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# Understanding the Challenges of Solid Waste Management: Insights from Urban Bangladesh

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***Abstract***

*Solid waste management is a process that involves the collection, processing, recycling, refuse, reuse and disposal of waste to protect public health and ensure environmental sustainability in a longer run. In Bangladesh, rapid urbanization along with limited waste-management infrastructure have caused significant challenges, resulting either large portions of municipal waste unmanaged or disposed of in open dumps. This study investigates the challenges of solid waste management in Narayanganj City Corporation (NCC) using a mixed-methods approach. A sample of 138 participants was selected based on a 99% population proportion. The results identify key issues in solid waste management within NCC and provide a foundation for future research. A regression model incorporating five independent variables was analyzed using STATA 14. Disposal location ($p = 0.000$) and timeliness ($p = 0.040$) were significant at the 99% and 95% confidence levels, respectively, demonstrating strong associations at $P \leq 0.01$ and $P \leq 0.05$. The p-values indicate an absence of multi-collinearity in the model. Qualitative analysis further revealed challenges, consequences of mismanagement, and the procedures involved in waste management.*

**Keywords:** Service quality perception, Citizen satisfaction, Waste management, Sustainability

## Introduction

Urban planning relies heavily on the effective provision of essential services such as industry, housing, waste disposal, and drainage (Rahman, 2008;

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Abubakar et al., 2022). The efficiency of these services varies significantly between countries. In developing nations, limited accountability often leads to inefficiency (Ahmed & Ali, 2004; Guerrero, Maas, & Hogland, 2013), whereas developed countries manage these services effectively with advanced technologies (Mmereki, Baldwin, & Li, 2016; Azevedo et al., 2021). South Asian countries, in particular, face notable challenges in environmental management, while some nations have established comprehensive systems (Dhokhikah & Trihadiningrum, 2012; Hoornweg & Thomas, 1999). Regional factors, including environment, climate, and culture, also play a crucial role in determining the effectiveness of waste management (Vergara & Tchobanoglous, 2012; Castillo & Otoma, 2013). While industrialized countries generate more waste, they often recycle efficiently through formal systems (Mmereki et al., 2016; Abubakar et al., 2022); in contrast, less developed countries produce less waste but rely on a combination of formal and informal management processes (Ali, Tanko, & Kovo, 2017; Ashikuzzaman & Howlader, 2020). A strong correlation exists between national income levels and solid waste management effectiveness: high-income countries manage waste at approximately $100 per ton, whereas low-income countries often manage it poorly at $35 per ton, resulting in environmental pollution and mismanagement (World Bank, 2018; Hoornweg & Bhada-Tata, 2012). Notably, 90% of solid waste in low-income countries is disposed of in ways that adversely affect both livelihoods and the environment (WB, 2018; Abubakar et al., 2022).

Bangladesh, home to over 165 million people (BBS, 2022), faces significant challenges in managing solid waste (Bhuiyan, 2010; Ahmed & Quader, 2011). Waste generation is an inevitable byproduct of daily life, arising from households, industries, medical facilities, and other sources (Alamgir et al., 2011; Asikuzzaman & Howlader, 2020). However, ineffective management has resulted in a persistent crisis that threatens public health and the environment (Rita, 2022; Alam, 2009). Despite initiatives by the Government of Bangladesh (GoB), including short-term (January 2024–December 2030), mid-term, and long-term (January 2031–December 2040) plans to improve waste management (Narayanganj City Corporation, 2021; Staff Correspondent, 2022), improper disposal remains a critical issue (Zurbrugg, n.d.; Thakur et al., 2021; Hoornweg & Bhada-Tata, 2012). Contributing factors include high population density, rapid urbanization, and inadequate infrastructure (Bhuiyan, 2010; Khan, Haque, & Hossain, 2024).

Effective solid waste management is widely recognized as essential for sustainable development and achieving the Sustainable Development Goals (Ahmed et al., 2017; Bowan, 2023). In Bangladesh, however, large amounts of waste continue to be discharged daily, often ending up in rivers and low-lying areas (Narayanganj City Corporation, 2021; Ahmed & Huq-Hussain, 2013). These practices increase the risk of disease, emit toxic gases, and pose serious threats to human health (McAllister, 2015; Rogers et al., 2002). Traditional waste management practices remain prevalent but are poorly aligned with contemporary needs (Jerin et al., 2022; Islam, 2021). Consequently, inadequate systems create disorder and environmental hazards, while many residents bypass official services and dispose of waste in open spaces or water bodies (Bhuiyan, 2010; Hossain et al., 2018; Barnabas et al., 2017; Vergara & Tchobanoglous, 2012).

This study aims to investigate the challenges and causes of solid waste mismanagement in Bangladesh, focusing on Narayanganj City Corporation as a case study (Ahmed & Quader, 2011; Abubakar et al., 2022). The objectives are to assess citizen satisfaction with waste management services, evaluate public understanding, examine policy implementation, and analyze service timeliness (Cervantes et al., 2018; Lagman-Bautista, 2020). By linking solid waste management processes with waste generation, this research develops a conceptual framework that highlights the consequences of mismanagement and explores potential solutions to benefit citizens (Marshall & Farahbakhsh, 2013; Kanchanabhandhu & Woraphong, 2016).

Although prior studies have examined solid waste management in Bangladesh, few provide in-depth analyses of specific local contexts (Ahmed & Huq-Hussain, 2013; Khan et al., 2024). By focusing on Narayanganj; an industrial city generating substantial solid waste; this research identifies the obstacles faced by affected communities and contributes to understanding current challenges in waste management. Following this introduction, the study presents a literature review, develops an analytical framework, describes the research methodology, and reports findings from both qualitative and quantitative data. The study concludes with key insights, implications, and recommendations for future research.

## Literature Review

Solid waste management (SWM) encompasses both recycling and disposal processes (Choudhury, 2021) and is typically classified into categories such as wood waste, rubber, and textiles (Ahmed & Ali, 2004; Guerrero, Maas, & Hogland, 2013). Although landfilling remains a common disposal method, it poses significant environmental and climatic risks. Improper dumping not only contaminates soil and water with hazardous substances but also exacerbates public health risks, underscoring the need for coordinated strategies at both national and regional levels (Hoornweg & Bhada-Tata, 2012; Abubakar et al., 2022).

In Bangladesh, recycling initiatives emerged in the 1980s and 1990s (Ashikuzzaman & Howlader, 2020); however, both governmental and NGO-led interventions have yet to achieve their intended outcomes (Ahmed & Huq-Hussain, 2013). A conventional SWM system typically comprises four stages: collection, transportation, disposal, and recycling (Talukder et al., 2021; Marshall & Farahbakhsh, 2013). To promote sustainability, numerous NGOs and community-based organizations are now collaborating to develop effective sorting and recycling mechanisms (Ali, Tanko, & Kovo, 2017; Azevedo et al., 2021).

Ahmed and Hussain (2011) identified inadequate disposal practices as key contributors to environmental degradation and urban pollution. Their analysis of waste types, quantities, and environmental factors highlighted the need for targeted interventions. Similarly, Chowdhury (2021) emphasized that waste is generally perceived as undesirable, highlighting the importance of timely and accountable services to ensure both employee responsibility and citizen satisfaction. Improvements across all phases—collection, transportation, final disposal, and recycling—require the application of scientific methods, stricter oversight of dumping sites, and efficient sorting techniques (Choudhury, 2021; Ristić, 2005).

Rapid urbanization in Bangladesh has significantly intensified waste generation. Islam (2021) reported that Dhaka currently produces 6,500 tons of solid waste daily, a figure projected to reach 8,500 tons by 2032, calling for comprehensive policy, structural, and procedural reforms. Consistent enforcement of regulations has been shown to enhance operational efficiency (Jerin et al., 2022; Marshall & Farahbakhsh, 2013). Mismanaged waste has far-reaching consequences, including environmental pollution, increased

public suffering, and heightened disease prevalence (Saha, 2013; Bakar et al., 2022). A case study by Ahmed and Quader (2011) in Narayanganj City exemplifies how inadequate waste management adversely impacts both the environment and public health, and provides actionable recommendations for improvement.

To mitigate such risks, Dewangan et al. (2022) advocated separating solid waste from air, water, and soil and promoting composting of biodegradable materials. Environmental health hazards are often directly linked to ineffective waste management, highlighting the necessity for systematic and comprehensive interventions (Ahmed & Huq-Hussain, 2013; Choudhury, 2021). Each stage of SWM, from generation to recycling, involves distinct procedures that require careful planning, monitoring, and execution to prevent detrimental outcomes (Talukder et al., 2021; Guerrero et al., 2013).

Previous studies have primarily focused on specific determinants of waste management and regional waste quantification. This research, however, seeks to address three central challenges in Bangladesh's SWM, clearly delineating its scope while proposing actionable solutions. Unlike earlier studies that relied predominantly on qualitative approaches, this study employs a mixed-methods design, combining qualitative and quantitative data with in-depth interviews. The objective is to identify key operational challenges within Narayanganj City Corporation, examine the underlying causes of inefficiencies, and assess the consequent impacts on residents.

## Conceptualizing Solid Waste Management: A Process Perspective

Solid waste management is defined as the systematic process of collecting, segregating, treating, and ultimately disposing of solid wastes (Hoornweg and Bhada-Tata, 2012). An effective waste management system is characterized by the 4R principles: Reduce, Reuse, Recycle, and Recover, which collectively indicate a comprehensive approach to solid waste management (Marshall and Farahbakhsh, 2013). These principles address methods for minimizing waste generation, reusing materials, implementing recycling systems, and facilitating resource recovery (Guerrero et al., 2013). As previously noted, solid waste management requires a systematic approach that incorporates all stages from inception to completion (Dhokhikah and Trihadiningrum, 2012). Each stage is essential for effective system

management, and the omission of any component can result in mismanagement (Ashikuzzaman and Howlader, 2020). For instance, failure to deposit waste at designated dumping sites can lead to health risks and environmental pollution. Adherence to established protocols, such as using triple-layered paper during waste transfer, is also necessary. The following section presents a detailed discussion of the solid waste management process.


**Fig 01: Procedures of solid waste management (Prepared by authors)**

### *I. Waste Generation and Segregation*

The first step in SWM involves identifying sources of waste and categorizing it into types such as organic, recyclable, and non-recyclable materials (Ahmed & Ali, 2004; Guerrero et al., 2013). Effective segregation at the household and industrial level reduces contamination, facilitates recycling, and minimizes environmental hazards (Ashikuzzaman & Howlader, 2020). Public awareness and education are critical at this stage, ensuring compliance with proper disposal practices (Guerrero et al., 2013; Adipah & Kwame, 2019).

### II. *Waste Collection*

Waste collection is conducted through scheduled operations designed to cover all residential and commercial areas. It includes Door-to-door collection where personnel pick up segregated waste directly from premises, ensuring convenience and compliance and Community bin collection where shared bins are strategically placed in neighborhoods to facilitate bulk collection. Specialized vehicles equipped with compartments for different waste types are used to minimize cross-contamination during collection (Talukder et al., 2021). Efficient route planning, considering household

density, waste generation rates, and traffic patterns, ensures timely and comprehensive service coverage (Choudhury, 2021).

### *III. Waste Transportation*

Collected waste is transported to intermediate transfer stations or directly to treatment facilities, depending on infrastructure availability. Transfer stations serve as consolidation points, enabling optimized transportation to final disposal or processing sites (Hoornweg & Bhada-Tata, 2012; Guerrero et al., 2013). Specialized vehicles ensure safe handling, reduce environmental impact, and prevent spillage or contamination.

### *IV. Waste Treatment and Processing*

Treatment methods are selected based on waste characteristics, environmental standards, and technological capacity. Treatment involves reducing the volume and hazard potential of waste before final disposal. This includes Recycling, where materials such as plastics, metals, and paper are processed for reuse, Composting, for biodegradable waste, converting it into useful organic fertilizer (Dewangan et al., 2022), and Energy recovery**,** including waste-to-energy processes, where appropriate (Marshall & Farahbakhsh, 2013).

### *V. Waste Disposal*

Final disposal occurs at designated landfills or engineered sites to prevent environmental contamination. Proper siting of disposal sites is critical to avoid degradation of soil, water, and surrounding ecosystems (Islam, 2021; Guerrero et al., 2013). Adherence to regulatory standards and established protocols, such as triple-layered waste handling, is essential to ensure environmental safety and public health.

### *VI. Monitoring, Enforcement, and Public Engagement*

Continuous monitoring and law enforcement are integral to maintaining system efficiency. This includes Regular inspection of disposal sites and treatment facilities, enforcement of municipal laws to prevent illegal dumping, training programs for waste management personnel to enhance technical capacity and safety practices, and public education campaigns to raise awareness of proper disposal methods and environmental consequences of mismanagement (Ashikuzzaman & Howlader, 2020; Guerrero et al., 2013).

**Effective Solid Waste Management: Towards an Analytical Framework**

Based on the above discussion, effective waste management for our selected case, i.e. NCC hinges on selecting appropriate disposal sites, as poor site selection often leads to mismanagement and environmental harm. In this industrial hub, inadequate site designation, especially in low-lying areas, worsens environmental degradation. The availability of proper sites reflects management quality. However, the lack of staff training and public awareness remains a key obstacle. To address this, targeted training and public education are crucial for building operational capacity and reducing public health risks, such as increased diseases like dengue, underscoring the urgent need for better waste management and community engagement. Robust regulatory enforcement is the foundation of effective waste management in NCC. Ensuring strict legal compliance from residents and employees underpins adherence to procedures. Citizen forums and participation with the city corporation foster accountability and enable feedback. Consistent collection and recycling initiatives further drive systematic, sustainable outcomes highlighting that collective action and strong oversight are central to achieving efficient waste management (Hoornweg & Bhada-Tata, 2012; Marshall & Farahbakhsh, 2013).

To analyze these issues, we conducted a regression model in which solid waste management was treated as the dependent variable, while other key influencing factors were considered as independent variables (See Figure 02).

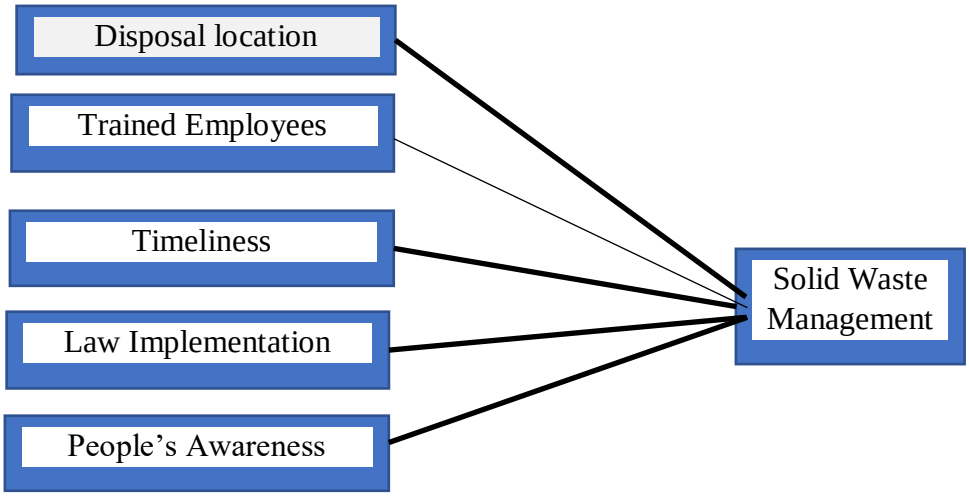


**Fig 02: Analytical Framework for understanding factors influencing solid waste management**

Now, $SWM = \alpha + \beta_1 DL + \beta_2 TRAIN + \beta_3 TIME + \beta_4 LAW + \beta_5 PEOP + e$

Here,

α = Intercept, SWM= Solid Waste Management, DL= Disposal Location, TRAIN= Trained Employees, TIME= Timeliness, LAW= Law Implementation, PEOP= People's Awareness

## Methodology

The overarching objective of this study **is** to identify the challenges associated with solid waste management (SWM) at Narayanganj City Corporation (NCC). Specifically, the study seeks to elucidate the procedures of solid waste management implemented by Narayanganj City Corporation, examine the challenges experienced by residents in areas affected by inadequate waste management, assess the efficacy of existing initiatives undertaken by Narayanganj City Corporation to improve SWM.

To address these objectives, the study adopts a mixed-methods approach, integrating both qualitative and quantitative research methodologies. Qualitative data are collected through focus group discussions (FGDs), direct observation, in-depth interviews (IDIs), and key informant interviews (KIIs). Quantitative data are obtained via a structured survey administered to residents of Narayanganj. Both primary and secondary sources are utilized, with primary data collected directly from the target population and secondary data drawn from NCC statistics, peer-reviewed articles, journals, books, e-resources, newspapers, and other scholarly publications.

A total of 138 participants were surveyed using statistical sampling techniques. From this group, 15 to 20 individuals were selected for in-depth interviews (IDIs) through convenience sampling to provide supplementary qualitative insights. Two focus group discussions (FGDs) (See Table 01) were conducted: the first included 8 to 10 service providers from Narayanganj City Corporation and lasted 30–35 minutes, while the second involved 7 to 10 participants, including vendors, drivers, and other stakeholders, and lasted 20–25 minutes.

| FGD No. | Participants | Duration |
|---|---|---|
| 1 | 8–10 NCC service providers | 30–35 minutes |
| 2 | 7–10 stakeholders (vendors, drivers, other personnel) | 20–25 minutes |

**Table 01: An Overview of Focus Group Discussions (FGDs)**

The survey encompassed three administrative areas of Narayanganj City Corporation: *Shiddhirganj* (Wards 1–9), *Narayanganj* (Wards 10–18), and *Kadamrasul* (Wards 19–27), all of which fall under the corporation's responsibility for solid waste management. Additionally, eight Key Informant Interviews (KIIs) were conducted with relevant authorities, including the Town Planner, Head of the Solid Waste Management Department, a junior officer, and community leaders. Data were collected between September and October 2023. The main questionnaire comprised seven sections, including socio-demographic variables, and employed a five-point Likert scale. A checklist was utilized to guide the collection of information from key informants. Data collection methods included structured questionnaires, interviews, and direct observations, with respondents categorized as either service providers or service recipients. Quantitative data were entered and analyzed using STATA, including regression analysis of the dependent and independent variables. The study included only residents of Narayanganj City Corporation. Informed consent was obtained from all participants, ensuring adherence to ethical research standards.

## Result

### *Descriptive statistics of respondents' compendium*

Understanding the socio-demographic characteristics of respondents is crucial for contextualizing the findings related to solid waste management practices in Narayanganj City Corporation. Effective waste management depends not only on infrastructure and policy but also on citizen engagement, which is influenced by factors such as age, gender, education, occupation, and income. The present study surveyed a diverse sample to capture these variations comprehensively. The socio-demographic data (See Table 02) reveal a diverse sample, capturing variations in gender, age, area, occupation, education, and income, which are crucial for understanding participation in solid waste management activities. Female respondents slightly outnumber males (52.2% vs. 47.8%), reflecting higher engagement among women in the

surveyed areas. In terms of age, the largest group of respondents is 18–24 years (42.8%), indicating that young adults represent the primary demographic engaged in or affected by waste management initiatives. The smallest age group is below 18 (5.8%), while participants above 40 constitute 8.7%. Geographically, most participants reside in Narayanganj (40.3%), followed by *Shiddhirganj* (36.7%) and *Kadamrasul* (23%), which aligns with the administrative coverage of Narayanganj City Corporation. Occupation-wise, students dominate the sample (55.6%), while laborers are least represented (6.3%). This occupational profile also explains the income distribution: a majority of respondents (65.2%) earn less than TK 10,000, and only a few exceed TK 50,000. Regarding educational attainment, nearly half of the respondents (46%) have completed degree-level or higher education, while a small proportion have no formal education (6.5%). Other education levels are distributed across certificates, high school, secondary, primary, and diploma holders.

**Table 02: Descriptive statistics of respondents' profile**

| **Variable** | **Category** | **Frequency (%)** | **Variable** | **Category** | **Frequency (%)** |
|---|---|---|---|---|---|
| Gender | Male | 47.8 | Occupation | Student | 55.6 |
| | Female | 52.2 | | Professional | 21.8 |
| Age | Below 18 | 5.8 | | Labor | 6.3 |
| | 18–24 | 42.8 | | Unemployed | 7.7 |
| | 25–30 | 26.1 | | Others | 8.6 |
| | 31–35 | 8.0 | Education | Degree/Higher | 46.0 |
| | 35–40 | 8.7 | | Diploma | 4.3 |
| | Above 40 | 8.7 | | Certificate | 15.1 |
| Area | Narayanganj | 40.3 | | High school | 14.4 |
| | *Shiddhirganj* | 36.7 | | Secondary | 7.9 |
| | *Kadamrasul* | 23.0 | | Primary | 5.8 |
| Monthly Income (TK) | Less than 10,000 | 65.2 | | Never attended | 6.5 |
| | 11,000–20,000 | 19.6 | | | |
| | 21,000–30,000 | 6.5 | | | |
| | 30,000–50,000 | 5.1 | | | |
| | Above 50,000 | 3.6 | | | |

Overall, the descriptive statistics highlight that the study captures a representative cross-section of residents, including young adults, women, students, and individuals with varying education and income levels. This diversity ensures that subsequent analyses of solid waste management challenges reflect the perspectives of all key stakeholders in Narayanganj City Corporation.

### *Correlation Analysis of Solid Waste Management*

The correlation analysis reveals several notable associations between solid waste management and its independent determinants, as well as among the independent variables themselves. By definition, the correlation of each variable with itself equals 1.0000.

| Variable | SWM | DL | TRAIN | TIME | LAW | PEOP |
|---|---|---|---|---|---|---|
| **SWM** | 1.0000 | | | | | |
| **DL** | 0.3883** | 1.0000 | | | | |
| **TRAIN** | 0.3099** | 0.3923** | 1.000 | | | |
| **TIME** | 0.3250** | 0.2972** | 0.5486** | 1.0000 | | |
| **LAW** | 0.0409 | -0.1405 | 0.0538 | 0.0059 | 1.0000 | |
| **PEOP** | 0.2012** | 0.2673** | 0.5805** | 0.5165** | 0.0470 | 1.0000 |

** The correlation holds significance at the 0.05 level.*
*** The correlation holds significance at the 0.01 level*

**Table 03: Correlation Analysis of Solid Waste Management**

The correlation analysis (See Table 03) reveals several notable associations between solid waste management and its independent determinants, as well as among the independent variables themselves. By definition, the correlation of each variable with itself equals 1.0000. The findings indicate that **disposal location (DL, r = 0.3883), trained employees (TRAIN, r = 0.3099), timeliness (TIME, r = 0.3250), and public awareness (PEOP, r = 0.2012)** are significantly correlated with solid waste management at the 0.05 level, highlighting their critical roles in shaping SWM effectiveness. In contrast, law implementation (LAW, r = 0.0409) shows a

weak, non-significant association with SWM, suggesting that legal enforcement alone may not strongly influence management outcomes in this context. Interrelationships among independent variables are also evident**. TRAIN (r = 0.3923), TIME (r = 0.2972), and PEOP (r = 0.2673)** are significantly correlated with disposal location, while **TIME (r = 0.5486) and PEOP (r = 0.5805)** show strong associations with trained employees. Additionally, public awareness demonstrates a meaningful correlation with timeliness (r = 0.5165), indicating that informed citizens contribute to more efficient and punctual waste management operations.

### *Test of Multicollinearity of independent variables*

Before performing regression analysis, it is essential to ensure that the independent variables do not exhibit high intercorrelations, which can compromise the reliability of the model. To assess this, a multicollinearity test was conducted using the **Variance Inflation Factor (VIF)** for each independent variable.

| **Variable** | **VIF** |
|---|---|
| **DL** | 1.23 |
| **TRAIN** | 1.86 |
| **TIME** | 1.58 |
| **LAW** | 1.04 |
| **PEOP** | 1.65 |

**Table 04: Test of Multicollinearity of independent variables**

The results (See Table 04) indicate that all VIF values are well below the critical threshold of 10, which signifies that multicollinearity is not present among the independent variables. Values between 5 and 10 may suggest potential multicollinearity, while values exceeding 10 indicate a serious concern; however, the observed VIFs confirm that each independent variable; disposal location (DL), trained employees (TRAIN), timeliness (TIME), law implementation (LAW), and public awareness (PEOP); contributes uniquely to the regression model. Therefore, the regression estimates can be interpreted confidently without bias arising from multicollinearity.

***Multivariate Analysis of Solid Waste Management.***

To identify the key determinants of solid waste management in Narayanganj City Corporation, a multivariate regression model was employed. This model examined the influence of independent variables—disposal location, trained employees, timeliness, law implementation, and public awareness—on solid waste management. The analysis aimed to quantify the strength and significance of these relationships, providing a rigorous basis for understanding operational and managerial challenges.

| **SWM** | **Coef.** | **Std. Err.** | **t** | **P>\|t\|** | **[95% Conf.** | **Interval]** |
|---|---|---|---|---|---|---|
| **DL** | .300768 | .0823844 | 3.65 | 0.000** | .1378036 | .4637325 |
| **TRAIN** | .0789477 | .0828983 | 0.95 | 0.343 | -.0850334 | .2429287 |
| **TIME** | .1578197 | .0760402 | 2.08 | 0.040* | .0074046 | .3082347 |
| **LAW** | .0358412 | .0349617 | 1.03 | 0.307 | -.0333165 | .104999 |
| **PEOP** | -.0402169 | 0819167 | -0.49 | 0.624 | -.2022563 | .1218225 |

Number of obs = 138
F (5, 132) = 7.09
Prob > F = 0.0000
R-squared = 0.2118
Adj R-squared = 0.1819
*At 5% significant level (P≤ 0.05)
**At 1% significant level (P≤ 0.01)

**Figure 05: Multivariate Analysis of Solid Waste Management**

The primary correlation analysis (See Table 05) revealed that only two variables, disposal location (DL, p = 0.000) and timeliness (TIME, p = 0.040), demonstrated significant associations at the $P \leq 0.01$ and $P \leq 0.05$ levels, respectively. The coefficient for disposal location is 0.300768 at a 95% confidence interval, while the coefficient for timeliness is 0.1578197 at a 99% confidence interval. The p-values for the remaining variables were not significant. The R-squared value of 0.2118 indicates that the independent variables explain approximately 21.18% of the variation in reporting challenges.

Disposal location emerged as a critical variable in identifying the challenges of solid waste management in NCC. Inadequate and insufficient disposal sites, along with limited resources, may contribute to

mismanagement. The regression analysis indicated a positive association, with a coefficient of 0.300768 and a p-value of 0.000, which is significant at the 1% level. Therefore, the null hypothesis (H01: There is no significant correlation between solid waste and disposal location) is rejected, and the alternative hypothesis is accepted.

Trained employees also showed a positive coefficient; however, the p-value was not significant (0.343), leading to acceptance of the second hypothesis (H02: There is no significant correlation between solid waste and trained employees). The coefficient for timeliness was 0.1578197, with a p-value of 0.040, significant at $P \leq 0.05$, resulting in rejection of the third null hypothesis (H03: There is no significant correlation between solid waste and timeliness) and acceptance of the alternative. Law implementation had a coefficient of 0.0358412, but the p-value was not significant (0.347), so the fourth hypothesis (H04: There is no significant correlation between solid waste and law implementation) is accepted. The association between solid waste management and people's awareness was negative and insignificant, with a p-value of 0.624 and a coefficient of -0.0402169, leading to acceptance of the fifth hypothesis (H05: There is no significant correlation between solid waste and people's awareness).

### *Discussion*

As mentioned earlier, qualitative data was collected through key informant interviews with individuals involved in solid waste management. Two focus group discussions (FGDs) were conducted at the Al-Amin Nagar Sanitary Landfill (Ward 18, NCC). The first FGD involved service providers, while the second included an excavator driver and waste collectors focused on specific waste reduction. The first discussion lasted approximately 30 to 35 minutes and included 8 to 10 service providers, all of whom were waste collectors. The second discussion lasted 25 to 30 minutes and involved 7 to 10 participants, including two excavator drivers and three waste vendors.

Non-governmental organizations (NGOs) and the Community Development Cluster (CDC) are responsible for collecting household waste. These organizations apply to the city corporation for permission to operate, after which city officials, including the relevant ward commissioner, review the applications. Among the applicants, one organization is selected to assume responsibility. The selected organization is required to deposit a mortgage of 1,00,000 TK and must renew this arrangement annually. If the

organization fails to perform adequately, the city corporation may deduct charges from the deposit or deny renewal for the following year.

Employees are either affiliated with NGOs or the Community Development Cluster (CDC). Both types of organizations seek permission from the city corporation and subsequently hire waste collectors. Annual renewal of their activities is required, subject to a nominal fee. All current service providers are male; no women are employed in these roles. According to the junior town planner, solid waste management in the Narayanganj City Corporation (NCC) is conducted through three primary processes such as Collection of waste, Transportation, and Final disposal.

A waste collector reported that waste from the Narayanganj and *Shiddhirganj* areas is disposed of at this dumping site. Some van drivers deposit waste at the *Jalkuri* dumping area, although it is designated for the union. Waste from *Kadamrasul* is transported to the Bandar Dumping Site. An employee of the waste collection team shared the following experience:

> *"Some women are aggressive and they do not want to provide their waste to the waste collector for the charge. As a result, it is his challenge. If any member of the city corporation walks that filthy area, he has to be accountable for this mismanagement."*

After the initial collection process, waste is transferred to groups responsible for segregation and sale. One participant described the system: waste collectors first sell waste at 25 TK per kilogram to women working near the dumping site. The waste is then sorted by quality and sold to three vendors, who subsequently sell it to various mills for recycling. According to the excavator driver, no significant problems are encountered, as workers have adapted to the environment and reside near the dumping site.

The junior town planner of NCC reported that the *Panchoboti* Compost Plant produces 22 tons of composted fertilizer per day on a one-acre site. The Clean Officer of NCC, Head of the Department of Solid Waste Management, stated that the city covers approximately 72.43 square kilometers and generates 1,000 tons of waste annually. Each resident produces an average of

0.56 kilograms of waste per day. Various types of waste are generated, with solid waste being one category.

The Clean Officer further noted that there are six dumping sites within Narayanganj City Corporation: *Panchoboti* Compost Plant, *Jalkuri* Dumping Site, *Jalkuri* Landfill (Extension), Al-Amin Nagar Sanitary Landfill, Bandar New Dumping Site, and Saidpur Dump Site. Of these, the Saidpur Dump Site is temporary.

The junior town planner of Narayanganj City Corporation (NCC) provided an overview of human resources. NCC operates 25 dumping vehicles and employs 31 truck drivers. The Clean Officer stated that NCC does not employ direct housing waste collectors. However, 1,135 road cleaners work from 6:00 to 10:00 a.m. A waste collector described their daily activities as follows:

> *"They have only one holiday. They do not work on Friday. If a worker misses a day, they must compensate by working more on Saturday, which doubles the workload."*

Another participant in the discussion stated:

> *"Without working regularly, I cannot maintain stability. It is my duty to clean the city. I take two holidays during Eid. I strive to work efficiently. I collect 100 to 120 units per house, but I always encourage all citizens to provide their waste, even if they pay only 50 TK. I never discourage anyone. If a resident does not provide their waste, it becomes my responsibility to address the challenge. I consistently aim to keep my ward clean."*

Another service provider discussed income and expenditure, noting that earnings are received directly from service recipients. After paying necessary charges, the remaining income can be saved. Another participant commented that the working hours are relatively short, with collection and dumping activities scheduled from 6:00 to 10:00 a.m., after which workers return home. A waste collector reported that earnings increase significantly during Eid and Puja holidays, and expressed satisfaction with the work. One

collector manages waste from 250 to 300 households and receives an average of 100 TK per month.

The town planner of NCC reported that Narayanganj City Corporation operates efficiently. However, the Solid Waste Management Policy 2021 has not yet been implemented. This policy aims to ensure waste is collected in three separate bins at the source and to enforce regulations against disposing of waste in drains. Its effectiveness will be evaluated following implementation. NCC currently operates under the Local Government Act 2009 and is working to achieve Sustainable Development Goal 11.6 by advancing waste management practices. Organic fertilizers are produced through aerobic decomposition; if not recycled regularly, methane (CH4), a greenhouse gas 26 times more potent than carbon dioxide (CO2), is generated. In addition to the Local Government Act 2009, NCC follows the National 3R Strategy 2010 and the Biomedical Waste Management Rule 2008 for medical waste.

An inspector from Ward 1 noted that the current counselor is effective and that mosquito control measures are regularly implemented. The city corporation deploys two teams, Team A and Team B, to inspect waste management across different areas daily. Public awareness is promoted through regular engagement, such as encouraging shopkeepers not to dispose of waste between 6:00 a.m. and 8:00 p.m. and to use bins provided at minimal cost. Shopkeepers are required to store waste until collection each morning. A significant challenge remains with hawkers who contribute to environmental pollution. Additionally, approximately 200,000 to 250,000 non-residents travel daily from *Bandar* to *Sadar*, exacerbating waste management issues. At the *Panchoboti* Compost Plant, organic waste is processed into compost. The recent 'Waste to Energy' project in *Jalkuri* is a notable initiative. Sheikh Rasel Nagar Park, previously inactive, has been renovated to align with eco-friendly standards, earning recognition from the Chinese government. Similarly, the Malta government recognized NCC for improvements at *Shiddhirganj* Lake Park. Upcoming projects include establishing a shop adjacent to the city corporation to purchase plastics from citizens, which will then be used to produce eco-friendly fruit baskets and plastic ropes. The junior town planner indicated that a report on NCC has been submitted to the World Bank. According to the Clean Officer, a project in *Jalkuri*, in partnership with a Korean group, will process 600 tons of waste

daily to generate 6 MW of electricity. The 'Waste to Recycle' facility is located in *Dashergaon* (Ward 25).

### *Unpacking the Conundrums of Solid Waste Management*

Despite several successful initiatives, the city corporation continues to encounter significant challenges in managing solid waste effectively. The Statistics Department of Narayanganj City Corporation reports the existence of only six landfills, two of which are still under development. These facilities are insufficient to accommodate waste generated across the city's extensive area. According to a junior cleaning officer, the corporation employs only one town planner, which is inadequate for comprehensive urban planning. In comparison, the Dhaka City Corporation reportedly employs seven or more planners, highlighting a resource gap. The Local Government Act of 2011 mandates strict enforcement, stipulating fines of up to 50,000 TK for violations of environmental regulations. The junior cleaning officer further recommended that government efforts should address not only specific localities but the entirety of Bangladesh, as sustainable development requires an integrated national approach. Additionally, the introduction of a reward system for reducing carbon dioxide emissions was suggested. Improper solid waste management leads to serious public health consequences, including outbreaks of cholera, hepatitis, typhoid, polio, and dengue. While legislation alone may not alter public attitudes, effective enforcement can mitigate mismanagement. A critical challenge identified is the inability to deliver medicines to rooftops with gardens, where stagnant water can accumulate and facilitate the breeding of *Aedes* mosquitoes. An inspector reported that vaccines for cancer (for girls aged 9 to 14), hepatitis, and other diseases are provided, but emphasized the need for comprehensive guidelines and promotion of personal hygiene among citizens. Many residents do not dispose of waste properly, often dumping it near their homes, which degrades the environment. Nevertheless, it was noted that sanitation workers generally fulfill their duties effectively. It was recommended that the city corporation should first identify key issues before implementing solutions. Conversely, new members participating in the focus group discussion reported no significant challenges in waste management, stating that operations proceed smoothly. Although initial adjustment to the environment posed difficulties, these were overcome over time. Persistent challenges include lack of strategic management, insufficient expertise, limited resources, inadequate budget,

rapid urbanization, shortage of qualified personnel, and restricted discretionary authority.

## Conclusion

### *Key Findings and Contributions*

The present study sought to identify challenges in effective solid waste management by examining operational processes, causes of mismanagement, and resulting consequences. Quantitative analysis revealed a statistically significant relationship between management effectiveness and both disposal location (p-value = 0.000, 99% confidence) and timeliness (p-value = 0.040, 95% confidence). Qualitative findings identified challenges such as insufficient awareness and lack of public interest. Effective solid waste management is critical for environmental protection and necessitates a holistic approach that integrates environmental, social, and cultural considerations. These interconnected dimensions are constrained by factors such as limited budgets and adverse health impacts. The local government allocates only 8% of total expenditure to solid waste management (BBS, 2022), amounting to 2,260 crores in 2020-21, which restricts operational effectiveness. Enhanced community engagement, in conjunction with government initiatives, is required to improve outcomes.

The findings indicate that both employees and citizens play essential roles in effective solid waste management. Prioritizing environmental and public health concerns is necessary. Workers require adequate training and clear operational guidelines, while citizens must adhere to environmental regulations and Local Government Engineering Department (LGED) procedures. By identifying key challenges and presenting statistical evidence, this study seeks to increase public awareness of the significant health risks associated with mismanaged waste.

### *Implications of Study and Future Scope of Research*

These findings will assist the Narayanganj City Corporation in understanding current citizen perceptions. The implications are categorized into three primary areas.

First, policymakers can utilize these findings to evaluate the sector's limited progress and identify existing constraints. Despite the presence of relevant laws, stakeholders have not achieved the desired outcomes, and this study highlights ongoing challenges. Second, the study provides an objective and scientific assessment, which may benefit students, authors, and professionals seeking to expand their knowledge. Finally, future researchers can reference this study in their literature reviews.

In conclusion, the study's triangulated perspectives underscore the shared responsibility of service providers and citizens, particularly in the context of limited funding and inadequate services. To enhance solid waste management, authorities should maintain consistent oversight and engage in ongoing dialogue with citizens to assess service quality. Such collaboration strengthens accountability and raises awareness of health risks associated with improper waste practices. Solid waste management remains essential to public health and environmental sustainability, necessitating active participation from all stakeholders.

While the findings from our study are valuable, we acknowledge that it is constrained by a cross-sectional research design and reliance on a single case study. Therefore, future research should employ multi-case study methods encompassing broader geographic areas to allow cross-case comparisons for testing the validity of our findings.

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