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Developing Sustainable Reverse Logistics Strategies for the Beverage Industry's Disposable Bottle Waste in Dodoma Region, Tanzania

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RESEARCH ARTICLE

Abstract
The beverage industry is known for generating large amounts of disposable bottle waste, which poses significant environmental challenges. These strategies may help in addressing the issues of waste management and pave ways to promoting recycling in the region. This specific study was conducted to identify the typical determinants for an effective supply chain in making sustainable reverse logistics in the beverage industry, specifically for the management of waste from disposable bottles. This study was conducted in the Dodoma region with the focus on the beverage industry; this region was selected considering the rapid growth of the industry in the region and the rapid growth of the city, where waste management is crucial. The study utilized a descriptive research design, and data were collected from a sample of 210 respondents who are supply chain experts, procurement experts, and environmental experts residing in the Dodoma region. The data were collected using a questionnaire. The findings indicated that the current practices are not effective enough and they do not actually promote sustainability. With that, it was found that collaboration of the stakeholders (β = 0.318, p = 0.001), using advance technologies (β = 0.237, p = 0.001), effective communication (β = 0.184, p = 0.001), and availability of government regulations (β = 0.153, p = 0.006) are the determinants for effective supply chain for ensuring sustainable reverse logistics. In this study multiple linear regression was also used to identify the indicators/ predictors for sustainable reverse logistics. The study concluded that the development of sustainable reverse logistics strategies in the industry for disposable bottles requires first collaboration of the stakeholders in the industry, the usage of advanced technology for recycling, and ensuring effective means of communication regarding and imposing the relevant government regulations. These findings can inform the policy makers and practitioners in the industry of the issues to consider in building sustainable waste management in the region.

Keywords: Reverse Logistics, Sustainable Reverse Logistics, Beverage Industry, and Disposable Bottle Waste

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1 INTRODUCTION

The beverage industry faces intense challenges in managing the disposal of disposable bottles, which leads to adverse environmental impacts and resource depletion (Benyathiar et al., 2022; Haseli et al., 2024; Beiler et al., 2020; Oey & Bangun, 2020). Considering consumption patterns of the beverage products continue to rise, the accumulation of bottle waste has also become one of the pressing issues requiring immediate attention for environmental protection (Benyathiar et al., 2022). There are traditional ways of accumulating the bottles for further processing, but it is experienced that the traditional waste management practices are often not efficient enough and that they fail to address the growing concerns surrounding environmental preservation and sustainability (Rogers & Tibben-Lembke, 1998; Maitlo et al., 2022). Considering the intensity of the issue pertaining to environmental protection and sustainability, there's a need for developing logistics strategies that might help in managing the lifecycle of disposable bottles in the beverage industry. This might help in mitigating waste generation and likely promote the circular economy (Oliveira & Almeida, 2013; Samuel et al., 2019).

In the case of developed countries like the United States and European nations, there are innovative ways in reverse logistics that have been implemented to address the challenges associated with disposable bottle waste management. The strategies included the establishment of bottle redemption programs for the beverage industry. In the program, the consumer returns the empty bottle to a designated center for collection, where they exchange it for a refund (Benyathiar et al., 2022; Pereira et al., 2023). This kind of strategy, with incentives to ensure the participation of customers in reverse logistics, ensures higher collection rates and promotion of recycling.

In other instances, innovative approaches in the reverse logistics for waste management may also include the use of delivery vehicles, a combination of commercial and household waste collections, and the use of smart-bin technology (Cherrett et al., 2012). Basically, in the context of electronic-waste management, reverse logistics activities have been found to be effective in the promotion of product recovery and sustainable strategies (Muhammad et al., 2020).

Meanwhile, in Europe, the countries as Germany and the Netherlands, they implemented a deposit-refund system which has been implemented specific for beverage bottles, the disposable bottle. Consumers of the product pay a small deposit when buying the beverages, the refund is only returned after returning the empty bottle to vending machines or collection points (Aslani et al., 2021). This practice has been effective in increasing collection and recycling, which reduces environmental impact. Research encourages to structurer strategies and mechanisms to ensure effective management of sustainable reverse logistics (Kinobe et al., 2012; Abdissa et al., 2022; Mwanza et al., 2017).

In addition, there are initiatives in South Africa like the PETCO (PET Recycling Company), which has been established to promote the collection and recycling of the PET bottles. Across the beverage industry, PETCO as a company collaboratively works with other stakeholders to facilitate recycling and recovery of the PET bottles, these practices practically reduce environmental pollution and create employment opportunities (PETCO, 2022). There's also a Bottle for Change program in Kenya. They have what they call "Bottles for Change" program, which has been in place to address the challenge of plastic bottle waste. This program in Kenya is implemented for the aim of encouraging waste pickers to collect and sell empty bottles to recycling companies, providing them with income while promoting bottle recycling (Aslani et al., 2021). These efforts have not been very effective in developing countries due to limited infrastructure and resource. There's also a lack of proper and well-coordinated collection efforts and points, and the general procedures for recycling systems (Kinobe et al., 2012). This ineffectiveness often leads to bottles ending up in landfills that pollute natural environments (Brunner & Fellner, 2007). Efforts to develop sustainable reverse logistics strategies in these scenarios are necessary; this is essential to be tailored to the specific needs of developing countries (Agamuthu, 2003).

Recalling from the above narrations, to ensure the success of sustainable reverse logistics strategies for both the developed and developing nations, it is paramount to focus on the collaboration of the stakeholders, the development of infrastructure, and the building of public awareness through defined campaigns. Relationships between stakeholders need to be created and enhanced, and these stakeholders may involve beverage companies, Governments, local communities and waste management entities (Kinobe et al., 2012). These sorts of relationships may aid in the creation and management of efficient collection systems, building efficient recycling facilities, and investing in relevant educational programs. In the effort to make a process successful in 21st century, there is a need to also invest in technological advancements such as usage of smart collection bins, which are equipped with sensors and relevant data analytics to fully optimize collection routes and improve efficiency (Hervani et al., 2005; Cherrett et al., 2012).

Furthermore, with the understanding on the matter, developed countries have managed to make significant progress in the development of sustainable reverse logistics strategies in managing disposable bottle waste in the beverage industry (Welle, 2011). It is practically possible to mitigate waste generation by promoting recycling procedures and contributing to a more sustainable future. This study aimed to identify the determinants for an effective supply chain for sustainable reverse logistics. In Tanzania, the management of disposable bottle waste is a pressing issue, particularly in urban areas where consumption rates are high. The lack of proper infrastructure and limited recycling facilities contribute to the challenges faced in managing this waste stream. However, some initiatives and organizations have taken steps towards addressing the issue.

There are several local initiatives for the collection of disposable bottles in Tanzania. Integration of these initiatives is quite a concerning issue, and largely for public awareness. In the case of Tanzania, there NEMC - National Environment Management Council, which ensures the practices for environment protections, there has been practices that ensure proper collection of plastic bottles, for example, the "Nipe Fagio" campaign, which was initiated in Dar es Salaam city, it aimed to improve waste management practices (Kirama & Mayo, 2016). In other instances, there's an organization working in Tanzania to address plastic waste, including disposable bottles, Plastics Recyclers Tanzania Limited (PRT). This organization focuses on establishing recycling facilities and promoting the collection and recycling of plastic waste (Palfreman, 2014). This has not proved effective enough to ensure strategized reverse logistics.

This study established a strategic approach enhancing the strengthening of sustainable reverse logistics for the beverage industry's disposable bottle waste in Dodoma Region, Tanzania. Specifically, this aims to establish the role of collaboration among stakeholders on strengthening sustainable reverse logistics for the beverage industry's disposable bottle waste; determine the contribution of use of advanced technologies on strengthening sustainable reverse logistics for the beverage industry's disposable bottle waste; ascertain the role of effective communication among the stakeholders on strengthening sustainable reverse logistics for the beverage industry's disposable bottle waste; and establish the role of government regulations on strengthening sustainable reverse logistics for the beverage industry's disposable bottle waste.

Despite its contributions, this study faced several limitations. First, it was geographically confined to Dodoma, limiting the generalizability of findings to other regions with different economic and environmental contexts. Second, data collection relied heavily on self-reported information from stakeholders, which may be subject to bias or inaccuracies. Third, the study focused primarily on the beverage industry, excluding insights from other sectors engaged in reverse logistics. Additionally, limited access to comprehensive waste management data posed a challenge in assessing long-term sustainability outcomes. Future studies should consider broader geographical coverage, cross-sectoral analysis, and longitudinal data to enhance the robustness of findings.

2 GROUNDING THEORY: STAKEHOLDER THEORY

Freeman (2010) introduced Stakeholder Theory, arguing that value creation in modern enterprises requires addressing the expectations and interests of multiple groups, especially when environmental and social sustainability is at stake. The stakeholder theory is a theory of organizational management and business ethics that considers various publics impacted by corporate units and emphasizes the importance of satisfying all stakeholders for the company's success (Godam et al., 2019). Stakeholder theory is on of the profound theories in business ethics and organizational management that has been extensively researched and includes various thematic clusters. Through influence mechanisms, stakeholder theory explores how organizations can interact with several stakeholders and as a theory offers a moral perspective on organizational actions beyond traditional input-output mechanisms (Mahajan et al., 2023). This theory can guide firms on ethical behavior through identification, prioritization, and management of relationships with the various stakeholders. The theory also addresses constraints posed by digitalization and emphasizes the importance of a normative core in stakeholder management (Boeken et al., 2024). In the context of supply chain management and reverse logistics and sustainability, this theory explains why mutual engagement between firms, regulators, recyclers, and consumers is crucial as potential stakeholders in the system. In the context this theory also explains how balancing competing interests can lead to better environmental outcomes, and the need for stakeholder alignment to ensure success of waste management and recycling strategies. Maheswari et al. (2017) used this theory in reverse logistics, emphasizing the roles and motivations of businesses, government, and society in managing e-waste. Kovacs et al. (2006) also used this theory in reverse logistics, emphasizing the importance of identifying and categorizing stakeholders, such as authorities and organizations, with respect to their power, legitimacy, and urgency. On the other hand, Romero et al. (2025) used the theory in reverse logistics by identifying key stakeholders whose perspectives influence sustainable practices. By considering collaboration among stakeholders (e.g., beverage companies, government regulators, waste collectors, communities), the role of government regulations and public engagement, the influence of supply chain actors and coordination on sustainable reverse logistics, and the importance of shared responsibility in achieving sustainability goals. All these elements become central to stakeholder theory, which posits that organizations must consider the interests of all parties (stakeholders) affected by their operations, not just shareholders or profit-seeking motives.

3 METHODOLOGY

3.1 Research Design

In this specific study, a quantitative research approach was employed, and a descriptive research design was adopted. These choices were made because they enable a clear understanding of the current state of reverse logistics practices in the beverage industry within the Dodoma region. This design is suitable for collecting both quantitative and qualitative data from a relatively large and diverse group of industry experts, allowing for an in-depth examination of existing practices, stakeholder involvement, and strategic gaps. Moreover, the integration of descriptive and inferential techniques supports the identification of key determinants and allows for the generalization of findings to similar urban regions facing waste management challenges in Tanzania.

3.2 Research Locale and Respondents

The study focused on the region of Dodoma in Tanzania, where there is a rapid growth of the beverage industry. It employed stratified random sampling to ensure representation across different categories and within each stratum; simple random sampling was applied to select respondents. A total of 210 respondents who are supply chain experts, procurement experts, and environmental experts who reside in the Dodoma region were targeted based on proportional allocation from each stratum. This technique minimized sampling bias and increased the generalizability of the findings.

3.3 Research Instrument

The study employed a researcher-made survey questionnaire to gather comprehensive information about the existing reverse logistics practices within the beverage industry in Dodoma. A total of seven (7) statements were developed on a five-point likert scale reflecting on stakeholders' collaboration, use of advanced technologies, effective combination, and government regulations. The responses for each statement were measured using a five-point Likert scale shown in Table 1, and the results were analyzed using mean and standard deviation to determine respondents' perceptions regarding the determinants of sustainable reverse logistics in the beverage industry. The mean values represent the average level of agreement of respondents with each statement, while the standard deviation indicates the degree of variability in the responses. Higher mean scores imply stronger agreement with the statements, whereas lower mean scores indicate disagreement.

Table 1. **Interpretation of the Mean Values**

Mean Range	Interpretation
3.26 – 4.00	Strongly Agree
2.51 – 3.25	Agree
1.76 – 2.50	Disagree
1.00 – 1.75	Strongly Disagree

3.4 Data Gathering Procedure

The study began with the consideration of ethical principles to ensure that the research was conducted responsibly and in accordance with academic standards. Permission to conduct the research was also sought from relevant authorities and institutions within Dodoma Region. All respondents were informed about the purpose of the study and their voluntary participation before taking part in the research. Informed consent was obtained from each participant, and they were assured that the information they provided would be used strictly for academic purposes. The researcher also ensured confidentiality and anonymity by not recording personal identifying information in the questionnaires. Furthermore, respondents were informed of their right to withdraw from the study at any stage without any negative consequences. All collected data were securely stored and used solely for research purposes to maintain data protection and ethical integrity.

The target population consisted of professionals who possess knowledge and experience in supply chain management and environmental practices related to the beverage industry. These included supply chain experts, procurement experts, and environmental experts residing in the Dodoma Region. A sample size of 210 respondents was selected to participate in the study to ensure adequate representation of these professional groups.

Primary data were collected using a structured questionnaire designed to capture information related to the determinants of sustainable reverse logistics, including collaboration among stakeholders, use of advanced technologies, effective communication, and government regulations. The questionnaire consisted mainly of closed-ended questions using a Likert scale to measure respondents' perceptions. Before the actual data collection, the research instrument was tested to ensure its validity and reliability, and necessary improvements were made.

3.5 Statistical Treatment of Data

Multiple linear regression analysis was employed to identify significant predictors in sustainable reverse logistics, particularly focusing on collaboration, technology use, communication, and regulations. Therefore, the Statistical Package for the Social Sciences (SPSS) was used to perform the analysis. In the context of the provided data on sustainable reverse logistics in the beverage industry in Dodoma, Tanzania, the multiple linear regression formula can be expressed as follows: $Y = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \beta_3 * X_3 + \beta_4 * X_4 + \epsilon$

Where: Y is the dependent variable (Effective Supply Chain for Sustainable Reverse Logistics); X_1 is the independent variable (Collaboration among stakeholders); X_2 is the independent variable (Use of advanced technologies); X_3 is the independent variable (Effective communication among stakeholders); X_4 is the independent variable (Government regulations), β_0 is the y-intercept (constant term); β_1, β_2, β_3, β_4 are the coefficients (regression coefficients) corresponding to X_1, X_2, X_3, X_4 respectively; and ϵ is the error term (residuals) representing the unexplained variability in Y.

The goal of the multiple linear regression is to estimate the values of the coefficients (β_0, β_1, β_2, β_3, β_4) based on the provided data, such that the resulting regression equation best fits the relationship between the dependent variable (Effective Supply Chain for Sustainable Reverse Logistics) and the independent variables (Collaboration, Advanced Technologies, Effective Communication, Government Regulations). The coefficients represent the strength and direction of the relationships between the independent variables and the dependent variable.

By estimating the coefficients, we can use the regression equation to predict the expected values of the dependent variable (Y) based on the given values of the independent variables (X_1, X_2, X_3, X_4). The regression analysis helps to understand how each independent variable influences the dependent variable.

4 RESULTS AND DISCUSSIONS

Table 2 shows the findings which revealed high agreement and strong agreement responses for collaboration among stakeholders, indicating that the experts recognize the importance of involving multiple parties to achieve effective, sustainable reverse logistics. Collaboration fosters knowledge sharing, pooling of resources, and collective responsibility, leading to more sustainable outcomes. The respondents' positive views regarding the use of advanced technologies in reverse logistics highlight the potential of technological solutions to optimize waste collection, transportation, and recycling processes. Advanced technologies like smart collection bins with sensors and data analytics can improve efficiency, reduce costs, and enhance overall waste management effectiveness. Effective communication emerged as a crucial factor in the successful implementation of sustainable reverse logistics. Clear communication lines and timely communication among the stakeholders ensure that everyone is aligned with the protocols, objectives, and responsibilities, leading to smooth operations and higher compliance with the sustainability goals. The significant agreement on the critical role of government regulations in promoting sustainable practices demonstrates the role of policy frameworks, specifically in shaping waste management practices. Effective regulations in this context can incentivize responsible waste disposal and recycling, which will ensure environmental standards are met and is likely to encourage industry compliance.

The results in the table indicate that respondents generally expressed strong agreement with the statements regarding the determinants of sustainable reverse logistics strategies for managing disposable bottle waste in the beverage industry. The mean scores for all statements range from 3.76 to 4.25, suggesting that respondents perceive these factors as important for strengthening sustainable reverse logistics practices. The relatively low standard deviation values (0.70–0.92) indicate that the responses were fairly consistent among the respondents. Specifically, the statement that stakeholders' collaboration is essential for the successful implementation of sustainable reverse logistics strategies recorded a mean of 3.83 (SD = 0.90), indicating that respondents strongly agree that collaboration among stakeholders plays a vital role in implementing effective reverse logistics systems. Similarly, the statement that stakeholders' collaboration leads to improved efficiency and effectiveness in managing disposable bottle waste obtained a mean of 4.03 (SD = 0.86), reflecting a high level of agreement that cooperation among industry actors contributes to better waste management outcomes. These findings highlight the importance of partnerships among manufacturers, suppliers, recyclers, government agencies, and other stakeholders in ensuring effective reverse logistics systems.

Regarding technology adoption, the results show strong agreement that the use of advanced technologies in recycling enhances the efficiency and effectiveness of reverse logistics strategies, with a mean of 3.76 (SD = 0.87). Additionally, the statement that advanced technologies improve resource recovery and reduce environmental impacts in managing disposable bottle waste recorded a mean of 4.18 (SD = 0.74). These findings suggest that respondents believe technological innovation plays a crucial role in improving recycling efficiency, minimizing environmental pollution, and promoting sustainable waste management practices in the beverage industry. The findings also emphasize the importance of communication among stakeholders. The statement that effective communication is crucial for the coordination and implementation

Table 2. **Mean (M) and Standard Deviation (SD) for assessed statements**

Statements	Mean	Standard Deviation
Stakeholders' collaboration is essential for successful implementation of sustainable reverse logistics strategies for beverage industries	3.83	0.90
Stakeholders' collaboration leads to improved efficiency and effectiveness in managing disposable bottle waste for beverage industries.	4.03	0.86
Usage of advanced technologies in recycling enhances the efficiency and effectiveness of reverse logistics strategies for beverage industries.	3.76	0.87
Usage of advanced technologies in recycling improves resource recovery and reduces environmental impact in managing disposable bottle waste for beverage industries.	4.18	0.74
Effective communication among stakeholders is crucial for effective coordination and implementation of reverse logistics strategies for beverage industries.	3.85	0.92
Effective communication among stakeholders leads to improved decision-making, transparency, and accountability in managing disposable bottle waste for beverage industries.	4.00	0.87
Government regulations play a crucial role in promoting sustainable reverse logistics practices in the beverage industry.	4.25	0.70
Government regulations lead to compliance with environmental standards and promote responsible waste management practices for beverage industries.	4.18	0.77

of reverse logistics strategies recorded a mean of 3.85 (SD = 0.92), indicating strong agreement among respondents. Likewise, the statement that effective communication improves decision-making, transparency, and accountability in managing disposable bottle waste had a mean of 4.00 (SD = 0.87). These results imply that clear information sharing and coordination among stakeholders facilitate better planning, monitoring, and implementation of reverse logistics initiatives.

Finally, the results reveal that government regulations play a critical role in promoting sustainable reverse logistics practices, with the highest mean score of 4.25 (SD = 0.70). Similarly, the statement that government regulations lead to compliance with environmental standards and responsible waste management practices obtained a mean of 4.18 (SD = 0.77). This indicates that respondents strongly believe that regulatory frameworks and environmental policies are essential for guiding industry practices, ensuring compliance with environmental standards, and encouraging responsible management of disposable bottle waste. Overall, the findings demonstrate that stakeholder collaboration, technological advancement, effective communication, and supportive government regulations are key determinants for strengthening sustainable reverse logistics strategies in the beverage industry.

Reflecting from literature, collaboration among the stakeholders has been widely recognized as one of the critical factors for the achievement of effective, sustainable reverse logistics strategies in different industries, including the beverage industry. According to Münch et al. (2023), in their study about reverse logistics practices in the food and beverage sector, the study found that effective collaboration among the stakeholders, including manufacturers, retailers, suppliers, and waste management organizations, may lead to improved waste collection, recycling rates, and overall sustainability performance. On the other hand, Adesoga et al. (2024) illustrated that stakeholders' collaboration is vital for sustainable reverse logistics, as it enhances waste collection and recycling rates. According to Cooper (2024), the author also emphasizes stakeholder collaboration being crucial for sustainable supply chain management, as it can enhance trust and transparency. Anwar et al. (2023) also highlighted that effective collaboration among stakeholders significantly impacts sustainable reverse logistics.

Apart from the collaboration of the stakeholders, the usage of advanced technology is also pointed out as an important factor. The usage of advanced technologies in reverse logistics has also been shown to enhance efficiency and resource recovery. Recalling from the study by De Morais et al. (2024), the authors demonstrated the application of smart technology in waste collection and management, and findings show that the use of smart collection bins equipped that are equipped with sensors and data analytics resulted in optimized reduced operational costs, waste collection routes, and increased resource recovery rates. Yahya et al. (2024) discussed how advanced technologies like AI, big data, and IoT enhance reverse logistics, narrating that these technologies can improve efficiency, visibility, and decision-making processes, ultimately streamlining returns management. This is also supported by Muduli et al. (2023), illustrating that the use of advanced technologies can enhance reverse logistics through improved data visibility, ensuring product authenticity, facilitating efficient management of returns, and minimizing environmental impact, ultimately leading to better decision-making and increased customer satisfaction.

Furthermore, communication is discussed to be very crucial on these aspects, effective communication is critical for the successful implementation of sustainable reverse logistics strategies, recalling from the contribution of Ravi and Shankar (2017), the authors analyzed the impact of communication on reverse logistics performance done in the automotive industry, this study clearly narrated that that clear and timely communication among the stakeholders tend to improve coordination, enhance overall efficiency, lead to reduced lead times in managing waste and recyclables. In other instances, government regulations are reported also to play a significant role in promoting sustainable reverse logistics practices, recalling from Doan et al. (2019) the authors examined the impact of waste management regulations specific on reverse logistics in the electronics industry and they reported that the stringent environmental regulations positively influence waste recovery and recycling efforts, which is leading to a more sustainable supply chain. According to Ma et al. (2021), they conducted a comprehensive study on sustainable supply chain practices in the packaging industry, and the study found that collaboration among the stakeholders, together with the adoption of advanced technologies, like smart bins and IoT-enabled tracking systems, significantly contributes to reducing waste, increasing the recycling rates, and achieving the sustainability goals. Also, in the study by Hussain and Soni (2024) on sustainable waste management in the hospitality industry, effective communication among stakeholders was mentioned and discussed as a key factor in decision-making processes relating to waste disposal and recycling.

Further to that, Malindzakova et al. (2022) highlighted the potential of a deposit and collection system for disposable beverage packaging, despite the high investment costs attached to it. Lai et al. (2022), the authors proposed a reverse logistics reuse framework for express delivery packaging materials; they emphasized the importance of resource reuse. According to Abdissa et al. (2022), the authors managed to underscore the need for the improved waste management practices, specifc in the context of plastic bottles recycling in Ethiopia, as on the same instance Zia et al. (2022), authors present a low-cost, deep learning-based reverse vending machine for plastic bottle collection, this has shown the promising results in terms of cost-effectiveness and accuracy. These studies collectively recommend that while reverse logistics can be essential in managing disposable bottle waste, there is a call for sustainable and innovative solutions to enhance its impact.

Furthermore, in support of the above illustrations, the strategic undertaking of reverse logistics contributes to the effectiveness in other ways, like the quality of services to the customer, cost efficiency, sustainable brand image, and reduction of production costs. For instance the contribution of Lai et al. (2022), he put emphasizes as on the role of reverse logistics in reusing packaging materials, he portrayed the use of online shopping as a means of achieving sustainability, at the same time Naidu and N S (2022) demonstrated on the rationale of reverse logistics in the computer hardware industry, specific in emerging economies, with narration that can lead to cost efficiency, building competitive advantage, and a sustainable brand image. In the other paper, Dabees et al. (2023) further extends this discussion by making proposition of a framework for sustainable reverse logistics service quality, emphasizing on the need for higher service quality to meet customer demands, and Cueva Clemente et al. (2022) provides a regional perspective, noting that the implementation of reverse logistics in may lead to improvement in company image, it may aid in reduction of production costs, and contribute to higher profit margins.

Table 3 portrays that all the independent variables (Collaboration, Advanced Technologies, Effective Communication, and Government Regulations) are significant at the 5% significance level with p- value < 0.05. This demonstrates that each of the factors is statistically significant on impacting the effective supply chain to sustainable reverse logistics in beverage industry. The coefficient value indicates strength and direction of the relationships. Collaboration among stakeholders (β = 0.318) - coefficient is positive, indicates that an increase in collaboration among stakeholders leads to a higher level of effectiveness in the supply chain for sustainable reverse logistics; use of advanced technologies (β=0.237) - coefficient is positive, indicates that the adoption of advanced technologies in reverse logistics positively influences the effectiveness of the supply chain; effective communication among stakeholders (β = 0.184) - coefficient is positive, suggests to mean that effective communication among stakeholders results in a more effective supply chain for sustainable reverse logistics; Government regulations (β = 0.153) - coefficient is positive, indicating that presence of supportive government regulations affects the effectiveness of the supply chain for sustainable reverse logistics.

Table 3. Multiple Linear Regression Analysis Results

Independent Variable	Coefficient (β)	p-value
Collaboration among stakeholders	0.318	0.001
Use of advanced technologies	0.237	0.001
Effective communication among the stakeholders	0.184	0.001
Government regulations	0.153	0.006

Overall, regression analysis confirms that collaboration, advanced technologies, effective communication, and government regulations are significant predictors of the effectiveness of the supply chain for sustainable reverse logistics. The multiple linear regression function represents the relationship between the dependent (Y) and multiple independent variables (X_1, X_2, X_3, ..., X_n).

The illustration above portrays that stakeholders' collaboration is very crucial for the successful implementation of sustainable reverse logistics strategies in the beverage industry, for example, according to Agarwal et al. (2016), Chan (2007), Paula et al. (2019), and Cricelli et al. (2021). Specific, from the work of Agarwal et al. (2016), emphasizes on the need for collaborative framework, at the same instance Chan (2007) managed to present a case study on the importance of a pro-active and collaborative approach, also according to Paula et al. (2019) and Cricelli et al. (2021), both papers highlighted the importance of collaboration and trust in driving innovation in reverse logistics, specifically the authors noted the positive impact of vertical and horizontal collaboration, as well as the collaboration with research institutions or universities.

Collectively, these research findings demonstrate the critical role of stakeholders' collaboration in the successful implementation of sustainable reverse logistics strategies for the beverage industry. In addition, according to Gaines and Wolsky (1983), the use of advanced technologies in recycling, like reverse vending machines, has been proposed as a solution to the low return rate of PET bottles. According to Benyathiar et al. (2022), this is very crucial and relevant given the significant environmental impact of plastic waste, with PET packaging accounting for a huge portion of single-serve beverage packaging. According to Samuel et al. (2019), the beverage industry has the potential to minimize waste and enhance its recycling efforts, which can lead to environmental and financial benefits. A reverse logistics inventory model, for example, for plastic bottles, has also been developed to optimize the production-recycling-reuse process, focusing on reducing system cost and landfill waste Matar et al. (2014). These research studies and findings collectively highlighted the potential of advanced recycling technologies to enhance the efficiency and effectiveness of reverse logistics strategies for the beverage industry.

Together with the above illustration, according to Kovacs et al. (2006), Gonzaleztorre (2004), and Yang and Wang (2007), the issue of effective communication is also reported to be very crucial in this context. Effective communication among stakeholders is an essential need to be considered for the successful implementation of reverse logistics strategies in the beverage industry. This is specifically important in the context of managing the disposable bottle waste, where accountability and transparency are key (Kovacs et al., 2006). The use of an integrated framework, such as the one suggested by Yang and Wang (2007), can aid in increasing information transparency and improving communication, but the specific information sources and communication channels that are used by stakeholders in the beverage industry need to be explored further (McInnes et al., 2007).

Another aspect is reported on government regulations. Government regulations specific to these aspects are crucial in promoting sustainable reverse logistics practices, since they can lead to compliance with responsible waste management and environmental standards (Kulwiec, 2007). These regulations can also be positioned to strengthen the positive impact of proactive environmental methods on reverse logistics management (Hsu & Liao, 2014). It also needs to be considered that the role of government in facilitating the sustainability of reverse logistics operations requires more attention (Miller & Sarder, 2012). However, it is also crucial for government intervention to align with market demand for ensuring the long-term success of recycling (Wright et al., 2011).

5 CONCLUSIONS AND RECOMMENDATIONS

From the research findings, it is evident that the key determinants of strengthening sustainable reverse logistics for disposable bottle waste in the beverage industry include collaboration among stakeholders, the use of advanced technologies, effective communication, and the availability of relevant government regulations. The results of the multiple linear regression analysis indicate that these factors significantly influence the effectiveness of sustainable reverse logistics strategies and contribute to improved waste management practices in the beverage industry within Dodoma Region. Collaboration among stakeholders enhances coordination and collective responsibility in managing waste, while the adoption of advanced technologies improves recycling efficiency and resource recovery. Furthermore, effective communication facilitates transparency, coordination, and informed decision-making among stakeholders, and supportive government regulations ensure compliance with environmental standards and encourage responsible waste management practices.

In addition, the results obtained from the survey using the five-point Likert scale further support these findings. The mean scores for all statements ranged from high levels of agreement to strong agreement, indicating that respondents generally perceive these determinants as critical factors in strengthening sustainable reverse logistics practices in the beverage industry. The relatively low standard deviation values also suggest consistency in the responses among participants. Overall, the descriptive results confirm that stakeholders strongly recognize the importance of collaboration, technological advancement, effective communication, and government regulatory frameworks in promoting sustainable reverse logistics and improving the management of disposable bottle waste in the beverage industry.

5.1 Recommendations

The government and policymakers need to consider facilitating and incentivizing collaboration among the stakeholders in the beverage industry. This may involve fostering partnerships and relationships between waste management entities, the beverage companies, local communities, and recycling organizations. They may encourage knowledge sharing, resource pooling, and collective responsibility. This may lead to more effective waste collection, recycling, and sustainable practices. The government may also invest in advanced Technologies, promote effective communication, and strengthen environmental regulations. Policymakers should review and strengthen existing environmental regulations related to waste management in the beverage industry. Stringent regulations can incentivize beverage companies to adopt sustainable practices and adhere to responsible waste disposal and recycling standards. The government can introduce green incentive programs that reward beverage companies for adopting sustainable reverse logistics practices. Policymakers should prioritize the development of recycling infrastructure in Dodoma. The government can work with private sector entities to establish recycling facilities and collection centers strategically located to facilitate efficient waste collection and recycling. Policymakers should encourage research and innovation in sustainable waste management practices. Supporting research institutions and initiatives focused on waste reduction, recycling technologies, and circular economy principles will drive continuous improvement in the beverage industry's waste management practices.

In conclusion, implementing the above recommendations will require collaborative efforts from the government, policymakers, beverage companies, waste management entities, and local communities. By embracing sustainable reverse logistics strategies, Dodoma's beverage industry can be a trailblazer in environmental stewardship, contributing to a more sustainable future for Tanzania and setting an example for other regions to follow.

5.2 Implementation Strategy

To effectively implement the above recommendations, a strategic, multi-phase approach is essential, involving planning, coordination, resource mobilization, and continuous monitoring. The first phase should begin with stakeholder mapping and engagement, where the government, beverage companies, recycling firms, NGOs, and local communities are brought together through workshops and forums. This phase will help define roles, responsibilities, and joint targets for sustainable reverse logistics. Simultaneously, a task force should be established under the leadership of the Ministry of Environment or a relevant regulatory authority to oversee the coordination and accountability of the initiatives.

The second phase should focus on infrastructure and technological investment. This includes public-private partnerships (PPPs) to fund and install smart collection bins, establish recycling centers, and deploy data-driven waste tracking systems. Incentive schemes such as subsidies and tax rebates must be institutionalized through policy directives and budget allocations. These incentives should be performance-based, rewarding companies that demonstrate measurable improvements in waste collection and recycling.

The third phase should emphasize awareness and capacity building. Government-led campaigns in schools, communities, and media outlets will educate the public on responsible disposal and recycling. Additionally, targeted training programs for stakeholders, particularly SMEs in the beverage and waste management sectors, will build local capacity to implement reverse logistics practices effectively. Finally, the strategy must include robust monitoring and evaluation mechanisms. Key performance indicators (KPIs), such as reduction in landfill waste, increase in recycled bottles, and stakeholder participation rates, should be tracked quarterly. Annual policy reviews and stakeholder feedback sessions will ensure adaptive learning and continuous improvement.

In essence, the success of this implementation strategy depends on shared ownership, transparent governance, adequate financing, and a strong commitment to environmental sustainability by all actors involved.

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