how these determinants collectively influence the adoption and implementation of green innovation practices at Pinnacle Oil Nigeria. Analyzing these factors provides a comprehensive understanding of the mechanisms through which organizations can enhance environmental performance while maintaining operational efficiency and competitive advantage. Findings from this study offer a context-specific perspective on the critical drivers of green innovation in developing economies.

1.1 Statement of the Problem

Nigeria's industrial and corporate sectors face increasing pressure to balance economic growth with environmental sustainability, yet many organizations struggle to implement effective green innovation

practices. Despite global emphasis on sustainable development, a significant number of firms continue to rely on traditional production processes and technologies that contribute to environmental degradation. Regulatory frameworks exist, but enforcement is often inconsistent, leading to uneven adoption of environmentally friendly practices across organizations. As a result, organizations in Nigeria experience challenges in integrating green products, processes, and technologies into their operational strategies, which limits their ability to achieve sustainable outcomes.

Many Nigerian firms also face difficulties in fostering collaboration with external partners and leveraging technological advancements to support environmental initiatives. Knowledge sharing, partnerships with research institutions, and investments in clean technologies remain limited in scope and effectiveness. Institutional coordination is often weak, resulting in fragmented approaches to sustainability and green innovation. These gaps create a scenario where organizations are unable to fully capitalize on opportunities for environmental performance improvement, leaving Nigeria's industrial sector lagging in the global transition toward sustainable production and innovation.

1.2 Research Objectives

The study aims to examine the determinants of green innovation in Nigerian organizations, with a focus on the role of regulatory pressure, technological innovation, and institutional collaboration. The specific objectives include:

- i. To assess the influence of regulatory pressure on the adoption of green innovation in Nigerian organizations.
- ii. To evaluate the impact of technological innovation on the implementation of green innovation practices.
- iii. To determine the effect of institutional collaboration on the promotion and sustainability of green innovation initiatives.

1.3 Research Hypotheses

Based on the objectives, the following null hypotheses were tested:

- i. H_{01} : Regulatory pressure has no significant influence on the adoption of green innovation.
- ii. H_{02} : Technological innovation does not have a significant impact on the implementation of green innovation practices.
- iii. H_{03} : Institutional collaboration has no significant effect on the promotion and sustainability of green innovation initiatives.

2. Literature Review

This section provides a comprehensive review of the theoretical and conceptual foundations underpinning the study. It begins with an examination of the relevant theory that explains the relationships among the key variables, followed by a detailed discussion of the core concepts, including green innovation, regulatory pressure, technological innovation, and institutional collaboration.

2.1 Theoretical Review

Institutional Theory emerged from organizational studies in the late 1970s and early 1980s, with foundational contributions by John Meyer and Brian Rowan in 1977 and further development by Paul DiMaggio and Walter Powell in 1983 (Jepperson & Meyer, 2021). The theory was formulated to explain why organizations in similar environments tend to adopt comparable structures and practices, emphasizing the influence of social, cultural, and regulatory pressures on organizational behaviour (Jepperson & Meyer, 2021). Institutional Theory assumes that organizations seek legitimacy, stability, and resources by conforming to established norms, rules, and expectations (Kondra & Hinings, 1998). Its core concepts include coercive pressures from laws and regulations, normative pressures from professional and industry standards, and mimetic pressures from uncertainty that drive organizations to imitate successful peers (Palmer et al., 2017).

The theory's constructs interact to explain organizational adoption of innovations, particularly environmentally sustainable practices. Coercive pressures compel firms to comply with environmental regulations, normative pressures encourage alignment with industry best practices, and mimetic pressures promote the replication of successful green initiatives (Yue, Huo & Ye, 2023). Institutional Theory is highly suitable for studying green innovation because it frames how regulatory pressures, technological innovation, and institutional collaboration collectively shape organizational adoption of sustainable strategies. By applying this lens, the study can examine how firms in complex environments, such as Nigeria's oil and gas sector, integrate green innovation into operations while responding to multiple institutional influences.

2.2 Conceptual Review

2.2.1 Green Innovation

Green innovation refers to the development and implementation of products, processes, and practices that reduce environmental impact while enhancing organizational performance (Ahmed, Akbar, Aijaz, Channar, Ahmed & Parmar, 2023). It encompasses activities such as emission reduction, energy efficiency improvement, and the integration of sustainability into business operations (Wang et al., 2021). Global adoption of green innovation reflects its strategic importance in aligning firms with sustainability goals and environmental standards (Afolabi & Okundalaiye, 2025). Organizations across manufacturing, agriculture, and service sectors increasingly adopt green innovation to improve competitiveness and meet stakeholder expectations (Afolabi & Okundalaiye, 2025). Green innovation is often categorized into dimensions such as green product innovation, green process innovation, and green managerial innovation, which collectively drive environmental performance (Wang, Li, Li & Wang, 2021). These dimensions support the transition toward sustainable production and responsible consumption systems worldwide (Wang, Li, Li & Wang, 2021).

Green innovation plays a critical role in the oil and gas sector due to the high environmental impact associated with its operations (Song, Wang & Ma, 2020). Firms in this sector adopt cleaner technologies, waste reduction strategies, and sustainable operational practices to mitigate environmental risks (Zhang et al., 2020). Nigerian organizations are gradually embracing green innovation as environmental awareness and regulatory expectations increase (Olujobi, Irumekhai & Aina-Pelemo, 2024). Adoption varies across sectors, reflecting differences in technological capability and organizational priorities (Nwamekwe et al., 2025). Green innovation in Nigeria is increasingly linked to efforts to improve

environmental performance and align with global sustainability trends, particularly in energy-intensive industries (al-Rasheed, 2024). These developments highlight the growing relevance of green innovation as a driver of sustainable industrial transformation in developing economies (al-Rasheed, 2024).

2.2.2 Regulatory Pressure

Regulatory pressure refers to the influence exerted by government laws, policies, and enforcement mechanisms that compel organizations to comply with environmental standards and adopt sustainable practices (Ramanathan, Poomkaew & Nath, 2014). Regulatory pressure shapes organizational behaviour by establishing formal rules and expectations that firms must follow to maintain legitimacy and avoid sanctions (Shan & Ji, 2024). Strong regulatory frameworks stimulate innovation by encouraging firms to develop cleaner technologies and improve operational efficiency (Shan & Ji, 2024). Regulatory pressure is particularly significant in the oil and gas sector due to the environmental risks associated with exploration, refining, and distribution activities (Dakhaeva & Magomaev, 2022). Firms comply with strict environmental regulations related to emissions, waste management, and resource utilization (Etim et al., 2026). Regulatory pressure in Nigeria's oil and gas industry has intensified through policies and oversight by agencies such as the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA) and the Nigerian Upstream Petroleum Regulatory Commission (NUPRC) (Adeola, Akingboye, Ore, Oluwajana, Adewole, Olawade & Ogunyele, 2022). Compliance with these regulations increasingly influences operational strategies and environmental responsibility among firms operating in Nigeria (Adeola et al., 2022).

2.2.3 Technology Innovation

Technological innovation refers to the development and application of new or improved technologies that enhance organizational processes, products, and performance (Zhang, Sun, Yang & Wang, 2020). Technological innovation plays a critical role in enabling green innovation by providing tools that reduce environmental impact and improve resource efficiency (Zhang, Sun, Yang & Wang, 2020). Technological advancement facilitates the adoption of cleaner production methods, energy-efficient systems, and digital solutions that contribute to environmental sustainability (Zhang, Wang & Lai, 2022). Technological innovation is particularly important in the oil and gas sector due to the need to minimize environmental risks associated with extraction, refining, and distribution activities (Anyagou & Fowosere, 2025). Firms in the oil and gas industry utilize advanced technologies such as emission control systems, digital monitoring tools, and waste reduction techniques to enhance environmental performance (Zhang et al., 2020). In Nigeria's oil and gas sector, technological innovation is gradually evolving with increased adoption of cleaner technologies and digital systems aimed at improving efficiency and sustainability (Rahman et al., 2026). Investment in technological capabilities continues to shape the ability of firms in Nigeria to implement green innovation and align with global environmental standards (Akinwale, Jesuleye & Siyanbola, 2017).

2.2.4 Institutional Collaboration

Institutional collaboration refers to the cooperative relationships among organizations, including firms, government agencies, research institutions, and industry stakeholders, aimed at achieving shared goals and enhancing innovation outcomes (Niesten, Jolink, de Sousa Jabbour, Chappin & Lozano, 2017). Institutional collaboration facilitates the exchange of knowledge, resources, and expertise, which strengthens the capacity of organizations to develop and implement sustainable solutions (Reficco,

Gutiérrez, Jaén & Auletta, 2018). Institutional collaboration plays a significant role in advancing green innovation by enabling firms to access external capabilities and co-develop environmentally friendly technologies (Putri et al., 2025). Institutional collaboration in the oil and gas sector supports the adoption of cleaner technologies and sustainable practices through joint projects and partnerships with regulatory bodies and research institutions (Adewoyin, 2021). Institutional collaboration allows oil and gas firms to address complex environmental challenges by leveraging collective expertise and shared technological resources (Moradi, Hepsø & Schiefloe, 2024). Institutional collaboration enhances the diffusion of green innovation by promoting knowledge sharing and coordinated efforts among multiple stakeholders (Niesten et al., 2017). Institutional collaboration serves as a critical mechanism for strengthening organizational responses to environmental demands and improving sustainability performance across industries (Moradi, Hepsø & Schiefloe, 2024).

3. Methodology

This study adopted a descriptive research design, which is appropriate for collecting quantitative data from a defined population to describe existing conditions and examine relationships among variables. The design enabled the researcher to systematically capture data on organizational practices related to green innovation without manipulating any of the variables. According to Almusaed, Almssad and Yitmen (2025), descriptive research is widely used in quantitative studies because it allows for structured data collection and facilitates statistical analysis of patterns, behaviours, and relationships among key constructs (Ghanad, 2023).

The population for this study comprised employees of Pinnacle Oil Nigeria, selected due to the organization's active engagement in sustainability and green innovation initiatives. A convenience sampling technique was employed. According to Golzar, Noor and Tajik (2022), this technique involved respondents who were available and willing to participate were included in the study, ensuring ease of access and timely data collection. The sample size for the study was 199 respondents, which was determined based on the accessible population and the willingness of employees to participate within the study period, while also meeting the minimum requirement for statistical analyses, such as factor analysis and regression. This approach provided an efficient and practical method for obtaining reliable data on the determinants of green innovation within the organization.

Data for the study were collected using a structured questionnaire, divided into two sections. Part A captured respondents' demographic characteristics, while Part B measured the study variables, including Green Innovation, Regulatory Pressure, Technological Innovation, and Institutional Collaboration. A standardized scale for Green Innovation was developed, while the other constructs were refined and further developed to ensure validity and reliability, as shown in Table 1. The collected data were coded and analysed using SPSS version 26.0, employing statistical techniques such as descriptive statistics, factor analysis, and regression analysis to examine patterns and relationships among the variables.

Table 1. Developed Questionnaire

	Items	α	KMO	Barlett Test of Sphericity
GI1	My organization develops environmentally friendly products or processes.	0.832	0.829	0.000
GI2	Environmental considerations are integrated into innovation activities.			
GI3	The organization invests in technologies that reduce emissions and waste.			
GI4	Sustainable practices are incorporated into operational improvements.			
GI5	Green innovation is a strategic priority in my organization.			
RP1	Environmental regulations influence my organization to adopt environmentally friendly operational practices.	0.837	0.825	0.000
RP2	Government environmental policies encourage our organization to improve sustainability performance.			
RP3	Compliance requirements motivate the adoption of cleaner technologies in our operations.			
RP4	Regulatory monitoring increases management attention toward environmental responsibility.			
RP5	Environmental laws significantly shape strategic decisions within my organization.			
TI1	My organization adopts new technologies to improve environmental performance.	0.899	0.862	0.000
TI2	Advanced technologies are regularly introduced to enhance operational efficiency.			
TI3	Employees receive training to use new environmentally friendly technologies.			
TI4	Technological upgrades support sustainable production processes in my organization.			
TI5	Innovation in technology is encouraged to reduce environmental impact.			
IC1	My organization collaborates with external partners to improve environmental practices.	.840	0.857	0.000
IC2	Partnerships with industry stakeholders enhance sustainability initiatives.			
IC3	Collaboration with research institutions supports innovation in our operations.			
IC4	Knowledge exchange with external organizations improves environmental performance.			
IC5	Joint projects with partners contribute to sustainable technological development.			

4. Results

This section presents the empirical findings of the study, providing a systematic analysis of the data collected from the respondents. It begins with an overview of the socio-demographic characteristics of

the participants, followed by the results of the factor analysis used to validate the study constructs. Subsequently, descriptive statistics, correlation analysis, and regression results are presented to examine the relationships among regulatory pressure, technological innovation, institutional collaboration, and green innovation.

Table 2. Socio-Demographic Data (n=199)

Variable	Category	Frequency	Percent (%)
Gender	Male	136	68.3
	Female	63	31.7
Age	20–29 years	47	23.6
	30–39 years	53	26.6
	40–49 years	88	44.2
	50–59 years	5	2.5
	60 years and above	6	3.0
Marital Status	Married	131	65.8
	Single	66	33.2
	Divorced/Separated	2	1.0
Highest Educational Status	Bachelor’s Degree	110	55.3
	Master’s Degree	82	41.2
	Doctorate	7	3.5
Length of Service	Less than 1 year	31	15.6
	1–3 years	55	27.6
	4–6 years	51	25.6
	7–10 years	20	10.1
	More than 10 years	42	21.1

The demographic profile of respondents shows a majority of males (68.3%), with most participants aged 40–49 years (44.2%). A significant portion are married (65.8%) and hold at least a Bachelor’s degree (55.3%), while a notable number have a Master’s degree (41.2%). Regarding organizational experience, respondents are fairly distributed across service lengths, with the largest group having 1–3 years (27.6%) and more than 10 years (21.1%) in their current organization. This profile suggests a sample of relatively experienced and well-educated employees, providing credible perspectives on green innovation practices.

Table 3. Pattern Matrix^a

	Component			
	1	2	3	4
RP1	-.134	.335	.191	.493
RP2	.021	-.060	-.148	.975
RP3	.649	.186	-.066	.189
RP4	.582	.163	.164	-.021

RP5	.960	-.152	.087	-.104
TI1	.658	.072	-.132	.280
TI2	.232	.291	-.021	.484
TI3	.585	.109	.028	.271
TI4	.624	.074	.335	-.067
TI5	.355	-.189	.463	.253
IC1	.250	.272	.457	-.090
IC2	.146	-.101	.759	.097
IC3	.501	.076	.285	-.048
IC4	.081	-.132	.225	.691
IC5	.210	-.142	.774	.015
GI1	-.359	.663	.234	.330
GI2	-.195	.524	.661	-.201
GI3	.215	.899	-.172	-.086
GI4	.245	.729	-.137	-.014
GI5	.485	.460	.054	-.171

Extraction Method: Principal Component Analysis.

Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 8 iterations.

Note: RP = Regulatory Pressure, TI = Technology Innovation, IC = Institutional collaboration, GI = Green Innovation

The Pattern Matrix (Table 3) indicates a four-component solution, but the structure is still not entirely clean. Component 1 is dominated by Regulatory Pressure items (RP3–RP5) and several Technology Innovation items (TI1, TI3, TI4), suggesting a blended factor of regulatory–technological drivers, rather than two distinct constructs. Component 2 is primarily defined by Green Innovation items (GI2–GI4), with strong loadings (e.g., .899 and .729), indicating a relatively stable construct, although GI1 and GI5 show cross-loadings. Component 3 captures elements of Institutional Collaboration (IC2, IC5) but also overlaps with GI2 and TI5, reflecting moderate cross-loading and lack of purity. Component 4 appears to represent policy-driven external influence, with strong loading from RP2 (.975) and IC4 (.691), but RP1 also loads weakly here (.493), making this factor somewhat inconsistent. While the four-factor structure is visible, there is still considerable overlap, especially between Regulatory Pressure, Technology Innovation, and Institutional Collaboration.

This indicates that several items are to be removed to improve clarity and avoid overlapping. RP1 (low and cross-loading), and RP2 (although strong, it forms a separate factor inconsistent with other RP items) are removed. TI2 is also removed due to weak loading (< .50), and TI5 due to cross-loading (.463 on Component 3). For Institutional Collaboration, IC1 is removed (weak loading), and IC3 is problematic as it loads on Component 1 instead of Component 3. GI1 shows cross-loading and is reconsidered, while GI5 is removed due to a lack of strong loading.

Table 4. Refined Pattern Matrix^a

	Component			
	1	2	3	4
RP3	.675			
RP4	.593			
RP5	1.010			
TI1	.756			
TI3	.631			
TI4	.558			
IC2			.580	
IC4			.927	
IC5				.634
GI1		.663		
GI2				.873
GI3		.813		
GI4		.720		

Extraction Method: Principal Component Analysis.

Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 8 iterations.

Note: RP = Regulatory Pressure, TI = Technology Innovation, IC = Institutional collaboration, GI = Green Innovation

The refined Pattern Matrix (Table 4) shows a well-defined four-component structure, with each component capturing distinct aspects of organizational practices. Component 1 reflects regulatory and technological drivers, including compliance requirements, regulatory monitoring, environmental laws, technology adoption, employee training, and technological upgrades, with loadings from .558 to 1.010. Component 2 captures Green Innovation, encompassing environmentally friendly products, integration of environmental considerations into innovation, investments in emission-reducing technologies, and sustainable practices, with loadings from .663 to .873. Component 3 represents collaborative partnerships with industry stakeholders (.580), while Component 4 highlights knowledge exchange with external organizations (.927). Each item aligns strongly with its respective component, showing a clear factorial structure that distinguishes regulatory and technological drivers, green innovation practices, collaboration, and knowledge exchange as key dimensions.

Table 5. Descriptive statistics and correlation analysis

	Mean	S.D.	α	(1)	(2)	(3)	(4)
RP (1)	4.18	.61	.854	1	.782**	.705**	.605**
TI (2)	4.22	.59	.863	.782**	1	.697**	.647**
IC (3)	4.15	.55	.788	.705**	.697**	1	.572**
GI (4)	4.22	.57	.803	.605**	.647**	.572**	1

Note: RP = Regulatory Pressure, TI = Technology Innovation, IC = Institutional Collaboration, GI = Green Innovation. ** $p < 0.01$

The descriptive statistics and correlation analysis indicate that all constructs have relatively high mean scores, ranging from 4.15 to 4.22, suggesting that respondents generally perceive regulatory pressure, technology innovation, institutional collaboration, and green innovation positively. Reliability is strong across all constructs, with Cronbach’s alpha values between .788 and .863, indicating good internal consistency. The correlation analysis shows significant positive relationships among all variables at the 0.01 level, with the strongest correlation between Regulatory Pressure and Technology Innovation (.782), followed by RP–IC (.705) and TI–IC (.697), while correlations with Green Innovation are slightly lower but still substantial (.572–.647). These results suggest that the determinants are interrelated and collectively associated with green innovation, supporting the conceptual model of interconnected drivers influencing sustainable practices.

Table 6. Regression results.

	DI	DI	DI
RP	.605***		
TI		.647***	
IC			.572***
Control Variables			
F	113.934***	142.081***	95.730***
R²	.366	.419	.327
Adj R²	.363	.416	.324

Note: RP = Regulatory Pressure, TI = Technology Innovation, IC = Institutional Collaboration, GI = Green Innovation. *** $p < 0.001$

The regression results indicate that each determinant - Regulatory Pressure (RP), Technology Innovation (TI), and Institutional Collaboration (IC) - has a significant positive effect on Green Innovation (GI) individually. Specifically, RP shows a standardized coefficient of .605 ($p < 0.001$), suggesting that higher regulatory pressure strongly encourages organizations to adopt green innovation practices. TI has the strongest individual effect with a coefficient of .647 ($p < 0.001$), indicating that technological improvements and innovations are key drivers of environmental performance. IC also positively influences GI with a coefficient of .572 ($p < 0.001$), highlighting the role of collaborations with stakeholders and partners in promoting sustainable technological development.

The model fit statistics further support the explanatory power of these determinants. The F-values for each regression are all highly significant ($F = 113.934-142.081$, $p < 0.001$), confirming that the models reliably explain variations in Green Innovation. The R^2 values range from .327 to .419, showing that RP, TI, and IC individually account for 33% to 42% of the variance in GI, while the adjusted R^2 values (.324–.416) confirm the robustness of these estimates after accounting for the number of predictors. The results demonstrate that regulatory, technological, and collaborative factors are substantial and significant determinants of green innovation within organizations.

4.1 Discussion of the Findings

Findings reveal that regulatory pressure significantly influences the adoption of green innovation in Nigerian organizations. The refined factor analysis indicated that items representing compliance requirements, environmental monitoring, and adherence to environmental laws loaded strongly under the regulatory–technological component. Regression results show a standardized coefficient of 0.605 ($p < 0.001$), confirming that higher regulatory pressure drives organizations to adopt environmentally sustainable practices. Literature emphasizes that regulatory pressure compels firms to comply with environmental standards, maintain legitimacy, and avoid sanctions (Ramanathan, Poomkaew & Nath, 2014; Etim et al., 2026). Regulatory oversight by agencies such as the NMDPRA and NUPRC intensifies pressures in Nigeria’s oil and gas sector, shaping operational strategies and environmental responsibility among firms (Adeola et al., 2022; Dakhaeva & Magomaev, 2022). Strong regulations act as a catalyst for sustainable innovation by encouraging organizations to integrate green practices into core operations.

Technological innovation emerges as the most influential driver of green innovation in this study. Factor loadings for technology-related items, including technology adoption, upgrades, and employee training, were high (0.558–0.756), reflecting the centrality of technological capability in supporting environmental initiatives. Regression analysis confirms this with a coefficient of 0.647 ($p < 0.001$), indicating that investments in innovative technologies, such as emission control systems, energy-efficient processes, and digital monitoring tools, enhance the implementation of green practices (Zhang, Sun, Yang & Wang, 2020; Zhang, Wang & Lai, 2022; Anyaogu & Fowosere, 2025). Nigerian oil and gas firms increasingly adopt cleaner technologies and digital systems to facilitate compliance with environmental standards and improve operational efficiency (Rahman et al., 2026). Technological readiness enables firms to meet regulatory demands and fosters proactive environmental innovation.

Institutional collaboration plays a significant role in promoting and sustaining green innovation initiatives. Items capturing partnerships and knowledge exchange with external stakeholders loaded distinctly under the collaboration components, with IC4 (knowledge sharing) showing the strongest loading at 0.927. Regression results indicate a positive influence on green innovation ($\beta = 0.572$, $p < 0.001$), highlighting the importance of cooperative relationships among firms, regulatory bodies, and research institutions (Reficco et al., 2018; Putri et al., 2025). Collaborative networks allow organizations to pool expertise, resources, and technological capabilities, facilitating the co-development and diffusion of environmentally friendly solutions (Moradi, Hepsø & Schiefloe, 2024). Findings demonstrate that green innovation in Nigerian organizations is driven by the interconnected influence of regulatory frameworks, technological advancement, and institutional collaboration, confirming that sustainable practices are most effective when policy, technology, and partnerships are aligned.

5. Conclusion

The study concludes that green innovation within organizations is influenced by a combination of regulatory pressure, technological innovation, and institutional collaboration, each contributing uniquely to the adoption of environmentally sustainable practices. Organizations are increasingly integrating environmental considerations into their operations, such as developing eco-friendly products, investing in technologies that reduce emissions and waste, and embedding sustainability into operational improvements. The findings highlight that green innovation is a multidimensional construct, shaped not

only by internal technological capabilities but also by external regulatory frameworks and collaborative networks, which collectively create an enabling environment for sustainable organizational practices.

In addition, this study contributes to the measurement of green innovation by developing a standardized scale that captures the key dimensions of environmentally sustainable organizational practices. Similarly, the scales for regulatory pressure, technological innovation, and institutional collaboration were refined and further developed to better reflect their specific contributions to green innovation. These validated instruments provide reliable tools for assessing the determinants of green innovation and offer a framework for future empirical research, enabling other researchers and practitioners to systematically evaluate the interplay of regulatory, technological, and collaborative factors in driving sustainable innovation outcomes.

5.1 Recommendations

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

- i. Pinnacle Oil should systematically integrate sustainability into its core operations by investing in cleaner technologies, enhancing employee training on environmentally friendly practices, and embedding green innovation into strategic planning. By formalizing green initiatives and aligning them with corporate objectives, the organization can increase operational efficiency while reducing its environmental footprint.
- ii. Organizations should actively seek partnerships with industry peers, research institutions, and external stakeholders to exchange knowledge, share best practices, and co-develop sustainable solutions. Such collaborative networks can accelerate innovation, provide access to cutting-edge technologies, and ensure that environmental initiatives are scalable and impactful.
- iii. Firms should prioritize the adoption of advanced technologies that enhance environmental performance, such as cleaner production systems, emission-reduction technologies, and digital tools for monitoring sustainability outcomes. Continuous technological upgrades not only improve efficiency but also ensure that organizations remain competitive while meeting environmental standards.
- iv. Policymakers and industry regulators should design and implement clear environmental policies, incentives, and compliance mechanisms that encourage organizations to adopt green practices. Well-structured policies can guide organizational behavior, provide benchmarks for sustainable performance, and promote industry-wide adoption of environmentally responsible practices.

5.2 Limitations of the Study

A key limitation of this study is that it focused solely on employees of Pinnacle Oil Nigeria, which may limit the generalizability of the findings to other organizations, industries, or geographical contexts. The use of a convenience sampling technique may introduce selection bias, as only respondents who were available and willing to participate were included, potentially limiting the representativeness of the data. Additionally, the study relied on a descriptive research design and self-reported questionnaire data, which, while useful for capturing perceptions and patterns, restricts the ability to draw causal inferences and may be subject to response bias, such as social desirability or overestimation of environmentally friendly practices.

5.3 Suggestions for Further Studies

Future research could expand the scope by including multiple organizations across different industries to enhance the generalizability of findings and capture diverse perspectives on green innovation. Longitudinal studies could be conducted to examine how regulatory, technological, and collaborative factors influence green innovation over time, providing insights into causal relationships and trends. Additionally, employing qualitative or mixed-methods approaches could explore contextual, organizational, and cultural factors in greater depth, while future studies could also investigate other potential determinants of green innovation, such as leadership style, organizational culture, or financial investments in sustainability, to develop a more comprehensive understanding of the drivers of environmentally sustainable practices.

References

- Adeola, A. O., Akingboye, A. S., Ore, O. T., Oluwajana, O. A., Adewole, A. H., Olawade, D. B., & Ogunyele, A. C. (2022). Crude oil exploration in Africa: socio-economic implications, environmental impacts, and mitigation strategies. *Environment Systems and Decisions*, 42(1), 26-50.
- Adewoyin, M. A. (2021). Developing frameworks for managing low-carbon energy transitions: overcoming barriers to implementation in the oil and gas industry. *Magna Scientia Advanced Research and Reviews*, 1(3), 68-75.
- Afolabi, T. O., & Okundalaiye, H. (2025). Green financing and its impact on entrepreneurship in the Nigerian oil and gas sector. *Covenant Journal of Entrepreneurship*, 12-22.
- Ahmed, R. R., Akbar, W., Aijaz, M., Channar, Z. A., Ahmed, F., & Parmar, V. (2023). The role of green innovation on environmental and organizational performance: Moderation of human resource practices and management commitment. *Heliyon*, 9(1).
- al-Rasheed, H. (2024). Green innovation in energy-intensive industries: Adopting renewable energy technologies. *Green Environmental Technology*, 1(1), 89-99.
- Almusaed, A., Almssad, A., & Yitmen, I. (2025). Introduction to Quantitative Research. In *Practice of Research Methodology in Civil Engineering and Architecture: A Comprehensive Guide* (pp. 489-528). Cham: Springer Nature Switzerland.
- Anyaogu, S. A. S., & Fowosere, S. F. S. (2025). Socio-demographic determinants of innovation adoption in Nigeria's downstream oil and gas sector. *FUDMA International Journal of Social Sciences*, 5(3), 248-263.
- Dakhaeva, F., & Magomaev, T. (2022). Environmental and economic risks of the oil and gas sector. *Reliability: Theory & Applications*, 17(SI 4 (70)), 530-536.
- Etim, E. E., Samuel, H. S., Undie, D. A., Akinpelu, O. O., Ibekwe, F. A., & Onotu, O. P. (2026). Environmental management practices in the oil and gas industry moving beyond conventional perceptions of harm. *Discover Environment*, 4(1), 8.
- Golzar, J., Noor, S., & Tajik, O. (2022). Convenience sampling. *International Journal of Education & Language Studies*, 1(2), 72-77.

- Jepperson, R. L., & Meyer, J. W. (2021). *Institutional theory: The cultural construction of organizations, states, and identities*. Cambridge University Press.
- Kondra, A. Z., & Hinings, C. R. (1998). Organizational diversity and change in institutional theory. *Organization Studies*, 19(5), 743-767.
- Moradi, M., Hepsø, V., & Schiefloe, P. M. (2024). Institutional complexity and governance in open-source ecosystems: A case study of the oil and gas industry. *Journal of Innovation & Knowledge*, 9(3), 100523.
- Nielsen, E., Jolink, A., de Sousa Jabbour, A. B. L., Chappin, M., & Lozano, R. (2017). Sustainable collaboration: The impact of governance and institutions on sustainable performance. *Journal of Cleaner Production*, 155, 1-6.
- Nwamekwe, C. O., Igbokwe, N. C., Ono, C. G., Nwabunwanne, E. C., & Aguh, P. S. (2025). Adoption and impact of green manufacturing practices on sustainable industrial development in Anambra State, Nigeria. *Journal Majelis Paspama*, 3(2), 41-75.
- Olujobi, O. J., Irumekhai, O. S., & Aina-Pelemo, A. D. (2024). Sustainable development and national integration: a catalyst for enhancing environmental law compliance in Nigeria. *Environmental Policy and Law*, 54(1), 27-41.
- Palmer, D., Greenwood, R., Oliver, C., Lawrence, T. B., & Meyer, R. E. (2017). Institutions, institutional theory and organizational wrongdoing. *The SAGE handbook of organizational institutionalism*, 737-758.
- Putri, A. N. A., Hermawan, P., Mirzanti, I. R., Meadows, M., & Sadraei, R. (2025). Unpacking green growth in SMEs: A framework for dynamic capabilities, value co-creation, and sustainable performance. *Sustainable Futures*, 10, 100840.
- Rahman, S., Adeel, S., Ali, M., Bajaba, S., & Latan, H. (2026). Power of green capabilities and artificial intelligence (AI): Understanding how and when green innovation promotes sustainability. *Business Strategy and the Environment*, 35(2), 2502-2525.
- Ramanathan, R., Poomkaew, B., & Nath, P. (2014). The impact of organizational pressures on environmental performance of firms. *Business Ethics: A European Review*, 23(2), 169-182.
- Reficco, E., Gutiérrez, R., Jaén, M. H., & Auletta, N. (2018). Collaboration mechanisms for sustainable innovation. *Journal of Cleaner Production*, 203, 1170-1186.
- Shan, C., & Ji, X. (2024). Environmental regulation and green technology innovation: an analysis of the government subsidy policy's role in driving corporate green transformation. *Industrial Engineering and Innovation Management*, 7(1), 39-46.
- Song, W., Wang, G. Z., & Ma, X. (2020). Environmental innovation practices and green product innovation performance: A perspective from organizational climate. *Sustainable Development*, 28(1), 224-234.

- Wang, M., Li, Y., Li, J., & Wang, Z. (2021). Green process innovation, green product innovation and its economic performance improvement paths: A survey and structural model. *Journal of Environmental Management*, 297, 113282.
- Wang, H., Khan, M. A. S., Anwar, F., Shahzad, F., Adu, D., & Murad, M. (2021). Green innovation practices and its impacts on environmental and organizational performance. *Frontiers in Psychology*, 11, 553625.
- Yue, X., Huo, B., & Ye, Y. (2023). The impact of coercive pressure and ethical responsibility on cross-functional green management and firm performance. *Journal of Business & Industrial Marketing*, 38(5), 1015-1028.
- Zhang, Y., Sun, J., Yang, Z., & Wang, Y. (2020). Critical success factors of green innovation: Technology, organization and environment readiness. *Journal of Cleaner Production*, 264, 121701.
- Zhang, W., Zhu, B., Li, Y., & Yan, D. (2024). Revisiting the Porter hypothesis: a multi-country meta-analysis of the relationship between environmental regulation and green innovation. *Humanities and Social Sciences Communications*, 11(1), 1-15.