Indonesian Journal of Environmental Management and Sustainability
e-ISSN:2598-6279 p-ISSN:2598-6260

Research Paper

Assessing Waste Management Practices and Their Impact on Environmental Sustainability in Afghanistan

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Abstract

This paper examines waste management's impact on environmental sustainability in Afghanistan against the backdrop of global waste management challenges. Globally, unsustainable waste management practices contribute significantly to environmental degradation, with 1.3 billion tons of food wasted annually-one-third of global production-exacerbating hunger for one in seven people. Global waste production has reached 2.01 billion tons annually, with construction contributing 35%. Packaging and paper waste account for 40-65% of waste treatment costs in Europe, and tourism adds 35 million tons of solid waste annually. Plastic waste production has risen to 300 million tons per year, threatening marine life with projections of sea pollution surpassing fish populations by 2050. In Afghanistan, financial and technical constraints lead to significant food loss and improper waste disposal, creating unsanitary environments and health hazards. Household waste mismanagement ranges from 20% to 80%, with Kabul generating 3,300 tons of waste per day by 2025, 70% of which is organic. Data from 127 respondents reveal a positive correlation (0.265) between waste management and sustainability, accounting for 26.5% of the variation, with a 0.249 coefficient confirmed at the 1% significance level.

Keywords

Waste Management, Environmental Sustainability, Waste Disposal Practices, Global Waste Challenges, Waste Management Impact

Received: 8 October 2024, Accepted: 16 December 2024
https://doi.org/10.26554/ijems.2024.8.4.166-171

1. INTRODUCTION

Globally, waste generation is increasing at an alarming rate. Since 2016, cities have produced over 2 billion tons of solid waste annually. Rapid population growth and urbanization are projected to increase this by 70%, potentially reaching 3.40 billion tons by 2050. This surge in waste production, coupled with insufficient waste management (WM), are major contributors to disease vectors and global climate change (Moslinger et al., 2023; Anuardo et al., 2022; Wilson et al., 2022). By 2025, global solid waste production is projected to reach 2.2 billion tons. Consequently, countries measures to minimize waste by embracing green and circular practices designed to close the loop in the supply chain (Mancini et al., 2021).

According to the FAO, approximately 1.3 billion tons of food, a third of global production, is wasted annually, posing significant environmental strain. At the same time, one in seven people worldwide faces hunger, with over 20,000 children under five dying daily due to malnutrition (United Nations, 2024; United Nations Environment Programme (UNEP), 2015). In resource-limited countries like Afghanistan, food waste is largely due to financial, managerial, and technical constraints in harvesting, storage, and cooling infrastructure (United Nations, 2024; United Nations Environment Programme (UNEP), 2015).

Urban waste comprising municipal solid waste (MSW), commercial and industrial (C&I) waste, and construction and demolition waste (C&D), amounts to 7 to 10 billion tons annually (United Nations Environment Programme (UNEP), 2015). The construction sector alone contributes 35% to global waste (Ali, 2023). Globally, 300 million tons of plastic waste are produced annually, with 11 million tons entering the ocean, and by 2050, the seas may contain more plastic than fish (United Nations, 2024).

Plastic levels in MSW range from 7% to 12%, and 'dry recyclable' materials range from 12% in high-income to 6% in low-income countries. Household hazardous waste (HHW) makes up less than 1% of MSW. Incinerators contribute to air pollution, and poor waste management practices pose environmental and health risks, particularly for marginalized groups (Gangwar et al., 2019; Abubakar et al., 2022; Dehghani et al., 2021). A substantial portion of household waste, ranging from 20% to 80%, is discarded improperly in open spaces or water bodies, further exacerbating health hazards (Istrate et al., 2020; United Nations Environment Programme (UNEP), 2015).

Additionally, paper waste percentages exhibit a correlation with income levels: 6% in low-income countries, 11-19% in middle-income, and 24% in high-income nations. Per capita paper consumption follows a similar pattern, with figures of 240 kg in North America, 140 kg in Europe, 40 kg in Asia, and 4 kg in Africa (United Nations Environment Programme (UNEP), 2015). In Kabul city, the solid waste management challenge is significant, generating 3,050 tonnes of waste daily in 2018 for a population of 5 million (Khoshbeen et al., 2020). By 2025, waste generation is expected to rise to 3,300 tonnes per day, with per capita generation increasing to 0.6 kg/day (Abdel-Shafy and Mansour, 2018). Waste characterization shows around 70% organic content, with a specific weight of 413 ± 52 kg/m^3 (Abubakar et al., 2022). Local observations, like Bagh-e-Babur's annual waste of 23,586 kg, emphasize the broader challenge (Mukhtar et al., 2016).

The inadequate management of waste presents a critical challenge to environmental sustainability, where improper waste management practices exacerbate pollution and health hazards. Despite global urgency, Afghanistan faces significant barriers in waste management due to financial and technical constraints. Kabul generates approximately 1,500 tons of solid waste daily, with only 20% effectively managed effectively, while the rest is either burned or dumped in informal landfills, causing pollution, (Yang et al., 2018). This study examined the impacts of waste management on environmental sustainability and highlighted the issues that significantly escalate the need for effective waste management practices. Urgent action is needed to implement sustainable waste management strategies in Kabul, incorporating modern engineering practices to ensure environmental sustainability and public health.

Recent statistics from Kabul, the capital city, reveal concerning figures: it generates approximately 1,500 tons of solid waste daily, with only 20% effectively managed. The rest is burned or dumped in informal landfills, polluting air, soil, and groundwater, while inefficient segregation hinders recycling. Lack of segregation worsens the issue of inefficiently utilizing recyclable materials. Methods like landfilling, incineration, composting, and recycling are used, but improper landfilling poses health and environmental risks (Yang et al., 2018). Emerging technologies, like saltwater flotation for plastic separation, aim to reduce health risks during recycling (Khoshsepehr et al., 2023). Thermal treatments can decrease solid waste volume by up to 90% and mass by 75%. Thermal treatments can decrease solid waste volume by up to 90% and mass by 75%. However, utilizing heat for waste treatment provides a means to recover energy that can be applied to heating or electricity generation. Thermal treatments can reduce waste volume by 90% and mass by 75%, offering energy recovery potential. Waste-to-energy technologies provide sustainable waste management and energy solutions for Afghanistan's development. Waste encompasses discarded materials or objects intended for disposal (United Nations Environment Programme (UNEP), 2015). It is classified into solids, liquids, and gases. Solid waste arises from industrial and consumer processes, including raw material extraction and product consumption (Ali, 2023; Almansour and Akrami, 2024).

Effective waste management is essential for environmental sustainability, addressing critical issues like solid, plastic, and construction waste (Arockiam JeyaSundar et al., 2020; Negash et al., 2021). Improper waste management leads to severe health and environmental problems (Hajam et al., 2023; Mahajan, 2023; Liehu et al., 2022). The absence of clear strategies results in waste accumulation and environmental risks (Ibrahim and Mohamed, 2016). Significant impacts include CO_2 emissions from incineration (Arushanyan et al., 2017), while urbanization drives construction waste, challenging sustainability and safety (Aslam et al., 2020, Lee et al., 2020). The novelty of this research lies in its quantitative analysis of the relationship between waste management practices and environmental sustainability in Afghanistan, a country facing distinct socio-economic challenges and limited technical infrastructure. The study offers actionable insights into developing sustainable waste management strategies suited to resource-constrained contexts.

2. EXPERIMENTAL SECTION

2.1 Methods

The population of the study is infinite, and the current study used quantitative research methods to investigate the effects of waste management on environmental sustainability. A random sampling technique is used to accurately generalize the result. The simple linear regression is run with the help of SPSS to obtain the findings of the study.

2.2 Population and Sampling

It represents the population to ensure that the findings from the research sample can be generalized to the population as a whole (Shukla, 2020; Ali, 2023). To determine the effect of waste management on environmental sustainability, a simple linear correlation technique is used. The study has been carried out with a closed-ended adopted questionnaire that is submitted to 127 respondents, comprising engineering students and lecturers' staff of the governmental organizations. The study population is infinite because the respondents were chosen from the academic universities and three local governmental organizations; municipalities, National Environmental Protection Agencies (NEPA), directorates of agriculture, irrigation, and livestock (DAIL), where each of them has a different population as per their structures. Furthermore, the sample random technique is used to carry

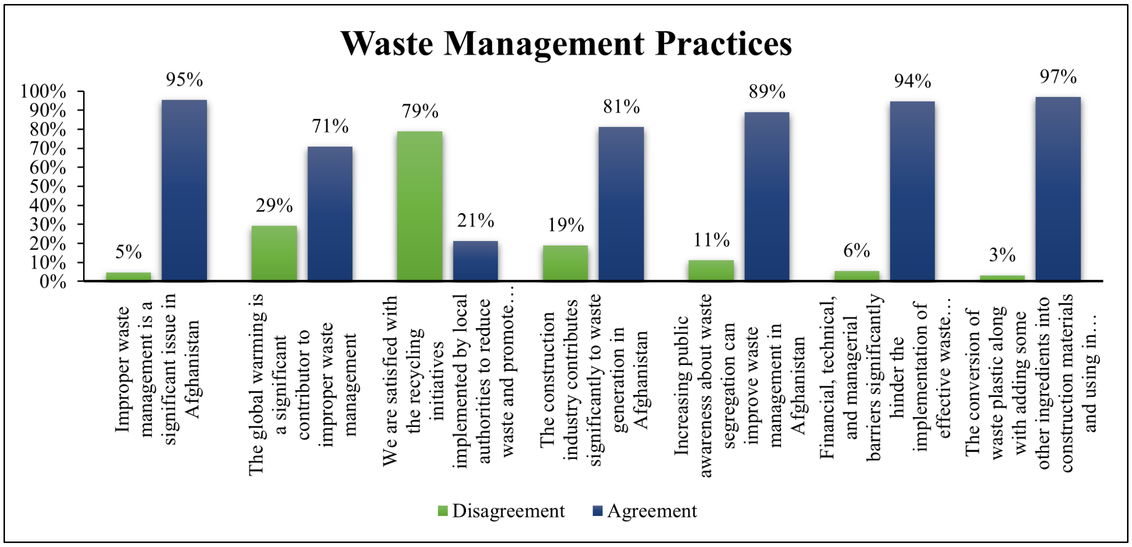

Figure 1. Response Rate of Waste Management Practices

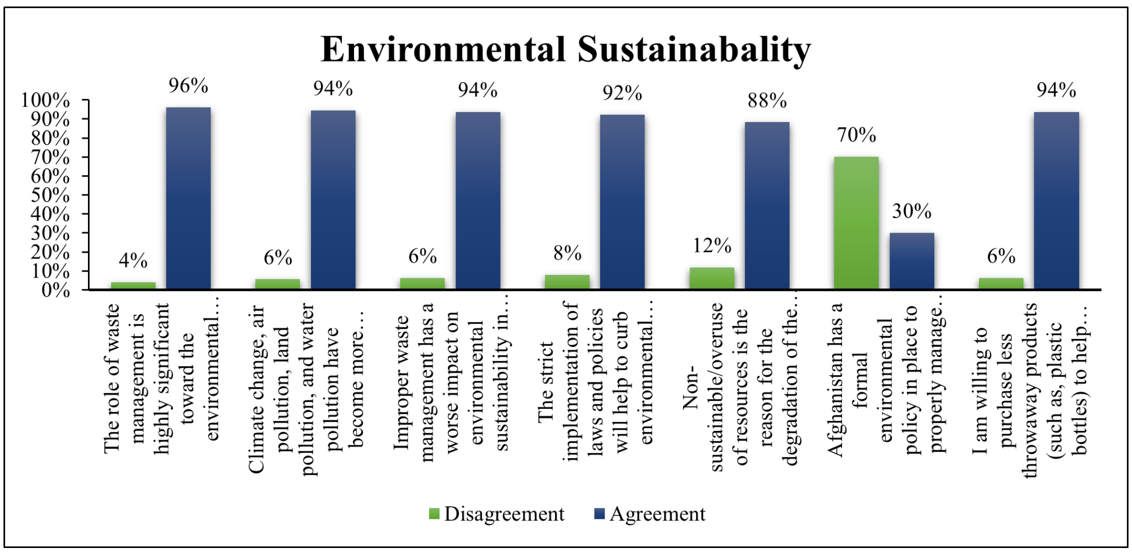

Figure 2. Response Rate of Environmental Sustainability

out the sampling because this technique gives efficient and unbiased results.

2.3 Data Collection

To effectively gather data, a Google form was developed, and each respondent of the targeted organizations was provided with a link to the form to answer the placed queries. The questionnaire consisted of adopted questions with five Likert scales, implying each question was designed to be responded to by one out of five options (strongly agree, agree, neutral, disagree, strongly disagree). The collected data from the 127 respondents from diverse fields and organizations were cleaned and categorized for the aim of analysis.

2.4 Model Specification

ES= β_0+ β_1 WM + ϵ_i, ES: Environmental Sustainability, β_0: Intercept, β_1: Slope coefficient, WM: Waste Management, ϵ_i: Error Term.

2.5 Data Analysis

To determine the structure and evolution of the current research field, a simple linear regression method was used. This method is used to model the relationship between two continuous variables. We used this method to determine the correlation between dependent and independent variables. This study aims to reveal and examine the effects of waste management on environmental sustainability and to offer engineering solutions for a cleaner future. The population of the study is infinite and the current study uses quantitative

Table 1. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Waste Management	127	3.00	5.00	4.0538	0.45453
Environmental Sustainability	127	2.80	5.00	4.2476	0.48335
Valid N	127				

Table 2. Correlation between WM and ES

WM & ES		WM	ES
Waste Management	Pearson Correlation	1	0.265**
	Sig. (2-tailed)		0.003
	N	127	127
Environmental Sustainability	Pearson Correlation	0.265**	1
	Sig. (2-tailed)	0.003	
	N	127	127

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

research methods to involve more people and accurately generalize the result. Simple linear and correlation techniques are used to analyze the data.

3. RESULT AND DISCUSSION

The study findings from the online questionnaires shed light on waste management practices in Afghanistan (Figure 1), revealing widespread recognition (95%) of improper waste management as a pressing issue. A significant portion (71%) of respondents link this issue to global warming. Dissatisfaction (79%) with local recycling initiatives signals a demand for better infrastructure and policies. Acknowledgment (81%) of the construction industry's role in waste generation highlights the need for tailored reduction measures. Public awareness (89%) of waste segregation emerges as vital, emphasizing the role of education. Identified barriers (94%) such as financial constraints call for comprehensive strategies. Support (97%) for innovative solutions like plastic conversion into construction materials indicates openness to sustainable practices. The data underscores the necessity for improved recycling programs, education, targeted interventions in construction, and innovative waste management approaches.

The survey data highlights widespread recognition of the critical role waste management plays in environmental sustainability (Figure 2), with 96% agreement. There's also strong consensus (94%) on the detrimental effects of improper waste management on pollution, particularly in Afghanistan, where formal environmental policies are disputed (70%). However, respondents expressed willingness to change, with 94% ready to reduce throwaway product usage if alternatives are available. The majority (92%) believe strict implementation of environmental laws can mitigate degradation. These findings underscore the need for enhanced waste management practices, strengthened policies, and collaborative efforts to foster sustainability.

The descriptive statistics of the study are presented in Table 1. The Waste Management (WS) variable had a high mean score of 4.05, and the Environmental Sustainability (ES) variable had a high mean score of 4.24. The maximum and minimum values for the Waste Management (WS) variable are 5 and 3, and for the Environmental Sustainability (ES) variable, they are 5 and 2.80, respectively. The standard deviation for the Waste Management (WS) variable is 0.454, while for the Environmental Sustainability (ES) variable, it is 0.483, respectively.

The coefficient of correlation between waste management and environmental Sustainability is 0.265. The value of 0.003 for the significance level, which can be seen in Table 2, shows that the correlation is significant and that the two variables are associated linearly. This demonstrates that an improvement in waste management can increase environmental sustainability.

R measures how well the observed values of the dependent variable correlated with the predicted values of the dependent variable (Table 3). The R-value of the model is equal to 0.265. Because of the high value that was shown by the simple correlation coefficients, it was found that there was a significant association between the variables. R squared has a value of 0.070, which shows that the model does fit the data well; therefore, the variation in the dependent variable (Waste Management) is completely explained by the regression model. This is because the model does fit the data well. The R square of the model was able to account for 7% of the variance in environmental sustainability that may be attributed to Waste Management. This indicates that Waste Management is responsible for a 7% variation in Environmental Sustainability.

ANOVA[b], Table 4 reports the variance analysis of the regression model derived from this investigation. The F-

Table 3. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.265[a]	0.070	0.063	0.44002

[a]Predictors: (Constant), Waste Management

Table 4. ANOVA

	Model	Sum of Squares	df	Mean Square	F	Sig.
	Regression	1.829	1	1.829	9.444	0.003[a]
1	Residual	24.202	125	0.194		
	Total	26.031	126			

[a]Predictors: (Constant), Waste Management,[b]Dependent Variable: Environmental Sustainability

Table 5. Coefficients

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	Constant	2.995	0.347		8.639	0.000
	Waste Management	0.249	0.081	0.265	3.073	0.003

[a]Dependent Variable: Environmental Sustainability

statistics illustrate the significance of the entire model. This significance, in turn, is indicative of the model's significance level. In other words, the study's overall model holds significance, given that the F-statistics' significance level is below 5 percent.

Regression Coefficient[a], the estimated coefficient of 0.249 for the waste management variable in relation to the dependent variable of environmental sustainability suggests a positive relationship between these two variables (Table 5). Specifically, for every unit increase in waste management practices (assuming other variables are held constant), there's an estimated increase of 0.249 units in environmental sustainability. This coefficient signifies the strength and direction of the relationship between waste management and environmental sustainability within the context of the study. The significance of waste management is depicted by the significance level. Therefore, waste management is significant at the 1 percent significance level.

4. CONCLUSIONS

This study examined the impacts of waste management on environmental sustainability in the context of Afghanistan. The findings significantly demonstrate that positive correlation coefficient of 0.265 between waste management and environmental sustainability. This suggests that improved waste management practices significantly enhance environmental sustainability and vice versa. The model's R-squared value of 7% highlights the variation in environmental sustainability due to managing wastes properly. Furthermore, raising the management of waste by 1 unit would significantly escalate the environmental sustainability by 0.249 units. This positive relationship is statistically significant at the 1% level, underscoring the strong impact of waste management on sustainability outcomes.

5. ACKNOWLEDGEMENT

The authors sincerely appreciate the valuable time and meticulous proofreading efforts of Dr. Fazlullah Akhtar, whose guidance was instrumental in the completion of this research.

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