African Journal of Emerging Issues
Peer reviewed | Double blind | Interdisciplinary

African Journal of Emerging Issues (AJOEI)
Online ISSN: 2663 - 9335
Available at: https://ajoeijournals.org

CORPORATE SUSTAINABILITY

GREEN INNOVATION AND ENVIRONMENTAL PERFORMANCE IN PLASTIC RECYCLING: EVIDENCE FROM ECOPOST LTD, NAIROBI, KENYA

[1*]Solomon Ndunda Kitundu, [2]Dr. Njoki Chege

[1]School of Business, Zetech University, Kenya*

ndundak@zetech.ac.ke

[2]School of Business, Zetech University, Kenya

catherine.chege@zetech.ac.ke

Publication Date: July 2026

ABSTRACT

Purpose of the study: To examine whether cleaner production technologies significantly influence the Recycling and Reuse Rate (%) at Eco Post Ltd, a plastic recycling MSME in Nairobi, Kenya, while assessing the moderating role of policy and regulatory support.

Short introduction of problem statement: The increasing accumulation of plastic waste has intensified the need for firms to integrate sustainability into their operations. However, despite growing theoretical evidence linking green innovation to environmental performance, there is limited firm-level empirical evidence on this relationship, particularly among micro, small, and medium enterprises (MSMEs) in developing economies.

Method/methodology: The study adopted a quantitative explanatory research design grounded in the Natural Resource-Based View (NRBV) and the Porter Hypothesis. Data were collected using structured questionnaires and 12 months of operational production records from a purposively sampled population of 60 respondents at Eco Post Ltd. Pearson correlation, multiple regression, and moderated regression analyses were used to test the study hypotheses.

Results of the study: The findings revealed that cleaner production technologies have a statistically significant positive effect on recycling and reuse performance ($\beta = 0.31$, $p = 0.002$). Waste management practices and eco-design also demonstrated strong positive effects on recycling performance. Additionally, policy and regulatory support significantly moderated the relationship between green innovation practices and recycling performance.

Conclusion and policy recommendation: The study concludes that cleaner production technologies and other green innovation practices significantly enhance recycling performance in plastic recycling MSMEs. The findings support both the Natural Resource-Based View and the Porter Hypothesis within a developing economy context. The study recommends that

managers invest in cleaner production technologies and eco-innovation initiatives, while policymakers strengthen supportive environmental policies and regulatory frameworks to accelerate the transition toward a circular economy and improve sustainable waste management practices in sub-Saharan Africa.

Keywords: *Cleaner production technologies, Green innovation, Recycling and reuse rate, MSMEs, circular economy, Natural Resource-Based View, Porter Hypothesis*

1. INTRODUCTION

Sustainability has moved from the margins of business strategy to the center of global economic discourse. As industrialization accelerates and consumption patterns shift across the world, the pressure on natural systems has intensified demanding more than voluntary corporate goodwill. Among the many dimensions of the sustainability crisis, plastic waste has proved especially stubborn. Its durability, scale, and the technical complexity of recovering it from diverse waste streams make it one of the most challenging environmental problems of our time (Jambeck et al., 2018). Even as international frameworks and national policies have urged action, global recycling rates for plastic have stagnated at alarmingly low levels, leaving vast quantities of recoverable material to degrade in landfills or disperse across ecosystems (Lebreton & Andrady, 2019).

One widely championed response to this challenge is green innovation broadly understood as the development and adoption of products, processes, and practices that simultaneously reduce environmental harm and support economic performance (Calabrese et al., 2019). The theoretical underpinnings of this argument are well established. The Natural Resource-Based View (NRBV), articulated by Hart (1995), holds that firms can build durable competitive advantage by cultivating capabilities oriented toward pollution prevention, product stewardship, and sustainable development. Complementarily, the Porter Hypothesis (Porter & van der Linde, 1995) asserts that thoughtfully designed environmental regulations do not merely constrain business activity they can catalyze innovation that ultimately offsets compliance costs and strengthens firm performance. Together, these frameworks suggest that eco-friendly practices are not only ethically sound but strategically viable.

2. STATEMENT OF THE PROBLEM

Despite the conceptual appeal of this argument, the empirical evidence remains heavily skewed toward large corporations in high-income settings. Research testing whether green innovation generates tangible environmental gains among MSMEs in developing economies is, at best, patchy (Horbach et al., 2020; Testa et al., 2020). This matter because in many parts of sub-Saharan Africa where informal recycling actors and small enterprises form the backbone of material recovery systems conditions differ fundamentally from those in industrialized contexts. Capital is scarce, technology access is uneven, regulatory enforcement is inconsistent, and market linkages for recovered materials are often fragile (Ogawa et al., 2020). Whether the benefits of green innovation hold under such constraints is an open and consequential question.

The African context adds urgency to this inquiry. Urban growth across the continent is generating waste faster than formal management systems can cope. African cities currently produce over 60 million tons of municipal solid waste annually, a figure projected to double

by 2050 (Kaza et al., 2022). Plastic constitutes a growing share of this burden, driven by rising consumption of packaged goods and limited adoption of sustainable alternatives (UN Habitat, 2020). In Eastern Africa, governments in Kenya, Rwanda, Uganda, and Tanzania have introduced regulatory instruments bans on single-use plastics, public-private partnerships, and material recovery incentive schemes reflecting political commitment to tackling the problem (Munyaneza & Buys, 2021). Even so, firm-level evidence on how these regulations interact with enterprise behavior to produce measurable recycling outcomes remains limited.

Kenya presents a particularly instructive case. The country's 2017 ban on single-use plastic bags drew international attention as a decisive policy intervention, yet analysts note it addressed only one sliver of the wider plastic challenge (Njeru, 2020). High-density plastics from packaging, construction, and industrial uses continued to enter waste streams largely unmanaged (Mburu et al., 2023). Responding to this gap, MSMEs have taken on a disproportionate role in plastic collection, sorting, and transformation. The Kenya National Bureau of Statistics (2024) estimates that MSMEs account for more than 80% of national employment and nearly half of GDP a contribution that extends, importantly, into the recycling sector. Companies like EcoPost Ltd, which converts post-consumer plastic waste into durable fencing posts and construction materials, embody the kind of market-oriented sustainability model that policymakers frequently invoke but seldom study rigorously at the operational level.

This study responds directly to that gap. Rather than relying on self-reported attitudes toward sustainability or composite indices of environmental commitment, it employs Recycling and Reuse Rate (%) the proportion of plastic waste input successfully converted into reusable or marketable output as a concrete, operationally verifiable measure of environmental performance. This choice reflects a broader methodological argument: that advancing understanding of green innovation requires moving beyond perceptual data toward indicators that can be traced, verified, and compared across time periods and contexts. By focusing on EcoPost Ltd and examining how specific green innovation practices influence measurable material recovery outcomes, the study generates evidence that speaks to both theoretical debates and practical policy questions in Kenya and across the region.

3. RESEARCH OBJECTIVES

This paper aims to assess the effect of cleaner production technologies on the Recycling and Reuse Rate (%) at EcoPost Ltd. Cleaner production technologies, as operationalized in this study, encompass process improvements, machinery upgrades, and operational adjustments specifically directed at minimizing waste generation and reducing material losses during the recycling and manufacturing process. By examining whether investments in these technologies translate into higher proportions of plastic waste being successfully recovered and transformed into marketable outputs, the study provides a direct empirical test of the NRBV's proposition that environmentally oriented capabilities generate measurable performance gains (Hart & Dowell, 2011).

This objective is situated within a broader argument about how firms in resource-constrained environments can leverage technological upgrading as a pathway to both environmental and operational improvement. It also speaks to the Porter Hypothesis by examining whether technology-driven efficiency gains the kind of innovation that well-designed policy ought to

stimulate manifest as concrete improvements in material recovery rates (Porter & van der Linde, 1995; Ambec et al., 2013).

4. RESEARCH HYPOTHEIS/QUESTIONS

To test the study objective empirically, the following null hypothesis is evaluated:

H_{01}: Cleaner production technologies have no significant effect on the Recycling and Reuse Rate (%) at EcoPost Ltd.

5. THEORITICAL REVIEW/ FRAMEWORK

The theoretical framework provides the foundation for explaining how green innovation practices influence environmental performance. This study is primarily anchored on the Natural Resource-Based View (NRBV) and the Porter Hypothesis, with Ecological Modernization Theory (EMT) providing complementary insights into sustainable industrial transformation. Together, these theories explain how internal environmental capabilities and external regulatory environments interact to improve environmental performance within manufacturing firms.

Natural Resource-Based View (NRBV)

The Natural Resource-Based View (NRBV), developed by Hart and later refined by Hart and Dowell (2011), extends the traditional Resource-Based View by recognizing environmental capabilities as strategic resources that can generate sustainable competitive advantage. Unlike conventional resources, environmentally oriented capabilities such as cleaner production technologies, waste reduction systems, recycling initiatives, and eco-design are viewed as valuable, rare, and difficult-to-imitate assets that simultaneously enhance organizational competitiveness and environmental performance.

According to NRBV, firms that successfully integrate environmental management into their core operations develop unique capabilities that improve resource efficiency, minimize waste, and enhance long-term organizational performance (Hart & Dowell, 2011). Recent empirical studies further demonstrate that organizations investing in green innovation practices achieve superior environmental and operational outcomes through improved productivity, efficient resource utilization, and reduced environmental impacts (Chen et al., 2022; García-Blandón et al., 2023). However, the effectiveness of these capabilities often depends on the broader institutional and regulatory environment within which firms operate.

The NRBV is particularly relevant to this study because it conceptualizes green innovation practices as strategic organizational capabilities that directly influence environmental performance. Cleaner production technologies, structured recycling and waste management systems, and resource-efficient production processes represent firm-specific competencies that improve the Recycling and Reuse Rate (%). Within the context of EcoPost Ltd, these capabilities enable the organization to convert plastic waste into valuable products while minimizing environmental degradation. Consequently, NRBV provides the principal theoretical lens for explaining how internal green innovation capabilities contribute to measurable environmental performance in resource-constrained MSMEs.

Porter Hypothesis

The Porter Hypothesis, proposed by Porter and van der Linde (1995), argues that well-designed environmental regulations can stimulate innovation, enabling firms to offset compliance costs while simultaneously improving productivity and competitiveness. Rather than viewing environmental regulation as a burden, the theory suggests that stringent but flexible regulations encourage organizations to develop innovative technologies, improve production processes, and enhance resource efficiency.

Empirical evidence largely supports this proposition. Ambec et al. (2013) argue that environmental regulations can stimulate technological innovation, reduce production inefficiencies, and improve environmental performance. Similarly, Testa et al. (2020) found that organizations operating within supportive regulatory environments are more likely to adopt green innovations that enhance both environmental and organizational performance. Nevertheless, the effectiveness of regulatory frameworks depends on factors such as enforcement consistency, institutional capacity, organizational readiness, and the availability of financial and technical support.

The Porter Hypothesis provides the theoretical basis for the moderating role of policy and regulatory support in this study. Within Kenya's evolving environmental policy landscape—including plastic waste regulations, Extended Producer Responsibility (EPR), and circular economy initiatives—government policies have the potential to strengthen the relationship between green innovation practices and environmental performance. For plastic recycling MSMEs such as EcoPost Ltd, supportive regulations and incentives can facilitate greater adoption of cleaner production technologies, improve recycling systems, and ultimately increase Recycling and Reuse Rate (%).

Ecological Modernization Theory (EMT)

Ecological Modernization Theory (EMT) emerged as an alternative perspective to traditional environmental management approaches by arguing that economic growth and environmental sustainability are mutually reinforcing rather than conflicting objectives (Mol, 1995). The theory maintains that technological innovation, institutional reforms, and organizational learning enable industries to reduce environmental degradation while maintaining productivity and competitiveness.

EMT emphasizes a transition from reactive pollution control toward preventive environmental management through cleaner technologies, efficient resource utilization, waste minimization, and sustainable product design (Fischer & Schot, 2019). It further recognizes that technological innovation alone is insufficient without supportive institutions, regulatory frameworks, and stakeholder collaboration that facilitate the adoption of environmentally sustainable practices (Hajer, 1995; Jänicke, 2008).

This perspective complements the NRBV and Porter Hypothesis by highlighting broader systemic changes required to achieve sustainable industrial development. Within the plastic recycling sector, cleaner production technologies, resource-efficient processes, and eco-design contribute to transforming production systems from linear consumption models towards circular economy principles. Consequently, EMT reinforces the argument that green

innovation practices not only improve Recycling and Reuse Rate (%) but also contribute to long-term environmental sustainability and industrial transformation within developing economies.

6. EMPIRICAL REVIEW

Studies on cleaner production technologies indicate that investments in resource-efficient machinery, process optimization, and cleaner manufacturing significantly improve environmental outcomes. For instance, Testa et al. (2020) found that firms adopting cleaner production technologies achieved lower waste generation, improved resource utilization, and enhanced operational efficiency. Similarly, García-Blandón et al. (2023) reported that European SMEs implementing cleaner production initiatives experienced significant improvements in environmental performance. Despite these findings, most studies have focused on large firms in developed countries, limiting their applicability to MSMEs operating in developing economies.

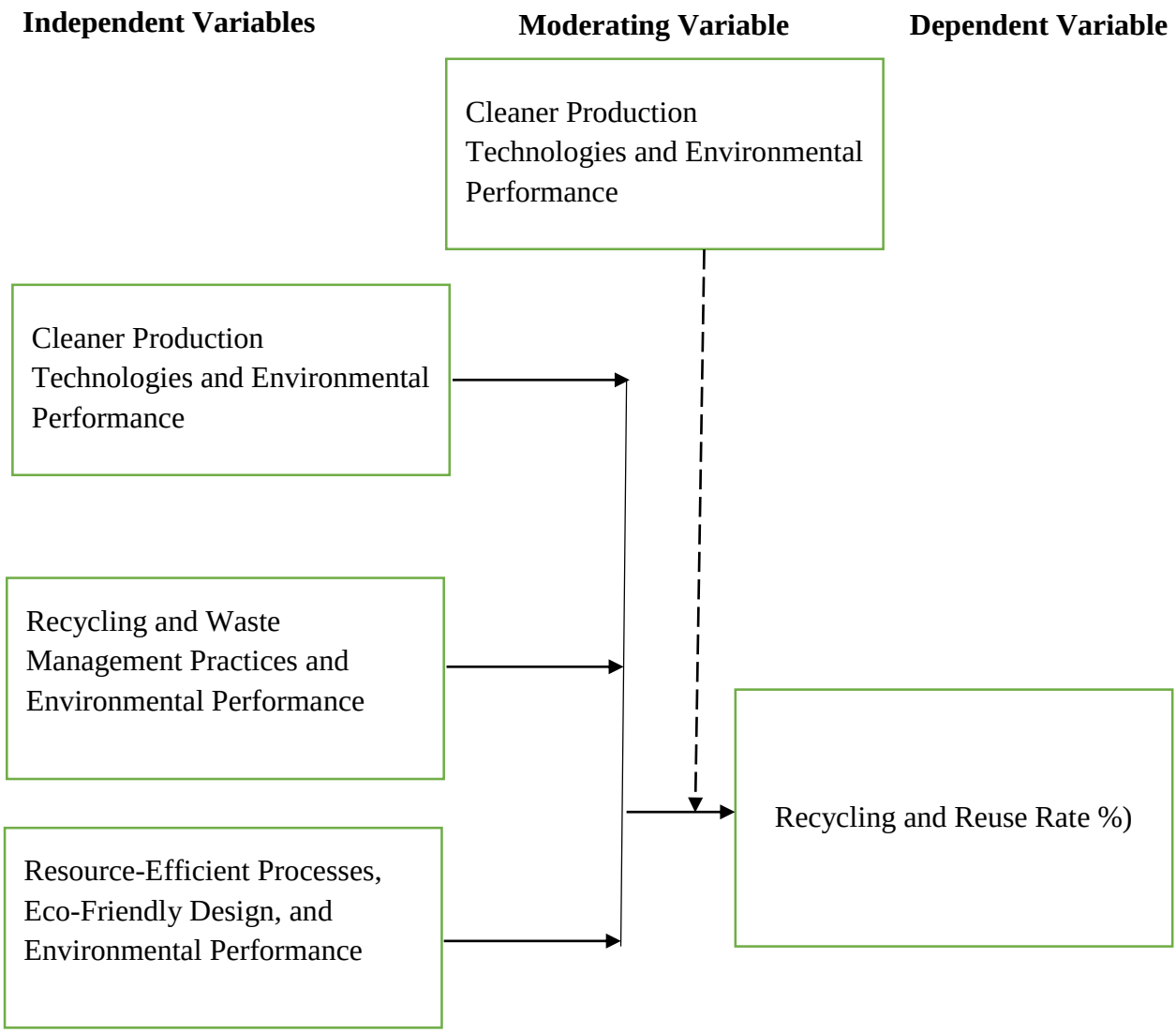
Research on recycling and waste management practices similarly highlights their importance in improving environmental performance. Geyer et al. (2017) established that effective waste management systems substantially increase material recovery while reducing plastic pollution. Likewise, Kaza et al. (2022) emphasized that structured waste segregation, collection, and recycling systems are essential for improving recycling rates and advancing circular economy objectives. In sub-Saharan Africa, however, waste management systems remain fragmented and heavily dependent on informal waste collection, resulting in lower recycling efficiency (Adeoti et al., 2021; Munyaneza & Buys, 2021). Within Kenya, existing studies have largely examined waste management from policy and municipal perspectives, with limited attention given to how firm-level recycling practices influence measurable environmental performance (Mburu et al., 2023).

Empirical evidence also supports the role of resource-efficient processes and eco-design in enhancing environmental performance. Kirchherr et al. (2018) argue that circular economy initiatives require products to be designed for reuse, repair, and recycling to maximize resource recovery. Similarly, the Ellen MacArthur Foundation (2019) and Testa et al. (2020) found that firms integrating eco-design and resource-efficient production processes achieved lower material consumption and improved environmental outcomes. Nevertheless, most empirical studies rely on composite sustainability indicators and predominantly examine multinational corporations, leaving limited evidence on MSMEs in developing countries.

The literature further demonstrates that policy and regulatory support significantly influences the relationship between green innovation and environmental performance. Chen et al. (2022) established that stringent environmental regulations strengthen the positive effect of green innovation on organizational performance, while Testa et al. (2020) found that policy incentives encourage firms to adopt environmentally sustainable technologies. Although Kenya has introduced progressive environmental policies, including plastic bans and Extended Producer Responsibility (EPR) regulations, implementation challenges and weak enforcement continue to constrain their effectiveness (Mburu et al., 2023). Consequently, empirical evidence examining policy and regulatory support as a moderating factor within MSMEs remains limited.

7. CONCEPTUAL FRAMEWORK

The conceptual framework illustrates the hypothesized relationship between green innovation practices and environmental performance within the context of this study. Drawing from the Natural Resource-Based View (Hart & Dowell, 2011), the Porter Hypothesis (Porter & van der Linde, 1995), and Ecological Modernization Theory (Mol, 1995), the framework posits that firms can enhance environmental performance by adopting green innovation practices while recognizing that the effectiveness of these practices is influenced by the prevailing policy and regulatory environment.



8. RESEARCH METHODOLOGY

The study adopted a quantitative explanatory research design. Explanatory designs are appropriate when the objective is to test causal relationships between variables and assess the strength and direction of associations (Creswell & Creswell, 2018). This design enabled systematic examination of how cleaner production technologies and related green innovation practices influence measurable environmental performance outcomes at EcoPost Ltd. A quantitative approach is particularly justified because the dependent variable Recycling and Reuse Rate (%) is objectively computable through production records. Unlike perceptual sustainability measures that depend entirely on managerial self-reporting, objective environmental metrics enhance reliability and reduce social desirability bias (Delmas & Blass, 2010). The explanatory design also permitted statistical testing of moderation effects specifically the influence of policy and regulatory support on the innovation–performance relationship consistent with methodological recommendations in green innovation research (Testa et al., 2020).

The target population comprised managerial and operational staff at EcoPost Ltd who are directly involved in production processes, waste management operations, environmental compliance, and strategic decision-making. Because the study is firm-specific and aims to generate granular operational insights, the unit of analysis is the firm, while the unit of observation consists of employees with functional knowledge of green innovation practices and production performance metrics.

Given the relatively small and specialized population within EcoPost Ltd, purposive sampling was employed. Purposive sampling is appropriate when respondents possess specific knowledge relevant to the constructs under investigation (Saunders et al., 2019). Participants were selected based on direct involvement in production or recycling processes, responsibility for environmental compliance, or managerial oversight of operational systems. A total of 60 respondents were recruited, achieving a 100% response rate, which substantially reduced concerns about non-response bias and enhanced the credibility of the dataset.

A structured questionnaire captured independent and moderating variable data using five-point Likert-scale items (1 = strongly disagree to 5 = strongly agree). Specifically, the instrument measured: the adoption intensity of cleaner production technologies (CPT); the quality and structure of recycling and waste management practices (RWM); integration of resource-efficient processes and eco-friendly design (REPED); and the perceived clarity and supportiveness of policy and regulatory frameworks (PRS). Likert scaling is widely employed in sustainability and innovation research due to its capacity to capture attitudinal and implementation intensity measures (Joshi et al., 2015). Content validity was assured through expert review by academic supervisors and sustainability practitioners familiar with circular economy practices. Internal consistency was assessed using Cronbach's alpha, with a threshold of $\alpha \geq 0.70$ considered acceptable (Hair et al., 2019).

Objective data on material input volumes and recovered material output were extracted from production records over a 12-month period to compute the Recycling and Reuse Rate (%). The formula applied was:

$$\textit{Recycling and Reuse Rate (\%)} = (\textit{Total Material Recovered} \div \textit{Total Material Input}) \times 100$$

This dual-instrument approach combining perceptual survey data with objectively measured operational metrics strengthens construct validity by linking theoretical constructs to observable and verifiable performance indicators.

Data were coded and entered into IBM SPSS (Version 26). Prior to inferential analysis, a suite of diagnostic tests was conducted to validate regression assumptions. Pearson correlation analysis was applied as an initial step to examine bivariate associations among variables and to identify multicollinearity risks. Multiple regression analysis was then employed to evaluate the independent contribution of each green innovation dimension to Recycling and Reuse Rate (%), while controlling for the influence of co-predictors (Field, 2018; Hair et al., 2019). To examine whether policy and regulatory support alters the strength of the innovation–performance relationship, moderated regression analysis was conducted by introducing interaction terms between each innovation predictor and the moderator (Hayes, 2018). The general regression model is specified as:

$$RRR = \beta_0 + \beta_1 CPT + \beta_2 RWM + \beta_3 REPED + \beta_4 PRS + \beta_5 (CPT \times PRS) + \beta_6 (RWM \times PRS) + \beta_7 (REPED \times PRS) + \varepsilon$$

Where RRR denotes Recycling and Reuse Rate (%), CPT = Cleaner Production Technologies, RWM = Recycling and Waste Management Practices, REPED = Resource-Efficient Processes and Eco-Design, PRS = Policy and Regulatory Support, and ε = error term. Statistical significance was assessed at the 5% level ($p < 0.05$).

9. RESULTS AND DISCUSSIONS

Descriptive Statistics

Descriptive statistics were computed to establish the central tendencies and dispersion of the key study variables. The results, presented in Table 1, reveal that EcoPost Ltd has made considerable progress in embedding green innovation practices across its operations.

Table 1: Descriptive Statistics of Study Variables

Variable	Mean	Std. Dev.	Interpretation
Cleaner Production Technologies (CPT)	4.12	0.52	High adoption
Recycling & Waste Management (RWM)	4.25	0.48	Very high adoption
Resource-Efficient Processes & Eco-Design (REPED)	3.98	0.55	Moderate-high adoption
Policy & Regulatory Support (PRS)	3.45	0.67	Moderate
Recycling & Reuse Rate – RRR (%)	78.6	6.8	High performance

Note. n = 60. Likert scale: 1 = strongly disagree to 5 = strongly agree.

The high mean scores for CPT (M = 4.12, SD = 0.52) and RWM (M = 4.25, SD = 0.48) indicate that environmentally oriented operational practices are well embedded within EcoPost Ltd. The relatively lower mean for PRS (M = 3.45, SD = 0.67) suggests that external institutional frameworks may not be as robust, potentially limiting the full realization of green innovation benefits.

Production Data Trends

An analysis of operational data over the 12-month observation period complements the perceptual survey data and provides an objective lens on recycling performance. Table 2 presents selected monthly performance indicators illustrating how material recovery evolved across the year.

Table 2: Selected Monthly Recycling and Reuse Rate Indicators (12-Month Period)

Month	Input (kg)	Recovered (kg)	RRR (%)
January	120,000	88,000	73.3
June	145,000	111,000	76.6
September	160,000	128,000	80.0
December	175,000	146,000	83.4

Note. RRR = Recycling and Reuse Rate. Values extracted from EcoPost Ltd operational records.

The data reveal a consistent upward trajectory in the Recycling and Reuse Rate, rising from 73.3% in January to 83.4% by December. This pattern is consistent with cumulative learning effects, incremental process optimization, and sustained investment in production technologies. The parallel increase in both input volumes and recovery quantities suggests that efficiency gains were not offset by declining material quality, pointing to the role of structured operational improvements rather than random variation.

Correlation Analysis

Pearson correlation analysis was conducted to examine the strength and direction of relationships among the study variables before proceeding to regression modeling. As reported in Table 3, all green innovation dimensions demonstrated strong positive associations with environmental performance.

Table 3: Pearson Correlation Matrix

Variable	CPT	RWM	REPED	PRS	RRR
Cleaner Production Technologies (CPT)	1.00	–	–	–	–
Recycling & Waste Management (RWM)	0.68**	1.00	–	–	–
Resource Efficiency & Eco-Design (REPED)	0.64**	0.71**	1.00	–	–
Policy & Regulatory Support (PRS)	0.42**	0.45**	0.47**	1.00	–
Recycling & Reuse Rate (RRR)	0.78**	0.82**	0.75**	0.60**	1.00

Note. ** $p < 0.01$ (two-tailed). $n = 60$.

The results confirm strong positive associations between all dimensions of green innovation and environmental performance. Cleaner production technologies showed a strong correlation with RRR ($r = 0.78$, $p < 0.01$), indicating that process-level technological improvements are closely associated with higher material recovery. Recycling and waste management practices exhibited the strongest association ($r = 0.82$, $p < 0.01$), suggesting that operational systems for material flow management are especially consequential. All inter-predictor correlations fell below the threshold of 0.90, indicating no severe multicollinearity concerns at this preliminary stage.

Regression Assumptions and Diagnostic Tests

Prior to conducting regression analysis, key assumptions were systematically tested. Variance Inflation Factor (VIF) values ranged between 1.8 and 2.6, well below the critical threshold of 10, and tolerance values exceeded 0.4, confirming the absence of problematic multicollinearity (Hair et al., 2019). Normality of residuals was assessed using histogram inspection, normal probability plots, and the Shapiro-Wilk test ($p > 0.05$ in all cases), indicating that the residuals were approximately normally distributed. A scatter plot of standardized residuals against predicted values showed no discernible systematic pattern, supporting the homoscedasticity assumption. The Durbin-Watson statistic of 2.03 confirmed the absence of autocorrelation. Partial regression plots further verified linear relationships between predictors and the

dependent variable. Collectively, these diagnostics confirm that the data satisfy the assumptions necessary for reliable regression-based inference.

Multiple Regression Analysis

Multiple regression analysis was conducted to estimate the independent effect of each green innovation dimension on Recycling and Reuse Rate (%). Table 4 presents the model summary, Table 5 the ANOVA results, and Table 6 the regression coefficients.

Table 4: Model Summary

R	R^2	Adjusted R^2	Std. Error of Estimate
0.848	0.720	0.708	3.45

Note. Predictors: CPT, RWM, REPED, PRS. Dependent variable: Recycling and Reuse Rate (%).

The model explains approximately 72% of the variance in Recycling and Reuse Rate (R^2 = 0.720, Adjusted R^2 = 0.708), indicating strong explanatory capacity. The ANOVA results confirmed that the model is statistically significant overall ($F = 30.45$, $p < 0.001$), validating the joint contribution of the predictors to environmental performance.

Table 5: Regression Coefficients

Variable	β (Beta)	t-statistic	p-value	Decision on H_0
Cleaner Production Technologies (CPT)	0.31	3.45	0.002	Reject H_{01}
Recycling & Waste Management (RWM)	0.38	4.75	< 0.001	Reject H_{02}
Resource-Efficient Processes & Eco-Design (REPED)	0.27	2.98	0.004	Reject H_{03}
Policy & Regulatory Support (PRS)	0.19	2.40	0.021	Significant

Note. Dependent variable: Recycling and Reuse Rate (%). Significance level: $p < 0.05$.

Cleaner production technologies emerged as a statistically significant positive predictor of Recycling and Reuse Rate ($\beta = 0.31$, $t = 3.45$, $p = 0.002$), supporting the rejection of H_{01}. This finding indicates that for every standardized unit increase in the adoption of cleaner production technologies, recycling efficiency increases by 0.31 units, holding other predictors constant. Recycling and waste management practices registered the strongest effect ($\beta = 0.38$, $p < 0.001$), while resource-efficient processes and eco-design also exerted a meaningful contribution ($\beta = 0.27$, $p = 0.004$). Policy and regulatory support demonstrated a direct positive effect on performance as well ($\beta = 0.19$, $p = 0.021$).

Moderation Analysis

Moderated regression analysis was conducted to examine whether policy and regulatory support alters the strength of each innovation–performance relationship. Interaction terms were introduced into the regression model following the procedure recommended by Hayes (2018). Results are presented in Table 6.

Table 6: Moderated Regression: Interaction Effects of Policy and Regulatory Support

Interaction Term	β (Beta)	p-value	Interpretation
CPT × PRS	0.12	0.041	PRS strengthens CPT effect
RWM × PRS	0.15	0.018	PRS strengthens RWM effect
REPED × PRS	0.10	0.049	PRS strengthens REPED effect

Note. All interaction terms significant at $p < 0.05$. PRS = Policy and Regulatory Support.

All three interaction terms were statistically significant, confirming that policy and regulatory support meaningfully amplifies the relationship between green innovation practices and environmental performance. The moderating effect was strongest for waste management practices ($\beta = 0.15$, $p = 0.018$), followed by cleaner production technologies ($\beta = 0.12$, $p = 0.041$) and eco-design ($\beta = 0.10$, $p = 0.049$). These results indicate that the returns to green innovation are not uniform they are conditional on the quality and consistency of the external regulatory environment.

The findings of this study provide robust empirical support for both the Natural Resource-Based View and the Porter Hypothesis, demonstrating that environmental performance at EcoPost Ltd is shaped by the interplay between internal capabilities and external regulatory conditions. Taken together, the results suggest that green innovation practices function not merely as compliance instruments but as strategic operational resources consistent with Hart's (1995) proposition that environmentally oriented capabilities can generate measurable firm-level gains.

Cleaner Production Technologies and Environmental Performance

The statistically significant effect of cleaner production technologies on recycling efficiency ($\beta = 0.31$, $p = 0.002$) constitutes the study's primary finding. This result reinforces the argument that process-level technological improvements represent a meaningful lever for enhancing material recovery, even within the resource-constrained environment of an MSME operating in a developing economy. Upstream interventions that reduce waste generation at the source whether through more efficient machinery, tighter process controls, or improved input sorting demonstrably translate into higher proportions of plastic waste being converted into usable outputs. This is consistent with Porter and van der Linde's (1995) contention that environmental innovations frequently carry efficiency benefits that extend beyond their initial ecological purpose.

A notable feature of the production data is the upward trajectory in Recycling and Reuse Rate over the 12-month observation window from 73.3% in January to 83.4% by December which suggests that the benefits of cleaner production technologies are cumulative rather than immediate. This pattern of incremental improvement aligns with learning-curve theory and points to the importance of sustained, rather than one-off, technological investment. It also underscores that even modest and phased improvements in process efficiency, which are more financially feasible for MSMEs than large-scale capital overhauls, can yield meaningful gains over time.

Broadly, these findings are consistent with the wider green innovation literature, which documents positive links between eco-innovation and environmental performance (Chen, 2008; Zhu et al., 2008; Horbach et al., 2020). What this study adds, however, is direct empirical evidence from a resource-constrained MSME in a developing economy a context that has been systematically underrepresented in the extant literature. The confirmation that NRBV and Porter Hypothesis dynamics operate within such settings challenges the implicit assumption that these theoretical frameworks are primarily applicable to large firms in stable, high-income regulatory environments. The study also advances prior work by operationalizing environmental performance through an objectively verifiable metric rather than perceptual indicators, thereby strengthening the evidentiary base for the relationships identified.

10. CONCLUSIONS

This study sought to examine the effect of cleaner production technologies on the Recycling and Reuse Rate (%) at EcoPost Ltd, a plastic recycling MSME in Nairobi, Kenya. Based on the empirical findings, the study rejects the null hypothesis that cleaner production technologies have no significant effect on environmental performance. The results demonstrate that cleaner production technologies have a statistically significant and practically meaningful positive influence on recycling efficiency, confirming that investments in environmentally sustainable production processes can substantially improve material recovery and environmental performance even within resource-constrained MSMEs.

The study further establishes that environmental performance is driven by the combined implementation of multiple green innovation practices rather than a single intervention. Specifically, cleaner production technologies, recycling and waste management practices, and resource-efficient processes incorporating eco-design all exert significant positive effects on the Recycling and Reuse Rate (%). This finding underscores the complementary nature of green innovation practices and suggests that organizations are likely to achieve greater environmental performance when these initiatives are implemented as an integrated operational strategy.

Another important conclusion is that policy and regulatory support plays a dual role in enhancing environmental performance. In addition to exerting a direct positive influence on recycling efficiency, policy and regulatory support significantly strengthens the relationship between green innovation practices and environmental performance. This finding provides empirical support for the Porter Hypothesis within the context of Kenyan MSMEs by

demonstrating that an enabling regulatory environment encourages firms to invest in innovation while simultaneously improving environmental outcomes.

The study also concludes that improvements in recycling efficiency are cumulative rather than immediate. The analysis of twelve months of operational production data indicates that continuous investment in technological and operational improvements leads to progressive gains in material recovery efficiency. This suggests that organizations should view green innovation as a long-term strategic investment whose benefits accrue over time through sustained implementation and continuous improvement.

While the study provides important empirical evidence on the relationship between green innovation and environmental performance, its findings should be interpreted within the context of certain limitations. The focus on a single organization limits the generalizability of the results to other firms and industries. Furthermore, although the inclusion of objective production data strengthened the analysis, the cross-sectional survey component and reliance on self-reported responses may constrain causal inference and introduce the possibility of response bias.

11. RECOMMENDATIONS

Based on the findings of the study, EcoPost Ltd and other firms operating within the plastic recycling sector should prioritize cleaner production technologies as a strategic investment rather than merely a regulatory compliance requirement. The evidence suggests that incremental investments in improved sorting systems, energy-efficient processing equipment, and enhanced quality control mechanisms can generate significant improvements in recycling efficiency over time while remaining financially feasible for MSMEs.

The study also recommends that firms strengthen their waste management systems and integrate eco-design principles throughout their production processes. Since recycling and waste management practices emerged as the strongest predictor of environmental performance, organizations should institutionalize systematic waste segregation, material recovery, and process optimization initiatives while designing products that facilitate reuse and recyclability. Such an integrated approach is likely to maximize resource efficiency and support long-term sustainability objectives.

For policymakers, the findings highlight the importance of creating an enabling regulatory environment that encourages green innovation. Government agencies should strengthen the implementation and enforcement of environmental regulations governing the recycling sector while simultaneously introducing supportive policy instruments such as tax incentives, subsidized access to cleaner production technologies, green financing mechanisms, and environmentally preferential public procurement. These interventions would reduce the financial and operational barriers that currently limit the adoption of green innovation among MSMEs.

In addition, national and county governments, together with industry associations and development partners, should invest in capacity-building programmes aimed at enhancing the technical and managerial competencies of recycling enterprises. Providing firms with practical

training on cleaner production technologies, waste management systems, and eco-design practices would facilitate the successful implementation and long-term sustainability of green innovation initiatives.

Finally, future research should extend this study by examining multiple recycling firms across different counties in Kenya and other sub-Saharan African countries to improve the external validity of the findings. Longitudinal research designs would provide deeper insights into the long-term effects of green innovation on environmental performance, while qualitative and mixed-methods studies could explore the organizational, managerial, and behavioral factors influencing successful implementation. Further investigation into the application of digital technologies and data analytics in improving material tracking, operational efficiency, and recycling performance would also contribute valuable knowledge to the growing body of literature on the circular economy and sustainable manufacturing.

REFERENCES

Ambec, S., Cohen, M. A., Elgie, S., & Lanoie, P. (2013). The Porter Hypothesis at 20: Can environmental regulation enhance innovation and competitiveness? Review of Environmental Economics and Policy, 7(1), 2–22. https://doi.org/10.1093/reep/res016

Bocken, N. M. P., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering, 33(5), 308–320. https://doi.org/10.1080/21681015.2016.1172124

Calabrese, A., Costa, R., Levialdi Ghiron, N., & Menichini, T. (2019). Materiality analysis in sustainability reporting. Technological and Economic Development of Economy, 25(5), 1016–1038. https://doi.org/10.3846/tede.2019.10550

Chen, Y. S. (2008). The driver of green innovation and green image: Green core competence. Journal of Business Ethics, 81(3), 531–543. https://doi.org/10.1007/s10551-007-9522-1

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications.

Delmas, M. A., & Blass, V. D. (2010). Measuring corporate environmental performance: The trade-offs of sustainability ratings. Business Strategy and the Environment, 19(4), 245–260. https://doi.org/10.1002/bse.676

Field, A. (2018). Discovering statistics using IBM SPSS statistics (5th ed.). SAGE Publications.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). Multivariate data analysis (8th ed.). Cengage Learning.

Hart, S. L. (1995). A natural-resource-based view of the firm. Academy of Management Review, 20(4), 986–1014. https://doi.org/10.5465/amr.1995.9512280033

Hart, S. L., & Dowell, G. (2011). Invited editorial: A natural-resource-based view of the firm: Fifteen years after. Journal of Management, 37(5), 1464–1479. https://doi.org/10.1177/0149206310390219

Hayes, A. F. (2018). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach (2nd ed.). Guilford Press.

Horbach, J., Rammer, C., & Rennings, K. (2020). Determinants of eco-innovations by type of environmental impact. Ecological Economics, 78, 112–122. https://doi.org/10.1016/j.ecolecon.2012.04.005

Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., Narayan, R., & Law, K. L. (2018). Plastic waste inputs from land into the ocean. Science, 347(6223), 768–771. https://doi.org/10.1126/science.1260352

Joshi, A., Kale, S., Chandel, S., & Pal, D. K. (2015). Likert scale: Explored and explained. British Journal of Applied Science & Technology, 7(4), 396–403. https://doi.org/10.9734/BJAST/2015/14975

Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2022). What a waste 2.0: A global snapshot of solid waste management to 2050. World Bank Group.

Kenya National Bureau of Statistics. (2024). Economic survey 2024. Government of Kenya.

Lebreton, L., & Andrady, A. (2019). Future scenarios of global plastic waste generation and disposal. Palgrave Communications, 5(1), 6. https://doi.org/10.1057/s41599-018-0212-7

Mburu, J., Mwangi, E., & Kariuki, P. (2023). Plastic waste management and the regulatory environment in Kenya: A post-ban assessment. East African Journal of Environmental Studies, 11(2), 45–61.

Njeru, J. (2020). The urban political ecology of plastic bag waste problem in Nairobi, Kenya. Geoforum, 41(6), 1046–1058. https://doi.org/10.1016/j.geoforum.2006.12.003

Ogawa, H., Batool, S. A., & Niber, J. (2020). Informal recycling sector in developing countries: A systematic review. Waste Management & Research, 38(8), 847–861.

Porter, M. E., & van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. Journal of Economic Perspectives, 9(4), 97–118. https://doi.org/10.1257/jep.9.4.97

Saunders, M., Lewis, P., & Thornhill, A. (2019). Research methods for business students (8th ed.). Pearson Education.

Testa, F., Boiral, O., & Iraldo, F. (2020). Internalization of environmental practices and institutional complexity. Journal of Business Ethics, 147(2), 287–307. https://doi.org/10.1007/s10551-015-2960-2

UN Habitat. (2020). World cities report 2020: The value of sustainable urbanization. United Nations Human Settlements Programme.

Zhu, Q., Sarkis, J., & Lai, K. H. (2008). Confirmation of a measurement model for green supply chain management practices implementation. International Journal of Production Economics, 111(2), 261–273. https://doi.org/10.1016/j.ijpe.2006.11.029