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EFFECT OF PLASTIC WASTE COLLECTION ON THE SUPPLY CHAIN OPTIMIZATION OF PLASTIC PRODUCTS IN KISUMU COUNTY, KENYA

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ABSTRACT

Manufacturers face challenges integrating product recovery into logistics despite its sustainability benefits. Supply chain optimization is vital for efficiency, cost reduction, and competitiveness. In Kisumu County, Kenya, about 30 tons of plastic waste are generated daily, creating environmental and economic challenges due to improper disposal and disrupted plastic product supply chains. Despite the growing awareness of the environmental impacts of plastic waste, there is a notable gap in the literature regarding the specific effects of plastic waste collection and transportation, product recovery and recycling, and remanufacturing and reprocessing on the supply chain optimization of plastic products in Kisumu County. The objective of this study was to assess the effect of plastic waste collection on supply chain optimization. The study was anchored on Triple Bottom Line Theory. The study utilized correlational research design and based positivist research philosophy. The study population consisted of 120 employees of the two plastic manufacturing companies in Kisumu County who were surveyed using census technique. Instrument reliability was verified using Cronbach's alpha coefficient at $\alpha = 0.7$. Data analysis employed multiple regression, and results presented in tables and charts. The results collectively demonstrated that reverse logistics practices positively influence supply chain optimization in plastic manufacturing firms in Kisumu County. In particular, waste collection through source separation and automatic sorting technologies, recorded the highest explanatory power ($R^2 = 0.502$, $P<0.05$), meaning that these practices account for about 50.2% of the variance in supply chain optimization. Plastic firms in Kisumu should strengthen source separation with clear guidelines, adequate facilities, and staff training, while gradually adopting automated sorting technologies through partnerships and incentives to optimize supply chains and sustainability.

Keywords: *Plastic Waste Collection, Supply Chain Optimization, Plastic Products, Reverse Logistics, Plastic Manufacturing Firms*

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INTRODUCTION

The adoption of sustainable reverse logistics (RL) has expanded significantly in recent years due to environmental concerns, regulatory frameworks, and legal obligations. Organizations recognize that sustainability demands logistics practices that are socially and environmentally responsible. This requires investment in pollution prevention, environmental management systems, and sustainable supply chain practices (Delmas & Montiel, 2009). In manufacturing, supply chain optimization is no longer just about delivering products efficiently it encompasses reducing costs, improving lifecycle management, enhancing customer service, and addressing sustainability goals (Dekker et al., 2004). Reverse logistics has thus evolved into a central pillar of modern supply chains, helping firms' lower costs, minimize waste, and strengthen competitiveness while contributing to sustainable development.

Reverse logistics can be defined as the set of processes associated with the reuse, recycling, repair, remanufacturing, or disposal of products and materials (Govindan et al., 2015). Unlike forward logistics, which moves raw materials toward finished goods and customers, RL focuses on retrieving products from end-users for value recovery. Differences between forward and reverse logistics emerge in cost structures, transportation, inventory control, and quality issues (Agrawal et al., 2015). The process begins with product collection, followed by inspection, sorting, disassembly, and reuse or recycling. Items unsuitable for recovery are discarded. This three-step system collection, inspection, and recovery enables companies to realize significant economic and strategic benefits, particularly through enhanced efficiency and waste reduction (Chanintrakul et al., 2009; Vedpal & Jain, 2011).

Waste product collection is the foundation of effective waste management and circular economy systems, as it determines both the quality and volume of materials available for recycling and remanufacturing (Balwada, Samaiya & Mishra, 2021; Bernat, 2023). Within supply chain contexts, efficient collection enhances downstream processes by ensuring a steady flow of high-quality secondary raw materials (Salem et al., 2023). This is particularly critical for plastics, which are heterogeneous, complex, and highly prone to contamination (Owusu-Sekyere, Osumanu & Abdul-Kadri, 2013). Ineffective collection often leads to downgraded recycles, undermining the efficiency of recycling systems and limiting supply chain optimization (Fråne et al., 2014). By contrast, well-structured collection systems support sustainability, reduce inefficiencies, and strengthen the circular use of plastics, directly contributing to both economic and environmental goals (Groot et al., 2014; Choi, Lim & Yoo, 2023).

Two major approaches strengthen plastic waste collection: source separation and automated sorting. Source separation, where households, businesses, and industries segregate waste at its origin, reduces contamination, lowers processing costs, and increases material recovery rates (Eriksen & Astrup, 2019; Ruj, Pandey, Jash & Srivastava, 2015). Automated sorting technologies, incorporating sensors, robotics, and artificial intelligence, further enhance accuracy, throughput, and consistency in recycling streams (Lubongo & Alexandridis, 2022; Lubongo, Bin Daej & Alexandridis, 2024). These innovations not only minimize human error but also increase transparency and traceability across the plastic supply chain (Ahmad, 2004; Kokoulin, Uzhakov & Tur, 2020). Together, source separation and automation establish the foundation for optimized reverse logistics systems, enabling more efficient recycling, remanufacturing, and sustainable supply chain performance (Serranti & Bonifazi, 2019).

The plastics industry highlights the urgency of reverse logistics. With plastic waste emerging as a critical global challenge, international frameworks such as the Basel Convention have tightened rules on plastic trade and waste management. The Ellen MacArthur Foundation warns that without decisive change, plastics in the ocean may outweigh fish by 2050 (MacArthur et al., 2016). As a result, corporations and governments are striving to build closed-loop systems where post-consumer plastics are collected, recycled, and reintegrated into production cycles, reducing reliance on virgin materials and minimizing environmental impacts. The European Union has led global efforts toward circular economy practices, mandating higher recycling rates and stricter controls on single-use plastics. The European Union (EU) Waste Framework Directive and single-use plastics directive aim to create sustainable markets for secondary raw materials. Similarly, the African Union's Agenda 2063 emphasizes sustainable waste management, while the Africa Circular Economy Alliance fosters collaboration to advance RL practices continent-wide. These initiatives reflect a shift toward systemic sustainability, where waste is viewed as a resource and RL underpins green growth.

Kenya has taken proactive steps in plastic waste management, notably banning single-use plastic bags in 2017. More recently, the country introduced an Extended Producer Responsibility (EPR) framework, holding manufacturers and importers accountable for the lifecycle of their products. The scheme incentivizes eco-friendly design, facilitates collection systems, and enhances recycling infrastructure. Stakeholders such as Petco Kenya support circular economy initiatives by linking informal waste collectors with formal recycling systems, thereby creating inclusive RL frameworks. Programs like the Plastic Packaging Material Recovery initiative integrate marginalized groups, improving efficiency and equity in waste recovery (Chopra & Meindl, 2016)

In Kisumu County, solid waste management remains a significant challenge. Approximately 75% of generated waste goes uncollected, resulting in widespread dumping, open incineration, and pollution of Lake Victoria. Weak infrastructure, inadequate disposal sites, and operational inefficiencies exacerbate the problem. Waste segregation is rare, exposing scavengers and communities to hazardous conditions. Collection services cover only 25% of the population, mostly in wealthier neighbourhoods, leaving peri-urban and rural communities to burn or bury waste themselves. These inefficiencies underline the urgent need for structured reverse logistics and integrated waste management systems (Obongo, Okotto & Kinaro, 2021).

Supply chain optimization (SCO) plays a critical role in enabling effective RL. Optimization seeks to maximize efficiency, minimize costs, and enhance responsiveness in product delivery (Christopher, 2016). Integrating RL within SCO strategies improves customer service, enhances asset recovery, and reduces environmental impact (Reverse Logistics Association, 2021). Chopra and Meindl (2016) describe SCO as the systematic improvement of procurement, production, and distribution processes to align with market demand. Effective SCO lowers costs, enhances agility, reduces lead times, and improves quality consistency directly influencing customer satisfaction. Techniques such as just-in-time manufacturing and advanced forecasting tools are widely used to improve coordination and reduce inefficiencies.

The financial implications of SCO are substantial. Streamlined operations reduce the cost of goods sold and logistics expenses, benefiting both firms and consumers (Simchi-Levi et al., 2014). SCO also boosts flexibility, enabling companies to adapt quickly to disruptions and market shifts. Quality improvements emerge from better supplier alignment and optimized processes, further strengthening competitiveness. Modern SCO approaches extend beyond cost reduction to include service quality, responsiveness, and sustainability metrics (Mentzer et al., 2001; Carter & Rogers, 2008). Incorporating environmental indicators, such as carbon footprint and waste reduction, ensures that optimization aligns with corporate sustainability objectives.

Plastic waste collection is a vital reverse logistics practice that underpins sustainable supply chains. Effective collection ensures high-quality secondary raw materials for recycling and remanufacturing, reducing contamination and inefficiencies (Balwada et al., 2021; Choi, Lim & Yoo, 2023). As plastics are highly heterogeneous, systematic collection and source separation are essential for circular economy performance (Owusu-Sekyere et al., 2013; Eriksen & Astrup, 2019). Automated sorting technologies further enhance accuracy, throughput, and transparency across recycling streams (Lubongo & Alexandridis, 2022; Kokoulin et al., 2020). Therefore, reverse logistics has transitioned from a narrow operational activity into a strategic imperative. Integrated with supply chain optimization, plastic waste collection enables firms to recover value, reduce waste, and achieve sustainability goals despite infrastructural challenges, particularly in contexts like Kisumu County.

Statement of the Problem

The plastic industry in Kenya is currently facing a pivotal moment, contending with numerous challenges that hinder its sustainability and operational effectiveness. A significant issue is the widespread absence of a structured approach to managing plastic products at the end of their life cycle, worsening environmental issues and wasting valuable economic prospects. In this light, the implementation of reverse logistics is identified as a crucial strategic requirement. Reverse logistics, which involves the movement of goods from their final destination for value recovery or appropriate disposal, presents an effective solution to various challenges faced by the sector. Economically, the Kenyan plastic industry is missing out on the potential recovery of substantial value from plastic wastes and other by-products. The current underutilization of secondary materials diminishes the economic vitality of the sector by overlooking opportunities for cost savings, revenue generation, and the promotion of a circular economy. Nevertheless, the sector report indicates that by adopting reverse logistics, the industry can tap into the hidden value within its waste stream, thereby creating a more resilient and self-sustaining supply chain. Recent research has primarily concentrated on the impact of reverse logistics on the operational and supply chain performance of firms. The studies reviewed have sought to assess the effect of plastic waste collection on the supply chain optimization of plastic products in Kisumu County, addressing a gap that this study aims to fill. The study tested the following null hypothesis.

H_0: There is no effect of plastic waste collection on supply chain optimization of the steel industry in Kisumu County.

LITERATURE REVIEW

Theoretical Review

The Triple Bottom Line (TBL) theory integrates economic, environmental, and social dimensions, offering a structured lens to evaluate sustainable business practices such as plastic waste collection in Kisumu County, Kenya. Economically, the application of TBL in reverse logistics reduces supply chain costs by reclaiming plastics for recycling and remanufacturing, decreasing raw material demand, and creating new revenue opportunities (Slaper & Hall, 2011; Srivastava, 2007). Refurbishing collected plastics into sellable products not only minimizes waste but also strengthens profitability, enhancing the competitiveness of manufacturing firms operating within circular economy models.

From an environmental perspective, the TBL framework highlights the importance of reducing ecological impacts throughout the product lifecycle. Effective collection of plastic waste in Kisumu supports this goal by cutting energy use and emissions associated with transportation and processing (Owusu-Sekyere, Osumanu & Abdul-Kadri, 2013; Groot, Bing, Bos-Brouwers & Bloemhof-Ruwaard, 2014). Additionally, structured collection and recycling mitigate contamination risks that threaten ecosystems such as Lake Victoria, where poor disposal practices contribute to pollution. Optimized collection processes also facilitate cleaner recycling streams, reinforcing the environmental sustainability of supply chains (Fråne et al., 2014; Eriksen & Astrup, 2019).

Socially, TBL underscores the welfare of stakeholders including workers, communities, and consumers. In Kisumu, equitable labor practices and safe working environments for waste collectors are essential for fostering responsibility and trust (Balwada, Samaiya & Mishra, 2021; Bernat, 2023). Community engagement initiatives, such as plastic donation and reuse programs, not only support underserved groups but also strengthen the company's social license to operate, building goodwill and consumer loyalty (Ruj, Pandey, Jash & Srivastava, 2015; Lubongo & Alexandridis, 2022). Together, these dimensions show how plastic waste collection enhances supply chain optimization while promoting sustainable development in Kisumu County.

Conceptual Framework

The conceptual framework (Figure 1) for this study shows the relationship between plastic waste collection and the supply chain optimization of plastic products.

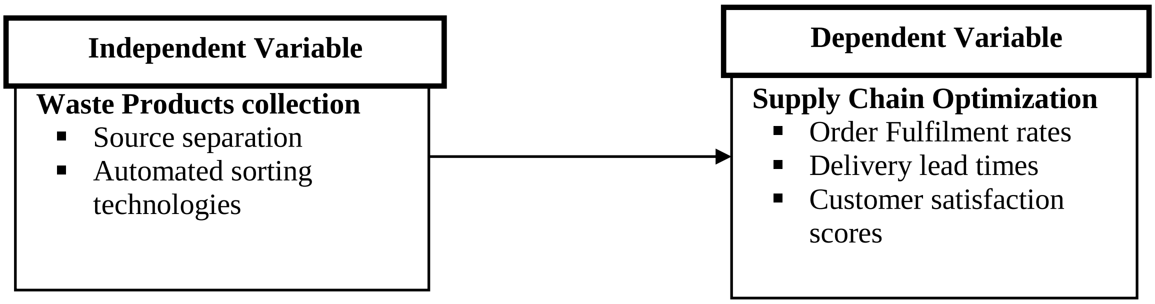

Figure 1: Conceptual Framework

Empirical Studies

The optimization of waste collection has become a central focus in both municipal and industrial supply chains due to its direct implications for sustainability, cost efficiency, and environmental management. Abbasi et al. (2022) explored this relationship in Tehran by modelling a waste-to-energy supply chain that integrated incineration, biogas production, centralized collection, and material separation. Using advanced optimization techniques such as Genetic Algorithms, their study highlighted how environmentally harmful emissions, particularly acid compounds, outweighed carbon dioxide in environmental impact. Interestingly, operational costs had little effect on financial goals, suggesting that supply chain optimization in waste-to-energy systems is primarily driven by environmental, rather than economic, factors.

Similarly, Kinobe et al. (2015) examined solid waste management in Kampala, Uganda, using Geographic Information Systems (GIS) to enhance waste collection efficiency. Their work identified optimal routes, vehicle types, and landfill locations to minimize travel distances and operational costs. For Kampala's municipal authority, GIS-based optimization proved critical in extending landfill lifespan and reducing expenditures. This approach demonstrated that waste collection optimization is not only a logistical improvement but also a vital tool for cost containment and minimizing social and ecological impacts.

Hannan et al. (2020) provided a broader analytical perspective by categorizing optimization objectives, constraints, and methodologies related to solid waste collection. Their review underscored the difficulties of aligning waste management systems with sustainable development goals (SDGs). They argued that while various optimization models exist, deficiencies remain in translating them into real-world supply chain improvements. This highlights the need for more integrative models that account for economic, environmental, and social dimensions simultaneously, bridging waste collection processes with holistic supply chain optimization.

The integration of circular economy principles into waste management also illustrates the potential for supply chain transformation. Karayılan et al. (2021) investigated the plastic packaging value chain, proposing models for industrial symbiosis, improved recycling efficiency, and bio-based plastics development. Their findings demonstrated that innovative recycling and upcycling methods significantly enhance circularity while lowering environmental impacts. This aligns waste collection with broader supply chain goals by embedding sustainability directly into product lifecycles. Similarly, Santander et al. (2020) studied distributed recycling networks for 3D printing plastics in France. By applying a mixed-integer linear programming model, they revealed that closed-loop supply chains not only reduce waste but also generate economic and environmental value. This localized recycling initiative highlighted the role of waste collection in enabling scalable, distributed, and circular supply chain models.

Valenzuela et al. (2021) contributed by reviewing reverse logistics models for plastic waste collection. Their analysis revealed a dominance of mathematical modelling, particularly mixed-integer linear programming, in addressing collection challenges. However, the study also exposed limitations, including the underutilization of stochastic models and an overemphasis on continuous variables. Despite extensive research, most studies focused narrowly on raw material recovery without explicitly linking collection to broader supply chain optimization outcomes.

Overall, the literature reveals a persistent knowledge gap in explicitly connecting waste collection to supply chain optimization in manufacturing. While Abbasi et al. (2022) and Kinobe et al. (2015) explored operational efficiencies, and Karayılan et al. (2021) and Santander et al. (2020) emphasized circular economy practices, few studies have comprehensively addressed how these initiatives directly enhance supply chain performance. Hannan et al. (2020) and Valenzuela et al. (2021) further highlighted methodological shortcomings in current models. Bridging this gap requires integrative research that positions waste collection as not only an environmental or logistical concern but also a strategic enabler of supply chain optimization in manufacturing organizations.

METHODOLOGY

This study adopted the positivist research philosophy, which emphasizes observation, empiricism, and objective truth in knowledge generation. Positivism is well-suited for research on reverse logistics and supply chain optimization, as it relies on quantifiable data to develop strategies for improving operational efficiency. A correlational survey design was employed to explore the relationship between reverse logistics and supply chain optimization without altering variables (Setyawati et al., 2020). The study was conducted in Kisumu County, targeting Jumbo Steel Mills and Tuff Foam Mattresses, both of which run plastic waste collection initiatives that engage local communities. The population included 120 employees in the production departments, as they are directly involved in processes such as automated sorting, separation, and recycling. Waste collectors were excluded due to their limited exposure to advanced recycling processes (Ingram & Schneider, 1991). A census technique was applied, allowing all employees to be included, ensuring accuracy and completeness of data (Rao, 2005; Baffour & King, 2017). The study ensured methodological rigor through reliability and validity tests. Cronbach’s Alpha showed all constructs exceeded the 0.7 threshold, confirming internal consistency (Cronbach, 1951; Ercan et al., 2007). The reliability test using Cronbach’s alpha showed acceptable internal consistency across constructs, with source separation (.713), automated sorting technologies (.811), order fulfillment rates (.759), delivery lead times (.785), and customer satisfaction scores (.792), confirming measurement scales were reliable. Construct and content validity were established using expert judgment and theoretical grounding (Cronbach & Meehl, 1955; Messick, 1995). Regression diagnostic tests confirmed compliance with assumptions, including linearity, low multicollinearity, and absence of autocorrelation (Durbin & Watson, 1992). Data analysis combined descriptive statistics and multiple regression models to assess how practices such as source separation, recycling, refurbishment, and reprocessing influence supply chain optimization. Data was analyzed using SPSS version 27.

RESULTS

The objective of this study was to examine the effect of plastic waste collection on the supply chain optimization of plastic products in Kisumu County. Waste product collection was analyzed through two main elements: source separation and automated sorting. For each of these sub-variables, Likert-scale questions were used to determine the extent to which plastic manufacturing companies in Kisumu County had adopted waste collection practices as a means of securing locally available raw materials. Prior to conducting multiple linear regression analysis on these variables and establishing their influence on supply chain optimization, construct scores were computed by taking the average score of all items within each sub-variable. These construct scores were then used to build the regression model. After verifying the assumptions of multiple regression and confirming the reliability of the reverse logistics measures, the study proceeded to assess the effect of reverse logistics elements on supply chain optimization in Kisumu County, Kenya. The results of this analysis are presented in the tables below.

Table 1: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.709[a]	.502	.493	.46083	2.336

a. Predictors: (Constant), Automatic Sorting Technologies, Source Separation
b. Dependent Variable: Supply Chain Optimization

The model summary (Table 1) reveals a substantial explanatory power, with an R Square value of 0.502, meaning that approximately 50.2% of the variance in supply chain optimization is explained by source separation and automatic sorting technologies. The adjusted R Square (0.493) further confirms the model's stability with the shrinkage being 0.009(0.502-0.493), and the Durbin-Watson statistic (2.336) indicates no autocorrelation concerns. The findings therefore imply that effective waste collection practices, particularly those leveraging technology, are crucial components of reverse logistics strategies in plastic manufacturing. By investing in these mechanisms, firms in Kisumu County can significantly enhance supply chain efficiency, by improving order fulfilment rates, delivery lead times and even improving customer scores.

Table 2: Regression Ceofficients

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.648	.158		10.452	.000
	Source Separation	.217	.035	.433	6.290	.000
	Automatic Sorting Technologies	.257	.031	.565	8.210	.000

Source: Survey Data, (2025)

The regression results (Table 2) above indicate that waste products collection, operationalized through source separation and automatic sorting technologies, has a significant positive effect on supply chain optimization among plastic manufacturing firms in Kisumu County. The unstandardized beta coefficients show that both source separation ($\beta = 0.217$, $p < 0.05$) and automatic sorting technologies ($\beta = 0.257$, $p < 0.05$) contribute positively to supply chain optimization. The unstandardized beta coefficients indicate the direct numerical impact of each predictor on supply chain optimization. Specifically, the coefficient for source separation ($\beta = 0.217$, $P<0.05$) suggests that a one-unit improvement in source separation practices results in a 0.217-unit increase in supply chain optimization, holding other factors constant. Similarly, the coefficient for automatic sorting technologies ($\beta = 0.257$, $P<0.05$) implies that for every one-unit increase in the adoption of such technologies, supply chain optimization improves by 0.257 units. These findings suggest that when firms adopt systematic practices for separating waste at the source and invest in automated sorting mechanisms, they enhance efficiency in material recovery, reduce operational bottlenecks, and streamline the reverse logistics process. The strong *t*-values (6.290 and 8.210, respectively) reinforce the strength of these predictors, demonstrating their reliability as drivers of improved supply chain optimization.

The standardized coefficients further emphasize the relative importance of the two predictors, with automatic sorting technologies ($\beta = 0.565$, $P<0.05$) having a stronger effect than source separation ($\beta = 0.433$, $P<0.05$) on supply chain optimization. Source separation has a standardized coefficient of $\beta = 0.433$, meaning that a one standard deviation increase in source separation leads to a 0.433 standard deviation increase in supply chain optimization. On the other hand, automatic sorting technologies have a standardized coefficient of $\beta = 0.565$, indicating a stronger influence. This means that, comparatively, investment in and adoption of automated sorting systems contribute more substantially to enhancing supply chain efficiency than improvements in source separation practices alone.

Discussions

The findings from this study provide a unique contribution to the body of literature on reverse logistics and waste management, especially within the context of plastic manufacturing firms. Unlike Abbasi *et al*. (2022), whose study concentrated on waste-to-energy optimization through incineration and biogas plants at the municipal level, the current results emphasize the micro-level effects of source separation and automatic sorting technologies on supply chain optimization. While Abbasi *et al*. (2022) highlighted that operational costs of energy generation plants had limited influence on financial objectives, the present findings demonstrate that technological efficiency in sorting waste exerts a direct and significant effect on optimizing supply chains. This distinction suggests that, beyond large-scale infrastructural systems, firm-level interventions such as automation and waste segregation are equally critical in strengthening supply chain resilience and performance.

In comparison with Kinobe *et al.* (2015), who employed GIS models to improve collection efficiency and reduce costs in Kampala's municipal waste system, the present study also highlights the importance of logistical efficiency in waste management. However, while Kinobe *et al*. (2015) primarily emphasized route optimization and vehicle allocation to reduce travel distances, the current study results highlight operational technologies within firms as drivers of supply chain optimization. This contrast brings out the fact that rather than focusing solely on collection networks and transportation logistics at a city level, firm-level adoption of automated sorting technologies and systematic source separation can yield significant improvements in supply chain efficiency.

The results of this study also extend the insights of Hannan *et al.* (2020), who identified gaps in solid waste collection systems and emphasized the role of optimization techniques in achieving sustainability goals. While Hannan *et al*. provided a broad review of methodologies and challenges, the current findings empirically validate the specific effectiveness of technological interventions such as automatic sorting, which showed a stronger standardized effect than source separation. This quantitative evidence strengthens arguments for prioritizing technological integration within reverse logistics models. Similarly, while Karayılan *et al.* (2021) and Santander *et al.* (2020) focused on circular economy principles and closed-loop systems at industrial or community levels, the findings of this study reveal how practical, firm-level interventions translate into measurable improvements in supply chain optimization. This is particularly significant because it demonstrates that local firms in developing economies can leverage relatively accessible tools such as waste segregation practices and automation to align with broader global sustainability trends.

Moreover, compared to Valenzuela *et al.* (2021), whose literature review on reverse logistics models revealed a predominance of mathematical and programming-based approaches, the current study introduces empirical, field-based evidence showing how specific variables function in practice. While the literature often emphasizes modelling frameworks and hypothetical scenarios, this study bridges the gap by demonstrating how source separation and sorting technologies explain over 50% of the variance in supply chain optimization. This provides actionable insights that extend beyond theoretical modelling to real-world application, especially within the African manufacturing context. The uniqueness of the present findings lies in showing that in regions like Kisumu County, where large-scale infrastructure such as incineration plants may be limited, firm-level strategies grounded in waste segregation and automation can serve as effective levers for supply chain optimization and sustainable competitiveness.

CONCLUSION AND RECOMMENDATIONS

The study concludes that plastic waste collection practices, specifically source separation and automated sorting technologies, play a crucial role in strengthening supply chain optimization in plastic manufacturing firms within Kisumu County. The findings show that when companies adopt systematic waste segregation and invest in automation, they achieve greater efficiency in material recovery, reduce operational delays, and streamline reverse logistics processes. Automated sorting emerged as particularly impactful, offering firms enhanced precision, consistency, and transparency in recycling operations. These practices not only improve order fulfilment and customer satisfaction but also align with circular economy principles by reducing waste and conserving resources. Overall, the study demonstrates that localized firm-level interventions are vital for building sustainable, competitive, and resilient supply chains in developing economies.

The study recommends that plastic manufacturing firms in Kisumu County strengthen source separation practices by establishing clear guidelines, providing adequate facilities, and investing in consistent employee training. This will embed separation into company culture, reduce waste management costs, and improve recycling efficiency. Additionally, greater adoption of automated sorting technologies is necessary. While recognized as more accurate than manual methods, their use remains limited due to cost and uneven investment. Firms should pursue phased adoption of automation, supported by incentives and partnerships, to enhance accuracy, reduce operational bottlenecks, and improve recovery rates. Collectively, these measures will not only optimize supply chains but also align firms with circular economy goals, strengthening sustainability and competitiveness in the plastics sector.

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