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Effect of Green Manufacturing on Performance of Sugar Manufacturing in Western Kenya

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ABSTRACT

Purpose; The study concentrated on effects of green manufacturing on performance of sugar manufacturing firms in western Kenya.

Methodology/design; The study utilized descriptive and causal research employing both qualitative and quantitative approaches. The study aimed at 10 sugar production companies in Western Kenya. The sample of 126 employees was selected from each company using a simple random sampling technique, focusing on the designated departments. Closed ended questionnaires were used based on a five-point Likert scale. The study was anchored on Natural Resource Based View and Transaction Cost Economics Theories. Validity and reliability of the instrument was tested. Data was analyzed using both descriptive and inferential statistics.

Findings: The study found out green manufacturing has considerable positive effect on performance of sugar manufacturing firms in western Kenya.

Implications/Value: The study seeks to guide policy makers and management in sugar manufacturing firms in identifying areas for the integration of green manufacturing strategies to establish a basis for developing and executing policies to enhance product and service quality, increase production process in effectiveness and efficiency, and optimize service costs throughout the supply chain network. It will also elucidate the primary motivations for firms in this sector to adopt a green manufacturing philosophy as a strategic approach to enhance overall performance.

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Introduction

Contemporary industrial advancements lead to heightened competitiveness among industrial sectors. This generates diverse beneficial and bad effects on multiple facets, one of which is the environment. Environmental implications occur throughout the operational workflow, beginning with acquisition of input materials, continuing through processing, and culminating in product reuse (Zhang, Wu, Zhang, Zhu, Lin, Zhang, & Smola, 2022). The cultivation and processing of sugarcane have been associated with detrimental impacts on the environment and society, such as habitat destruction, excessive water use, significant pesticide dependence, and air and water pollution (Sugar task force, 2020). Notwithstanding these apprehensions, Kenyan sugar businesses have not undertaken any initiatives to showcase their sustainability policies and environmental effects. The environmental management system was established to offer fundamental rules ensuring that business operations align with environmental sustainability (Affandi, Sarwani, Erlangga, Siagian, Purwanto, Effendy & Juhaeri 2020).

As articulated by Çankaya and Sezen (2019), green manufacturing represents a paradigm in which organizations strive to conduct their production processes in a manner that safeguards the broader environment from adverse impacts. The desired outcome of green manufacturing is that the production processes of the firm do not result in the pollution of air, soil, and water. Kithure, 2022), also indicated that the practice of green manufacturing enhances the operational efficacy of manufacturing enterprises. Consequently, it is essential for companies to utilize inputs that exhibit comparatively minimal environmental repercussions. He underscored the importance of creating products that are recyclable and produce minimal pollution. Moreover, it is imperative for manufacturing firms to prioritize the minimization of effluent waste generation.

Globally, Yildiz and Sezen's 2019 study demonstrated that environmentally responsible manufacturing exerts substantial favourable influence across the three key indicators of triple bottom performance: environmental, economic, and social performance. A further investigation conducted by Srisawat and Srisawat (2020) revealed a noteworthy positive influence of green manufacturing on the sustainability of firms. The implementation of Green Manufacturing is associated with using fewer resources generating less waste. Eltayeb (2019) looked at certified companies in Malaysia that were involved in green manufacturing activities, with an emphasis on sustainability. According to the research, an organization's operational success and environmental sustainability are greatly affected by how green manufacturing and GSCM (GSCM) interact with one another.

Regionally, Afum, Agyabeng-Mensah, and Owusu (2020) set out to determine how incorporation of green supply chain bridges the connection between green manufacturing practices and corporate sustainability in the Ghanaian setting. Green manufacturing processes have a favourable and profound influence on sustainability productivity, their study also showed that green supply chains are more likely to be integrated when ecologically sustainable manufacturing practices are used. Fasasi (2024), conducted a study Nigerian oil and chemical manufacturing sector on integrating resource-efficient and eco-friendly approaches and the findings demonstrated that green manufacturing enhanced production output, significantly reduced waste, and lowered operational costs in a Nigerian oil & chemical plant.

In Kenya, Bor (2021) executed a study to assess the practices of GSCM and their influence on the productivity of the Food and Beverage Processing Sector in Kenya. Findings indicated that enhanced productivity has been linked to various eco-friendly production approaches, including operational workflows aimed at minimizing waste and conserving water, maximizing capacity utilization, reducing hazardous waste during production, implementing eco-design in products, and employing eco-efficient production processes. In summary, it’s imperative for manufacturing

entities to embrace environmentally sustainable production practices. Based on their research, Musau and Rucha (2021) found that green manufacturing helps manufacturing enterprises in Mombasa County improve their operational performance. Product quality has been improved by the implementation of green manufacturing, which has reduced production costs significantly, minimized market failures, and ensured that products correspond to standards. Product delivery, time to market, and responsiveness to changing customer preferences have all seen significant improvements.

Statement of the Problem

The cultivation and refinement of sugarcane have been associated with detrimental supply chain practices impacting both the environment and society. These practices encompass the degradation of natural habitats, excessive consumption of water resources, a significant dependence on pesticides, and the contamination of air and water (Sugar task force, 2020). The NEMA report from 2015 indicated that despite the gradual adoption of supply chain solutions such as wastewater treatment by sugar mills, the environmental contamination resulting from these operations continues to rise.

Furthermore, manufacturing firms in Kenya have been encountering a decline in profitability within their production and operations management (KAM, 2019). The mainstream media in 2023 reported on a troubling narrative concerning the contaminated atmosphere surrounding the Transmara sugar factory, where inhabitants faced the peril of potential blindness due to hazardous air quality. The factory's toxic emissions and the lack of regulation in waste disposal have led to a significant contamination of the air with harmful chemicals, thereby presenting considerable health hazards to the local population. The NEMA report of 2021 indicated that the disposal of bagasse-solid waste by the West Kenya Sugar Company has resulted in a range of detrimental effects. The leachate produced from the bagasse has led to the burning of crops on adjacent farms and has even infiltrated wells and streams, thereby compromising water quality.

While a variety of literature indicates the numerous potential advantages of green manufacturing for firms, empirical studies examining the correlation between this practice and the performance of sugar manufacturing firms remain limited. It is evident that a deficiency in understanding persists, which the present research aims to address. This establishes a foundation for the present study to explore further impact of green manufacturing practice on the performance of sugar manufacturing firms in Western Kenya.

Main Objective

To determine the effect of green manufacturing on performance of sugar manufacturing firms in Western Kenya.

Research Hypotheses

HO1: Green manufacturing has no significant effect on performance of sugar manufacturing firms in Western Kenya.

Literature Review Theoretical Review

Natural Resource Based View Theory

The resource-based view was initially articulated by Wernerfelt, B. (1984), who conceptualized a firm as an extensive array of resources, in contrast to the conventional perspective that considers only categories like labor, capital, and land. In 1995, Hart introduced the Natural Resource-Based View (NRBV) theory, which was a development of the existing Resource-Based View by incorporating the dimension of the natural environment into its framework. The Resource-based view theory has been extensively applied to expound the influence of adopting eco-friendly initiatives (green manufacturing) on firm’s productivity (Yildiz and Sezen, 2019). Resource-

Based View (RBV) is widely acknowledged as a highly referenced and impactful theory within management studies, emphasizing the significance of resources as the primary means of attaining sustainable competitive advantages for organizations (Namjoo & Keramati 2018). For instance, the implementation of green manufacturing and cleaner production strategies frequently leads to a competitive edge and improved performance for enterprises (Shan and Wang 2019). The Natural Resource-Based View was of significance to this research as it posits firms can attain internal proficiency by leveraging their core competencies, including environmental risk reduction, end-to-end environmental responsibility, and green development strategies.

Transaction Cost Economies Theory (TCE)

The theory of transaction cost economics was initially introduced by Williamson in 1981 and subsequently elaborated upon by Sarkis, Zhu and Lai, (2011). The theory examines the extent of effort and expense necessary for two parties to engage in an economic exchange or transaction, encompassing searching costs, bargaining costs, and control costs. This theory examines the systematic arrangement of transfer which take place whenever a commodity or service is conveyed from a producer to an end-user, through a unique technologically interface. In relation to of organizational exchanges, the associated expenses may encompass oversight and management of personnel, as well as the acquisition of necessary inputs and capital equipment. The Transactional Cost Model proved relevant in this study as it elucidated the inefficiencies stemming from companies' inability to integrate contributions from various functional areas, thereby hindering their understanding and attainment of established objectives. This theory was integrated with green manufacturing, while adopting cleaner production methods that aim to lower production costs, thereby enhancing the performance of firms.

Conceptual Review

Green manufacturing

Yildiz and Sezen (2019) articulate that green manufacturing incorporates strategizing and conducting activities that prioritize energy efficiency and resource conservation within the production system, aiming to minimize environmental pollution to the greatest extent possible. According to Eltayeb (2019) green manufacturing: sustainable design of goods, sustainable process, sustainable supply chain management, and sustainable product disposal stage. Green manufacturing practices serve as crucial elements of GSCM practices, significantly enhancing a firm's sustainability efforts. Consequently, organizations that adopt environmentally friendly production methods within their operational frameworks are more likely to attain environmental stewardship across multiple performance dimensions, as evidenced by several studies, including those conducted by (Srisawat & Srisawat, 2020; Yildiz & Sezen, 2019). The integration of product creation and development significantly affects sustainable production, effective planning, and control mechanisms, facilitating the systematic identification, quantification, assessment, and mitigation of waste in relation to its environmental impact, while striving to optimize resource efficiency.

Performance

Marendi and Sarhaye (2017), Performance encompasses the capacity to meet obligations, achieve established objectives, satisfy requirements, and realize commitments as anticipated or promised. Performance reflects the organization’s ability to achieve own objectives by judicious and effective use of resources. Organizational performance encompasses the systematic activities undertaken by government entities or their agencies, which include planning, implementing, reviewing, evaluating, and reporting on the efficacy of their policies, programs, and projects.

Performance metrics related to efficiency might encompass production cycle durations, throughput rates, equipment utilization, and inventory turnover ratios. As articulated by Chopra and Meindl (2019), cost serves as a measure of the efficiency with which resources are employed

in the manufacturing of products or the rendering of services. This entails the reduction of costs throughout the supply chain, all the while ensuring that the requisite standards of quality are upheld. Cost performance metrics can encompass total production expenses, material expenditures, labour costs, and overhead allocations. As noted by Oarkland (2014), quality is centred on fulfilling or surpassing customer expectations in relation to the characteristics of a product or service. This encompasses elements such as reliability, durability, functionality, and adherence to specifications. Performance metrics of high caliber may encompass defect rates, customer satisfaction indices, product reliability assessments, and warranty claim statistics.

Empirical literature review

Green Manufacturing and Performance of sugar manufacturing firms in Western Kenya.

Yildiz and Sezen (2019) demonstrated that environmentally friendly production exerts considerable positive influence across three key indicators of triple bottom performance: environmental, economic, and social performance. Srisawat and Srisawat (2020) conducted an additional study that revealed a significant beneficial impact of eco-friendly production on the environmental stewardship of firms. Ononye, Ndudi, Aloamaka, Mba and Ejumudo (2022) while evaluating how quality performance and an entrepreneurial mindset affect green manufacturing and financial success revealed that in polymer manufacturing firms in Southern Nigeria, green manufacturing positively impacted financial performance. This link was mediated by improved quality performance and amplified by entrepreneurial orientation. Tarus, Kimitei & Kapkiyai (2024) did a study on impact eco-friendly production, information sharing on productivity of manufacturing companies in Nairobi County, Kenya and their findings from a sample of 242 Nairobi manufacturing firms demonstrated that performance was significantly improved by green manufacturing.

Muthangya (2021), in his research on the impact of green supply chain strategies on the performance of building, mining, and construction enterprises in Kenya, findings revealed that in construction-related firms, green manufacturing, along with environmentally design, procurement, and reverse logistics, all had significant positive associations with firm performance—highlighting green operations as a strong performance lever. Bor (2021) conducted a study examining the practices of GSCM and their effect on the productivity of the Food and Beverage Processing Sector in Kenya. The findings indicated that enhanced productivity is linked to various eco-friendly production practices, including processing methods aimed at minimizing waste and conserving water, maximizing capacity utilization, reducing hazardous waste during production, implementing eco-design in products, and employing eco-efficient production strategies. In summary, it is imperative for production companies to embrace environmentally sustainable industrial output practices.

This research assessed the impact of environmentally sustainable manufacturing practices on the performance of sugar manufacturing companies in western Kenya. It implemented these practices through water conservation, waste reduction and treatment, capacity utilization, and product and process design, drawing comparisons to prior studies that indicated a positive correlation between sustainable manufacturing and corporate performance.

Research Methodology

The research employed a descriptive and causal design to investigate the impact of green manufacturing on the performance of sugar manufacturing firms in western Kenya, utilizing both quantitative and qualitative methodologies. The investigation happened in Western Kenya, the region that hosts the majority of sugar mills and it focused on a target population consisting of 10 sugar companies located in western Kenya; Chemelil Sugar Company, Kabras Sugar Company, Mumias Sugar Company, Muhoroni Sugar Company, Nzoia Sugar Company, South Nyanza Sugar Company, Kibos Sugar and Allied Industries, Butali Sugar Mills Limited, Transmara

Company, and Busia Sugar Company. The research encompassed 190 individuals occupying leadership positions, including managers, middle managers, and supervisors, from the procurement and production departments of the chosen sugar factories.

The study used simple random sampling technique, focusing on the designated departments, specifically targeting managers, middle-level managers, and supervisors within the procurement and production sectors. The research employed the methodology proposed by Yamane (1967) to determine the sample size. The study comprised a sample size of 129 respondents, determined through the application of the Yamane formula, utilizing a confidence level of 95% and a precision level of 0.05 (5%).

$n= N/1+N (e^2)$

Where n is the sample size required

N is the population size

e is the precision level

$190/1+190(0.05^2)$

= 129 respondents

The research utilized a self-administered questionnaire featuring both structured and semi-structured inquiries aligned with the study objectives, serving as a principal tool for the collection of primary data. The research instrument's construct and content validity were assessed by the study. Construct validity was tested using factor analysis, which showed if the chosen items accurately represented the study's constructs. The reliability of the research instrument was tested using Cronbach's alpha, and the coefficients of the variable were above 0.7 (70%), indicating that a dependability instrument was used. The Statistical Package for Social Sciences (SPSS) software was then used to edit and analyze the data using descriptive statistics indexes including mean, percentages, and frequency distribution method. It was displayed using frequency tables. Data was analyzed using regression analysis.

Y = a + BX + e

Where Y= Firm performance

x= Independent variables

b= coefficient for the independent variables

e= error term

Ethical consideration

Ethical considerations were adhered to by obtaining consent from the companies to secure authorization for the study. Approval was obtained from the managing directors and all participants prior to the commencement of the study. The confidentiality and anonymity of respondents were meticulously preserved, employing numerical identifiers in lieu of names where appropriate. The objective of the study was conveyed to the respondents through either verbal communication or written instructions. To circumvent plagiarism, the study duly recognized the sources of data and information derived from others. NACOSTI was established to guarantee the adherence to ethical standards in research endeavours. The study upheld a consistent standard of integrity throughout its duration. No participant was compelled or obligated to provide answers to inquiries they were not inclined to address.

Findings and Discussion

Response Rate

Participants were given a total of 129 questionnaires utilizing a drop and pick method. Of the 129 individuals initially targeted, 95 completed and submitted the questionnaires. Consequently, the response rate was determined to be 73.6%, as illustrated in Table 4.1. Kothari (2014) posits that a response rate of 70% or higher is commendable and advisable for the generalization of study findings to a broader population.

Table 4.1 Response Rate

Response	Frequency	Percent (%)
Responsive	95	73.6
Unresponsive	34	26.4
Target	129	100.0

Source: Field data (2025)

Reliability

The data displayed in Table 4.2 reveals that study's Cronbach's Alpha variable was 0.830, surpassing the 70% threshold, thereby demonstrating the reliability of the instrument was employed.

Table 4.2 Reliability test

Green supply chain practices	Cronbach's Alpha	Items	Results
Green Manufacturing	0.830	5	Reliable

Source: Field data (2025)

Descriptive Data Results

Effects of Green Manufacturing on performance of sugar manufacturing firms

Table 4.3 presents statics on effects of green manufacturing on performance of sugar manufacturing firms.

Table 4.3 Effects of Green Manufacturing on performance of sugar manufacturing firms

Green manufacturing practices	SD	D	FA	A	SA
Company generates low or no waste or pollution	**3 (3.2%)**	**4 (4.2%)**	**24 (25.3%)**	**39 (41.1%)**	**25 (26.3%)**
Company incurs lower raw material costs	**3 (3.2%)**	**7 (7.4%)**	**18 (18.9%)**	**37 (38.9%)**	**30 (31.6%)**
Our firm uses eco-friendly product and process design.	**0 (0%)**	**5 (5.3%)**	**30 (31.6%)**	**37 (38.9%)**	**23 (24.2%)**
Company ensures capacity utilization through quality production.	**2 (2.1%)**	**18 (18.9%)**	**20 (21.1%)**	**33 (34.7%)**	**22 (23.2%)**
We treat our wastes products before disposal	**1 (1.1%)**	**1 (1.1%)**	**30 (31.6%)**	**35 (36.8%)**	**28 (29.5%)**

Source: Field data (2025)

The findings presented in table 4.3 reveal that 67.4% of responders concurred with the assertion that the company produces minimal or no waste or pollution, whereas 7.4% expressed disagreement with this claim. A significant portion of the respondents, 70.5%, concurred that their firms experience reduced raw material costs. Meanwhile, 18.9% of the respondents moderately agreed with this assertion, while 10.6% expressed disagreement regarding the notion that their company incurs lower raw material costs.

Upon assessing the extent to which firms engage in eco-friendly product and process design, it was found that 63.1% of respondents expressed agreement, while 5.3% voiced disagreement on the matter. A significant portion of the respondents, 57.9%, concurred that their organizations effectively guarantee capacity utilization via quality production, while 21.1% expressed moderate agreement with this assertion. A significant proportion of respondents, 66.3%, affirmed that their companies engage in the treatment of waste products prior to disposal. Meanwhile, 31.6% expressed a moderate agreement with this practice, while a minority of 2.2% voiced their disagreement.

This outcome aligns with Yildiz and Sezen (2019) research that characterized eco-friendly manufacturing with the strategic development and execution of energy-efficient initiatives that minimize resource consumption within the production framework, thereby generating minimal environmental pollution. Additionally, the findings of Fianko, Amoah, and Dzogbewu (2021) indicate that green design positively influences external green practices, including green purchasing and green construction, which, in turn, demonstrate a direct positive relationship with environmental performance. The findings stand in contrast to those of Naeem, Shaukat, Mustafa, and Jameel (2022), who concluded that green manufacturing practices did not consistently lead to notable enhancements in overall sustainable supply chain performance in their investigation of GSCM in Pakistan.

Inferential Statistics

Normality Test

The Jaque Bera test results demonstrate that the residuals exhibited a skewness of 0 and a kurtosis of 3, as indicated by the corresponding values. The joint test revealed that the Jaque Bera chi-square statistic for deviation from normality produced p-values of 0.029 and 0.008, both below the 0.05 threshold, indicating that a normal distribution is maintained by the residuals.

Table 4.4 Jaque -Bera Test of Normality

Variable	Obs	Pr (Skewness)	Pr (Kurtosis)	adj Prob>chi	Joint chi2(2)
Performance (Y)	93	0.908	0.540	0.620	0.029
Model residuals	93	0.640	0.770	0.440	0.008

Source: Field data (2025)

Test for Multi-collinearity

Variance inflation factors (VIFs) together with their reciprocals were computed for each independent variable to evaluate multi-collinearity, specifically through the analysis of tolerances. It is generally accepted that the VIFs ought not to surpass the value of ten. The VIF was below 10, indicating that independent variable in question contravened the assumption.

Table 4.5 Test for Multi-collinearity

Model		Collinearity Statistics	
		Tolerance	VIF
1	GM	.862	2.765

Source: Field data (2025)

Linearity

Green manufacturing and Performance

An ANOVA test was executed to examine linear interrelationship between green manufacturing practices and the performance of sugar manufacturing firms. The p-value for deviation from linearity was found to be 0.109, exceeding the threshold of 0.05, thereby suggesting the presence of a linear relationship.

Table 4.6 Green Manufacturing.

	Sum of Squares	Df	Mean Square	F	Sig.

Between groups	(Combined)	16.558	16	1.035	4.447	.000
	Linearity	11.158	1	11.158	47.947	.000
	Deviation from linearity	5.400	15	.360	1.547	.109
Within groups		18.152	78	.233		
Total		34.710	94			

Source: Field data (2025)

Homoscedasticity

The Levin test was employed to assess the homogeneity of variance. The probability value for green manufacturing was recorded at 0.125, exceeding the threshold of 0.05, thereby suggesting a state of homogeneity.

Table 4.7 Test of Homogeneity of Variances

		Levin Statistic	df1	df2	Sig.
Green manufacturing	Based on Mean	1.532	13	78	.125

Source: Field data (2025)

Simple Regression Analysis

Green Manufacturing and Performance

From table 4.8 at 95% confidence level green manufacturing account for 56.7% of performance variation across sugar manufacturing firms as indicated by an R^2 value of 0.567.

Table 4.8 Model summary

Model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.567[a]	.321	.314	.50323

Predictors: (Constant), green manufacturing

Source: Field data (2025)

ANOVA[a]

Table 4.9 shows that the P value for green manufacturing is 0.000, which is below the 0.05 threshold at a 95% significance level. This suggests the model's capability to examine correlation between green manufacturing and the performance of sugar producing enterprises. Consequently, HO1 is rejected due to the presence of a favourable and strong association between green manufacturing and the performance of sugar producing enterprises.

Table 4.9 ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	11.158	1	11.158	44.060	.000[b]
	Residual	23.552	93	.253		
	Total	34.710	94			

a. Dependent Variable: performance

b. Predictors: (Constant), green manufacturing

Source: Field data (2025)

Regression coefficient

P=2.199+0.458X1

If all factors held constant at 0, the unit change in the p value will be 2.199 a single unit increase in green manufacturing will result in 0.458 increase in performance of sugar manufacturing firms. This is in line with Srisawat and Srisawat (2020) study that revealed a strong affirmative impact of eco-friendly manufacturing on corporate sustainability.

Table 4.10 Regression coefficient

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	2.199	.268		8.206	.000
	Green manufacturing.	.458	.069	.567	6.638	.000

Dependent Variable: performance

Source: Field data (2025)

Conclusion

The study further concludes that green manufacturing and performance are positively and significantly related. Green manufacturing practices result in substantial cost savings, improved product quality and innovation, enhanced brand image and customer loyalty. Additionally, they foster employee engagement and their safety and ensure compliance with environmental regulations, thereby enhancing profitability and competitive advantage which results to long-term sustainability and resilience.

Recommendations

Investing in green manufacturing technologies and processes can significantly enhance operational efficiency, ensure capacity utilization and reduce environmental impact. It is utmost necessary for the firms to use inputs with relatively low environmental impacts. They should ensure waste treatment and its reduction before disposal to protect the environment and ensure water conservation by avoiding disposal of untreated effluents into water sources.

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