Assessment of Barriers to Effective E-Waste Management in Hotels in Naivasha Sub-County, Kenya

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ABSTRACT

The rapid growth of electrical and electronic waste (e-waste) has emerged as a major environmental and public health challenge, particularly in developing countries where, inadequate recycling infrastructure and weak institutional capacity hinder sustainable waste management. Although the hospitality industry is an important generator of e-waste due to its intensive use and frequent replacement of electrical and electronic equipment, empirical evidence on the barriers to its effective management in hotels remains limited, especially in Sub-Saharan Africa. This study assessed the barriers hindering effective e-waste management among classified hotels in Naivasha Sub-County, Kenya.

An explanatory sequential mixed-methods design was employed involving 69 stratified randomly selected hotels and five purposively selected key informants from environmental, public health, tourism, and regulatory institutions. Quantitative data were analyzed using descriptive statistics, Pearson's correlation, hierarchical multiple regression, and analysis of variance (ANOVA), while qualitative data were subjected to thematic analysis and integrated through triangulation.

Limited access to licensed e-waste recyclers (91.3%) and inadequate recycling infrastructure (88.4%) emerged as the most prevalent barriers, followed by inadequate staff training (59.4%), high disposal costs (53.6%), limited environmental awareness (53.6%), weak regulatory enforcement (49.3%), and unclear institutional procedures (47.8%). Barriers exhibited a significant negative relationship with effective e-waste management ($r = -0.589$, $p < 0.001$) and remained a significant independent predictor after controlling for other explanatory variables ($\beta = -0.247$, $p = 0.016$). Conversely, applicable regulatory frameworks were the strongest positive predictor of effective e-waste management ($\beta = 0.561$, $p < 0.001$). The final hierarchical regression model explained 69.6% of the variance in effective e-waste management ($R^2 = 0.696$; Adjusted $R^2 = 0.672$; $F(5,63) = 28.843$, $p < 0.001$), demonstrating substantial explanatory power. Qualitative findings corroborated the quantitative results by identifying weak institutional coordination, inadequate technical capacity, and insufficient investment in formal recycling systems as persistent systemic constraints.

The findings demonstrate that institutional and structural barriers, rather than operational factors alone, are the principal determinants of effective e-waste management in hotels. This study contributes novel empirical evidence from the hospitality sector in a developing-country context, underscoring the need for integrated policy interventions that strengthen recycling infrastructure, improves access to licensed recyclers, enhances regulatory enforcement, builds organizational capacity through targeted training, and provide economic incentives to support formal e-waste management. The findings also offer practical guidance for policymakers, environmental regulators, and the industry in advancing sustainable e-waste governance and circular economy initiatives.

Keywords: E-Waste, E-Waste Generation, E-Waste Management, Barriers, Naivasha Sub-County

INTRODUCTION

Electrical and electronic waste (e-waste) is among the fastest-growing solid waste streams globally, driven by rapid technological advancement, increasing consumption of electrical and electronic equipment (EEE), shorter product life cycles, and accelerated technological obsolescence (Parajuly et al., 2019; Forti et al., 2020). E-waste comprises discarded electrical and electronic equipment containing circuitry or battery-powered components that have reached the end of their useful life. Although it contains valuable recoverable materials, improper disposal releases hazardous substances such as lead, cadmium, mercury, and persistent organic pollutants, posing significant environmental and public health risks (Dias et al., 2022).

Global e-waste generation continues to increase at an estimated annual rate of 3–5% and is projected to exceed 120 million metric tonnes by 2050 (Liu et al., 2023). However, formal collection and recycling systems remain inadequate in many developing countries, where e-waste is commonly managed through open dumping, uncontrolled burning, and informal recycling, leading to environmental contamination and inefficient resource recovery (Maes & Preston-Whyte, 2022). Consequently, strengthening e-waste management has become central to sustainable development and circular economy initiatives aimed at minimizing pollution while promoting resource efficiency (Murthy & Ramakrishna, 2022).

The hospitality industry is an important yet understudied contributor to this challenge. Hotels rely extensively on electrical and electronic equipment for accommodation, food production, communication, security, lighting, climate control, and digital service delivery. Continuous technological upgrades, smart building systems, energy-efficient technologies, and periodic renovations have increased both the volume and diversity of hotel-generated e-waste (Reijnders, 2024; Vishwakarma et al., 2023). Although sustainable management strategies such as recycling, refurbishment, repair, and Extended Producer Responsibility (EPR) are increasingly promoted worldwide, their implementation remains constrained in many developing countries by inadequate recycling infrastructure, weak regulatory enforcement, limited technical capacity, low stakeholder awareness, and high disposal costs (Shahabuddin et al., 2023; Wirtu et al., 2025).

Kenya faces similar challenges. The country generates approximately 53,000 metric tonnes of e-waste annually, increasing at an estimated rate of 8–12%, yet only about 5% enters formal recycling systems (Mungai & Maina, 2025). Hotels contribute substantially to this waste stream through the continual replacement of computers, televisions, refrigeration systems, lighting equipment, communication devices, and other electronic infrastructure required for quality service delivery (Karemeri et al., 2024). However, existing studies in Kenya have primarily focused on general environmental management in hotels, including solid waste, wastewater, procurement, and food waste management (Osiako & Kummitha, 2020; Chiro et al., 2020; Odeny et al., 2020; Ndung'u & Magaju, 2024), while e-waste research has largely been confined to households, universities, and healthcare facilities (Kamweru, 2019); Kiplagat et al., 2017; Getonto et al., 2021). Consequently, little is known about the institutional, technical, economic, technological, and behavioral barriers influencing e-waste management within Kenya's hospitality sector.

Naivasha Sub-County, one of Kenya's leading tourism destinations, has experienced rapid expansion of hotels and tourism infrastructure, increasing the use of electronic equipment and the potential generation of e-waste. Understanding the barriers that constrain effective e-waste management is therefore critical for strengthening environmental governance, improving regulatory compliance, and advancing sustainable tourism and circular economy initiatives. Accordingly, this study assessed the barriers to effective e-waste management among classified hotels in Naivasha Sub-County, Kenya. The findings provide sector-specific empirical evidence to inform policy development and promote sustainable e-waste management within the hospitality industry.

METHODOLOGY

Study Area

The study was conducted in Naivasha Sub-county, Nakuru County. The County, one of the 47 Counties in Kenya, bordering 8 other counties: Laikipia to the North-East, Kericho to the West, Narok to the South-West, Kajiado and Kiambu to the South-East, Baringo to the North, Nyandarua to the East and Bomet to the West, covers an area of 7,504Km^2. It is divided into 11 Sub-counties and 55 electoral wards, located between Longitudes 35.41º East or 35º 24' 36" East and 36.6º East or 36º 36' 0" East and Latitude 0.23º North or 0º 13' 48" North and 1.16º South or 1º 9`36" South. Naivasha Sub-county, covering an area of 1,685Km^2, is divided into 8 electoral wards: Biashara, Maiella, Mai Mahiu, Viwandani, Hells Gate, Olkaria, Naivasha East and Lake View Wards (Mekolela et al., 2025). The Sub-county, bordering Gilgil Sub-county to the west, Narok County to the South-West, Kajiado, and Kiambu Counties to the South-East, and Nyandarua County to the East, with a population of 355,383 (KNBS, 2019), is the biggest in Nakuru County, both by size and population.

Economic Drivers of the Study area

The export of horticulture, tourism and hospitality, energy, and fisheries sectors are the leading economic drivers of the Naivasha Sub-county economy in that order, earning and employing significantly more than their national share, within Naivasha Sub-county (Mengich et al., 2025). The Sub-county had 102 classified hotels as of the year 2024, defined by accommodation, food and beverage services (TRA, 2024). The key socio-economic activities of Naivasha Sub-county include; Agriculture and Horticulture, Tourism, Livestock Farming, Trade and Commerce, and Real Estate development (CGoN, 2023). The upper reaches of the Sub-county are characterized by smallholder farming involving the cultivation of maize, beans, and vegetables, while the mid reaches comprises of mixed farming, with large scale livestock ranches, and farming enterprises, culminating to the lowlands dominated by horticulture farming, especially around Lake Naivasha to a radius of approximately 50Km^2 (Onyango *et al.,* 2023).

Population of the Study

The population of the study was all the classified hotels within Naivasha Sub-county, offering at least accommodation, food and beverage services. An exhaustive list of 102 hotels and their bed capacities was obtained from the Tourism Regulatory Authority (TRA), comprising of 34 hotels along Moi South Lake Road, 47 within Naivasha Town, 6 at Kinamba area, 4 each along North Lake Road, Nairobi – Nakuru Highway, and at the Police Line area, and 1 each at Karai, South Lake Junction, and Karagita areas (TRA, 2024). Upon scrutiny, 16 facilities were excluded because they were either temporary camping sites, seasonal utilities like Airbnb, had been double-listed, or were not operational at the time of the study due to various reasons, leaving a total of 86 hotels making up the target population.

Research design

This study adopted an explanatory sequential mixed-methods design in which quantitative data were collected and analyzed first, followed by qualitative data to explain, contextualize, and enrich the quantitative findings. The design enabled the integration of numerical trends with participants' perspectives, providing a more comprehensive understanding of the barriers hindering effective e-waste management in hotels (Leavy, 2022). Quantitative methods established the magnitude and relationships among the study variables, while qualitative interviews explored the underlying institutional, technical, economic, and behavioral factors shaping these relationships. The findings from both phases were integrated through triangulation to enhance the validity, depth, and interpretation of the results (Manzoor, 2020). The relationship of the variables is highlighted in the figure of the conceptual framework, in Figure 1.

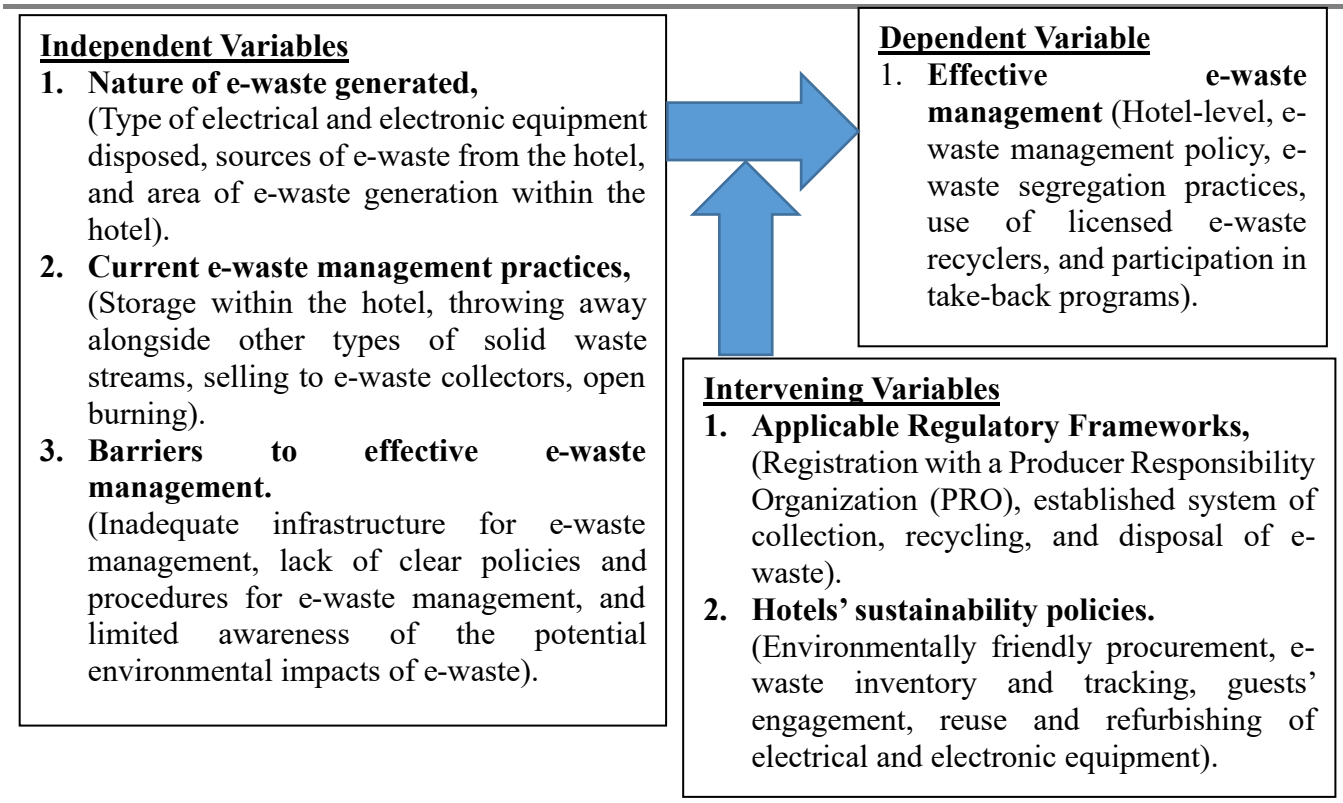

Figure 1: Schematic presentation of the Conceptual Framework

Sample size determination

The study adopted proportionate stratified random sampling, for sample size determination. The 86 classified hotels were stratified into five categories based on 100% bed capacity as provided by NEMA in the Eleventh Schedule of the Environmental Management and Coordination (Water Quality) Regulations, 2024 (NEMA, 2024). These categories are; Category 1 (≤ 25 Persons Bed Capacity), Category 2 (≥ 26 ≤ 50 Persons Bed Capacity), Category 3 (≥ 51 ≤ 75 Persons Bed Capacity), Category 4 (≥ 76 ≤ 100 Persons Bed Capacity), and Category 5 (≥ 101 Persons Bed Capacity).

The choice of bed capacity for stratification was based on the fact that it is a reliable indicator for hotel size, operational complexity, resource consumption, and the volume of electrical and electronic equipment used, hence the potential for e-waste generation. This stratification was targeted towards ensuring that the sample adequately captures the diversity of hotels, and improves the representativeness and precision of the study findings. For the stratified sample size determination, the researcher applied the Cochran's formula (finite population version)

$n_0 = \frac{z^2 p\,(1-p)}{e^2}$ where;

Z = Z-Score (1.96 for 95% confidence level),

p = Estimated proportion of the population with the characteristic (assumed 0.5 for maximum variability),

e = Margin of error (0.05 for ±5% error),

N = Total number of hotels in the population.

$$n_0 = \frac{1.96^2 x 0.5 x 0.5}{0.5^2} = \frac{3.8416 x 0.25}{0.0025} = \frac{0.9604}{0.0025} = 384.16$$

The value obtained was then applied for the finite population N, which in this case was 86, to get the final sample size.

$$n = \frac{n0}{[1+\left[\frac{(n0-1)}{N}\right]}$$

$$n = \frac{384.16}{[1+\left[\frac{(384.16-1)}{86}\right]]} = \frac{384.16}{[1+\frac{383.16}{86}]} = \frac{384.16}{(1+4.55)} = \frac{384.16}{5.55} = 69.2 \text{ (Approx. 69)}$$

Sampling technique

After the sample size determination, proportionate allocation was applied across the five strata using the proportional allocation formula for stratified random sampling nh = (Nh / N) × n within each stratum to select the participating hotels (Lohr, 2021), Where;

nh = Sample size for stratum h,

Nh = Population size of stratum h,

N = Total population, and,

n = Total Sample Size calculated above.

The results obtained were as shown in table 1 below;

Table 1: Table of Stratified Sample Size

Hotel Category	**Hotels in Population**	**Sample size (nh)**
1 (≤ 25 Persons Bed Capacity)	17	14
2 (≥ 26 ≤ 50 Persons Bed Capacity)	26	21
3 (≥ 51 ≤ 75 Persons Bed Capacity)	12	10
4 (≥ 76 ≤ 100 Persons Bed Capacity)	16	13
5 (≥ 101 Persons Bed Capacity)	15	11
Total		**69**

The purposively selected sample of key informants was; One (1) National Environment Management Authority (NEMA) Officer, One (1) County Government Environment Officer, One (1) Public Health Officer, One (1) Information and Communication Technology (ICT) Officer, and One (1) Tourism Regulatory Authority (TRA) Officer. The quantitative analysis was based on the 69 hotel respondents while the qualitative analysis involved responses from the 5 key informants.

Data collection procedure

Data collection followed a structured and technology-assisted procedure to ensure accuracy, completeness, and consistency. The sampled hotels were geo-referenced and mapped using **ArcGIS**, enabling verification of their spatial distribution across the study area and facilitating GPS-assisted navigation during fieldwork. This approach minimized location errors and ensured that data were collected exclusively from the selected hotels.

Quantitative data were collected using a structured questionnaire developed and deployed through **KoBo Toolbox**, a secure mobile data collection platform that supports real-time data capture, automated validation,

and encrypted data storage. The digital platform minimized data entry errors, improved response completeness, and enhanced the overall quality and integrity of the dataset.

Questionnaires were administered to management-level staff in the sampled hotels by the principal researcher, with assistance from a trained research assistant where necessary. Prior to data collection, respondents were informed of the study objectives, procedures, and their rights as participants, after which written informed consent was obtained. Qualitative data were collected through semi-structured interviews with purposively selected key informants representing relevant environmental, public health, tourism, and regulatory institutions. Interview appointments were scheduled in advance, and all interviews were conducted by the principal researcher following informed consent. The quantitative and qualitative data collection phases were implemented sequentially in accordance with the explanatory sequential mixed-methods design.

Data Analysis

Data analysis followed a rigorous mixed-methods approach consistent with explanatory sequential design. Quantitative data were analyzed using IBM SPSS Statistics. The analysis began with data cleaning, coding, and screening for completeness, outliers, and consistency. Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarize the prevalence of barriers to effective e-waste management across classified hotels.

Inferential analysis was conducted in stages. Pearson correlation analysis was used to determine the direction and strength of relationships between barriers and effective e-waste management. Hierarchical multiple regression analysis was then employed to determine the predictive power of independent variables, entered in blocks to assess incremental explanatory contribution. The first model included operational variables (barriers and nature of e-waste generated), while the second model introduced institutional and policy-related variables (regulatory frameworks and hotel sustainability policies). Model fit was evaluated using R^2, adjusted R^2, F-statistics, and analysis of variance (ANOVA), with statistical significance set at $p < 0.05$.

Qualitative data from key informant interviews were transcribed verbatim, coded inductively, and analyzed thematically. Emerging themes were categorized into institutional, technical, economic, and behavioral dimensions. Triangulation was applied to integrate quantitative and qualitative findings, enhancing validity and providing a more comprehensive explanation of observed statistical patterns.

Data Presentation

Data were presented using a structured combination of tables, figures, and narrative descriptions. Quantitative findings were organized into three main categories: descriptive statistics on barriers to e-waste management; correlation analysis results, and hierarchical regression outputs. Tables were used to present frequencies and percentages of identified barriers, while regression coefficients, significance levels, and model summaries were systematically reported to support inferential interpretation.

Qualitative findings were presented thematically under key categories corresponding to institutional constraints, technical capacity gaps, economic limitations, and behavioral challenges. Verbatim quotations from key informants were selectively included to support and contextualize emerging themes. The integration of quantitative and qualitative data was presented narratively to highlight convergence, complementarity, and divergence between datasets.

RESULTS

Sample, Response Rate and Reliability of the Research Instrument

A total of 102 classified hotels in Naivasha Sub-county, as of 2024, were identified from records held by the Tourism Regulatory Authority, together with their bed capacities and specific locations. Upon scrutiny, 16 facilities were excluded because they were temporary camping sites, seasonal utilities such as Airbnb listings,

double-listed, or not operational at the time of the study, leaving a target population of 86 hotels. Using Cochran's formula (finite population version) for stratified sample size determination, the target sample size was set at 69 respondents at a 5% margin of error and 95% confidence level. A total of 69 management-level hotel staff and 5 key informants provided valid entries for quantitative and qualitative analysis respectively, representing an effective response rate of 100%, as summarized in Table 2.

Table 2: Response Rate of Administered Questionnaires

Administered questionnaires	Questionnaires filled and valid	Response rate (%)
69	69	100

Data was collected through face-to-face interviews using a structured questionnaire and a key informant interview guide, supported by a trained research assistant who guided respondents where necessary. Response rates above 80% are considered exceptional and required for publication purposes (Taherdoost & Madanchian, 2024). The 100% rate achieved in this study was therefore satisfactory and robust. Prior to analysis, diagnostic checks were performed to confirm the completeness, consistency, and suitability of the datasets for statistical processing. The data were screened for missing values, entry errors, and outliers, ensuring that only high-quality responses were subjected to descriptive and inferential analysis in SPSS (Izah et al., 2024). To further guarantee accuracy and reliability, the questionnaire was pretested and refined, with internal consistency confirmed by a Cronbach's Alpha coefficient of 0.76, indicating satisfactory reliability.

Demographic Characteristics of the Respondents

Management-level hotel staff accounted for the majority of participants (69, 93.2%), with the remaining 5 (6.8%) key informants drawn from government institutions responsible for regulating the environmental, public health, and hotel sectors' interface. This confirms that the study mainly captured the views of hotel representatives, who were its principal target. Additional demographic indicators considered were age, gender, and level of education, which were deemed critical as they shape knowledge, attitudes, and decision-making, all of which may influence e-waste generation and management in hotels (Bhutto et al., 2023). The study also captured respondents' years of experience in the industry, the number of hotels they had worked in, and their tenure in their current position, since these indicators of experience determine how well managers understand hotel operations and their ability to solve problems and implement practical e-waste management strategies (Zrnić, 2026). These results are summarized in Table 3.

Table 3: Demographic Data of Respondents

Variable	Category	Frequency (n)	Percentage (%)
Sampling Unit	Hotel Managers	69	93.2
	Key Informants	5	6.8
Age (Yrs)	18 – 35	17	24.6
	36 – 50	47	68.1
	Above 50	5	7.2
Gender	Female	39	56.5
	Male	30	43.5
Education	Secondary	6	8.7
	Tertiary	63	91.3
Training in hotel management	No	13	18.8
	Yes	56	81.2
Experience (Yrs)	1 – 10	35	50.7
	11 – 20	30	43.5
	21 – 30	3	4.3

	Over 30	1	1.4
No. of hotels worked for	1	12	17.4
	2	28	40.6
	3	22	31.9
	>3	7	10.1
No. of Yrs. in current position	1 – 2	17	24.6
	3 – 4	29	42.0
	≥ 5	23	33.3

Hotel characteristics

The hotel characteristics investigated included the age of the hotel since commencing operations, star-rating classification, average annual occupancy rate, whether the hotel operated within a chain or independently, staff establishment, whether the hotel had a documented environmental or sustainability policy, sources and areas of e-waste generation, and awareness of and compliance with regulations. Most hotels (58.0%) were 11–20 years old since commencing operations, while 27.5% had operated for less than 10 years, and only 14.5% were more than 20 years old. These factors are important because older hotels tend to generate more e-waste due to accumulated and outdated equipment, whereas higher star-rated hotels, despite potentially generating more e-waste, may manage it better owing to greater resource capacity and adherence to standards (Azarmi et al., 2020).

The majority of hotels were 1- to 5-star rated (85.5%), with 3-star hotels forming the largest share (29.0%), while 1- and 2-star hotels each accounted for 14.5%, matching the proportion of unrated hotels. Only 8.7% of hotels were 4-star rated. The most common annual occupancy rate was 51–75% (47.8%), while hotels with occupancy of ≤50% and those with ≥75% each accounted for 21.7%; the remaining 8.7% had undetermined occupancy rates. Most hotels operated independently (76.8%), while 23.2% operated as part of a hotel group. In terms of staffing, 62.3% of hotels employed fewer than 50 staff, 18.8% employed 51–100, 8.7% employed 101–150, 4.3% employed 151–200, 4.3% employed 201–250, and only 1.4% employed over 250 staff. Higher occupancy rates may be associated with more intensive use of electronics and greater e-waste generation, while larger staff numbers may indicate larger operations, more electrical and electronic equipment (EEE), and greater capacity for e-waste management (Abdulkadir et al., 2025).

A majority of hotels (63.8%) did not have a documented environmental or sustainability policy, while only 36.2% did. This indicator was expected to reflect hotels' level of accountability and structured policy direction, which contributes to more organized and effective e-waste management in the sector (Chachage et al., 2024). Table 4 presents these results.

Table 4: Hotel Characteristics

Variable	**Category**	**Frequency (n)**	**Percentage (%)**
Hotel Age (Yrs)	1 – 10	19	27.5
	11 – 20	40	58.0
	21 – 30	10	14.5
Star-rating	1	10	14.5
	2	10	14.5
	3	20	29.0
	4	13	18.8
	5	6	8.7
	Not Rated	10	14.5
Occupancy/Year (%)	26 – 50 %	15	21.7
	51 – 75 %	33	47.8
	Over 75 %	15	21.7

	Not determined	6	8.7
Operations	Independently	16	23.2
	Group of hotels	53	76.8
No. of Staff	10 – 50	43	62.3
	51 – 100	13	18.8
	101 – 150	6	8.7
	151 – 200	3	4.3
	201 – 250	3	4.3
	Over 250	1	1.4

Descriptive Results on Barriers to Effective E-Waste Management

The study examined barriers to effective e-waste management through respondents' ratings of seven factors: inadequate infrastructure for e-waste management, limited access to licensed e-waste recyclers, lack of clear policies and procedures, cost of e-waste disposal, limited awareness of environmental impacts, lack of training, and lack of enforcement of regulations. Hotels face multiple, interrelated barriers to effective e-waste management. The most dominant barrier was limited access to licensed e-waste recyclers (91.3%), followed by inadequate recycling infrastructure (88.4%), both indicating a weak external support system for formal e-waste disposal.

Moderate-level barriers included lack of training on proper e-waste management (59.4%), high cost of e-waste disposal (53.6%), and limited awareness of environmental impacts (53.6%), reflecting internal organizational capacity gaps within hotel operations. Lower, though still significant, barriers were weak enforcement of regulations (49.3%) and the absence of clear institutional policies and procedures (47.8%), pointing to governance and policy implementation challenges within the sector. These results are presented in Table 5 and Figure 2.

Table 5: Barriers to Effective E-Waste Management

Barrier	**Least obstacle**		**Moderate obstacle**		**Biggest obstacle**	
	n	%	n	%	n	%
Limited access to licensed e-waste recyclers:	2	2.9%	4	5.8%	63	91.3%
Inadequate infrastructure for e-waste management:	2	2.9%	6	8.7%	61	88.4%
Lack of training on appropriate e-waste management:	10	14.5%	18	26.1%	41	59.4%
Cost of e-waste disposal:	7	10.1%	25	36.2%	37	53.6%
Limited awareness of the environmental impacts of e-waste:	10	14.5%	22	31.9%	37	53.6%
Lack of enforcement of the regulations:	7	10.1%	28	40.6%	34	49.3%
Lack of clear policies and procedures for e-waste management:	2	2.9%	34	49.3%	33	47.8%

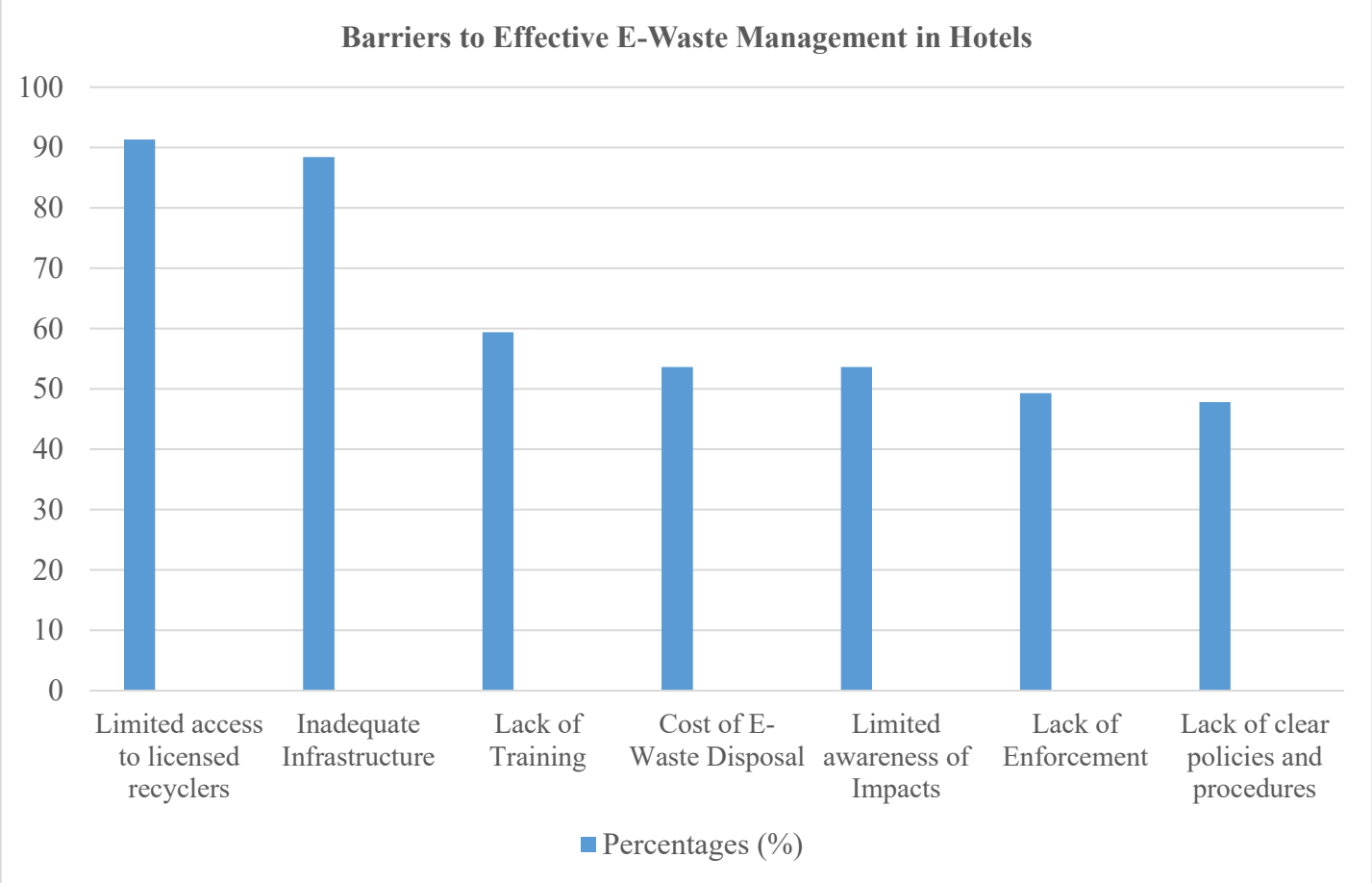

Figure 1: Barriers to Effective E-Waste Management in Hotels

Correlation Analysis

Pearson's correlation analysis was performed to examine the bivariate relationships among the study variables, including barriers to effective e-waste management, effective e-waste management, applicable regulatory frameworks, and hotels' sustainability policies. The results are presented in Table 6.

Barriers to effective e-waste management exhibited a statistically significant moderate negative correlation with effective e-waste management ($r = -0.589$, $p < 0.01$), indicating that higher levels of institutional, technical, economic, and behavioral constraints were associated with lower levels of e-waste management effectiveness. Similarly, barriers were negatively correlated with current e-waste management practices ($r = -0.638$, $p < 0.01$) and applicable regulatory frameworks ($r = -0.576$, $p < 0.01$), suggesting that environments characterized by stronger barriers also tended to exhibit weaker implementation of management practices and regulatory mechanisms.

In contrast, applicable regulatory frameworks demonstrated a strong positive correlation with effective e-waste management ($r = 0.800$, $p < 0.01$), highlighting the potential importance of regulatory support in promoting environmentally sound e-waste management practices. Hotels' sustainability policies were also positively associated with effective e-waste management ($r = 0.558$, $p < 0.01$), indicating that hotels with more established sustainability initiatives generally reported better e-waste management performance.

Overall, the correlation analysis demonstrates that institutional, technical, economic, and behavioural barriers are inversely associated with effective e-waste management, whereas supportive regulatory frameworks and organizational sustainability policies are positively associated with improved management outcomes. These

findings provide preliminary evidence for the subsequent hierarchical regression analysis by identifying variables that are significantly related to effective e-waste management.

Table 6: Pearson's Correlation Matrix for Independent, Dependent & Intervening Variables

Correlations							
		Nature of e-waste generated	Current e-waste management practices	Applicable regulatory frameworks	Barriers to effective e-waste management	Effective e-waste management	Hotels' sustainability policies
Nature of e-waste generated	Pearson correlation	---					
	N	69					
Current e-waste Management Practices	Pearson correlation	.464**					
	Sig. (2-tailed)	0.000					
	N	69	69				
Applicable Regulatory Frameworks	Pearson correlation	.458**	.581**				
	Sig. (2-tailed)	0.000	0.000				
	N	69	69	69			
Barriers to effective e-waste management	Pearson correlation	-0.184	-.638**	-.576**			
	Sig. (2-tailed)	0.130	0.000	0.000			
	N	69	69	69	69		
Effective e-waste management	Pearson correlation	.453**	.520**	.800**	-.589**		
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		
	N	69	69	69	69	69	
Hotels sustainability policies	Pearson correlation	.578**	.311**	.547**	-0.222	.558**	
	Sig. (2-tailed)	0.000	0.009	0.000	0.067	0.000	
	N	69	69	69	69	69	69

**** Correlation is significant at the 0.01 level (2-tailed)**

Hierarchical Multiple Regression Analysis

Hierarchical multiple regression analysis was performed to examine the extent to which the study variables predicted effective electrical and electronic waste (e-waste) management among classified hotels. Variables were entered sequentially to evaluate their independent and incremental contributions to the explained variance in the dependent variable. In Model 1, the predictor variables comprised the nature of e-waste generated, current e-waste management practices, and barriers to effective e-waste management. Model 2 incorporated the intervening variables—applicable regulatory frameworks and hotels' sustainability policies—to determine whether they significantly improved the explanatory power of the model beyond that of the primary predictors.

Regression Model Summary

The regression model summaries are presented in Table 7. Model 1 was statistically significant, $\mathbf{F}(3, 65) = 19.22$, $p < 0.001$, explaining 47.0% of the variance in effective e-waste management ($\mathbf{R^2} = 0.470$; Adjusted $\mathbf{R^2} = 0.452$). This indicates that the combined effects of the nature of e-waste generated, current e-waste management practices, and barriers to effective e-waste management provided a moderate level of explanatory power.

The inclusion of applicable regulatory frameworks and hotels' sustainability policies in Model 2 significantly improved the model's explanatory capacity. The final model was statistically significant, $F(5, 63) = 28.84$, $p < 0.001$, and accounted for 69.6% of the variance in effective e-waste management ($R^2 = 0.696$; Adjusted $R^2 = 0.672$). Compared with Model 1, the increase in explained variance demonstrates that regulatory and organizational factors contribute substantially to understanding effective e-waste management beyond the influence of operational factors alone. These findings underscore the importance of incorporating institutional and policy-related variables when modelling e-waste management performance in the hospitality sector.

Table 7: Summary of Multiple Regression Analysis Models

Model	R	R square	Adjusted R square	Std. Error of the Estimate
1	.686[a]	0.470	0.446	0.20462
2	.834[b]	0.696	0.672	0.15742

Predictors: (Constant), Barriers to effective e-waste management, Nature of e-waste generated, current e-waste management practices.

Predictors: (Constant), Barriers to effective e-waste management, Nature of e-waste generated, current e-waste management practices, hotels' sustainability policies, applicable regulatory frameworks.

Analysis of Variance (ANOVA)

The ANOVA results confirm that both regression models provide statistically significant prediction of the dependent variable. Model 1 was significant, $F(3, 65) = 19.215$, $p < 0.001$, indicating that the set of three independent variables collectively predicts effective e-waste management. Model 2 was highly significant, $F(5, 63) = 28.843$, $p < 0.001$, confirming that the addition of the two intervening variables strengthens the overall prediction. In both models, at least one predictor has a statistically significant effect on the outcome variable, as shown in Table 8.

Table 8: Model-Comparison ANOVA Analysis

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2.414	3	0.805	19.215	.000[a]
	Residual	2.722	65	0.042		
	Total	5.135	68			
2	Regression	3.574	5	0.715	28.843	.000[b]
	Residual	1.561	63	0.025		
	Total	5.135	68			

Dependent Variable: Effective E-Waste Management,

Predictors: (Constant): Barriers to Effective E-Waste Management, Nature of E-Waste Generated, & Current E-Waste Management Practices.

Predictors: (Constant): Barriers to Effective E-Waste Management, Nature of E-Waste Generated, Current E-Waste Management Practices, Hotels' Sustainability Policies, And Applicable Regulatory Frameworks.

Regression Coefficients

The standardized regression coefficients for the hierarchical models are presented in Table 9. In Model 1, barriers to effective e-waste management emerged as the strongest predictor, exhibiting a statistically significant negative association with effective e-waste management ($\beta = -0.497$, $p < 0.001$). This indicates that higher levels of institutional, technical, economic, and behavioural barriers were associated with lower levels of e-waste management effectiveness. The nature of e-waste generated was also a significant positive predictor ($\beta = 0.340$, $p = 0.002$), suggesting that variations in the characteristics and volume of e-waste generated were associated with differences in management effectiveness. In contrast, current e-waste management practices did not significantly predict effective e-waste management ($p = 0.733$).

Following the inclusion of the intervening variables in Model 2, applicable regulatory frameworks emerged as the strongest positive predictor of effective e-waste management ($\beta = 0.561$, $p < 0.001$), indicating that stronger regulatory support was associated with improved management outcomes. Although the magnitude of the regression coefficient for barriers decreased, barriers remained a statistically significant negative predictor ($\beta = -0.247$, $p = 0.016$), demonstrating that their adverse influence persisted even after accounting for regulatory and organizational factors. Hotels' sustainability policies exhibited a positive but non-significant association with effective e-waste management ($\beta = 0.168$, $p = 0.077$), while the nature of e-waste generated and current e-waste management practices were no longer statistically significant in the final model. The attenuation of the barrier coefficient following the inclusion of regulatory variables suggests that institutional and policy-related factors partially explain the relationship between barriers and effective e-waste management, highlighting the importance of a supportive regulatory environment in enhancing e-waste management performance within the hospitality sector.

Table 9: Coefficients Analysis

Coefficients[a]								
		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B	
		B	Std. Error	Beta (β)	t	Sig.	Lower Bound	Upper Bound
Model								
1	(Constant)	0.872	0.242		3.607	0.001	0.389	1.355
	Nature of e-waste generated	0.564	0.171	0.340	3.292	0.002	0.222	0.906
	Current e-waste management practices	0.072	0.212	0.045	0.342	0.733	-0.350	0.495
	Barriers to effective e-waste management	-0.959	0.229	-0.497	-4.183	0.000	-1.417	-0.501
2	(Constant)	0.509	0.193		2.628	0.011	0.122	0.895
	Nature of e-waste generated	0.127	0.156	0.076	0.811	0.421	-0.185	0.438
	Current e-waste management practices	-0.082	0.167	-0.051	-0.492	0.624	-0.415	0.251
	Barriers to effective e-waste management	-0.476	0.192	-0.247	-2.487	0.016	-0.859	-0.094
	Applicable Regulatory Frameworks	0.573	0.107	0.561	5.378	0.000	0.360	0.786
	Hotels' sustainability policies	0.161	0.089	0.168	1.800	0.077	-0.018	0.339

Dependent Variable: effective e-waste management

DISCUSSION

Structural and Institutional Barriers as the Dominant Determinants of Effective E-Waste Management

This study demonstrates that effective e-waste management among classified hotels in Naivasha Sub-County is constrained primarily by structural and institutional barriers rather than deficiencies in routine operational practices. Descriptive analysis showed that the most critical barriers were limited access to licensed e-waste recyclers (91.3%) and inadequate recycling infrastructure (88.4%), followed by lack of staff training (59.4%), high disposal costs (53.6%), limited environmental awareness (53.6%), weak regulatory enforcement (49.3%), and absence of clear institutional policies (47.8%). The predominance of these external barriers suggests that hotels operate within an underdeveloped formal e-waste management ecosystem where environmentally sound collection, transportation, treatment, and recycling services remain inaccessible or prohibitively expensive.

These descriptive findings are reinforced by the correlation analysis, which revealed a strong negative relationship between barriers and effective e-waste management ($r = -0.589$, $p < 0.01$). Furthermore, barriers were negatively associated with current e-waste management practices ($r = -0.638$, $p < 0.01$) and applicable regulatory frameworks ($r = -0.576$, $p < 0.01$), indicating that barriers not only reduce overall environmental performance but also undermine the implementation of existing operational practices and diminish the effectiveness of regulatory interventions. These relationships illustrate that barriers function as systemic constraints that simultaneously weaken organizational capacity and institutional performance.

The hierarchical regression analysis provides even stronger evidence for the central role of barriers. In Model 1, barriers emerged as the strongest predictor of effective e-waste management ($\beta = -0.497$, $p < 0.001$), explaining a substantial proportion of the observed variation in management effectiveness ($R^2 = 0.470$). Although the inclusion of applicable regulatory frameworks and hotel sustainability policies substantially improved the explanatory power of the model ($R^2 = 0.696$), barriers remained statistically significant in Model 2 ($\beta = -0.247$, $p = 0.016$). The persistence of this negative effect after controlling for institutional and organizational variables demonstrates that barriers are robust determinants of environmental performance whose influence cannot be eliminated solely through regulatory or managerial interventions.

These findings support the systems-thinking perspective, which argues that environmental outcomes emerge from interactions among institutional arrangements, technological infrastructure, organizational capabilities, economic incentives, and stakeholder relationships rather than from isolated organizational actions. Hotels may possess positive environmental intentions, yet their ability to translate these intentions into effective e-waste management remains constrained by limited recycling infrastructure, inaccessible licensed recyclers, high disposal costs, weak enforcement mechanisms, and inadequate institutional coordination. Consequently, improving organizational practices alone is unlikely to generate meaningful environmental improvements unless broader systemic barriers are simultaneously addressed.

The present findings are consistent with recent international studies. Baričević et al., (2024), reported that inadequate collection infrastructure and insufficient treatment facilities remain among the greatest impediments to sustainable e-waste management, particularly within developing economies where recycling capacity is still evolving. Similarly, Stef et al., (2025), demonstrated that fragmented institutional arrangements, inadequate infrastructure, and weak stakeholder coordination continue to undermine implementation of environmentally sound e-waste management despite growing environmental awareness. Likewise, Awasthi & Pandey, (2026) emphasized that successful transition toward circular economy systems requires well-developed recycling infrastructure, accessible formal collection systems, and effective collaboration among governments, producers, recyclers, and waste generators. The current study extends this body of knowledge by demonstrating that these structural deficiencies similarly constrain environmental performance within the hospitality sector, an industry that has received comparatively limited empirical attention despite its increasing dependence on electronic technologies.

The economic dimension of these barriers is equally important. More than half of the respondents identified disposal costs as a major obstacle (53.6%), suggesting that transportation, handling, and treatment costs discourage hotels from engaging licensed recyclers. Similar observations were reported by Faibil et al., (2023), who found that high recycling costs encourage prolonged storage of obsolete electronic equipment and increase reliance on informal disposal pathways, thereby elevating environmental and public health risks. Collectively, these findings suggest that effective e-waste management depends on simultaneous improvements in infrastructure availability, institutional coordination, technical capacity, and economic incentives rather than isolated organizational initiatives.

Regulatory Frameworks as Enabling Rather Than Sufficient Conditions

A major contribution of this study is the demonstration that regulatory frameworks function as enabling mechanisms rather than independent solutions for effective e-waste management. The hierarchical regression analysis showed that introducing regulatory frameworks into Model 2 substantially increased explanatory power from 47.0% to 69.6%, while applicable regulatory frameworks emerged as the strongest positive predictor ($\beta = 0.561$, $p < 0.001$). These findings confirm the important role of institutional governance in improving environmental management outcomes within the hospitality sector.

However, the continued significance of barriers in the final model indicates that regulations alone cannot overcome implementation challenges. Although stronger regulatory frameworks partially moderated the negative influence of barriers as reflected by the reduction in the standardized coefficient from $\beta = -0.497$ to $\beta = -0.247$; their influence remained statistically significant. This suggests that legislation becomes effective only when supported by adequate recycling infrastructure, technical expertise, financial incentives, institutional coordination, and effective enforcement mechanisms.

These findings are particularly relevant within the Kenyan context, where progressive policy instruments, including the Extended Producer Responsibility (EPR) Regulations, provide a comprehensive legal framework for e-waste management. Nevertheless, implementation remains constrained by limited institutional capacity, inadequate recycling infrastructure, and uneven enforcement. Similar conclusions have been reported by Hasse, (2025), who observed that although stronger environmental regulations improve organizational compliance, infrastructural deficiencies and weak institutional capacity continue to impede effective implementation. Likewise, Seva-Larrosa & García-Lillo, (2025) demonstrated that institutional barriers remain significant predictors of poor environmental performance even after accounting for regulatory influences.

Organizational Capacity, Sustainability Policies, and Systems Thinking

An interesting finding of this study is that organizational initiatives alone were insufficient to improve e-waste management performance. Current e-waste management practices were not statistically significant in either regression model ($\beta = 0.045$, $p = 0.733$ in Model 1; $\beta = -0.051$, $p = 0.624$ in Model 2), while hotel sustainability policies showed only a positive but statistically insignificant contribution ($\beta = 0.168$, $p = 0.077$). These findings suggest that internal organizational commitment has limited influence where broader institutional constraints remain unresolved.

The qualitative findings strongly support this interpretation. Key informants consistently identified weak enforcement, limited institutional coordination, inadequate technical expertise, insufficient recycling infrastructure, high disposal costs, and low public awareness as interconnected barriers limiting effective implementation of environmental policies. Rather than operating independently, these factors reinforce one another. Weak enforcement discourages investment in recycling facilities, inadequate infrastructure increases disposal costs, high costs discourage utilization of licensed recyclers, and limited technical knowledge contributes to poor segregation and prolonged storage of obsolete electronic equipment. The convergence between quantitative and qualitative findings therefore provides strong evidence that effective e-waste management is fundamentally a systems problem requiring coordinated institutional responses.

This interpretation is consistent with Wang et al., (2023), who argued that favorable organizational conditions can easily be overridden by structural constraints such as inadequate infrastructure, financial limitations, and limited technical expertise. Similarly, Zaki, (2025) concluded that barriers are systemic in nature and cannot be effectively addressed through isolated operational improvements. Gashi et al., (2025) further demonstrated that even under strong regulatory environments, inadequate infrastructure, high recycling costs, and limited access to licensed recyclers continue to constrain environmental performance. Collectively, these studies reinforce the present finding that reducing systemic barriers is likely to produce greater improvements than introducing additional organizational policies alone.

Implications for Circular Economy Implementation and Environmental Policy

The present study contributes to the growing literature on circular economy implementation by extending existing evidence beyond manufacturing industries and municipal waste systems to the hospitality sector. The findings demonstrate that successful transition toward circular economy practices depends not only on organizational commitment but equally on the development of supportive institutional ecosystems capable of facilitating collection, recycling, and recovery of end-of-life electronic products.

From a policy perspective, the findings suggest that removing systemic barriers should receive greater priority than introducing additional regulations alone. Expanding regional access to licensed recyclers, investing in collection and recycling infrastructure, strengthening institutional coordination among regulatory agencies, improving enforcement mechanisms, and enhancing technical capacity within hotels are likely to produce greater environmental benefits than isolated legislative reforms. Financial instruments including recycling subsidies, tax incentives, and strengthened Extended Producer Responsibility schemes could further reduce disposal costs and encourage greater utilization of licensed recycling services.

Overall, the study confirms that barriers to effective e-waste management constitute the most stable and influential determinant of environmental performance in hotels. Their consistent significance across descriptive, correlational, regression, and qualitative analyses demonstrates that sustainable improvements will require integrated interventions addressing institutional, technical, economic, and behavioural constraints simultaneously. Such a systems-oriented approach offers the greatest potential for strengthening environmental compliance, improving resource recovery, reducing environmental contamination, and accelerating Kenya's transition towards a circular economy within the hospitality sector.

CONCLUSION

This study assessed the barriers influencing effective electrical and electronic waste (e-waste) management among classified hotels in Naivasha Sub-County, Kenya. The findings indicate that effective e-waste management is constrained by a combination of institutional, economic, technical, technological, and behavioural barriers. The most prominent barriers include limited access to licensed e-waste recyclers, inadequate recycling infrastructure, insufficient staff training, high repair and recycling costs, limited awareness of the environmental impacts of e-waste, weak enforcement of existing regulations, and the absence of clear institutional policies and procedures. Collectively, these barriers are associated with reduced effectiveness of e-waste management within the hospitality sector.

The findings further indicate that institutional and structural barriers remain key determinants of effective e-waste management, even where supportive regulatory frameworks exist. These results suggest that policy interventions are likely to be more effective when complemented by investments in recycling infrastructure, strengthened regulatory enforcement, organizational capacity building, and improved access to licensed recycling services. By providing empirical evidence from Kenya's hospitality sector, this study addresses an important knowledge gap in sector-specific e-waste management and contributes to the growing body of literature on sustainable waste governance in developing countries. The findings offer practical guidance for policymakers, environmental regulators, and hotel managers seeking to strengthen circular economy practices and promote environmentally sustainable e-waste management within the hospitality industry.

RECOMMENDATION

Address existing barriers to effective e-waste management in hotels, by developing targeted strategies to address them, as they have the potential to trigger a multiplier effect on all the other interventions including enforcement of regulations, awareness creation, and hotel-level sustainability policies. Such strategies may include; development of infrastructure, provision of targeted incentives including subsidizing recycling costs, especially for legacy, stored e-waste, enhanced awareness creation on the impacts of poor e-waste management and disposal, improved access to recycling options, enhanced monitoring and enforcement of regulations especially the EPR regulation, and gazettement and enforcement of a stand-alone e-waste regulation.

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ETHICAL CONSIDERATIONS

Ethical Approval

Ethical approval for this study was obtained from the Kabarak University Ethics Review Committee (KUREC) in accordance with the national research ethics guidelines. Research authorization was subsequently granted by the National Commission for Science, Technology and Innovation (NACOSTI) under license number NACOSTI/P/26/4186063, covering the administration of survey-based questionnaires involving human participants, within Naivasha Sub-county.

Conflict of Interest

The authors affirm their complete impartiality, declaring that no conflicts of interest exist, thereby reinforcing the credibility, transparency, and integrity of the research findings.

Data Availability

The datasets generated and analyzed during this study are available from the corresponding authors upon reasonable request.