Waste Flow Diagram (WFD) Report

Kushtia Municipality Bangladesh

2025

WASTE CONCERN

BORDA SOUTH ASIA

german cooperation

A REPORT ON

Waste Flow Diagram
Kushtia Municipality

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Abbreviations

3R	Reduce, Reuse, Recycle
BMZ	Federal Ministry for Economic Cooperation and Development
FSTP	Faecal Sludge Treatment Plant
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GHG	Greenhouse Gases
ISWA	International Solid Waste Association
MSW	Municipal Solid Waste
NGO	Non-Governmental Organisation
SDG	Sustainable Development Goals
WFD	Waste Flow Diagram

Chapter 1
About the Waste Flow Diagram

1.1. What is a Waste Flow Diagram?

The Waste Flow Diagram (WFD) tool estimates the amounts of solid waste that leak into nature and oceans from various sources. Through a scenario function, it simulates how improved waste management could reduce environmental pollution and avoid marine litter.

The WFD was developed since insufficient waste management is considered one major source of marine litter, especially along coasts and rivers. Understanding the leaks and pathways of plastic waste into the environment is key to developing effective measures to beat plastic pollution.

Marine litter poses a global risk to marine ecosystems, the fishing and tourism industry, and possibly human health. About 60 to 90% of marine litter consists of plastics, much of which comes from single-use products and packaging. According to estimates, between 4.8 and 12.7 million tons of plastic debris leak into the world's oceans each year. In a business-as-usual scenario, annual marine plastic pollution will triple by 2040.

On behalf of BMZ, the tool was developed in cooperation with GIZ, the University of Leeds, Eawag- Sandec, and Waste Aware. It is based on a preliminary method that was applied in two case studies as part of the report.

1.2. Waste Flow Model

The adequate collection and disposal of municipal solid waste (MSW) is a global challenge, particularly impacting low- and middle-income countries, as recognized by its inclusion in the United Nations Sustainable Development Goals (SDG 11 "Sustainable cities and communities"). Indicator 11.6.1 aims to monitor the "proportion of municipal solid waste collected and managed in controlled facilities out of total municipal solid waste generated by cities". According to current estimates, 2 billion people worldwide have no access to waste collection services, and 3 billion people's waste is managed in an environmentally unsound manner (Wilson et al., 2015). This has severe impacts both on human health and the environment, with one rapidly emerging problem being plastic pollution.

Plastic pollution is a reality and affects all ecosystems of our planet. It causes severe danger to animals, blocks drains and waterways, triggers and worsens floods, degrades landscapes, and is already present almost everywhere, including the food chain. More than 6,300 million tonnes of plastic have been produced since the 1950s (Geyer et al., 2017), of which 360 million tonnes of plastic were produced in 2018 alone. All of this plastic eventually becomes waste. Currently, only 9% of the total global plastic waste is recycled, while 12% is burned or incinerated. The remaining 79% accumulate on landfill sites or the natural environment.

Oceans are thought to be a major final sink for some of this plastic, as about 80% of marine litter is believed to derive from land-based sources (Eunomia, 2016). For macro plastics, this is largely a result of a lack of waste collection infrastructure and poor waste management practices, particularly within low- and middle-income settings. Furthermore, increasing populations and consumption of resources are exacerbated by these issues, with a need to promote reduction, reuse, and recycling within solid waste management (SDG 12.5). Once in the ocean, the larger macroplastic items undergo degradation into innumerable secondary microplastics that are beyond any control and have deadly impacts on marine life and the health of the oceans (SDG 14.1). It is, therefore, paramount to prevent macro plastic pollution at source before it becomes uncontrolled in the environment and potentially enters waterbodies.

The structure of the waste flow model is introduced, and the underlying simplifications are considered for its development. Additionally, the user interface of the Excel-based model is discussed before specifying the linkage with the SDG indicator 11.6.1 and its accompanying methodology.

Figure 1: *Adequate Solid Waste Management is Linked to a Number of SDG Indicators*

Figure 1 includes: 11.6 – by 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management; 12.5 – by 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse; and 14.1 – by 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities including marine debris & nutrient pollution.

The WFD aims to provide a rapid assessment methodology for mapping the flows of macro waste in a municipal solid waste management system at the city or municipality level, including quantifying the sources and fate of any plastic pollution.

This aim can be summarised into six objectives:

- To provide a rapid assessment of a city or municipality's municipal solid waste management system and visualize the flows of waste, including informing the SDG 11.6.1 sub-indicators.
- To use observational-based assessments to quantify the sources of plastic leakage into the environment from the municipal solid waste management system and determine the eventual fate of this uncontrolled waste.
- To identify the high-priority sources of plastic pollution to make informed interventions.
- To allow benchmarking and comparison between cities.
- To run scenarios to gain approximate insights into how proposed interventions may impact the solid waste management system and plastic pollution.
- To quantify the effectiveness of applied interventions.

Chapter 2
Town Profile

2.1. Location

Kushtia Municipality is a prominent urban centre located in the southwestern region of Bangladesh, serving as the administrative, economic, and cultural hub of Kushtia District. Established on April 1, 1869, under the Municipal Act of 1868, this municipality has undergone significant transformations over time. From the Mughal period, its strategic location has made it a significant trade centre. Situated on the bank of the Gorai River, Kushtia serves as a vibrant cultural and economic hub, renowned for its contributions to industries, as well as its association with the mystic poet Lalon Shah, making it a centre of both commerce and heritage. Today, Kushtia stands as an 'A' category municipality, reflecting its growth and development over the years.

Table 1: General Information of Kushtia Municipality

Name of the Town/City	Kushtia Municipality			
Province/District/State/UT	Kushtia, Khulna, Bangladesh			
Area of the Town (sq. km)	42.79 (BBS, Small Area Atlas of Bangladesh 2016)			
Number of Wards	21			
Total Population	2022: 2,21,804 (Census 2011)		Estimated Present: 2,26,800 (2024)	
	Male	Female	Male	Female
	112,226	109,578	114,754	112,046
Population growth rate (%)	1.69%			
Floating Population (If applicable)	253 (BBS, 2022)			
No. Properties	Residential	Commercial and Institutional		Others
	37.51 %	8.48%		54.01%
No. of Notified Slums	38			
No. of Non-Notified Slums	57			

Figure 2: *Location Map of Kushtia Municipality*

2.2. Demography

Kushtia Municipality covers an area of 42.79 sq km, consisting of 21 Wards and 19 Mouzas. Before 2015, Kushtia had 12 wards. According to the data from the Bangladesh Bureau of Statistics (BBS) 2011, the total area was 13.4 sq km. As of 2022, the estimated population has increased to 2,21,804, with a growth rate of 1.69%. The population density is 5,184 persons per km², with variations across different wards. Kushtia is one of the fastest-growing municipalities in Bangladesh, with potential for industrial and overall development. Population projections indicate that Kushtia Municipality will reach approximately 333,172 by 2035.

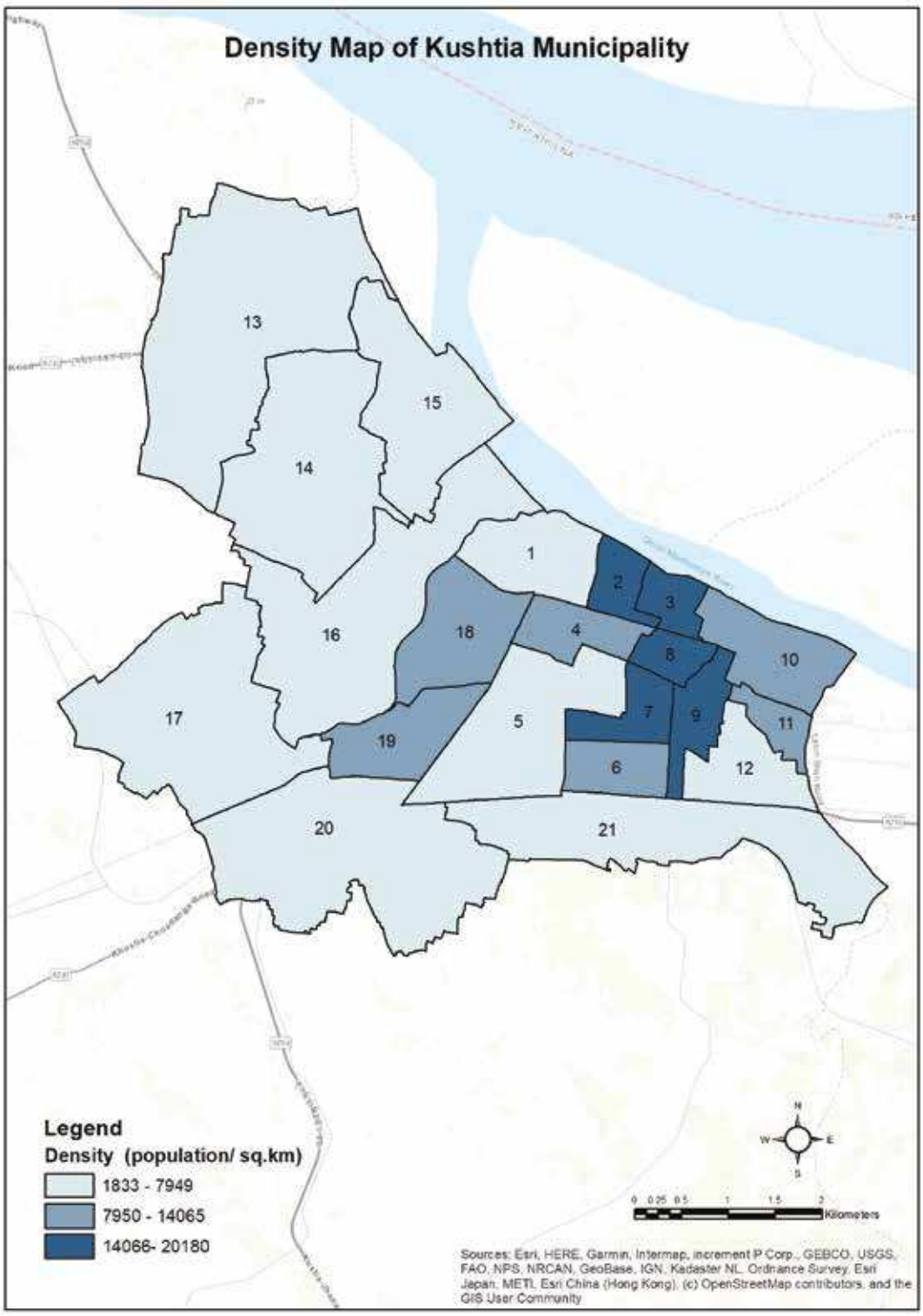

Figure 3: *Population Density Map of Kushtia Municipality*

2.3. Economy

The economy of Kushtia Municipality is comprised of both the Formal and Informal Sectors. Two key drivers of economic development, employment generation and productivity growth, play a vital role in ensuring the region's prosperity and physical growth. To support the economic well-being of the workforce, various projects must focus on creating job opportunities. A socio-economic study highlights that the primary occupation in Kushtia Municipality is in the service sector. The area has significant potential for industrial development. Additionally, migration to Kushtia is substantial, with 75% of the migrant population coming from adjacent rural areas, contributing to the town's dynamic growth.

2.4. Administrative Division

Table 2: Ward-wise Information of Kushtia Municipality.

Ward. No.	Area (Sq. Km)	No. of Households	Population	General Income Status	Remarks
1	1.42	1,587	9185	Mixed-income area	Kamalapur Nabin Pramanik Primary School
2	0.55	2,081	10703	Mixed-income area	Thanapara temple
3	0.46	2,262	12028	Mixed-income area	Lovely tower
4	0.72	1,939	8824	Mixed-income area	Eidgah Para
5	2.56	3,272	14587	Mixed-income area	Stadium field
6	0.80	1,918	11488	Mixed-income area	Jailkhana Mor
7	0.65	1,665	8072	Mixed-income area	Housing Kodomtola mor
8	0.37	1,478	8610	Mixed-income area	Rajar Hat
9	0.70	1,551	10318	Mixed-income area	Hazrat Nafarshah Mazar
10	0.91	2,436	12209	Mixed-income area	Shamsul Ulum Madrasa
11	0.55	1,097	6035	Mixed-income area	Mohini Mils
12	1.53	1,751	9665	Mixed-income area	Harshankarpur Water Tank
13	5.84	2,538	14856	Mixed-income area	Trimohoni Bazar
14	3.03	1,600	10074	Mixed-income area	Jugia Mondol Para
15	1.51	1,670	10079	Mixed-income area	Kana Biler Mor
16	5.97	2855	14561	Mixed-income area	Mongolbaria Bazar
17	4.16	3,641	9454	Mixed-income area	Sugar Mill Dhaka Dhalu para
18	1.43	7,530	16746	Mixed-income area	Udibari Munshurshahar Mazar
19	1.37	4,744	16846	Mixed-income area	Chourhash Jagati Bazar
20	3.91	1,623	11506	Mixed-income area	Kumargara BTC Mor/ BRB Group
21	4.37	2,051	13077	Mixed-income area	Lahini School Para
Total	**42.79**	**51,289**	**238922**		

2.5. Land Use

According to the land use survey findings, the study area shows that the largest category of land use is for Residential and Homestead purposes, covering 3,429.25 acres of the total area. Water bodies are the third highest category, occupying 10.87% (993.47 acres) of the land, while approximately 34.87% (3,188.21 acres) of the land is dedicated to agricultural use.

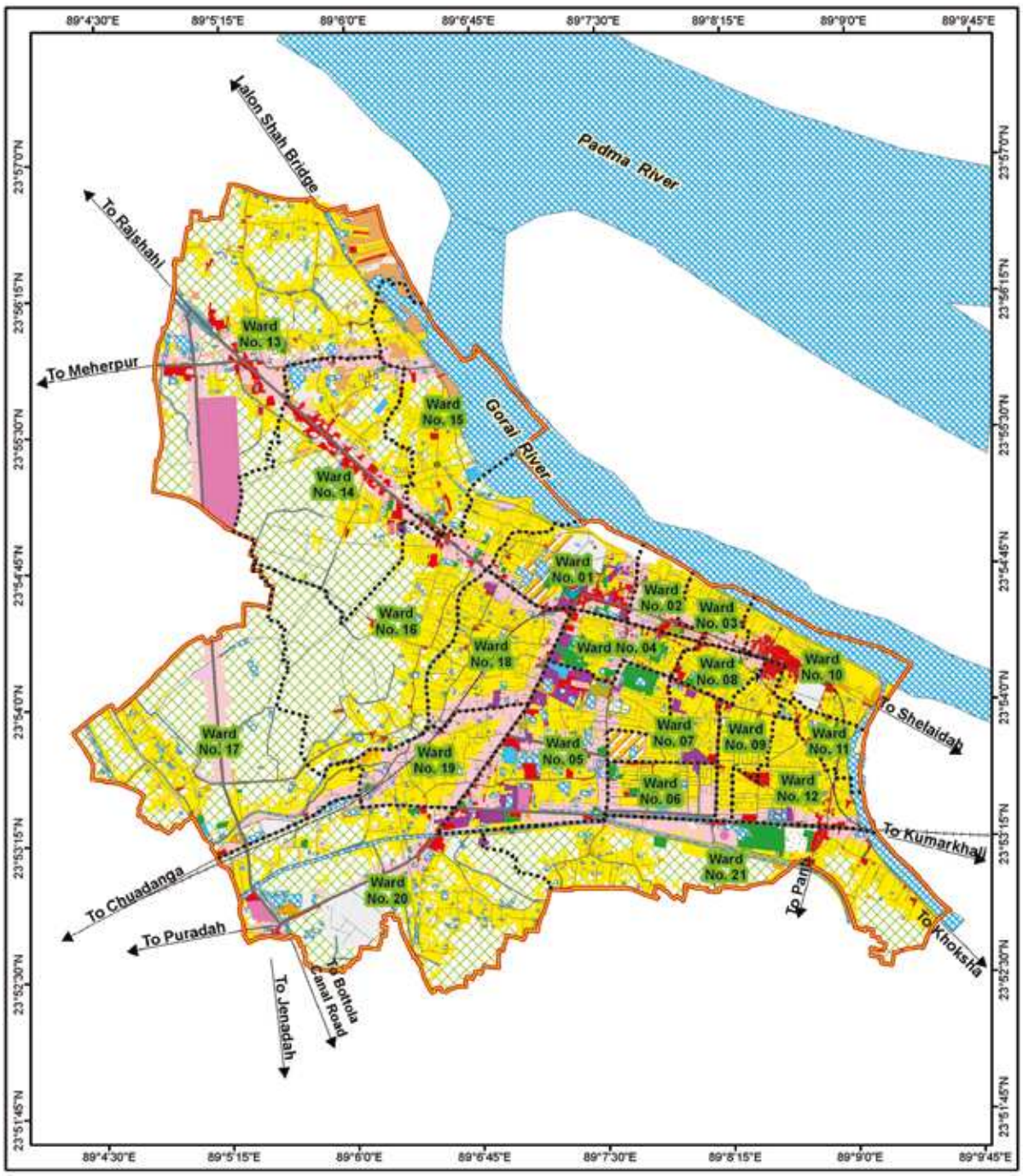

Figure 4: *Land Use Map of Kushtia Municipality*

Chapter 3
Solid Waste Management in Town

3.1. Segregation

At present, 99.8 tonnes of solid waste are generated daily within the municipal area. Municipal solid waste primarily consists of food, vegetables, fruits, polyethylene, paper, and cloth. The Municipality provides primary waste collection services. It is reported that approximately 50% of households in the old wards are covered by house-to-house waste collection services. However, it is also observed that none of the HHs follow waste segregation. Segregation of recyclable waste is generally not practised. A portion of recyclable waste is collected by feriwalas directly from households. However, most of it is disposed of along with domestic and commercial waste. Therefore, recyclable waste is usually mixed with street garbage in municipal bins and dumpsites. Most residents dispose of their solid waste in vacant spaces and open drains. This is primarily due to a lack of awareness-raising programs by the Municipality or Civil Society Organizations. Waste from the households is collected with the help of Primary Collection Service Providers (PCSPs) from the NGOs.

Figure 5: *Waste collection Without Source Segregation*

There are 38 slums in the Municipality area, with approximately 5833 households, which is about 16.24% of the total households in the municipality area. Currently, no waste collection service is provided by the municipality in the slums. Slum-dwellers are presently disposing of their waste in low-lying areas or natural drainage canals near the slums.

3.2. Transportation

Waste is collected between 9 AM to 5 PM. On average, the municipality collects 63 tons of solid waste daily. Currently, around 48 rickshaw vans are used to collect the garbage from the HHs. The Rickshaw vans (length 1.2 m x width 1.06 m x height 0.76 m) can accommodate approximately 350 kg to 400 kg of waste per trip. Approximately 16.8 tons of waste are collected per day through the rickshaw vans per trip.

Figure 6: *Current Door-to-Door Van Service for Household Waste Collection*

Source: Field Survey, 2021

The current design of the secondary storage area and collection points is inefficient and a source of environmental pollution. After collecting household waste, van drivers accumulate waste at transfer stations or open waste collection points. Two designated Secondary Transfer Stations (~ 225 sq. feet with roof and walls) exist. The authority's waste sorting system is inefficient, as it is done manually. This makes it time-consuming and not cost-effective.

Figure 7: *Secondary Transfer Station*

The municipality collects waste from these Secondary Waste Storage facilities through Garbage trucks with varying capacities of 5-ton, 3-ton,2-ton, and 1.5-ton. They are 9 in number, with an average age of 20-25 years. The repair cost of the truck amounts to BDT 99,73,610 per year. The maximum waste-carrying capacity of the current fleet is 15 trips per day. This results in a total carrying capacity of 38 tons per day. Total fuel consumption per day is found to be 75 litres per day.

Figure 8: *Truck for Secondary Waste Collection*

3.3. Waste Treatment

There is a compost plant and an FSTP in the landfill site of Kushtia Municipality. The compost plant uses the box method of composting with passive aeration technology. The municipality has outsourced its compost plant to a private company with the experience and license to produce and market the produced compost. The compost plant requires repair and maintenance as it was constructed more than 15 years ago. There are 12 composting boxes. The composting occurs under a covered roof. Leachate is collected and reused in the composting process. There are four drying beds for dewatering the faecal sludge. The percolate is treated using a trickling filter. The plant was designed by Waste Concern in 2008. The plant can compost 5 tons of organic waste and 18 cubic meters of faecal sludge daily. Co-compost is produced using municipal organic waste and dewatered faecal sludge.

Since 2016, the plant has been operated by a private-sector company named ERAS. As per the lease agreement, the private company has to pay BDT 50,000 per annum as lease money for the compost plant and the FSTP. The municipality is responsible for paying the electricity and water bills and the salaries of four security guards. The private sector bears all the O&M costs for the compost plant and FSTP. ERAS produces about 25-30 tons of co-compost per month. It is marketed by another company named Aprokashi Ltd, which possesses the Department of Agriculture Extension license to market compost commercially. The compost is sold at a price between BDT 10-15 per kg. The current lease of the plant is valid till 2024.

The municipality provides 5 tons/day of municipal waste to the plant at no cost to the private sector. AID Foundation supplies faecal sludge of 18 cubic meters per day to the FSTP. The municipality has leased 6 vacuum trucks to a private sector (AID Foundation). The private sector collects faecal sludge, amounting to 18 cubic meters daily. The municipality has fixed a rate for collecting faecal sludge based on the type of vacuum truck used. The city has one vacuum truck of

1000 litres, two trucks of 2000 litres, 2 vacuum trucks of 2500 litres, and one with a capacity of 4000 litres. As per the agreement, all O&M costs, fuel, and manpower are provided by the operator, as well as vehicle maintenance costs up to BDT 10,000 per vehicle. The fee collected for cleaning septic tanks and pit latrines is shared between the operator and the municipality at a 70:30 ratio. Recycling organic waste will also help increase landfill site's life and reduce GHG.

Figure 9: *Compost Plant*

Figure 10: *Co-Compost Plant at Baradi*

3.4. Disposal

Currently, the municipality disposes of solid waste at Majhidanga Mouza under the Kara Para Union situated in Ward No. 14. 2.75 km north of the core commercial and residential areas. The total site area is 15.12 acres. The site was acquired as a landfill site in 2017, and all the due processes related to land acquisition are complete. The site is currently used as a waste disposal facility using crude dumping methods. The collected waste is disposed of daily in an uncontrolled manner. A significant portion of the waste (60.27%) remains uncollected and unmanaged and is being indiscriminately disposed of in low-lying areas; this results in waterlogging during the monsoon season.

Figure 11: *Kushtia Municipality Landfill Site*

Figure 12: *Access Road to Landfill Site*

3.5. Reuse/Recycle

Currently, the efficiency of solid waste collection is estimated at 35%, excluding the waste collected by the informal sector for recycling. It is estimated that 5.7 tons of recyclables are managed by the informal sector per day. 17. There are an estimated 108 waste pickers in the town, of which eight are working in the landfill site. Apart from waste pickers, house-to-house waste collectors are also involved in collecting recyclable items from the waste. There are currently 45 rickshaw van drivers involved in the collection and selling of recyclable items. Feriwallas also collect recyclable items directly from the source (i.e., households, institutions, shops). Recyclable items collected by waste pickers, van drivers, and feriwallas are sold to junk shops locally. These shops are known as Vangari Dokan. There are 8 Vangari Dokan near the landfill and 11 in the town. These Vangari Dokan then sell the items to industries. The following table shows the number of recyclables collected by different actors in Kushtia.

Table 3: Recyclable Collected by Different Informal Sector Actors

Sl. No.	Actors	No.	Amount Collected/ Actor (Kg/day)	Total Collection for Recycling (Ton/day)	Remarks
1	Feriwalla	8	50	0.4	Clean
2	Tokai (Town)	100	40	4.0	Soiled
3	Tokai (Landfill)	8	39	0.312	Soiled
4	Van Collectors	45	22	0.990	Semi-Soiled
Total				**5.702**	

Source: Field Survey (2022).

The following Tables show the types of recyclables collected by the different actors as well as the selling price of recyclables in Kushtia.

Table 4: Types of Recyclables Collected by Different Actors

Recyclable Items Collection/buy	Landfill Tokai		Town Area Tokai		Van Driver		Feriwalla	
	Kg/day	(%)	Kg/day	(%)	Kg/day	(%)	Kg/day	(%)
Metal	3.86	9.93	2.0	5.03	0	0	6.375	12.75
Glass	2.43	6.25	1.75	4.41	0	0	4.52	9.04
Rubber	2.86	7.36	2.0	5.03	0	0	3.585	7.17
Paper	5.43	13.97	4.0	10.06	2.88	13.63	5.545	11.09
Leather	3.0	7.72	4.33	10.89	0	0	0.695	1.39
Plastic	21.3	54.78	25.67	64.58	16.58	78.47	19.32	38.64
Others	0	0	0	0	1.67	7.90	9.96	19.92
Total	**38.88**	**100.0**	**39.75**	**100.0**	**21.13**	**100.0**	**50**	**100.0**

Source: Field Survey (2022)

Table 5: Price of Different Recyclable Items

Actors	Avg. Selling price of Recyclables (Tk/Kg)						
	Metal	Glass	Rubber	Paper	Leather	Plastic	Other
Landfill Tokai	42	5	3	36	15	23	0
Town Area Tokai	42	5	3	35	10	23	0
Van Driver	0	0	0	44	0	23	22
Ferriwala	50	10	3	38	3	29	0
Landfill Vangari Shop	55	8	5	41	0	33	0
Town Area Vangari Shop	53	12	8	45	14	29	0

Source: Field Survey (2022)

The following table shows the average income of the different actors involved in collecting and selling recyclable items from the waste.

Table 6: Average Monthly Income of Informal Sector Actors Involved in Recycling

Actors	Avg. Monthly Income (BDT)
Landfill Tokai	8,777.0
Town Area Tokai	
Van Driver	10,875.0
Ferriwala	12,000.0
Landfill Vangari Shop	29,562.0
Town Area Vangari Shop	

Source: Field Survey (2022)

Chapter 4:
Methodology

In order to prepare the Waste Flow Diagram (WFD), the following methodology (consisting of six steps) has been followed:

1. *Collection of* **Population Data** *and Update for the Current Year*

2. **Waste Generation Rate (WGR)** (kg/capita/day)
   - *Low, Middle, High Income Areas*
   - *Commercial & Institutional Areas*

3. **Waste Composition**
   - *Source of waste generation (for domestic, commercial and institution points)*
   - *Land fill*

4. **Waste Collection Efficiency**
   - *Number of Vehicles used for primary and secondary collection*
   - *Amount of Waste & Number of Trips per day by collection vehicle*

5. **Waste Collected by Informal Sector**
   Informal Sector waste collection system to find out the amount of waste diversion by informal sector for recycling

6. *Identification of Waste Leakage from Hot Spots and Quantification of Leakage*

Figure 13: *Methodology for WFD*

4.1. Collection of Population Data and Update for the Current Year

The Bangladesh Bureau of Statistics (BBS) publication was used to estimate the target population of Kushtia Municipality. Since the information provided in the publication is based on the census year of 2022, the population data would need to be updated to estimate the current population. For instance, if provisions are to be made for the population in the year 2024, then the target population can be determined by the following formula:

$Pt = Po (1+r)^{n}$

Where, Pt = Population of the projected year t (in this case, 2024)

Po = Population of the base year (in this case, 2022)

r = Growth rate

n = Number of years.

4.2. Calculation of Waste Generation Rate (WGR)

Waste is mainly generated from two sources: domestic and non-domestic. Three different income groups (low-income, middle-income, and high-income) have been selected to estimate domestic waste generation. From each of the income groups, a sample survey was conducted to collect data regarding waste generation rate (kg/cap/day). Similarly, a sample size was selected to determine the non-domestic waste generation for the convenience of data collection and to achieve greater accuracy. Markets, katcha bazars, restaurants, schools, and offices have been selected for the determination of the waste generation rate from non-domestic sources. The survey was conducted for a minimum of three days in both residential and non-residential areas. Moreover, a sample survey was conducted to account for the amount of waste generated from street sweeping.

Table 7 below depicts sample sizes required under pre-defined sampling errors for household surveys. This table can guide the number of households to be included in a survey to obtain reliable results.

Table 7: Calculation of Sample Size for a Household Survey

Total No. of HH	Required Sample Size Allowing 95% Confidence Level		
	±5% Sampling Error	±7% Sampling Error	±10% Sampling Error
100	50	50	49
250	152	110	70
500	217	141	81
750	254	156	85
1,000	278	164	88
2,500	333	182	93
5,000	357	189	94
10,000	370	192	95
25,000	378	194	96
50,000	381	195	96
100,000	383	196	96
1,000,000	384	196	96
100,000,000	384	196	96

Source: Enayetullah, I., Rothenberger, S., Zurbrugg, C., and Sinha, A.H.M.M. (2006): "Decentralized Composting for Cities of Low- and Middle Income Countries, A User's Manual," EWAG, Switzerland and Waste Concern, Bangladesh.

Table 8: Format for Recording Data for Daily Generation Rate of Solid Waste.

House No	Family Size	Day 1	Day 2	Day 3	Total
1					
2					
3					
.					
.					
.					
100					
Total	**A**				**B**

During the survey, total waste generation from these categories has been measured and summed up for individual categories. Then, the total waste has been divided by the total population for individual categories.

$$\text{WGR (waste generation rate)} = \frac{\text{Total waste generation}}{\text{Total Population}} \text{ kg/capita/day}$$

The total waste generation of the municipality is calculated by multiplying WGR by the municipality's current population.

4.3. Waste Composition

The physical and chemical composition of the waste is very important for the selection of waste treatment, recycling, and disposal options. In order to assess the physical composition of waste, a field survey was conducted at the landfill site, and samples of waste were collected from different types of truck loads (open, covered, demountable container, tractor-trailer. The following format has been used to analyze the physical composition of waste carried by the truck. However, it should be noted that there are seasonal variations in the physical composition of waste.

Table 9: Format for Recording Waste Composition

Components	Residential (high/medium/ low income) /Market Waste			Waste at the Truck				Total Weight	%
	Day 1	Day 2	Day 3	Type 1	Type 2	Type 3	Type 4		
Vegetable/ Food Waste								a	a/A X100
Bones								b	b/A X100
Paper								c	c/A*100
Textile									
Plastic									
Grass/ Wood									
Leather/ Rubber									
Metals									
Glass/ Ceramic									
Miscellaneous									
Total								**A**	**100**

The physical composition of the waste generated from the household and market has also been assessed, along with the physical composition at the landfill site. Households and market areas have been surveyed for three days during data collection. Waste from these two sources has been separated into similar components.

4.4. Waste Collection Efficiency

The municipal offices were also visited during the waste composition survey to collect the number of waste collection Vehicles such as tipping trucks, waste collector vans, rickshaws, etc. Data on trips generated by these waste collection vehicles were also taken from the municipalities to determine the total amount of collected waste by the municipalities. Then, the efficiency of waste collection for the respective municipalities was measured.

$$\text{Efficiency} = \frac{\text{Total collected wastes by the waste collection vehicle}}{\text{Total waste generation in a municipal}} \textbf{ X 100}$$

4.5. Waste Collected by Informal Sector

Informal waste pickers play a crucial role in waste management and resource recovery in Kushtia Municipality. They contribute by collecting, sorting, trading, and, in some cases, processing recyclable waste materials. These activities provide a vital income source for a large number of marginalized individuals. During the field survey, the percentage of waste collected by the informal sector was assessed, highlighting their significant role. Before landfill disposal, informal groups gather recyclable materials, particularly plastics, either from waste pickers, van drivers, or dustbins/secondary transfer stations. In some instances, they purchase recyclable waste directly from waste pickers. This data has been used to develop the Waste Flow Diagram (WFD), emphasizing the informal sector's integral contribution to sustainable waste management practices.

4.6. Identification of Waste Leakage from Hotspots and Quantification of Leakage

The remaining waste that has not been collected by either the municipal authority or the informal sector is often left in dustbins, on roadsides, or discarded into local water bodies. These uncollected wastes were included in the waste composition survey to develop the Waste Flow Diagram (WFD). Hotspots were identified within the municipality, and the volume of leakage from these areas was quantified, highlighting the extent of unmanaged waste and its impact on the environment.

4.7. Data Analysis and Preparation of WFD

After collecting data from the waste composition survey, it was screened and analyzed to ensure accuracy. Based on this data, the Waste Flow Diagram (WFD) for the respective municipality was developed, reflecting the detailed composition of waste and highlighting key areas for effective waste management.

Chapter 5
Results & Discussion

5.1. Waste Generation Information

Currently, the municipality has a population of 2,26,800. The waste generation rate in Kushtia is categorized into four different categories (High income, Upper middle income, Lower middle income, and Low income). The overall waste generation rate from these categories is 0.44 kg/capita/day. A total of 99.8 tons of solid waste is generated daily, amounting to 36,427 tons per year within the municipality.

Table 10: Overall Waste Generation Rate at Kushtia Municipality

Income Level of Inhabitants	Waste generation rate (kg/p/d)	Overall waste generation (kg/p/d)
High Income	1.58	**0.44**
Upper Middle Income	0.83	
Lower Middle Income	0.63	
Low Income	0.43	

Source: Field Survey (2021).

5.2. Waste Management

Waste collection efficiency is nearly 38% (13,843 tons) in the whole municipality area. A bulk portion of 57% (20,707 tons/year) of the waste remains unmanaged during the process. Out of the collected waste of 13,870 tons/year, a majority portion of 12045 tons/year is disposed of in landfills. All the unmanaged waste gets disposed of in open drains & nearby land or waterbodies, which leads to environmental pollution.

Key Information:

- Out of the inorganic waste of 1851 tons/year, which gets recycled, a major portion of 408.13 tons/year comes from plastic products. 121.39 tons/year of waste comes from paper-made products.
- During the waste management process, a lot of leakage is produced from the collected waste. Hereby, it shows the different quantities of leakage that are produced from the solid waste.
- From the unmanaged solid waste of 20,706.45, the organic portion is 15,474 tons/day. The rest of the 5232.52 tons/day belongs to the inorganic part. Table 11 shows the details of the inorganic portion of the uncollected waste.

Table 11: Break-up of Unmanaged Inorganic Waste

Sources of Inorganic Waste	Waste Quantity (tons/year)
Paper	121.39
Plastic	408.13
Metals	24
Others	4453.48
Total	**5007**

- A Sankey diagram can be presented to show the overall waste generation & management scenario.

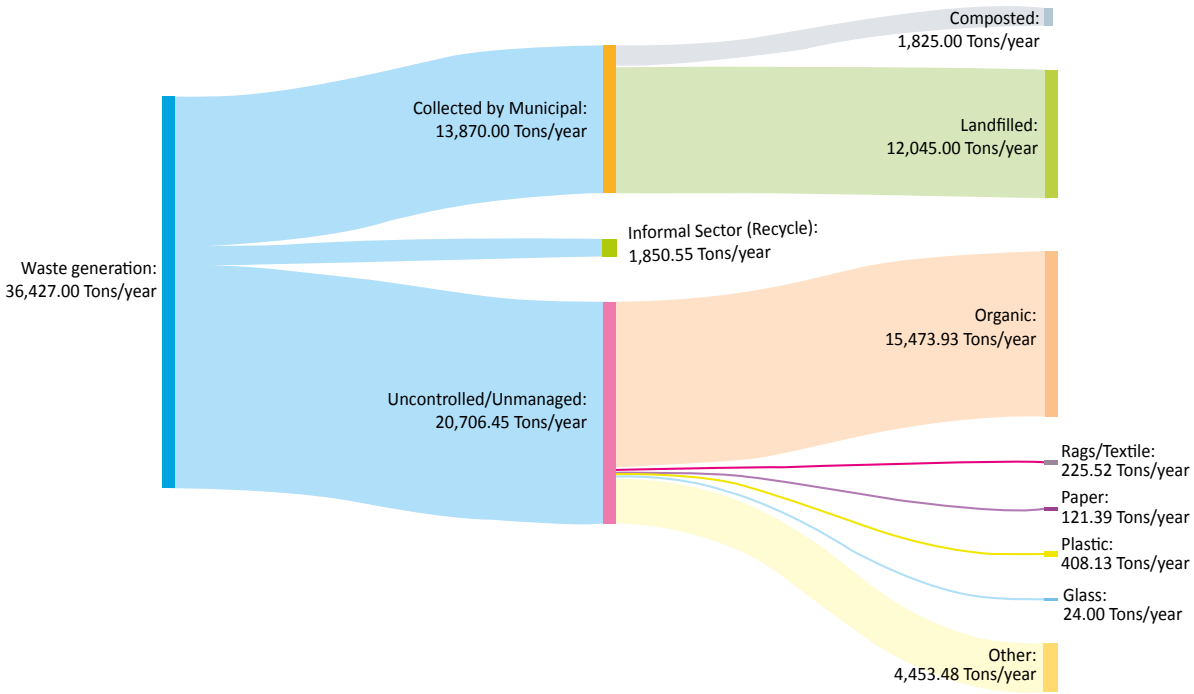

Figure 14: *Sankey Diagram of Waste Flow of Kushtia Municipality*

Chapter 6
Way Forward

WAY FORWARD

Based on the above results, the following steps can be undertaken:

- Currently, waste collection efficiency is nearly 38%, which is significantly behind the Government of Bangladesh's target of achieving 75% collection efficiency by 2025.
- The municipality should develop a comprehensive waste management plan to align with the National 3R Strategy for Waste Management, the Solid Waste Management Handling Rules 2021, and the Government's Nationally Determined Contribution (NDC).
- The NDC has set the target that 50% of the collected organic waste should be used for resource recovery to reduce GHG emissions by 2030.
- Promoting source segregation and the 3R Strategy (Reduce, Reuse, & Recycle) can effectively divert both organic and inorganic waste from open dumps, enabling resource recovery. This approach not only helps reduce GHG emissions but also fosters green job opportunities.
- Using the WFD, the municipality can set targets for waste diversion programs and collaborate with the private sector to launch resource recovery initiatives, such as Material Recovery Facilities (MRFs), composting, and anaerobic digestion plants, through the Public-Private Partnership (PPP) approach. Furthermore, these resource recovery projects align with the Government's Climate Change Trust Fund mandate for support.
- Infrastructure improvement is needed to support efficient waste collection, transportation, and processing, ensuring that waste is managed in an environmentally sustainable manner.
- Capacity building and community engagement to raise awareness and encourage active participation in waste management practices, fostering a collaborative approach to sustainable waste management.

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Annexures

Annexure 1

Questionnaire - Informal Sector Waste Recyclers

1. Respondent Name and Address:.....
2. Occupation:.....
3. Place of Survey:.....
4. Gender and Age:..... Male/Female, Year:.....
5. Education: Illiterate, Primary, JSC, SSC, HSC, Graduate, Masters
6. Number of Family Members: Male:..... Person, Female:..... Person
7. Are any other members of the family involved in plastic recycling work? Y / N

   If yes, how many people, Male:..... person, Female:.....person
8. Why do you take this work as an occupation? a) High income scope, b) Family work, c) Other work is not available, d) Other reason .....
9. How many days do you work in a week?:..... Days
10. Monthly income/expenditure: Income:..... Taka, Expenditure..... Taka
11. How many days are you working in this job?: Month/Year
12. Do you have any work except this job: Y/N,

    If yes, what is that job: .....
13. Do you sell or buy any type of Plastic material? Y/ N

    If yes, then what.....

    i. PET purchase amount (Month/day)..... Kg

       Purchase price/per kg..... Selling amount (Month/Day)..... Kg

       Selling price/per kg.....

    ii. HDPE purchase amount (Month/day)..... Kg

       Purchase price/per kg..... Selling amount (Month/Day)..... Kg

       Selling price/per kg.....

    iii. PVC purchase amount (Month/day)..... Kg

       Purchase price/per kg..... Selling amount (Month/Day)..... Kg

       Selling price/per kg.....

    iv. LDPE purchase amount (Month/day)..... Kg

       Purchase price/per kg..... Selling amount (Month/Day)..... Kg

       Selling price/per kg.....

v. PP purchase amount (Month/day)..... Kg

Purchase price/per kg..... Selling amount (Month/Day)..... Kg

Selling price/per kg.....

vi. PS purchase amount (Month/day)..... Kg

Purchase price/per kg..... Selling amount (Month/Day)..... Kg

Selling price/per kg.....

vii. Other (Mention name).....

Purchase amount (Month/day)..... Kg

Purchase price/per kg..... Selling amount (Month/Day)..... Kg

Selling price/per kg.....

14. Tin purchase amount (Month/day)..... Kg

Purchase price/per kg..... Selling amount (Month/Day)..... Kg

Selling price/per kg.....

15. Iron purchase amount (Month/day)..... Kg

Purchase price/per kg..... Selling amount (Month/Day)..... Kg

Selling price/per kg.....

16. Paper purchase amount (Month/day)..... Kg

Purchase price/per kg..... Selling amount (Month/Day)..... Kg

Selling price/per kg.....

17. In your information, how many people are in this occupation?:..... people.

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For Further Information Contact:

WASTE CONCERN

Level-3, House No. 270, Road No. 19, New DOHS, Mohakhali,
Dhaka-1206, Bangladesh
Telephone : +88 02 48810 841, +88 02 48810 842
Fax : +88 02 2222 99486
E-mail : office@wasteconcern.org
Web : www.wasteconcern.org