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4R Road Map
On Solid Waste Management

@Dhaka CALLING Project
Under
Promoting Advocacy and Rights (PAR) Activity

November, 2022

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Preface

The study titled “4-R Road Map on Solid Waste Management” of the Dhaka CALLING Project. Dushtha Shasthya Kendra (DSK) along with the Bangladesh Resource Center for Indigenous Knowledge (BARCIK), Coalition for the Urban Poor (CUP), and Institute of Innovations for Gender & Humanitarian Transformations (inSights) has been implementing the Dhaka Citizens Advocacy Collaboration against Polluting Environment (Dhaka CALLING) project which focuses on how to improve the governance system of solid waste management through strengthening the capacity of the CSOs, promoting civic participation, and cross-sectoral partnership in the process. The project is being funded by the United States Agency for International Development (USAID) and technically supported by the Counterpart International’s (CPI) Promoting Advocacy and Rights (PAR) Activity. The project is being implemented in Ward 06 (Molla slum) and Ward 19 (Korail slum) of Dhaka North City Corporation (DNCC) & in Ward 14 (Balurmath slum) and Ward 55 (Boubazar slum) of Dhaka South City Corporation (DSCC) for the period of January 2021 to December 2022.

The project was to develop a Roadmap based on the 4R (Reduce, Reuse, Recycle and Recover) principles of waste management for municipal solid waste in Bangladesh focusing on marginalized people, such as those residing in slums. The study was awarded to Dr. Ijaz Hossain (consultant) by Dushtha Shasthya Kendra (DSK).

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Abbreviations

4R	Reduce, Reuse, Recycle and Recover
AD	Anaerobic Digestion
BAU	Business-us-Usual
CBO	Community Based Organization
CDM	Clean Development Mechanism
DNCC	Dhaka North City Corporation
DoE	Department of Environment
DSCC	Dhaka South City Corporation
EPR	Extended Producer Responsibility
FGD	Focus Group Discussion
GoB	Government of Bangladesh
GPS	Global Positioning System
ha	Hectare
IRRC	Integrated Resource Recovery Center
KII	Key Informant Interview
LGRD	Local Government and Rural Development
MoEF	Ministry of Environment and Forest
MoEFCC	Ministry of Environment Forest and Climate Change
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
NGO	Non-Governmental Organization
QR	Quick Response (code)
RDF	Refuse Derived Fuels
SMS	Short Messaging Service
SUP	Single Use Plastics
SW	Solid Waste
SWM	Solid Wastes Management
ToR	Terms of Reference
VAT	Value Added Tax
WtE	Waste to Energy

Contents

Executive Summary 1

1.0 Background 6

2.0 Introduction 7

3.0 Objectives and Strategic Goals 8

4.0 Methodology 8

5.0 Literature Review 9

6.0 Stakeholder Engagement 16

7.0 Assessment of the Bangladesh MSW Value Chain 18

8.0 4R Roadmap on Solid Waste Management 19

8.1 Flowchart of the Proposed MSW Value Chain 21

8.2 Description of the Roadmap 22

8.3 4R Roadmap for MSW Management showing Action Plan and Targets 27

8.4 Activities and Milestones of the 4R Roadmap for MSW Management 28

8.5 Implementation of the Roadmap 31

8.6 Financial Implications of Implementing the Roadmap 36

8.7 Vision of the Roadmap 39

8.8 Recommendations for Policymakers 40

9.0 Recommendations 41

Bibliography 43

Annex A: ToR of the Assignment 45

Annex B: The Waste Concern IRRC Model 50

Annex C: MSW Management in Bangladesh Cities and Town 52

Annex D: Analysis of MSW Value Chain Components for Bangladesh 57

Annex E: Organic Content of Soil in Bangladesh 61

Annex F: Financial Viability of a Composting Plant 62

Executive Summary

There are several government documents dealing with MSW management; however, none of these provide a clear-cut strategy or roadmap. The SWM Rules 2021 has set out the rules for MSW management, but does not provide an action plan. The major objective of this project by Dhaka CALLING was to develop a road map/action plan (replicable model) focusing on 4R aligned with the vision statement of the government so that efficient policy options could be pursued, adopted, and negotiated with the government for better implementations.

Primary data collection was conducted in the city of Dhaka. The methodology consisted of literature survey of good practices at home and abroad coupled with 6 KIIs and 3 FGDs. The consultant during the course of the work also observed waste collection from households, transfer station waste handling, transportation of wastes and the status of landfills and open dumps. The consultant extensively used the expert knowledge of Waste Concern.

According to the latest projection urban SW is expected to reach 142,000 Tons/day by 2041. If this enormous quantity of solid wastes is not managed properly, many urban centers especially where collection efficiency is low, would become unlivable as a result of rotting garbage on streets and in open dumps. Some of the worst affected by poor management of MSW will be the marginalized people. This Roadmap is expected to allow City Corporations in cooperation with CBOs to manage MSW efficiently such that 100% collection efficiency is achieved and the resource value of wastes are preserved according to the 4R principles.

Development Process and Description of the Roadmap

From in-depth study of literature, site visits and expert knowledge, the main issues with MSW management in Bangladesh were identified. To start the process the MSW management model called the IRRC developed by Waste Concern was chosen. In the existing practice, the collected wastes are taken straight to the landfill/open dump via Transfer stations if there are any. In the new flowchart proposed for the Roadmap to facilitate resource recover according to the 4R principles and to improve collection from low-income communities several elements of sustainable MSW management have been added to the value chain.

The 4R Roadmap for short, medium and long term has been developed for the four sequential segments of the MSW management value chain, and the *Action Plan and Targets* is presented at the end of the *Executive Summary*. Salient features the 4 segments are given below.

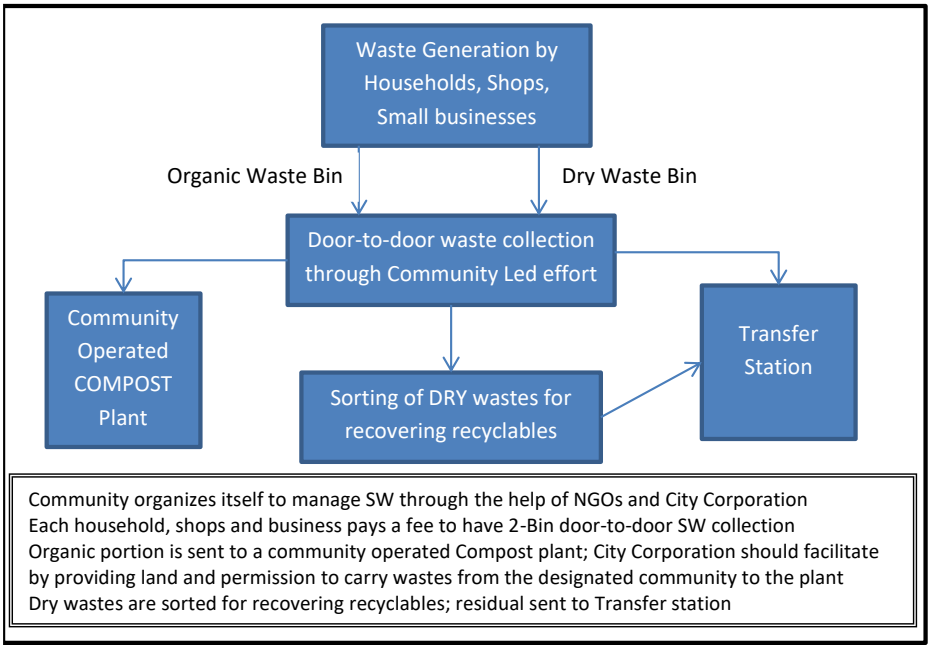
1. Generation – the production of solid waste from urban activities

Awareness raising regarding reducing wastes, no littering, source segregation, and EPR have been incorporated. These activities need to continue well into the long term.

2. Collection and Transport

In the short term the Roadmap suggests at least 80% collection efficiency. *In the medium term the Roadmap envisages 100% collection efficiency in all urban centers of Bangladesh.* Figure below shows a model for waste collection from low-income communities; Informal sector workers managed by the community can be engaged. This MSW model, practiced successfully at many places around the world, is expected to be a win-win solution for all stakeholders – general public, the waste generators and the City Corporations/Pourashavas.

Transportation of wastes needs improvement. *Manually driven vehicles have to be replaced by 3-wheeler motorized versions and GPS fitted improved garbage trucks must be deployed.*



3. Sorting and Recycling

Material Recovery Facility (MRF) has been incorporated in the MSW value chain for sorting mixed wastes to recover materials such as plastics, rags and paper; these can be *converted to RDF or only the separated plastics can be used in a Pyrolysis plant to produce fuel oil.*

4. Treatment and Disposal

Special emphasis has been laid on Composting or Biogas production from organic material; if implementation proceeds as planned, landfilling of waste material will keep on decreasing. To ensure that only inert materials are landfilled, two policy interventions are needed –

1. *Landfill ban on combustible material such as plastics*
2. *Landfill ban on organics*

Roadmap Implementation

To implement the Roadmap for a city or town a responsible authority along with a monitoring plan would be needed. The targets for the monitoring plan are given in the Roadmap. Following are the authorities that will be responsible –

A. DoE and MoEFCC (for enforcing the SW rules and 3R/4R guidelines)
B. Mayors of cities and Chairman of Pourashavas of towns (implementing authority)
C. LGRD (in case the Pourashava Chairman does not have the capacity to implement)

The following aspects of implementing the Roadmap are covered in the report – (i) Prime/ Secondary Stakeholders (ii) Infrastructure/Technology Requirement (iii) Private Sector Participation in the MSW Value Chain (iv) Scope of Research and Innovation (v) Community Participation (vi) Awareness Raising (vii) Capacity Building.

Financial Implications of Implementing the Roadmap

To achieve the short term objective of the Roadmap, infrastructure along with the various technologies that can handle 47,000 Tons/day of wastes need to be created; Tk. 26,320 crore investment would be required. Calculations suggest that the operational expense can be recovered from the sale of various products from the project.

The viability of a composting facility processing 1 Ton/day of wastes has been worked out. A discounted financial model shows that for a 10% discount rate, to recover all costs, fertilizer has to be sold at Tk. 44/kg if land is leased. However, if land is available from government, and waste is delivered free of cost to site, then the price is less than Tk. 10/kg.

Vision of the Roadmap

The vision is to transform MSW value chain from the existing basic level to one that incorporates the 4R principle. City Corporations are not able to provide full door-to-door collection services in low-income communities. The implementation of the Roadmap will result in 100% wastes collection and resource recovery. The Table below shows the costs and benefits of implementing the Roadmap; health, environmental and GHG emission reduction benefits could not be quantified. If these could be quantified, the benefits stream will greatly outweigh the Tk. 26,320 crore investment cost. The other major benefit is that the Roadmap land requirement of 679 Bighas is far less than the BAU land requirement (ten times more).

COSTS	BENEFITS
➢ **Tk. 26,320 crore** (investment) ➢ **Tk. 10,636 crore** annually **(**operational cost) ➢ Cost of 3-wheelers (from collection fees) ➢ Cost of Garbage Trucks (from City Corporations' budget) ➢ Awareness Campaign (sponsored by Brand owners)	➢ **Tk. 10,993** crore as direct financial benefit annually ➢ Only 10% of the BAU land requirement (90% land savings) ➢ City roads free from stench, vermin, insects, waste SUP ➢ No clogging of drains by waste plastic bags ➢ Reduction in health costs of urban dwellers ➢ Reduction in GHG emissions ➢ Organic fertilizers to alleviate loss of soil fertility ➢ Biogas to alleviate gas crisis ➢ Solid (RDF) and liquid (fuel oil) fuels to alleviate energy crisis

Recommendations

- **Awareness raising** regarding waste minimization and waste segregation; EPR for brand owners to induce them to reduce packaging can also yield good results
- **100% Collection** based on a 3-Bin segregated model of collection and transport. NGOs and CBOs to organize slum dwellers in Community led action groups
- **4R in Community led actions** to facilitate the 100% collection target and 4R application to MSW management especially in low-income communities
- **MRF** addition to the Roadmap strengthens resource utilization, which is the hallmark of 4R. In MRF plastics will be separated for conversion in **RDF or pyrolysis plants**
- **Composting or producing biogas/fertilizer using organic wastes** is fundamental in achieving Recovery of the 4R process. Government should draw up a masterplan for organic fertilizer; **Private sector participation** needs to be encouraged by allowing them easy access to wastes and land. Business model for composting is needed
- **Landfill bans for Combustibles and Organics** if implemented and enforced, are probably the most effective tools in reducing landfill load
- **Tribunal for monitoring and enforcing** SW rules and regulations. Penalties for non-compliance and tax incentives for households that practice source segregation.

4R Roadmap for MSW Management showing Action Plan and Targets of the Roadmap

	Generation	Collection + Transport	Sorting + Recycling	Treatment + Disposal
Short Term (2022-2025) Waste Generation in 2025 = 47,000 Tons/day	2-Bin Source separation (If feasible) Awareness raising about reducing wastes (to continue)	> 80% collection with emphasis on slums 3-wheeler motorised vehicles (transition gradually)	> 25% of collected wastes processed in MRF or IRRC Combustibles processed in RDF/Pyrolysis plants	Organic wastes from MRF Composted/Biogas Open dumpsites closed (gradually)
Medium Term (2026-2030) Waste Generation in 2030 = 57,000 Tons per day	2-Bin Source separation EPR (50% of packagings either reduction or collection)	100% collection > 50% of garbage trucks improved and fitted with GPS locator	> 50% of collected wastes processed in MRF or IRRC Combustibles processed in RDF/Pyrolysis plants	Organic wastes from MRF Composted/Biogas All landfills are sanitarty landfills
Long Term (2031-2041) Waste Generation in 2041 ~ 80,000 Tons per day	3-Bin Source separation 100% EPR for all brand owners either reduction or collection	100% collection 100% of garbage trucks improved fitted with GPS locator	100% of collected wastes processed in MRF or IRRC or Incinerated	Only inerts can be landfilled Organic and combustible landfill ban

Material Recovery Facility (MRF) is the facility where mixed wastes are sorted into different fractions. A MRF with a RDF plant is often integrated with a landfill
Refuse Derived Fuel (RDF) is made from combustible material recovered from the mixed wastes at a MRF. It mainly consists of plastics, rags and paper
Integrated Resource Recovery Center (IRRC) – IRRC is suitable for small and medium sized towns. 85-90% of the incoming waste from the community can be converted into economic resources (such as compost, biogas, recyclables, Refuse Derived Fuel (RDF) within the IRRC. In partnership with UN-ESCAP, Waste Concern is replicating the IRRC model
Extended Producer Responsibility (EPR) is a mechanism whereby brand owners are made responsible for the packagings used in their products. EPR reduces the load of MRFs either by reducing wastes generation (use of less packaging) or by some type of mechanism that returns post-consumer packagings to the respective brand owner for appropriate disposal

1.0 Background

Dushtha Shasthya Kendra (DSK) has initiated a consortium project titled 'Dhaka Citizens' Advocacy Collaboration against polluting environment (Dhaka CALLING) with other consortium members – Bangladesh Resource Center for Indigenous Knowledge (BARCIK), Coalition for the Urban Poor (CUP), and Institute of Innovations for Gender and Humanitarian Transformations (inSights) with the financial support from the United States Agency for International Development (USAID) and technical support of Counterpart International (CPI) to conduct a study on solid waste management to develop a Roadmap focusing on reduce, reuse and recycle.

There are several government documents dealing with MSW management such as (GoB, 2021), (MoEF, GoB, 2010) (GoB, 2010). However, none of these actually provides a roadmap. Whenever, NGOs and even the city corporations want to execute certain MSW management practices they cannot find a concise document that charts the course of a workable strategy. The SWM Rules 2021 has set out the rules for MSW management, wherein it recommends developing implementation plans based on the rules. Implementation plans can only be developed based on a roadmap or strategy, which does not exist. This project by Dhaka CALLING has been designed to fill that gap.

Some of the worst affected by poor management of MSW are the marginalized people such as slum dwellers; facing the nuisance of uncollected MSW in their everyday life because city corporations/Pourashavas do not provide full service in slum areas. Slum dwellers are left on their own to manage their wastes. Their own management often implies dumpling in any open space near their homes. Often the city corporation does not facilitate collection by not permitting slum dwellers to deposit their wastes in government designated community bins or Transfer Stations because the slum dwellers have no legal status. This quandary implies that 100% of waste will never be collected in large cities where there are slums. The city authorities must change this practice and find a way of managing slum solid wastes.

Because of growing population, increasing urbanization and improvement in the standard of living, solid wastes produced is increasing at an alarming rate. Heaps of garbage on roadsides is a common sight in nearly all urban centers. Other than the big cities, most towns are unable to collect more than 50% of the solid wastes generated. As a result, the rotting garbage creates stench and infestation by vermin/rodents, and is a cause for severe health risks and environmental pollution. The accumulated garbage clogs drains leading to water logging. In addition to this, the collected wastes are often dumped in low lying areas at the outskirts of towns in open dumps creating a hazardous situation for the city dwellers.

In such a situation the importance of proper management of MSW can hardly be overemphasized. If the growing situation is allowed to continue most urban centers will simply become unlivable. The government is trying its best but due to a lack of a clear cut vision of what needs to be done, the progress is fragmented and slow. In the context of Bangladesh following are the main reasons why MSW management is extremely important –

- Urban solid waste problem is growing due to rapid urbanization
- Lack of adequate government funds to deal with the enormous problem
- Lack of land to build sanitary landfills
- Wasting the resource value of wastes (depriving country of organic fertilizer)
- Landfilling plastic wastes thus creating resource loss plus problems for the landfill

The roadmap developed through the efforts of DSK is expected to lead to 4R sustainable management of MSW in Bangladesh, and thus tackle all the issues listed above. Additionally, the Roadmap will address the challenges of waste management in low-income communities.

2.0 Introduction

Bangladesh has been experiencing rapid economic growth and urbanization for at least one decade. It is well know that there is a direct relationship between growth and waste generation. Currently in Bangladesh, solid waste generation is more than 35,000 Tons/day, and Dhaka city alone is responsible for 6,500 tons/day. Figure 1 shows MSW generation and population in Bangladesh from 1990 to 2025. According to the projections performed in a Waste Concern study in 2014[1], the total waste generated will be 47,000 Tons in 2025. If the trend continues then by 2030 and 2041, the total solid waste generation will reach 57,000 and 80,000 Tons/day respectively. In the latest study to be published soon (Waste Concern, 2022), the projected waste generation in 2041 will be 142,000 Tons/day[2].

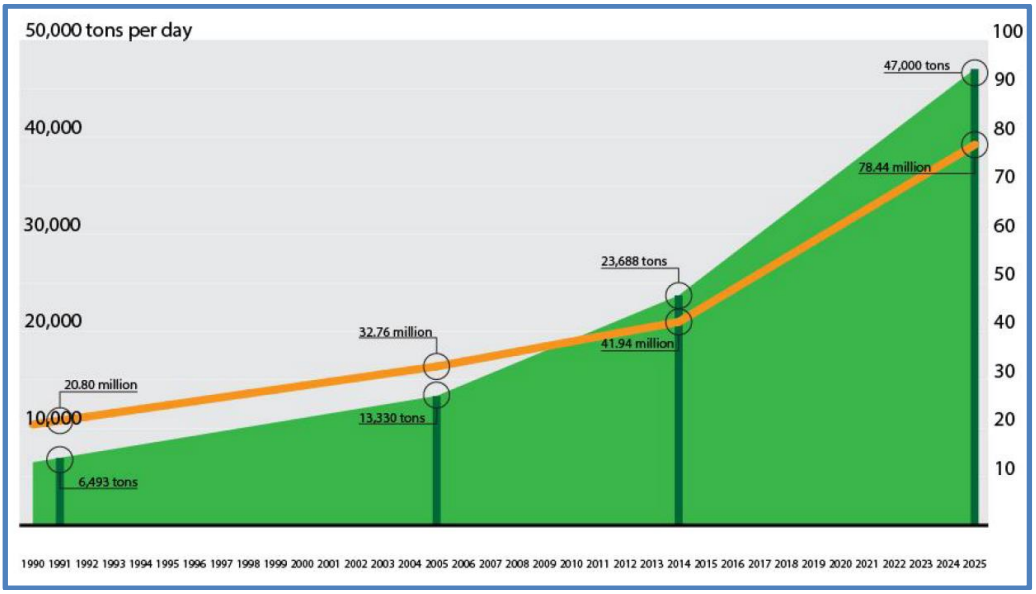


Figure 1: Total Waste Generation and Urban Population – Historical and Projection

Managing municipal solid wastes in urban centers of developing countries is a big challenge. Even though this is principally the result of shortage of funds, other

[1] Waste Database 2014 (Waste Concern, 2014)

[2] The large variation from the 2014 prediction is due to the higher per capita GDP assumed in the latter study

factors such as poor management arising out of incomplete training and capacity development, technology deficiency and lack of stakeholders' participation can play big roles. In Bangladesh, the problems are greater because the usual way of dealing with MSW, i.e. landfilling, is proving to be extremely difficult and unsustainable because of the acute shortage of land. This has prompted the government to look at alternative solutions. One solution that has been given preference is the incineration of MSW. While incineration is one of the solutions, it is certainly not the optimum one. Most importantly, it is not consistent with the 4R (Reduce, Reuse, Recycle and Recover) principle of solid waste management. It is not compatible with circular economy because incineration can lead to substantial resource destruction.

3.0 Objectives and Strategic Goals

The major objective of the activity is to come out with a road map/action plan (replicable model) focusing on 4R and keeping align with the vision statement of the government so efficient policy options could be pursued, adopted, and negotiated with the government for better implementations.

a. The specific objective of the study is to develop a 'Road Map on Solid Waste Management' focusing on reduce, reuse, recovery and recycle in the urban solid wastes sector for the concerned government and other relevant stakeholders.

b. The study shall sketch out integrated sustainable solid waste management process focusing on the SWM Rules 2021 and other relevant environmental laws and shall focus on the scopes, opportunities, and challenges of this sector that could be carried forward.

The findings of the study will be published as a 'Road Map on Solid Waste Management' that will work as a catalyst to initiate and promote advocacy dialogues, meetings, seminars, training, etc. at various levels and work as an influencing tool while implementing the Dhaka CALLING project. The ToR of the project is given in Annex A.

4.0 Methodology

This report is based on both primary and secondary data. The primary data has been gathered from the consultant's visits to three slums and visits[3] to observe waste collection from households, waste handling at Transfer Stations, transportation of wastes both from door-to-door collection and from Transfer Stations to landfills, and the conditions of landfills and open dumps. Secondary data on Bangladesh scenario and international best practice was gathered from literature and consultation with Waste Concern[4]. 6 KIIs with stakeholders from DoE, NGOs, Waste Sector Experts and DNCC, and 3 FGDs at 3 slums at different locations were used to supplement the data and information collected.

[3] Visits by consultant to various points in Dhaka city to observe MSW management and the slums visit for FGDs
[4] Waste Concern is a consulting company; they are the leading experts on MSW in Bangladesh

The learnings from the Key Informant Interviews and Focus Group Discussions[5] were incorporated into the Roadmap to make it responsive to the needs of marginalized groups of people. The assigned task to develop a 4R Roadmap for MSW management in Bangladesh followed the conceptual framework shown in Figure 2 and the following steps –

1. Analysis of existing MSW management in urban centers of Bangladesh
2. Development of MSW management framework for Bangladesh incorporating best practices around the world and the 4R principle of SW management
3. Using successful models of Community Led MSW management along with the findings of the FGDs and KIIs, development of the 4R MSW Management Roadmap

Primary data collection was conducted in the city of Dhaka. Other than the data and information collected by the consultant from visits, all data used in this report are either from published sources or from Waste Concern (their own proprietary data and information). In various places the consultant employed his expert knowledge of the topic.

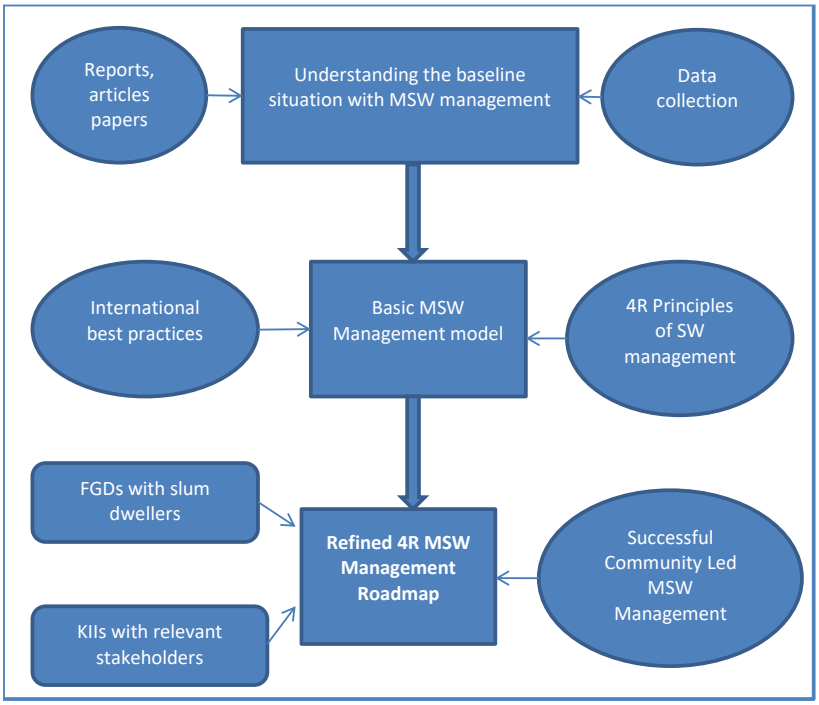


Figure 2: Conceptual Framework of the 4R MSW Roadmap Project

5.0 Literature Review

Rules, Regulations, Strategies and Plans

There are many documents that deal with various aspects of MSW management in Bangladesh. These documents formulated by different departments of the GoB provide rules and regulations as well as policies, strategies, plans and guidelines for

[5] The findings of the KIIs and FGDs are summarized in Section 6.0

sustainable solid wastes management. Seven of those documents were found to be directly relevant to developing the Roadmap (Enayetullah & Hashmi, 2006) (MoEF, GoB, 2010) (GoB, MoRDCLGD, 2014) (Rajuk, 2015) (GED, 2015) (GoB, 2021) (LGD, GoB, 2009).

The documents listed in Table 1 were scanned to find the principal aims with regard to SW management and the targets set to achieve those aims; Table 1 also summarizes the aims and targets. It was found that almost all aspects of sustainable solid waste management are covered by these documents. In the column titled "Relevance to Roadmap", the aspects that need to be covered in the Roadmap were determined.

Table 1: Review of Government Documents Pertaining to SW Management

	Name of Document	Aims and Targets	Relevance to Roadmap
1.	Solid Waste Management Action Plan for Eight Secondary Towns in Bangladesh 2005 (Enayetullah & Hashmi, 2006)	➢ Waste Concern created this plan for LGED based on 4R concept of MSW management; focusses on converting waste into resource ➢ This is one of the earliest efforts to introduce sustainable MSW management in the country by Waste Concern by advocating that wastes is a resource.	**4R** **Waste to Resource**
2.	National 3R Strategy 2010 (MoEF, GoB, 2010)	➢ Encouraging organic waste recycling through composting and biogas, and combustibles recovery through refuse-derived fuel (RDF) ➢ Minimizing waste disposal in open dumps, rivers, flood plains and landfills by at least 20% within 2015 ➢ Producing source-separation instruction tools ➢ Raise awareness about waste reduction, recycling and reusing through Environmental education & public relation activities ➢ Waste reduction by 20%	**MRF and RDF** **Prevent open dumping** **Source separation and organics recycling by Composting/Biogas** **Awareness Raising**
3.	National Strategy for Water Supply and Sanitation, 2014 (GoB, MoRDCLGD, 2014)	➢ Promote source-level waste segregation ➢ Establish community based primary collection and link with secondary collection transportation and final disposal ➢ Pursue organic waste recycling through composting, bio-gas and reuse derived fuel ➢ Plan sanitary/regional landfills for an urban area/a group of urban areas ➢ Prevent keeping waste materials on footpaths, roadsides and other public places	**Community based primary collection** **RDF** **Regional landfills for a group of urban areas** **Prevent waste disposal on public places**
4.	Dhaka Structure Plan 2016 (Rajuk, 2015)	➢ Reduce waste generation ➢ Establish waste transfer stations at proper places and prevent public nuisance ➢ Ensure greater private sector participation in MSW management ➢ Engage in public awareness-raising actions in the form of seminars, workshops, TV	**Transfer Stations** **Private sector participation advocated** **Awareness raising**

		advertisements, newspaper supplements, dramas	**through media**
5.	Seventh Five-year plan (FY 2016-2020) (GED, 2015)	➢ Entrusts the Local Government Division with matters related to waste management ➢ To ensure the practice of 3R (Reduce, Reuse & Recycle), following the National 3R Strategy for Waste Management ➢ To enforce Solid Waste Management Rules	**LGD empowered** **3R** **Stresses enforcement of SWM rules**
6.	Solid Waste Management Regulations 2021 (in Bangla) (GoB, 2021)	➢ Disposal of wastes in accordance with the regulations of authorities including local government; Disposal of waste separately ➢ Prohibition on dumping, storing and burning of waste outdoors ➢ Glass, plastic, polyethylene, multi-layered packaging, bottles, and cans to be collected from consumers and recycled or disposed if appropriate ➢ Determine work plans and implementation procedures for recycling and disposal ➢ Public awareness of proper waste management	**Awareness Raising** **Solid wastes disposal following rules** **Stresses EPR** **Composting and energy recovery** **Advocates developing Implementation Plans**
7.	Local Government (City Corporation) Act, 2009 (LGD, GoB, 2009)	➢ Adequate arrangements for the removal, collection and proper disposal of refuse from all public streets, drains, and all buildings and land vested in the Corporation ➢ Where there is no door-to-door collection, refuse accumulating in any premises or land shall be deposited by the owner in public dustbins ➢ All of the refuses removed and collected shall be the property of the Corporation	**All solid wastes must be collected** **Solid wastes must be deposited in designated dustbins**

MSW Management in Bangladesh

The first step of MSW management, which is collection, has been studied quite extensively in Bangladesh. According to the latest study covering the whole country, Waste Concern (2022) estimated that the collected percentage varies from 73% in Dhaka to less than 50% in smaller towns. Many other studies have confirmed the low collection efficiency. Haque (2017) studied solid wastes management of Rajshahi City, which is the 5th largest city, and found the collection efficiency to be around 66% and that there was no treatment of any sort and open dumping is practiced. To improve MSW management, among other suggestion made in the paper, *Environmental Magistracy and Environmental Police Force* was one of them.

One of the main challenges of waste collection in Bangladesh is well reflected in Figure 3. Prodhan & Kaeser, 2020 in their study of solid waste management in Dhaka found that lower income groups have a greater propensity to dump wastes. As a result the challenges of MSW collection in slums are much greater than in areas of upper income group.

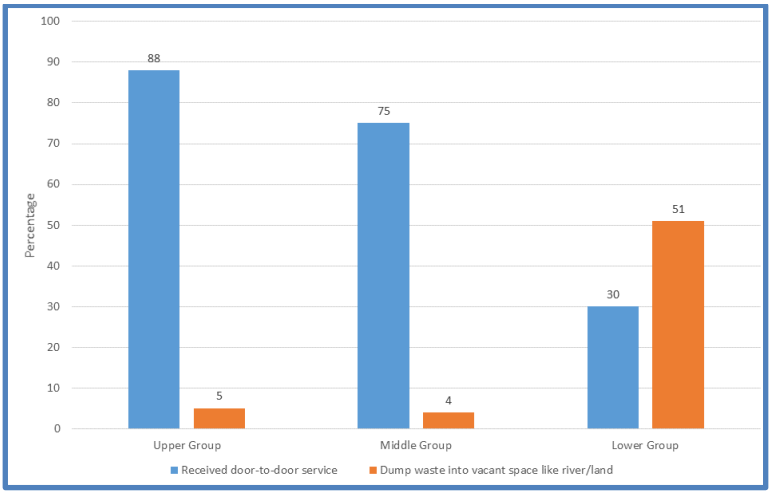


Figure 3: Door-to-door service and Waste Dumping Percentage[6]

Jerin et al. (2022) in their article – *An overview of progress towards implementation of solid waste management policies in Dhaka, Bangladesh* – have made the following suggestions regarding wastes generation and collection especially in informal settlements, "community-led total sanitation approach for waste generation at the household level; to ensure making particular laws regarding waste collection on a regular basis, and mandatory enforcement of those for the uncollected wastes; regular collection from the informal settlements by introducing subsidized waste collection fees and provisions should be mentioned in those laws or policies; there should be a common collection point in the informal areas and the need to encourage the dwellers to put their waste in those specified points".

Jerin, Sara, Hasan, & Quayyum (2020) found that – "With few exceptions, the overall waste management system cannot be termed as an efficient sequential process of waste minimization, recycling, and disposal based on global standards. Though the establishment of several secondary transfer stations (STSs) has improved the environmental conditions and cleanliness of the cities, the waste segregation and recycling practices in the pathways from households to landfill do not adhere to the 3R Policy. Both the recyclable and non-recyclable waste are collected and dumped all together at different levels of waste management, i.e. collection from households, dumping at STSs, and later in the landfill without any formal procedures of sorting and recycling. In order to implement the existing policies, adequate funding and monitoring bodies should be introduced to the waste management sector".

Sonia, Faysal, & Hossain (2022) studied the waste management system of the Gopalganj municipality and identified the following barriers – awareness, lack of workforce, and waste vehicles. They emphasized city corporation-NGO collaboration for developing an effective waste management system.

Several authors have studied the potential of waste to energy and biogas potential for various cities of Bangladesh (Das, Islam, & Huda, 2019; Islam, Rafi, & Hossain,

[6] Prodhan & Kaeser (2020); Consultant also found waste dumping on low lying areas near slums

2019). They were all of the opinion that the prospects of waste to energy from incineration were low, but there are good prospects of energy through the aneorobic digestion (AD) route.

The IRRC Model of Solid Waste Management

The Integrated Resource Recovery Center (IRRC) model of waste management has been developed by Waste Concern (Waste Concern, 2022b). The IRRC model of MSW management says that "The current system of waste management is focused on end-of-pipe solution. It is not sustainable and overlooks the enormous potential of turning waste into resource. The informal sector recovers some valuable materials downstream, but the majority organic waste does not have a chance to be recovered without leveraging appropriate technology and systems". Following are the specific features and advantages of the IRRC –

- Based on 3R principles; a physical facility integrated with social system
- Recovers 80 percent of waste as resources (both organic and inorganics)
- Promotes source separation; Decentralized, close to generated waste
- It can be implemented in slum areas
- Apart from production of Compost/Biogas/RDF this model reduces greenhouse gases

IRRC has been replicated in six countries by UNESCAP with the technical support from Waste Concern (Enayetullah, 2018). More information on the IRRC model for MSW can be found in Annex B. In Bangladesh, the IRRC is being piloted in 4 towns; the one in Jessore with the following units has transformed a crude uncontrolled dump site into a controlled integrated landfill site with resource recovery facilities (Waste Concern, 2019) –

– Waste Sorting Unit (mechanized) with capacity of 1/2 Ton/hr
– Composting (box system with forced aeration) and mechanical dryer (20 Tons/day)
– Biogas plant with electricity generation units (18 Tons/day)
– FSM treatment with co-composting facility (10 M^3/day)
– Controlled landfill unit with collection and treatment of leachate

Global Best Practices

Community-Based Waste Management

Several well developed models on Community-based waste management programs are found in literature. These programs are cooperation between communities, NGOs and the city corporations and are meant to run independently. Plastic Smart Cities (2022) lists the following beneficial features of such programs –

- Direct community-member engagement and accountability
- Tracking of waste collection and reduction
- Segregation of waste at the household level
- On-site utilization of valuable and reusable items
- Composting of organic waste
- Collection and transportation of waste to treatment site by a public collection service

This type of community based MSW programs have been successfully deployed in Davao City, Philippines, Phu Quoc, Vietnam and Indore, India.

Incorporating Informal Sector in SW Management

The challenges of waste collection from poor communities have been encountered by many developing countries (USAID, 2006). However, many countries have been able to meet the challenge by engaging the informal sector in the MSW collection and subsequent management of the solid wastes. In the Boxes below, three case studies are presented.

Incorporating Informal Sector Workers in SW Management (EPA, 2020)

In recent years the City of Bangalore has focused on micro-level planning for waste collection and treatment to reduce their costs and improve efficiency. Incorporating informal sector workers into the solid waste management system has been a key component of this effort. Currently, more than 15,000 informal sector workers handle waste in the city. These workers provide skilled labor that significantly reduces the city's solid waste management costs. Since 2016 the city has formalized their relationship with the informal sector. The city provides informal sector workers with identification cards, offers certification courses, and has formed memoranda of understanding with groups of informal sector workers. One added benefit of working with the informal sector is that the city has reduced their dependence on traditional contractors, who sometimes overcharge for services and can be difficult to manage. Groups of informal sector workers are typically based at transfer stations. Workers at some of these centers provide door-to-door collection, and then receive financial support from the city. Informal sector workers in Bangalore have found innovative ways to integrate technological solutions into their work. Some have developed phone applications to monitor when their customers' waste bins have been emptied, how much waste was collected, and how well it is segregated (a requirement in India). This review allows informal sector workers to rate their customers' performance; higher ratings can lead to lower collection service fees.

Brazil's National Solid Waste Policy (EPA, 2020)

The government of Brazil passed a law in August 2010 to establish the Brazilian National Policy on Solid Waste. This legislation aims to better integrate and involve informal sector workers in the recycling process, and to provide incentives for local agencies to develop organizations for informal sector workers. Through the creation of a solid waste plan, Brazil aims to close and recover dumping sites, which will also provide social and economic benefits to informal sector workers. The law requires waste management services to prioritize the recruitment, organization, and functionality of informal sector workers.


100% waste collection in 98% wards, govt tells NGT

A total of 313 urban local bodies with 6,902 wards having 2.36 core population in the state generate 11,085 tonnes of municipal solid waste p

DHNS, AUG 10 2021, 22:31 IST | UPDATED: AUG 11 2021, 03:03 IST

A total of 313 urban local bodies having 2.36 core population in the state generate 11,085 tonnes of municipal solid waste per day. Credit: DH File Photo

Successful Waste Collection in India
(Athrady, 2021)

The Karnataka government has informed the National Green Tribunal (NGT) that out of 6,902 wards in the urban local bodies in the state, 6,764 (98 per cent) wards have achieved 100 per cent door-to-door collection of waste while 5,395 (78 per cent) wards have achieved 100 per cent source segregation.

A total of 313 urban local bodies with 6,902 wards having 2.36 core population in the state generate 11,085 tonnes of municipal solid waste per day, including wet and dry waste. In this, 10,662 tonnes of waste is being collected every day, the state informed the Green Bench.

Earlier, the Tribunal had asked all the states, including Karnataka, to submit details about the implementation of solid, plastic, biomedical waste management rules in urban local bodies and gram panchayats.

A total of 5,876 tonnes of waste is being processed generating 672 tonnes of city compost and 158.16 cubic meter biogas. Efforts are being taken to sell the city compost through the Agriculture Department, the state said in the affidavit.

The government also informed that has plans to establish two waste and energy plants to handle 800-tonne non-recycled combustible dry waste in the state with one jointly by BBMP and KPCL and another by NTPC.

Use of MRF in Developing Countries

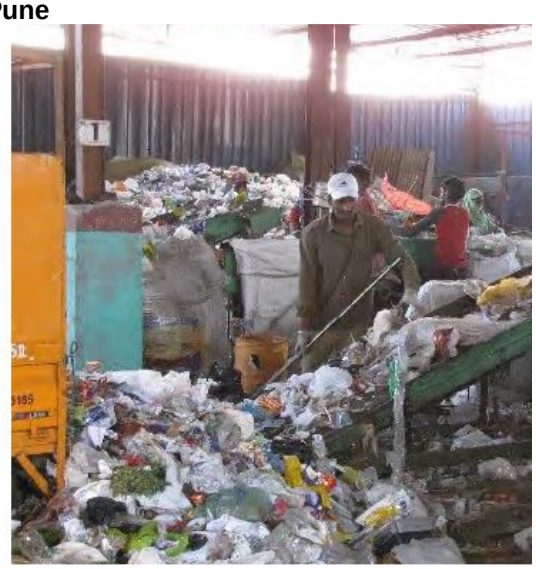
In sustainable management of MSW, Materials Recovery Facility (MRF) plays a very important role because these sort mixed wastes and help in recovering materials from a waste stream. MRFs have been used in developed countries from a long time back and can be very sophisticated with lots of high tech equipment, and hence MRFs are expensive to construct. Gradually all countries including developing ones are introducing MRF in their MSW management value chain. MRFs can vary from very simple manual ones, to very sophisticated ones. In Bangladesh, of course the low-tech ones have to be used. In the Box below, a low-tech MRF in India is described (EPA, 2020).

Low-Tech Manual MRF in Pune, India

(EPA, 2020)

MRFs are specifically designed to sort and recover recyclable materials. They can be located at a transfer facility or a standalone location. MRFs employ a combination of technologies to sort recyclables. Common technologies include rotating-cylindrical screens that separate materials according to size, overhead magnets to collect items containing iron or steel, and conveyor belts that move materials slowly past teams of workers who remove recyclable items. Although high-technology MRFs are not common in developing countries, many cities use smaller-scale facilities to coordinate the separation of recyclable materials by using lower-technology solutions, such as hand sorting.

Hand Sorting Recyclables at a Facility at Pune



Role of Landfill Ban Laws

The use of legal instruments can be very effective in controlling landfilling. To understand the effects of certain rules and regulations that have worked internationally in managing MSW it is instructive to study Figure 4 depicting the waste management in Sweden from 1994 to 2012 (OECD, 2019). In 1994, Sweden introduced the Producer Responsibility law, also known as Extended Producer Responsibility (EPR). As can be seen the quantity of wastes going to landfills started to decrease. However, the most dramatic drop in the quantity of wastes reaching the landfill occurred after the 2002 ban on landfilling of combustibles; at the same time there was a sharp increase in the Incineration with energy recovery technology. This is of course expected because the combustibles were now reaching incineration facilities. The third drop in landfilling occurred in 2005, when Sweden banned all organic material being landfilled. This reduced the landfilled quantity in 2012 to a very small value.

All along with the Producer Responsibility Law and the two landfill bans, Sweden has applied a landfill tax. That means the more landfilling a city corporation does, the

more tax it has to pay. By using the four MSW management legal instruments, Sweden has reduced their landfilling to a minimum. In this scenario, only the inert material and the ash from the incineration plants are reaching the landfill. This is most optimum level of MSW treatment. As can be seen the policy mix of landfill tax and landfill bans were effective in diverting municipal waste from landfills in Sweden. All successful MSW management examples have been driven by a monitoring, enforcement and penalties.

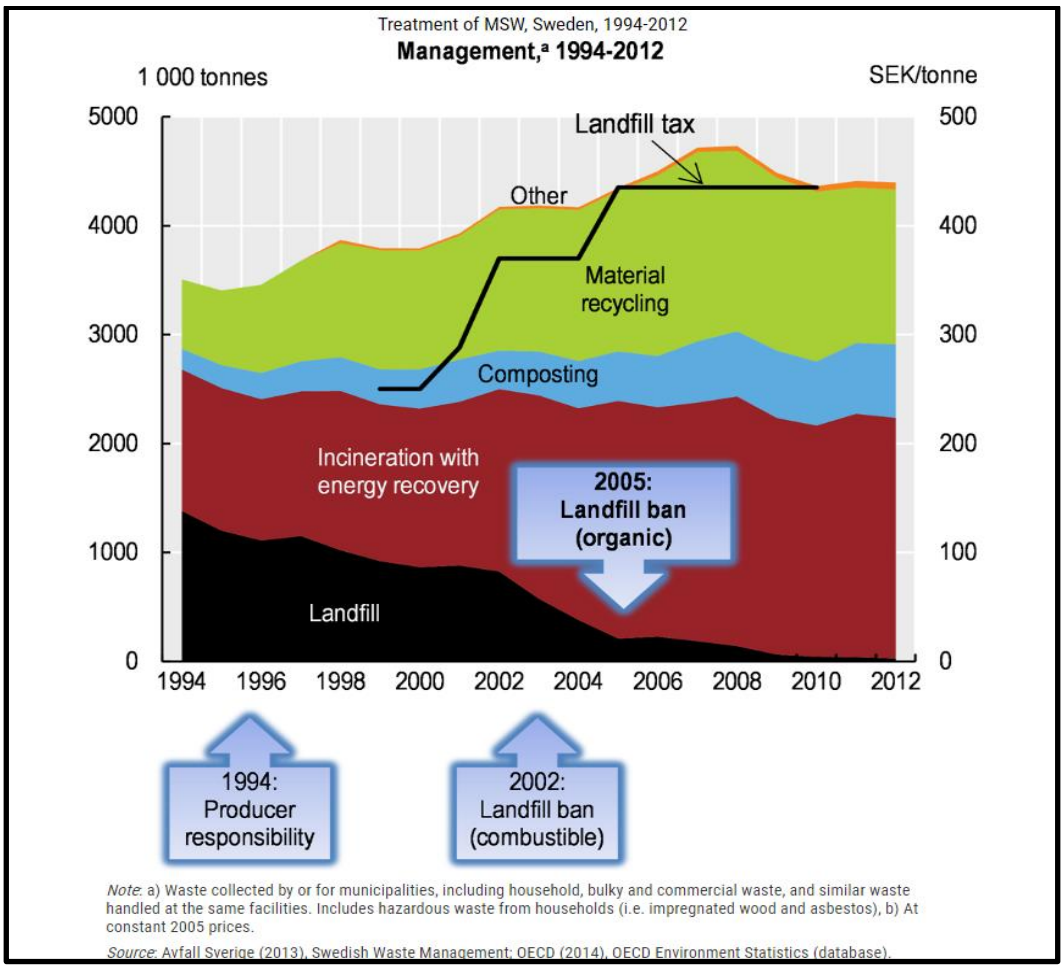


Figure 4: Effect of Tax and Landfill Bans on Quantity of Material Landfilled[7]

6.0 Stakeholder Engagement

Stakeholders were engaged through KIIs and FGDs to understand the forces for and against the proposed 4R Roadmap. The consultant has personally engaged with the stakeholders to understand the underlying issues. Table 2 summarizes the findings. The findings of the KIIs and FGDs were used for developing the Roadmap, especially the community-based model for MSW management.

[7] (OECD, 2019); The recent successes in India have been driven by the formation of the National Green Tribunal (NGT). Recently, the NGT fined the West Bengal government Rs. 4,500 crore for not meeting their MSW management goals

The most important learnings for the consultant came from the FGDs. The ability to pay for the collection from slums was a major factor in the decision of the community. It was found that the slum community does not have the ability to pay beyond Tk. 100 per family. Some CBOs were charging half that amount, but in those slums they had to rely on the NGOs for vehicles, protective equipment and dresses. Another significant finding was that the members of the community were willing to perform source segregation if 2-bins were provided. This means the organic wastes can be used in a community owned compost plant. Thus, the cooperation of the city authorities is vital in developing a 4R MSW community-based management system for low-income communities.

Table 2: Stakeholder Engagement – Opinions of Stakeholders

Groups	Number Interviewed	Relevant Comments and Opinions from the Key Informant Interviews (KIIs)
DoE	**2**	• 3R Strategy was formulated in 2010; no update of that has been made • DoE encourages 3R applications in all aspects of solid management, but have not developed a framework or taken any specific actions • 3R in the IRRC model by encouraging Pyrolysis of plastics wastes • CDM projects in 64 districts to set up compost plants are underway
NGO	**1**	• Have organized low-income communities to practice Community-Led MSW management; Awareness raising on source separation is underway • On the whole, these have been successful but many challenges remain. They require active support and cooperation from the city corporation to have an effective 4R compliant MSW management
Waste Sector experts	**2**	• Community-led solid wastes management should be encouraged • Integrated waste management is the way forward in Bangladesh • Transportation of wastes must be done in an efficient manner • Open dumping of wastes must be eliminated as early as possible • Incineration is an effective treatment process where land availability is an issue, but it destroys the resource value of the organic waste. Moreover, it is an expensive process when organic content is high and combustible material is low. The government must have a clear-cut vision on which treatment technology they want to use
DNCC	**1**	• Dealing with slum dwellers is difficult because households do not possess holding numbers and as such do not enjoy legal status • Community bins are often misused and/or overused • Setting collection fees is difficult • They are in contact with NGOs and working with them to device a good model for low-income communities

No.	Location of FGD	Number of participants	Observations and Relevant Comments
I.	Balurmath & Boubazar Slum Engineer's House, Hazaribagh Ward- 14 & 55 Dhaka South City Corporation (DSCC) 21 July 2022 3-4:30 pm	14 (Female-11; 13 were youth and 2 were ethnic minority)	➢ Low lying areas were being used as wastes dumping ground; streets were generally dirty ➢ Wastes collection from households managed by DSCC through contractors; collectors take no responsibility of keeping the streets clean ➢ Collection fee per family is Tk. 100/month ➢ One person residing in one room is also considered a family; FGD participants said the fee is high
II.	Korail Slum Jamai Bazar Awami League Club, Ward- 19, Banani, Dhaka. Dhaka North City Corporation (DNCC) 25 July 2022 34:30 pm	19 (Female-15; 1 was ethnic minority; 10 were aged 18 to 35	➢ Wastes collection from households managed by CBOs ; collection fees set by CBO, and is Tk. 60 per family per month ➢ Waste collectors were also responsible for keeping the streets clean ➢ Not fully sustainable because some financial and logistical support is provided by NGOs
III.	Molla Slum World Vision School, Ward- 06, Mirpur-12, Dhaka Dhaka North City Corporation (DNCC) 26 July 2022 12:30-2 pm	17 (Female-11)	➢ Waste collectors were dumping wastes in low lying areas near the slum instead of carrying the wastes to the Transfer Stations ➢ Collection fees set by CBO is Tk. 50. FGD participants were happy with the fees amount, but the collection process was dependent on NGO's donations of vans for carrying wastes

7.0 Assessment of the Bangladesh MSW Value Chain

Based on the primary data collected via the KIIs and the FGDs (summary of the findings is given in Section 6.0 – Stakeholder Engagement) and the secondary information from the literature survey, the present status of MSW management in Bangladesh was established. To accomplish this task, the consultant also observed the present MSW management in Dhaka city, i.e., the door-to-door waste collection, the wastes handling in Transfer Stations, the transportation of wastes and prevailing situation of the landfills. Annex C gives the full descriptions of the various waste management practices in Bangladesh.

The assessment of the the present Bangladesh MSW management practices were done for eight elements of the MSW value chain. The summary of the full assessment, which appears in Annex C, is provided below –

Source segregation – All source segregation pilot projects have failed to produce positive results. Feriwallas (door-to-door purchasers), collect on payment items from households, and as such prevent materials going to the waste bin. These items are mostly reused

Collection – In most towns the proportion of solid wastes collected is less than 50%[8]. The main reason is that in all urban centers*, slums and poor communities are incompletely served by the municipal waste collection services*

Transportation – From households to transfer stations, rickshaw vans are used. From roadside dustbins and transfer stations to landfills, garbage trucks are used, but all the trucks are not proper garbage trucks designed to carry MSW

Sorting (MRF) – Waste pickers from the informal sector perform a function at several levels to extract recyclables from MSW (dustbins; secondary transfer stations; landfills). Only 3-4 pilot project MRF for sorting mixed wastes exists in the country; so very little scope of RDF or Pyrolysis plants

Composting – Composting of MSW is a relatively new practice in the country; being implemented in few towns under either CDM projects of the MoEFCC or IRRC piloting. In small scale the private sector are trying to get involved in this activity

Anaerobic digestion – No practice of anaerobic digestion (AD) using MSW

Incineration – No incineration of MSW being practiced but a project for Dhaka and one for Narayanganj have been initiated

Disposal – Landfills and Open Dumps; only one sanitary landfill at Dhaka

From the assessment above it is clear that the present MSW management in Bangladesh is at a very basic level. Collected wastes after transit at the Transfer Station are dumped at the nearest available landfill, which in most cases is an open dump. Segregation or sorting, the process fundamental to implementing 4R, is absent in the value chain. Other than recycling, which occurs by virtue of the informal sector, there is no resource recovery.

8.0 4R Roadmap on Solid Waste Management

To develop the roadmap both primary and secondary data and information were used. First, all rules and regulations pertaining to MSW management in Bangladesh were thoroughly reviewed. Following that the published literature on local successful practices and global best practices in MSW management were studied. The primary data collection consisted of 6 KIIs and visits to three slums of Dhaka city to participate in 3 FGDs. The consultant during the course of the work also observed waste collection from households, transfer station waste handling, transportation of wastes and the status of landfills and open dumps.

[8] Waste Database 2021 by Waste Concern; soon to be published

Based on the analysis of the issues with MSW management in Bangladesh, the activities and targets that are needed to develop a 4R MSW management system were determined. To start the process the basic model of MSW management developed by Waste Concern, which is being piloted and practiced in Bangladesh, was chosen. This model called the IRRC incorporates the Bangladesh government's 3R strategy and the country experience of Waste Concern. Waste Concern is the leading consulting group in the country specializing in solid waste management. They have developed an integrated solid waste management model specifically applicable to developing countries. More details of this model are provided in Annex B. This model has been piloted in several Asian countries. The Bangladesh government has endorsed this model with some modifications for smaller towns. This model served as the starting point for developing the 4R Roadmap for Bangladesh. Waste Concern were extensively consulted and engaged in the Roadmap development task. Current world best practices of the 4R principles were evaluated and incorporated where appropriate.

The Roadmap has been developed for the four sequential components of the MSW management listed in Table 3. The justification for inclusion in the Roadmap of the different elements of the components is also given in Table 3.

Table 3: Incorporation of 4R Principles in Different Components of the Roadmap

	Component	Elements of the Component of the Roadmap	Justification for Inclusion in Roadmap
I.	**Generation of solid waste**	Awareness raising about waste minimization, source separation and reusing of materials 2-Bin source separation in the Short and Medium Terms and 3-Bin source separation in the Long Term Extended Producer Responsibility (EPR) has been focused in the Roadmap for reducing plastics packaging and collection from wastes	In 4R principle, the first "R" is reduce and second "R" is reuse As stipulated in the Solid Wastes Rules 2021 3R Strategy
II.	**Collection and Transport**	Waste Collection Model for Low-income communities; informal sector workers managed by the community engaged to deal with wastes and their treatment In the short term at least 80% collection efficiency; medium term 100% collection efficiency 3-wheeler motorized vehicles for door-to-door collection, and GPS fitted improved garbage trucks	City Corporations need a good model for waste collection from low-income communities SW Rules 2021 stipulates 100% collection Present transportation of wastes is very inefficient
III.	**Sorting and Recycling**	MSW sorted in MRFs so that organics can be made available for Compost/Biogas production; combustible will be available for RDF/Pyrolysis, and inerts will go to landfills Recycling in Bangladesh is a very successful totally informal sector activity; recycling will be further enhanced by the outputs of MRFs	Presently without MRF, organics are going to landfill, which is contrary to the 4R principles More material than presently being recycled will be recycled as a result of MRFs

IV.	**Treatment and Disposal**	Compost Plant or Biogas plant (Composting and Biogas production are 4R compatible activities) Landfill only for inert material 1. Landfill ban of combustible material 2. Landfill ban for organics	Strongly recommended in 3R Strategy and SW Rules 2021 Whatever treatment method is employed, certain amount of material will have to be landfilled

One of the challenging aspects of MSW management is plastics wastes. The main environmental issue with plastic wastes being faced globally is that due to single-use plastics (SUP). While some SUPs are essential such as packagings of food for storage and retail, others such as straws and coffee cups are not. Moreover, for many SUPs there are alternatives; e.g. paper straws and cups. Littering of SUP which is the cause of mismanagement can only be dealt by awareness campaigns leading to behavioral change. Since behavioral change is difficult to achieve, the government will soon have to take decisions regarding SUP in line with UN guidelines. Many countries including India have banned several SUP items. The full write-up on how to deal with plastic packaging is given in Annex D. In the Roadmap plastics that remain in the mixed wastes is proposed to be dealt with by sorting in MRFs and then treated in a RDF plant or Pyrolysis plant.

8.1 Flowchart of the Proposed MSW Value Chain

The flowchart of the proposed MSW value chain based on the findings of the KIIs and FGDs and analysis of the prevailing MSW management in Bangladesh urban centers, including the slum areas, is shown in Figure 5. The existing MSW management consists of the first three rows of boxes (waste generation, collection and Transfer Station) and the last row, i.e., landfill. In the 4R flowchart, after the first three rows of boxes another two rows of activities have been inserted. The first activity introduced is the MRF, where organics and inorganics (combustible and non-combustible) are separated. The RDF/Pyrolysis box is part of the row where organics and inorganics are treated. The second set of activities introduced deal with processing the separated fractions.

In the existing MSW management, wastes from the Transfer Stations are sent straight to landfill. Thus, all the steps shown in Figure 5 between the Transfer Station and the Landfill are missing. The resource values of the wastes are thus being destroyed in the prevailing practice. In the proposed Roadmap several steps have been added to make it 4R compliant. The MRF through sorting recovers resources that would otherwise be lost. The sorted wastes are treated based on whether it is organic or inorganic in two sets of treatment facilities. Organic wastes go to Composting and Biogas plants. The inorganic part, depending on whether it is combustible or not, is sent to either RDF/Pyrolysis plants or the landfill.

The flowchart shown in Figure 5 has incorporated MSW management from slums. It can be seen that from the “Composting” box there is an arrow going to a comment

box; it is proposed that communities, if able to perform their own collection, can set up their own composting plant. If this model can be implemented then not only will the load on City Corporation decrease but also the slum dwellers will be able to manage their own SW and produce organic fertilizer thus lowering their door-to-door wastes collections fees.

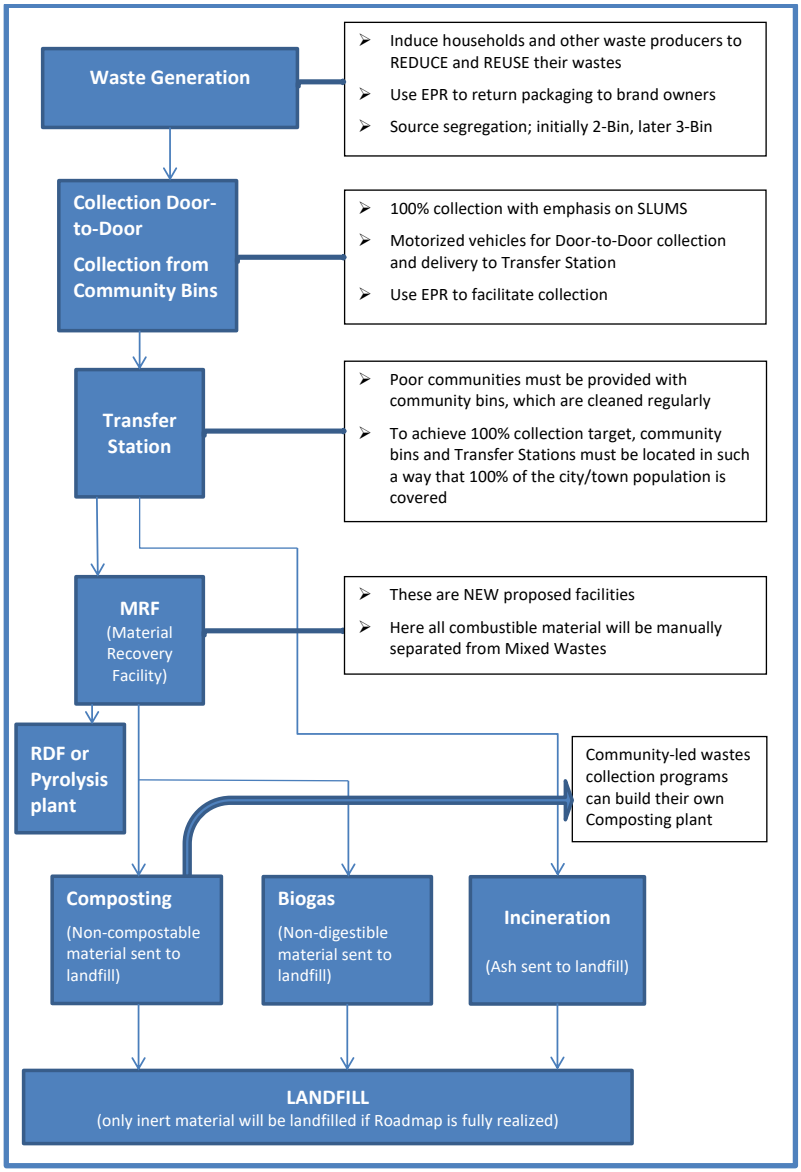


Figure 5: The Flowchart of the Proposed 4R MSW Value Chain

8.2 Description of the Roadmap

The four components of MSW value chain as contained in the 4R Roadmap are described –

I. <u>Generation – the production of solid waste from urban activities</u>

Waste management systems in Bangladesh have been of the traditional type without 4R principles such as reuse and reduce. In the 4R principle, the first "R" is reduce. Achieving this first R is probably the most difficult task because human beings are not naturally inclined to this. Therefore the first and foremost thing in the Roadmap is awareness raising. If individuals can be motivated towards minimizing wastes, and reusing materials (the second “R”) for as long as possible, MSW management requirement is significantly reduced. As stipulated in Solid Wastes Rules 2021 (GoB, 2021) the Roadmap has included 2-Bin source separation in the Short Term and 3-Bin source separation in the Long Term.

Extended Producer Responsibility (EPR) has been focused in the Roadmap. Using EPR, plastics wastes especially those that are the most difficult to manage can be dealt with effectively. For brand owners, there is often scope of reducing the packaging of their products. Another way brand owners can contribute in reducing waste generation is to induce consumers to return discarded packaging for some sort of reward.

Awareness raising regarding reducing wastes, no littering, source segregation, and EPR have been incorporated. These activities need to continue into long term.

II. Collection and Transport

The most important thing in MSW management is efficiency of collection. It is often the first criteria to judge a MSW management system. It is often the case that high-income areas receive a lot of attention from City Corporations, and as such the collection efficiency is 100%. However in poor areas such as slums, the collection efficiency is low. It is not unusual to find low lying areas being used as a dumpsite within the city limits.

City authorities responsible for waste management often fail in increasing their collection efficiency because they do not have a good model for waste collection from poor community areas. The Roadmap, therefore, places high priority to increasing collection efficiency in low-income areas. In several cities similar to Bangladeshi cities Community Led wastes collection models have shown great success. Good examples of Community based wastes collection and treatment models can be found in published resources (EPA, 2020). In Bangladesh also, NGOs working with slum dwellers, have developed successful models. City Corporation should actively engage with CBOs and NGOs to find cost effective solutions for urban slums. In Figure 6, a model for waste collection for low-income community is presented.

In this model, informal sector workers managed by community can be engaged to deal with wastes collection and treatment, or the wastes can be sent to the

nearest Transfer Station. In the latter case, the city corporation should facilitate the smooth transfer of wastes.

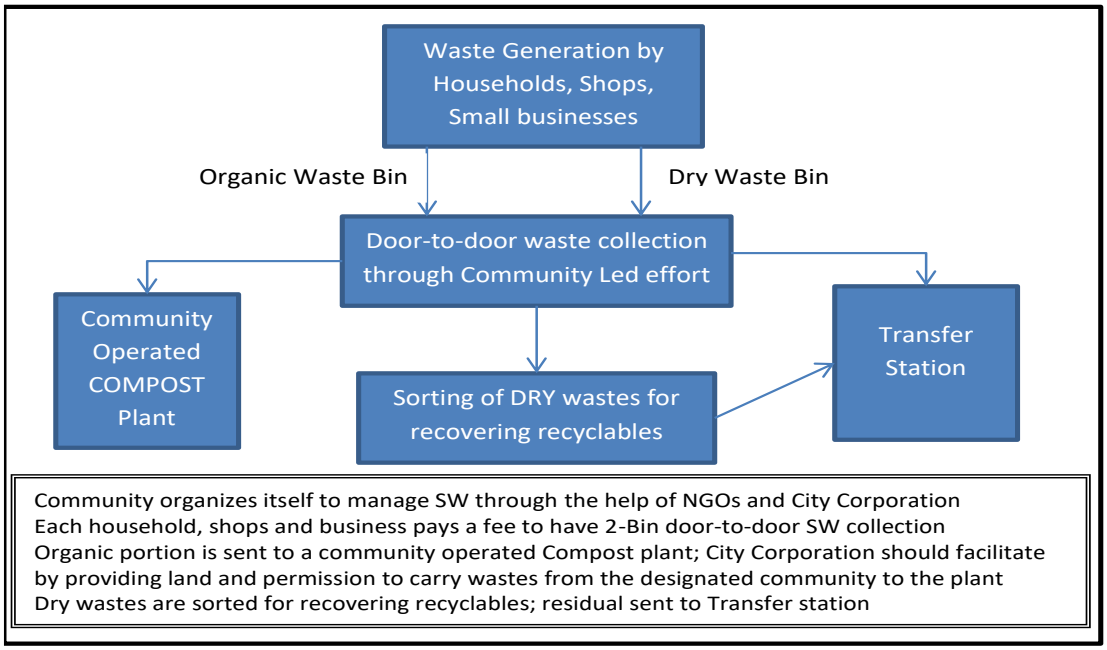


Figure 6: Model for Waste Collection from Low-Income Communities

In the short term the Roadmap suggests that all cities should try to achieve at least 80% collection efficiency by paying special attention to those areas where collection efficiency is low and collection faces many barriers. *In the medium term the Roadmap envisages 100% collection efficiency in all urban centers of Bangladesh.* 100% collection efficiency implies that all areas are automatically covered. 100% collection efficiency is standard in developed countries, and even many cities in developing countries have achieved nearly 100% collection efficiency; Karnataka, India is a good example (Athrady, 2021).

The transportation of wastes after door-to-door collection to Transfer Stations, and from Transfer Stations to disposal site needs a lot of improvement if a sustainable MSW management system is to be built. First, the present manually driven cart type vehicles have to be replaced by at least the 3-wheeler motorized versions. Without these the collection cannot be improved because human beings cannot easily push/pull the heavy carts. This also effectively limits the weight of wastes per cart. Motorized 3-wheelers are already in use in India; in other countries more improved vehicles are being used.

Transportation of wastes from Transfer Stations to disposal sites needs to be improved. First, all vehicles need to be covered type preferably with compactor, and second, these need to be fitted with GPS locator so that their movement in the city can be tracked. QR codes pasted on community bins to confirm waste pickup can also be employed to improve city collection.

3-wheeler motorized vehicles and GPS fitted improved garbage trucks have been recommended.

III. Sorting and Recycling

Sorting is the process which allows recovery of material from wastes. Without sorting the material will land up in a landfill, which is value destruction, and completely antithetical to the 4R principle. In Bangladesh, the sorting of wastes has not been introduced except for in a few IRRC pilots. Starting in the Short Term, the Roadmap stipulates that the entire volume of MSW will be treated in MRFs so that organics can be made available for Compost/Biogas production; combustible will be available for RDF/Pyrolysis, and only inerts will go to landfills. MRFs and its variations have been in use in developed countries for a long time. The technology used in MRFs can vary from very sophisticated sorting machines routinely used in developed countries to simple manual sorting on a conveyor belt. Depending on funds availability, this is to be decided. In India the low-tech equivalent is used. Bangladesh can start with the simple technologies and gradually move up the technology ladder. In many developing countries this process has already started, but Bangladesh is yet to introduce MRF. Through the IRRC model of MSW management, Waste Concern is already piloting a similar concept in smaller towns of Bangladesh.

Roadmap has incorporated the Material Recovery Facility (MRF) in the MSW value chain.

Recycling in Bangladesh is a totally informal sector activity. Only recently, some large companies have started recycling plastic wastes. However, the collection of plastics remains totally an informal sector activity. The recycling value chain and the actors involved have been discussed in Annex C. As can be seen from the Figure in Annex C, a very efficient recycling industry exists in Bangladesh. Not only that, there is a high degree of reuse materials in households, and materials such as bottles, containers and even shoes purchased from households by feriwallas are often used by others. In fact, writing paper and newspaper bought from households are used to make bags.

In Bangladesh, nearly 100% of metals are recycled. All paper that can be retrieved in a dry state is recycled. Glass is also mostly recycled. The problematic material is plastics. This has been discussed earlier. In the Roadmap, the recycling of dry material has not been given much emphasis because these are already been recycled. However, the MRF may be able to recover some more material from the mixed wastes that can be recycled. These recovered materials will be sent to the appropriate recycling factories. The emphasis has been placed on dry material that gets mixed up with organic or wet wastes. The MRF is expected to recover from wet mixed wastes material such as plastics, rags and paper. Since these are wet and dirty these cannot be recycled. These three recovered material are processed in a Refuse Derived Fuel (RDF) plant to produce a solid fuel.

It is proposed that be either converted to RDF or the plastics from the separated component can be used in Pyrolysis plant to produce oil for transport.

IV. Treatment and Disposal

From the Flowchart depicting the MSW value chain used in the Roadmap, it can be seen that the organic material coming out of the MRF can be treated in either a Compost Plant or a Biogas plant. In the event the government decides on Incineration (proposed to be tried in 4 major cities), the MRF can be eliminated and all material can be transferred to a Mass Burn Facility, with or without energy recovery. It is to be noted that without sufficient combustible material energy recovery will not work. The high levels of combustible material removed by waste pickers imply that, incineration is not likely to work in Bangladesh.

Composting and Biogas production are considered to be activities that have high sustainable development value. Composting not only restores value to a material that would otherwise be lost (in incineration or landfill), but also produces a fertilizer that can restore organic balance in soils. Annex E shows the organic content of soils in Bangladesh. As can be seen, soils in many areas of Bangladesh are seriously depleted of organic content.

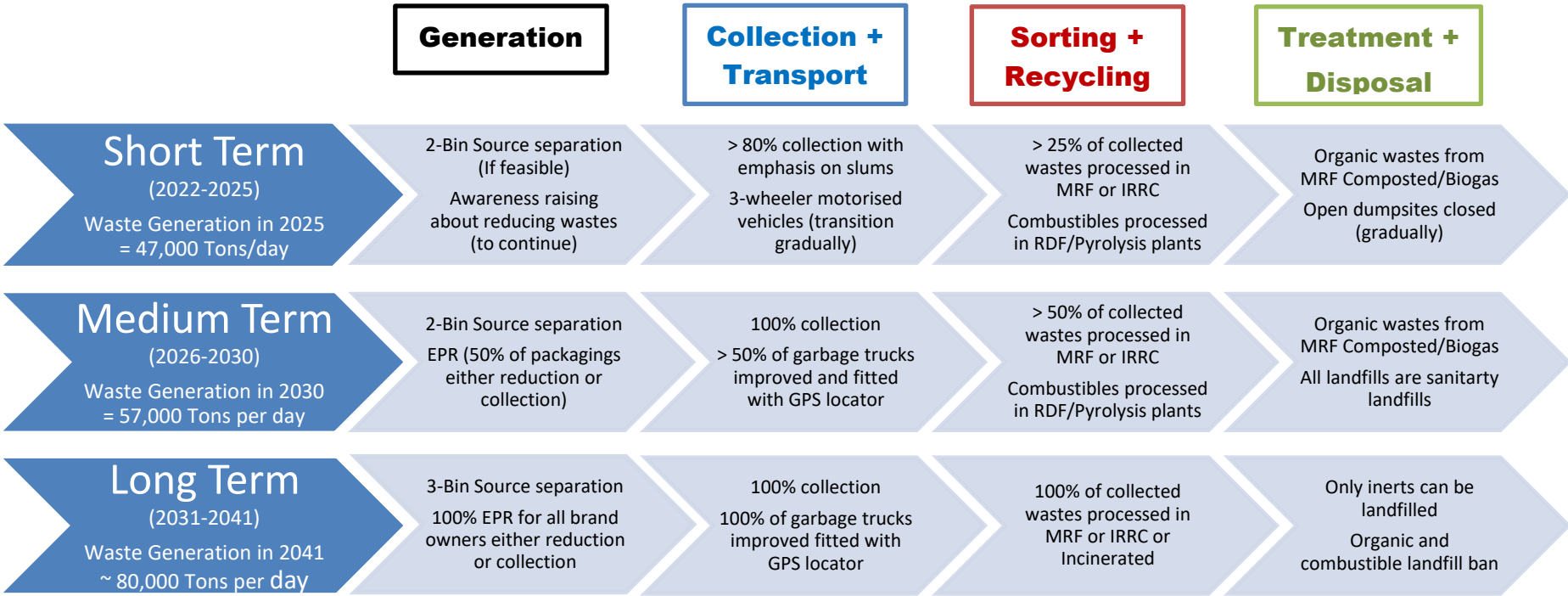
Without extensive practice of **COMPOSTING** throughout Bangladesh, the 3R strategy or the 2-Bin/3-Bin source separation of wastes is meaningless. City corporations or Pourashavas alone will not be able to achieve the widespread dissemination of the composting technology; Private sector/community initiatives should be encouraged by providing adequate facilities (wastes and land). The government should provide sufficient incentive for organic fertilizer production similar to chemical fertilizer production. Commercial banks should be approached to develop compost fertilizer production into a feasible business model.

Whatever treatment method is employed, a certain amount of material will always have to be landfilled. Even if incineration is employed, the ash has to be landfilled. In the Roadmap, during the short term, a lot of material will have to be landfilled because building the required number of MRFs will take time, but as more and more MRFs and associated treatment plants are built landfilling of wastes will progressively keep on decreasing. If the Roadmap can be implemented in totality very little material will reach landfills. To ensure that only inert material (such as construction wastes) are landfilled two policy interventions are needed –

1. **Landfill ban of combustible material such as plastics**
2. **Landfill ban for organics**

8.3 4R Roadmap for MSW Management showing Action Plan and Targets

The 4R Roadmap has been developed for short, medium and long term implementation. During each term the actions and targets for the 4 segments are set out in the flowchart below. The presentation of the Roadmap is this matrix format is particularly helpful in understanding what needs to be done and when. If it is decided that the focus would be only on Collection+Transport, then one needs to consult the respective column of the matrix. If the only the short term implementation actions are desired then one needs to consult the respective row of the matrix.



Material Recovery Facility (MRF) is the facility where mixed wastes are sorted into different fractions. A MRF with a RDF plant is often integrated with a landfill
Refuse Derived Fuel (RDF) is made from combustible material recovered from the mixed wastes at a MRF. It mainly consists of plastics, rags and paper
Integrated Resource Recovery Center (IRRC) – IRRC is suitable for small and medium sized towns. 85-90% of the incoming waste from the community can be converted into economic resources (such as compost, biogas, recyclables, Refuse Derived Fuel (RDF) within the IRRC. In partnership with UN-ESCAP, Waste Concern is replicating the IRRC model (Annex B)
Extended Producer Responsibility (EPR) is a mechanism whereby brand owners are made responsible for the packagings used in their products. EPR reduces the load of MRFs either by reducing wastes generation (use of less packaging) or by some type of mechanism that returns post-consumer packagings to the respective brand owner for appropriate disposal

8.4 Activities and Milestones of the 4R Roadmap for MSW Management

Timeline	Descriptions of Activities and Milestones
Start (3-6 months)	**Develop a detailed plan to implement the Roadmap** including – Funds requirement, land requirement, logistics, etc. Since allocation of land can take time, this planning can be broken up into phases. Then plans can be developed for the different phases. Since the plans would be executed by the Mayors' Offices around the country, the **Association of Mayors** can be entrusted with the responsibility of implementing the plans. To start the process, a project office needs to be set up headed by a project manager with required staff and budget. The project manager can then develop the implementation plan according to the government's requirement, and seek funding.
Year 1	1. Awareness program initiated to reduce waste generation including convincing brand owners to use less packagings 2. **Improving collection efficiency is the No. 1 task**. Present focus is on high-income areas. Low-income areas need to be given priority because it is precisely in these areas that collection efficiency is low. Some good practices have been outlined 3. Take decisions on whether to use Composting or Biogas treatment process; if desired both processes can be employed; for large cities Incineration can be the treatment process; in that case the wastes would be transported straight to the incineration plant from the Transfer Stations much like the present practice; no MRF, RDF/Pyrolysis plants or Composting/Biogas plants would be required 4. Take all steps to build MRFs around the country. To reduce costs and deal with land availability issues, transfer stations can be remodeled into MRFs. In addition, the MRFs can be part of a landfill
Milestone (midterm)	• All preparations are in place to start building MRFs (Funds, Land, DoE clearance, Contractor, etc.)
Year 2 and 3	1. As set in targets, build the required number of MRFs along with RDF/Pyrolysis plants; Build required number of treatment plants 2. Hire people to operate MRFs and RDF/Pyrolysis plants; Set up RDF and Pyrolysis products sale facilities and contracts 3. Hire people to operate Compost/Biogas plants or engage Private sector; Set up sale facilities and contracts as necessary

Milestone **(Short Term)**	• > 80% collection in cities with emphasis on low income areas including slums • > 25% of total city solid wastes processed in MRF or IRRC • Compost, Biogas/Fertilizer, RDF and/or Pyrolysis products being utilized and/or sold • Only inerts from MRFs going to landfill; all open dumpsites closed
Year 4 and 5	1. Start enforcement of the EPR program with major brand owners; prepare list of all brand owners and train the smaller ones **2.** The present system relies on manually operated vehicles for transport of wastes after door-to-door collection. At the very least motorized 3-wheelers need to be used. For segregated collection, transport needs to be segregated also into two collection compartments. At MRF these should be specially handled. **Organics from segregated collection can be used by private operators** 3. Continue improving collection efficiency using best practices from around the world 4. Continue building and operating MRFs, RDF/Pyrolysis plants, Composting/Biogas plants to achieve the targets set
Milestone **(midterm)**	• EPR piloting ongoing in full swing • Improvement in collection efficiency beyond the Short Term Milestone • Construction of MRF on track to achieve the Medium Term Milestone • Construction of Compost/Biogas plants on track to achieve targets set
Years 6-8	1. Pass law to mandate that brand owners must collect post-consumer packaging wastes equivalent to 50% of their usage by 2025 and 100% by 2031; monitor and enforce 2. Continue improvement in the transport of MSW (more use of motorized 3-wheelers). Increase segregated collection of wastes from households into two compartments. Start installing GPS locator on garbage trucks transporting MSW 3. Continue improving collection efficiency using best practices from around the world 4. Continue building and operating MRFs and RDF plants and Composting/Biogas plants as required to achieve the targets set
Milestone **(Medium Term)**	• EPR (weight equivalent of 50% of packagings used by brand owners collected and properly disposed) • > 90% collection in all towns and cities with emphasis on low-income areas • > 50% of total collected wastes processed in MRFs or IRRCs • Products from RDF/Pyrolysis plants and Compost/Biogas plants being utilized and/or sold

Year 9+	**1. Pass landfill ban on combustibles and Organics from 2031; monitor and enforce** **2. Initiate 3-Bin Source separation along with awareness campaign for 3-bin source separation** **3. Monitor and enforce EPR for all brand owners** **4. Monitor progress of conversion of transport vehicles to requirements set in the Roadmap** **5. Monitor progress of 100% of solid wastes reaching MRFs**
Milestone **(Long Term)**	• EPR (weight equivalent of 100% of packagings used by brand owners collected and properly disposed) • 100% collection of MSW using motorized vehicles in all urban centers of Bangladesh • 100% of garbage trucks are of the improved type, and 100% have GPS locator • 100% of towns and cities have sufficient number of MRFs/IRRCs; However, if government permits some urban centers can use incineration as the final treatment process with only the ash going to a Landfill • Only inerts being landfilled (no combustibles or organic material going to any landfill)

8.5 Implementation of the Roadmap

This Roadmap is designed for the whole country. The idea behind it is to show how 4R principles can be incorporated into a sustainable MSW management plan for the cities and towns of Bangladesh. To implement it in its entirety is a huge endeavor. It cannot be one big project. To implement this Roadmap, it needs to be broken up into several bits. For example, there can be one for Dhaka, one for Chittagong, one for towns in Sylhet district, or one for towns in Rajshahi division excluding the big towns, etc. Table 4 outlines four ways how elements of the Roadmap can be implemented.

Table 4: Options of Approving the Roadmap for Implementation

	Options	Scopes	Remarks
1.	Approve the Roadmap for a specific region or area	All the activities under the Roadmap can be pursued but for a specific urban center	
2.	Approve one or two segments of the Roadmap to begin work	A part of the Roadmap can be implemented. For example, Sorting, or Treatment and Disposal can be pursued	A priority segment may be chosen; 2nd most prospective option
3.	Approve a single activity and start work	RDF production, sale and use are new in Bangladesh. This can be pursued as a single activity to gain knowledge	
4.	Approve a special package for NGOs/CBOs to manage wastes from communities	Under the umbrella of the Roadmap, a special package can be developed for NGOs and CBOs to independently pursue with the assistance of informal sector workers. The entire MSW value chain from waste generation to disposal can be managed without burdening the city corporation	Most prospective of all the options

To implement the Roadmap a detailed implementation plan with budgets has to be developed. For that detailed information of waste collection, location of MRF, RDF/Pyrolysis plants, Compost/Biogas plants, land availability and price, etc. would be needed. An indicative budget for preliminary decision making is given in the next section. A monitoring plan has to be also developed. However, the targets for the monitoring plan are given in the Roadmap. Following are the authorities that will be responsible for implementing the Roadmap –

1. The MoEFCC (for enforcing the 4R rules)
2. Mayors of cities and Chairman of Pourashavas in towns (implementing authority)
3. LGRD (in case the Pourashava Chairman does not have the capacity to implement)

Several important aspects regarding implementing this Roadmap are discussed in the following sub-sections.

Prime/Secondary Stakeholders and Their Roles

The prime stakeholders are the following –

1. The authority responsible for waste collection (most places it is the Mayor's Office)
2. The authority responsible for framing solid waste rules and 3R/4R guidelines
3. Waste generators (households, commercial establishments, institutions, etc.)
4. Recyclers (plastics, metals, glass, paper, others)

The secondary stakeholders are the following –

1. The waste collectors
2. The informal sector persons involved in collecting recyclables
3. Transfer station workers
4. Brand owners
5. Entrepreneurs interested in waste business
6. Civil society (those responsible for clean city)
7. NGOs working on MSW management in slums
8. Academicians and researchers working on waste management

The roles of the stakeholders are given in Table 5.

Table 5: The Prime and Secondary Stakeholder and their Roles

	Stakeholders	Roles
Primary Stakeholders		
1.	The authority responsible for waste collection	➢ Principal stakeholder; responsible for MSW management from collection to final disposal ➢ To facilitate sustainable MSW management by encouraging Community Led efforts in waste management including providing land and wastes for Compost/Biogas projects ➢ To facilitate public-private partnership in building waste management infrastructure
2.	The authority responsible for framing Solid Wastes rules and 3R/4R guidelines	➢ Responsible for formulating the laws and setting standards to control the disposal of MSW ➢ Provide guidelines to perform the operations in an environmentally sound manner ➢ Facilitate the 4R management of MSW
3.	Waste generators (households, commercial establishments, institutions, etc.)	➢ Reduce waste generation; reuse materials ➢ If required by law, segregate wastes into different bins ➢ Assist in recycling wastes as far as possible ➢ Dispose wastes responsibly without littering
4.	Recyclers (plastics, metals, glass, paper, others)	➢ Assist in improving and increasing recycling by following best practices
Secondary Stakeholders		
1.	The waste collectors	➢ To perform door-to-door collection and carry collected wastes to the Transfer Stations; to keep the city clean

2.	The informal sector persons involved in collecting recyclables	➢ To collect all types of recyclables and greatly assist in the Recycling Value Chain. Without their hard work, recycling of wastes would be greatly limited
3.	Transfer station workers + waste loaders (on trucks)	➢ To assist in the MSW value chain to keep the city clean
4.	Brand owners	➢ Through EPR, assist in MSW management by (i) Minimizing packaging (ii) packaging return scheme (iii) collecting packaging from transfer stations
5.	Entrepreneurs interested in waste business	➢ Engage in public-private partnership ➢ Build businesses using the opportunities available
6.	Civil society (activists responsible for clean city)	➢ Monitor city cleanliness from a civic perspective ➢ Assist in awareness raising regarding the 4R MSW management; Propose ways to improve MSW management
7.	NGOs working on MSW management in slums	➢ Evolve new and innovative ways to manage MSW especially in low-income communities ➢ Raise awareness of slum dwellers in sustainably managing their wastes and assist them to interface with city authorities to carry their wastes
8.	Academicians and researchers working on waste management	➢ To develop new and innovative MSW management methods and techniques ➢ To impart training and assist in capacity building

Infrastructure/Technology Requirement for the Roadmap

The Roadmap is critically dependent on a set of infrastructures and technologies. The infrastructures required are –

I. Material Recovery Facility (MRF) – sufficient to process the maximum quantity of wastes generated in a day

II. Landfill – this should not be a problem if the 4R Roadmap is followed. According to the Roadmap, the quantity of material that will go the landfill will gradually reduce such that in 2041, only inert material (that which cannot be used in any way), will reach the landfill. This is expected to be less than 10% of the total volume of the wastes generated in a year.

The following are the technologies and equipment/vehicles that will be required –

I. Sufficient number of motorized 3-wheelers to transport wastes from households and other urban activities to transfer stations

II. Sufficient number of garbage trucks with GPS locator to carry wastes from transfer stations to MRF and from MRF to landfill

III. Sorting machines at the MRF (can be manual sorting with low-tech equipment)

IV. RDF/Pyrolysis plants as required

V. Composting and/or Biogas plants as required

A specific infrastructures and technologies requirement can be worked out when more details of actual implementation are available. Moreover, the decisions on what level of technology to employ or the infrastructure cost per square meters are required.

Private Sector Participation in the MSW Value Chain

MSW management is essentially a public sector activity. It is the responsibility of the city authority usually under the mayor to provide this service. However, it has been found that in developing countries due to lack of funds, this service is deficient. Over the years, the city authorities have found ways and means to reduce the cost burden by engaging the private sector in various capacities in the value chain. In Bangladesh today, the door-to-door collection has been totally outsourced to the private sector, with the city corporations exercising only supervisory role. Different business models have been developed some for slums by NGOs.

The transportation of wastes from Transfer Stations including managing the wastes in Transfer stations has been exclusively a public sector operation. In the new 4R Roadmap suggestion has been made to locate MRFs with the Transfer Stations or adjacent to it. These transfer stations can be operated by the private sector. A private-public joint venture can be created to achieve this. MRFs remote from locations can also be private operations. Hoverer, strict guidelines have to be developed to facilitate the operations. There might be a tendency to not perform the sorting and separation properly and thus send non-permitted materials to landfills. At any rate, the business model will be complicated because a MRF operation may or may not be profitable depending on the price of the recyclable, RDF/Pyrolysis material. A through study with piloting would be required to develop a business model that can be used by the private sector. There is, however, good scope of private sector participation in the following areas in MSW management value chain –

1. RDF/Pyrolysis plants
2. Compost/Biogas plants

These are best suited to the private sector. Through the Build, Own and Operate (BOO) model the private sector can get involved. There are many available models. The main barrier in these would be land availability. The city corporations should provide the land on lease to the private operators. The entrepreneurs who manage to win the contracts through a tendering process would operate the plants with wastes supplied from the MRFs and sell the products. If land and wastes is provided (delivered to plant sites), then these can be profitable businesses. If not, then concessionary funds on easy terms can be arranged. The following steps need to be followed to build these businesses –

1. After contract award, sign a land lease deal with City Corporation
2. Sign a raw material (delivered to site) deal with City Corporation
3. Arrange financing and secure all permissions including environmental clearance
4. Construct plant and get utility (electricity, water) connections
5. Set up sale contracts for the products and develop the supply chain
6. Operate plant and sell products

Scope of Research and Innovation

Even though there is no dearth of literature on MSW management, there is continuous need for research and innovation. This is because each country has some unique characteristics which cannot be accommodated with models from another country. The most important differences arise from the differences of people's behaviors and the per capita income. Even to replicate one country's model in another country, a significant amount of experimentation and trials are required.

The following is a non-exhaustive list of research/innovation areas –

- Use of more biodegradable materials; more reuse of materials
- Packaging minimization
- More efficiency and cost-effective collection of wastes
- Improvement in waste transportation
- Novel ways of treating organic and inorganic wastes

Community Participation, Awareness Raising and Capacity Building

Municipal corporations using standard MSW management procedures and technologies can only do so much. Real improvement in MSW management, one that incorporates 4R principles can only be achieved through community participation. If wholehearted and 100% community participation can be obtained then the waste management process becomes an extremely easy task, and even circular economy can be achieved. Theoretically speaking, if every individual participated completely by not littering, by segregating wastes and assisting in collection, a 100% circular economy could be created. But since, humans are prone to behaviors that are antithetical to a circular economy model behavior; there is great need for awareness raising.

In a developing country, where educational level is low awareness raising is extremely important, and play a big role in developing an efficient MSW management system. In most cases people are often not aware of the consequences of their action such as littering. If people voluntarily participated in non-littering most cities would be clean. If people took a little bit of trouble and care, all wastes can be disposed segregated which will make further processing easy and inexpensive. For example, when dry materials such as plastics, leather or paper are mixed with wet wastes, recycling not only becomes difficult and expensive, in most cases is rendered useless. Thus through awareness programs such knowledge need to be imparted to people. The following awareness campaign can be thought of –

- Leaflets distributed to every home or building
- Public awareness campaigns through television
- Awareness campaigns pasted on community bins or designated spots on roads

- Campaigns in schools
- Campaigns through SMS and social media platforms

The Roadmap proposed has several new concepts that those involved in MSW management may not be familiar with. Even though the MRF is being piloted in several towns, it is not something that most city corporations or Pourashavas are familiar with. The addition of the RDF/Pyrolysis component to handle combustible wastes is also something new. The full management of MRF and Composting/Biogas facilities including landfilling requires rigorous capacity building. The Roadmap will be very difficult to implement without adequate training of Municipal Corporation staff. Fortunately, the training and capacity building material is not difficult, and can be developed quite easily. It is important that a continuous process of community participation, awareness raising of households and capacity building of those involved in activities of the waste value chain is essential for a good and smooth implementation.

8.6 Financial Implications of Implementing the Roadmap

As remarked earlier that without specific details of implementation it is not possible to draw out a full budget for this Roadmap. However, tentative cost implications of implementing this Roadmap or parts of it can be calculated. Waste Concern for their IRRC has worked out indicative investment and operations cost for the various technologies of the MSW management for Bangladesh. Table 6 shows the cost information of the various technologies employed in the MSW value chain. The data from Table 6 can be used to estimate the profitability of a composting facility.

Table 6: Cost of Different Technologies for Treating MSW[9]

Technology	Land Requirement	Capital cost (USD)	Operational Cost (USD)
Clean Materials Recovery Facilities (MRF)	0.5 ha/ 100 ton	30,000/ton	20/ton
Dirty (raw waste) Materials Recovery Facilities (MRF)	0.7 ha/ 100 ton	20,000/ton	50/ton
Composting	1.1 ha/ 100 ton	30,000/ton	10/ton
Anaerobic Digestion (AD)	1.5 ha/ 100 ton	50,000/ton	15/ton
Pyrolysis	0.75 ha/100 ton	70,000/ton	20/ton
RDF	0.75 ha/ 100 ton	65,000/ton	25/ton
Incineration	0.5 ha/100 ton	175,000/ton	60/ton
Controlled Landfill	6 ha/ 100 ton (with 10 m height, for 20 years)	500,000/ha	10/ton

A small composting facility, ideal for a community that is generating 1 Ton of organic waste per day is considered. The data for the financial analysis is presented below, while the Excel worksheet for calculating the price of fertilizer (without profit) is presented in Annex F.

[9] Data from Waste Concern

Financial analysis data

Organic waste = 1,000 kg per day; Fertilizer production = 250 kg per day
Investment Cost = Tk. 3,000,000; Operation Cost = Tk. 365,000 per year
Land requirement = 3 Bigha; Land leasing cost = Tk. 3,300,000 per year
Project life = 20 years; Discount rate = 10%; Taka/$ = 100

Table 7 shows the effect of changing some key parameter values on the price of fertilizer; it can be seen the largest effect on the price comes from land price. This is to be expected because land around large cities has become very expensive. Thus, for breakeven fertilizer has to be sold at Tk. 44/kg if land is to be leased. However, if land is available from government, then organic fertilizer is certainly a profitable business (waste delivered free of cost to plant site). Even if operation cost is doubled the price moves upward by only Tk. 4/kg.

The reason the effect of interest rate is low for this exercise is that the land lease which is almost equal to the total initial investment is paid out annually, and this cost does not occur with the initial investment, as would happen if the land had to be bought outright at the very beginning of the project. In the above exercise the cost of waste delivery to site has not been taken into account. Neither has the cost of marketing and selling the fertilizer been taken into account. Additionally, VAT, sales tax and other expenses have not been taken into account.

Table 7: Price of Compost to recover Costs for Different Cases

Cases	Taka/kg
Base Case	44
Interest free loan	42
Operation cost doubled	48
Land leasing cost halved	26
No land leasing cost	8
No land leasing cost; Operation cost doubled	12

The financial implication of the Roadmap can be worked out from the data of Table 6. A case study for 100 Tons per day of waste has been worked out for the various segments of the value chain starting from *Generation* and ending with *Disposal*; the land requirement, the initial investment, and the operations cost are worked out using the data from Table 6. It is assumed that 100 Tons/Day of generated wastes are collected, transported and sorted in a MRF. From the MRF, the organic portion (70% of the total) goes to the composting and biogas plants in the ratio 85:15. The 30% inorganic material is separated into four fractions – one goes for recycling, one to the RDF plant, one to the Pyrolysis plant; and the last fraction, i.e., the inert material or that which cannot be sent to any of the processing or treatment plants is sent to the landfill; the landfilled material is assumed to be 10% of the total waste considered in this case study.

The cost implications of managing 100 Tons/day of MSW are worked out in Table 8. Some segments have not been costed in Table 8. This is because these are usually borne by the waste generator (as collection fees) or are the responsibilities of the city corporations/Pourashavas (awareness campaign and wastes transport). Transport is wholly the responsibility of the city corporations.

From the analysis of costs and financial benefits of the 100 Tons/day wastes project, it can be seen that the annual financial benefits stream is roughly equal to the annual operation costs. As it stands, the profitability is such that the investment costs cannot be recovered. It is worth mentioning that very conservative prices of products have been assumed. For example the price of organic fertilizer has been taken as Tk. 20/kg. In the retail market, organic fertilizers sell at prices that are 40-50% more than chemical fertilizers; the price of urea is Tk. 22/kg. Additionally the sustainable development benefits such as reduced landfilling, lowering of GHG emission, energy recovery and production of an organic fertilizer to enrich the depleted soils of Bangladesh have not been accounted for.

Table 8: Cost Implications of Managing 100 Tons/day of MSW

		Capacity Tons/Day	**Land (Bigha)**	**Investment (crore Taka)**	**Annual Operation Cost (crore Taka)**	**Annual Benefits (crore Taka)**
	Generation	100	Funded through Government awareness campaign			
	Collection	100	Collection fees			
	Transportation	100	Responsibility of City Corporations or Pourashavas			
	Sorting – MRF for dirty wastes	100	210	20	18.25	
	Recycling	5	Recyclables recovered at the MRF to be sold			1.83
	Energy Recovery RDF Pyrolysis	 10 5	 22.5 11.25	 6.5 3.5	 0.9125 0.365	 3.65 3.31
	Treatment Composting AD	 60 10	 165 90	 18 5	 2.19 0.5475	 10.95 3.65
	Disposal in Landfill	10	180	3	0.365	
	Total	**100**	**679**	**56**	**22.63**	**23.39**

Notes –
Prices of material for recycling = Tk. 10/kg
Price per kg of RDF (solid fuel), Pyrolysis oil, Compost fertilizer, are Tk. 10, Tk. 55, Tk. 20 respectively
Composting of 100 Tons of wastes produce 25 Tons of organic fertilizer
AD (biogas and liquid fertilizer) – The financial benefits are assumed to be double that of compost

The case study discussed is for standalone facilities. However, if an *Integrated Landfill & Resource Recovery Facility* is adopted then both the Investment cost and Operation costs can be reduced by 25%. In that case the investment can be recovered in approximately 6.5 years.

To achieve the short term objective of the Roadmap, an infrastructure along with the various technologies that can handle 47,000 Tons/Day of wastes need to be created. Extrapolating from the case study done for 100 Tons/Day, 47,000/100*56 = Tk. 26,320 crore investment would be required. As shown in the case study the operations expense can be recovered from the sale of various products from the project.

8.7 Vision of the Roadmap

The vision of this Roadmap is to transform MSW value chain in Bangladesh from the existing basic level to one that incorporates the 4R principle of SW management. Without the Roadmap the urban centers will remain dirty due to uncollected MSW, which will have adverse impacts on human health and environment. Moreover, a lot of organic and inorganic resources would be wasted and the land requirement for landfills will be huge.

The focus of this Roadmap is the low-income communities because it has been observed during primary data collection and also from literature[10] that City Corporations are not able to provide full door-to-door collection services in these areas. With respect to MSW management and its impact on the cleanliness of cities, Table 9 compares the existing situation to the post-implementation situation.

Table 9: Comparison of Existing and After Roadmap Implementation Situations

Existing Situation	After Implementing the Roadmap
Incomplete wastes collection	100% wastes collection
Open dumping	Sanitary landfill; only inert material landfilled
Dirty cities (garbage on streets; stench due to rotting garbage; insect and vermin; drain clogging)	Clean cities
Health hazards (airborne particles spreading diseases)	Health hazards eliminated
Environmental degradation	Clean environment
GHG emission	Greatly reduced GHG emission
No resource recovery	Organic fertilizer; Biogas; Solid and liquid fuels

The reason this Roadmap needs to be implemented is that the urban centers would soon become overwhelmed by the increasing burden of MSW. According to the latest projection the total urban SW of the country is expected to reach 142,000 Tons/day by 2041[11]. If this enormous quantity of solid wastes is not managed properly, the conditions of many urban centers especially those where collection

[10] Prodhan & Kaeser (2020); found low-income communities have a greater propensity to dump wastes
[11] Wastes Database 2021 (unpublished); data collected through personal communication from Waste Concern

efficiency is low, would become unlivable as a result of rotting garbage on the streets and in the open dumps.

Table 10 shows the costs and benefits of implementing the Roadmap; the health, environment and GHG emission reduction benefits could not be calculated because the evaluation criteria for Bangladesh are not available. However, without doubt these three benefits will be huge. If these three benefits could be quantified in financial terms and added to the financial benefits, to give the total benefits, the benefits steam will greatly outweigh the Tk. 26,320 crore investment. The Roadmap land requirement of 679 Bighas is far less than the Business-us-Usual land requirement (ten times more), and will offset the investment cost.

Table 10: The Costs and Benefits of Implementing the Roadmap

COSTS	BENEFITS
➢ **Tk. 26,320 crore** (investment) ➢ **Tk. 10,636 crore** annually **(**operational cost) ➢ Cost of 3-wheelers (from collection fees) ➢ Cost of Garbage Trucks (from CC budget) ➢ Awareness Campaign (sponsored by Brand owners)	➢ **Tk. 10,993** crore as direct financial benefit annually ➢ Only 10% of the BAU land requirement (90% land savings) ➢ City roads free from stench, vermin, insects, waste SUP ➢ No clogging of drains by waste plastic bags ➢ Reduction in health costs of urban dwellers ➢ Reduction in GHG emissions ➢ Organic fertilizers to alleviate loss of soil fertility ➢ Biogas to alleviate gas crisis ➢ Solid (RDF) and liquid (fuel oil) fuels to alleviate energy crisis

8.8 Recommendations for Policymakers

Policymakers need to understand many associated things to take decisions. Therefore, the following recommendations specifically intended for policymakers has been formulated –

- Awareness Campaign is an absolute must for a good MSW management system. Awareness should be raised at policy making level first to bring the responsible authorities into a common understanding or common platform
- For source segregated collection behavioral attitude is the most challenging aspect. Awareness raising is the only available tool. However, penalties for non-compliance and tax incentives could be introduced for households that practice source segregation
- Formation of ward level SW management committee to oversee source segregation and collection and to enforce general cleanliness in the ward may be considered
- There is no authority empowered to enforce rules. City authorities must be made accountable for environmental degradation. There is an urgent need to

set up a tribunal for monitoring SW practices and to enforce SW rules and regulations

- To build a 4R compliant MSW management system is a massive task. Public-private partnership is essential for achieving this task. Private sector participation need to be greatly encouraged by allowing them easy access to wastes and land
- Loss of soil fertility because of depleting organic content is reaching alarming proportion. SDI data (see Annex E) shows that nearly one-third of land have organic content less than 1%, whereas a healthy soil should have 3.5%. Government should prepare a countrywide masterplan for organic fertilizer; this will promote Composting and Biogas fertilizer production
- There are many success stories around the world that Bangladesh can emulate; Kerala and Indore of India have achieved their goals of 100% collection and a clean and livable city through the following –
    - Awareness > Innovation > Funding > Enforcement

9.0 Recommendations

The existing documents on MSW management in Bangladesh mostly deal with source separation, composting and sanitary landfill. The full range of 4R activities has not been incorporated. The proposed Roadmap incorporates the 4R principles in all the steps of the MSW value chain. The Roadmap is specifically targeted towards MSW management in low-income communities. This Roadmap is thus the first of its kind for Bangladesh. The following recommendations are made to achieve the objectives –

- **Awareness raising** regarding waste minimization and waste segregation are of prime importance in 4R waste management; EPR to induce brand owners to reduce packaging can also yield good results
- **100% Collection** government must aim for 100% collection based on a 3-Bin segregated model of collection and transport. Since this model will be difficult to achieve, the government should seek assistance from NGOs and CBOs to organize slum dwellers in Community Led Action Groups
- **4R in Community led actions** need to be undertaken to facilitate the 100% collection and 4R application to MSW management especially in low-income communities. The government should mandate that CBOs would be assisted with leased land and wastes delivered to site free of cost so that informal sector workers can be organized to provide the full value chain from generation/collection to treatment/disposal. This MSW model, practiced successfully at many places around the world, is expected to be a win-win

solution for all stakeholders – general public, the waste generators and the City Corporations/Pourashavas

- **EPR** According to the "Polluter Pays" principle Brand Owners must be made responsible for the packagings they use for their products. For effective management of post-consumer packaging wastes they would have to contribute financially or logistically (Take-back, Recycling coupon, Post-consumer collection, etc.) towards the collection of discarded packagings of products in proportion to their usage
- **MRF and RDF in the MSW value chain** The Roadmap strengthens resource utilization, which is the hallmark of 4R. In Bangladesh, even though there is a lot of recycling through the informal sector, a large quantity of plastics wastes goes to the landfill because these are mixed with wet wastes, rendering those useless to collectors. In MRFs, plastics will be separated and converted to RDF or converted to fuel oil in a pyrolysis plant. Moreover, rags and paper in the mixed wastes will be separated and their energy content recovered by including these with plastics in RDF
- **Composting or producing biogas/fertilizer using the organic wastes** Composting is fundamental to achieving Recovery of the 4R process. All organic wastes must be either composted or used in a biogas plant. Compost fertilizer can save foreign exchange by displacing chemical fertilizer, and is known to be three times more effective than chemical fertilizer. The production of organic fertilizer by composting MSW should be developed into a viable business model. Without adequate government support this very important industry cannot develop
- **Landfill bans for Combustibles and Organics** if implemented properly and enforced, these bans are probably the most effective in reducing landfill load. Taxes on waste generation and dumping for commercial and industrial establishments are also effective instruments in reducing landfilling

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Annex A: ToR of the Assignment

Dhaka CALLING Project
Terms of Reference (ToR)
for
Hiring Consultant for 4-R Road Map on Solid Waste Management-
Scopes, Opportunities and Challenges (4.11.2)

1. Background and rationale

Solid waste management is a multi-dimensional issue, connected with the environmental human rights, public health, culture, and socio-economic aspects, and has become an alarming issue for city dwellers, especially for the marginalized groups. This group often can't access their rights and civic services due to their faint voices, ineffective implementation of legal frameworks, highly centralized city governance, and complex nature of the service delivery system. City authorities are mostly responsible for managing city waste. Having its limited resources and multifaceted, multiple challenges the city authorities are managing municipal solid waste by focusing on the collection, transportation, and dumping facilities in compliance with the health codes and environmental regulations. Recently the govt. has set a vision to convert waste into resources and passed the Solid Waste Management (SWM) Rules 2021 to bring this chaotic sector under discipline and curtail risks and threats caused by the mismanagement of solid wastes. However, the SWM Rules 2021 is not a complete package and it requires further attention and left ample scope to work on. Following the different vision statements of the govt. and comply with its goal the Dushtha Shasthya Kendra (DSK) has initiated a consortium project titled **'Dhaka Citizens' Advocacy Collaboration against polluting environment (Dhaka CALLING)** with other consortium members – Bangladesh Resource Center for Indigenous Knowledge (BARCIK), Coalition for the Urban Poor (CUP), and Institute of Innovations for Gender and Humanitarian Transformations (inSights) with the generous financial support from the United States Agency for International Development (USAID) and technical support of Counterpart International (CPI) to conduct a study on solid waste management that could sketch a road map focusing on reduce, reuse and recycle.

2. The objective of the study

The major objective of the activity is to come out with a road map/action plan (replicable model) focusing on 4R and keeping align with the vision statement of the government so efficient policy options could be pursued, adopted, and negotiated with the government for better implementations.

3. The specific objective of the study

a. The specific objective of the study is to develop a 'Road Map on Solid Waste Management' focusing on reduce, reuse, recovery and recycle in the urban solid wastes sector for the concerned government and other relevant stakeholders.
b. The study shall sketch out integrated sustainable solid waste management process focusing on the SWM Rules 2021 and other relevant environmental laws and shall focus on the scopes, opportunities, and challenges of this sector that could be carried forward.
c. The findings of the study will be published as a **'Road Map on Solid Waste Management'** that will work as a catalyst to initiate and promote advocacy dialogues,

meetings, seminars, training, etc. at various levels and work as an influencing tool while implementing the **Dhaka CALLING** project.

4. Specific tasks of the Consultant

- to sketch out a replicable plan/model that could be implemented and promoted in Bangladesh keeping marginalized groups at the heart of this plan/model;
- to hold preparatory discussions with responsible persons of the Consortia members about the overall preparation, planning, and execution strategy of the task;
- to prepare all necessary methods, tools & strategies and efficiently conduct them;
- to illustrate best practices, challenges, and lessons from other countries/models, etc. [As one of the good practices, to consider the example of good practices on Solid Waste Management and/or Community Led Waste Management System (CLWMS) of DSK in the road map for making the document more pragmatic.]
- to illuminate the health and environment vulnerability picture of disadvantaged groups- women, children, socially excluded and persons with special needs;

5. Methodology of the assignment

The consultant will develop a detailed methodology focusing on each objective and finalize it in consultation with the Evaluation Committee. The consultant should cover, but not limited to:

- Literature review in line with the study objectives, scopes, and challenges;
- Mix method approach combining qualitative and quantitative analysis; Analysis based on segregated data.
- Secondary data (field visits and primary data collection if required), and its analysis;
- Focused group discussions (FGDs), and Key Informants Interviews (KIIs) etc.

6. Documents to be studied

The firm/consultant should review and analyze, but not limited to:

a) Existing national and International laws, policies, and regulatory frameworks relevant to environmental pollution and waste management;

b) Solid Waste Management Rules 2021, Environment Conservation Act 1995, Environment Conservation Rules 1997, National Environmental Policy 2018, National Waste Management Policy/Guidelines, National 3R Policy, 7th & 8th -5-year plan, Perspective Plan of Bangladesh, 2021-2041, Bangladesh Delta Plan, National Environmental Action Plan, City Corporation Act 2009, Vision 2041, Sustainable Development Goals, National Menstrual Hygiene Management Strategy 2021, etc.

c) Acts, policies, and regulatory frameworks on environmental conservation, climate change mitigation, natural resource management, waste management, air pollution, land use, river, etc.

7. Deliverables and conditions of the assignment

Under the supervision of DSK and in consultation with the concerning assigned persons of the partners, the consultant should deliver the **'Road Map on Solid Waste Management'** with the following:

1. Study implementation vision/proposal: Consultant shall submit the proposal within three days of acceptance of the assignment his understanding about the

assignment. The proposal must provide a detailed study framework, expected outcomes, foreign practices, methodologies, and details of key issues to be studied, way out/ recommendations (Short term –within Dhaka CALLING project implementation period & Long term-concerned Govt. and related CSOs' further work scope) and a list of any documentation, information, and surveys required;
2. Agenda, presentations, questionnaires, and other study technique guidance prepared for the consultant process throughout the task;
3. Draft Final Report: The Draft Final Study Paper has to synthesize all findings, challenges, scopes, lessons, best practices, conclusions, and recommendations;
4. Finalize the draft report based on the feedback and comments shared by the project staff/partners;
5. The Final Report: the final report will be counted as **'Road Map on Solid Waste Management'**. The Final Report has to synthesize all findings, background studies, challenges, scopes, lessons, conclusions, recommendations and should include a programmatic and policy framework (with the account of all comments and additional corrections asked by concerning assigned persons/partners, if any, that will be shared in the following submission of the Draft Final Report);
6. A report of 10-15 pages without annexes will be shared with the Dhaka CALLING.
7. A summary of the study (preferably 2500 words both in Bangla and English versions) for wider dissemination (through the various activities- training, meetings, consultation workshops, etc.) of the project;
8. The Consultant have to present the findings of the study at different local & national level meetings, seminars, conferences under the project that brings together government representatives, duty bearers, public representatives, NGOs, media, different stakeholders, and other development partners;
9. Report on the outcome discussions of the presentation to be included in the final report.

8. Ownership of materials to be developed

The ownership of overall supplies/resources/materials/reports/publications relating to this study shall remain solely with the Dhaka CALLING project.

9. DSK's role and reporting line

It is the responsibility of the consultant to plan and carry out the assignment. DSK will provide financial support as agreed and will ensure timely feedback. Moreover, for arranging FGD with marginal community people, DSK will provide support. The consultant will be responsible for maintaining correspondence and outputs in a timely and efficient manner keeping DSK informed via written email and in-person correspondence.

10. Branding and Marking

Materials i.e. reports, presentations that will be made under this activity will follow all branding and marking issues of the donor and will have prior approval from CPI.

11. Timeline & Payment

The assignment will be paid in four (4) installments. The consultant is expected to complete the assignment from the **date of agreement to 60 days (Draft report, feedback addressing, Final Report)**. The payment will be made in four installments based on the milestones stated in the following table-

Milestone	Amount to be paid (%)
Agreement signed and approved of the Study proposal along with a work plan	25%
First draft report & an executive summary of the study	25%
Successful insertion and compilation of feedbacks in the draft report & presentation	20%
Approval of final report & executive summary of the study	30%

12. Penalty clause

The consultant is expected to provide services within the agreed timeframe as well as submit the final report maintaining the quality as mentioned in section 7. If for any reason, the consultant fails to deliver services within the stipulated time, the consultant needs to inform DSK well ahead of time with a valid and acceptable explanation. Failing to do this may evoke a penalty clause at the rate of 0.5% for each day of delay. If the quality is not maintained as mentioned in section 7, DSK will deduct 10% of the total agreement amount.

13. Bindings

All documents, papers, data, and resources produced through this study are to be treated as the Dhaka CALLING project's property and restricted for public use without prior consent. The contracted firm/consultant will submit all original documents, materials, data, and resources DSK.

14. Negotiations

Once the proposals are evaluated, DSK may enter into a negotiation with one or more than one consultants for final selection. If negotiations fail, DSK will invite a consultant whose proposal received the next highest score to negotiate a contract. If none of the invited proposals led to an agreement fresh Requests for Proposals (bidding documents) will be called.

15. Award of contract

The consultant is expected to commence the assignment within one week of signing the contract.

16. Disclaimer

DSK reserves the right to accept or reject any or all proposals without assigning any reason whatsoever.

17. Key qualifications, experience, and skills of the Expert

The consultant should have the following criteria:

- Master's degree in Engineering/Urban Planning/Environment Science/Development Studies/Economics/Law/Sociology or other relevant subjects;
- Demonstrated familiarity with environmental policy in Bangladesh through publication or written work will be strongly preferred;
- Ten (10) years of professional experience in the relevant field and
- At least 3 documents on relevant previous works.

18. Selection process

The Consultant will be hired based on the headhunting method. Invitations will be circulated to different experts/consultants/professionals. A selection board will be formed comprising DSK consortia & CPI representatives. The board will review the quality and skills of the consultant and will award the assignment with some specific notes and justifications.

Guideline for application

Topic	**Maximum Page Limit**
Technical Proposal	
Cover Page	1 Page
Table of Content	1 Page
Understanding of the Assignment and Proposed methodology	2 Page
Work Schedule	1 Page
Any other relevant information (if required only)	2 Page
Relevant works	1 Page
CV highlighting related experience and assignment completed. For Firms roles of the team members needs to be highlighted with detailing their previous experiences.	3 Page
TIN certificate (with client name, contact person, and mobile number), Firms certificate, VAT registration, etc.	
Financial Proposal	
Budget detailing out: • Consultancy days and fees (days should be mentioned for a key member of the team) • Any other expenditure (please mention nature of expenditure) • 15% VAT and 10% taxes (Item-wise summary of cost for the assignment with detailed breakdown). The budget should not contain income tax as a separate head; it can be blended with the other costs as it will be deducted from the source. However, VAT can be mentioned in the budget as per government regulation. The organization will deduct VAT and Tax at source according to the Government of Bangladesh rules and deposit the said amount to the Government treasury. • Total amount	

Evaluation criteria

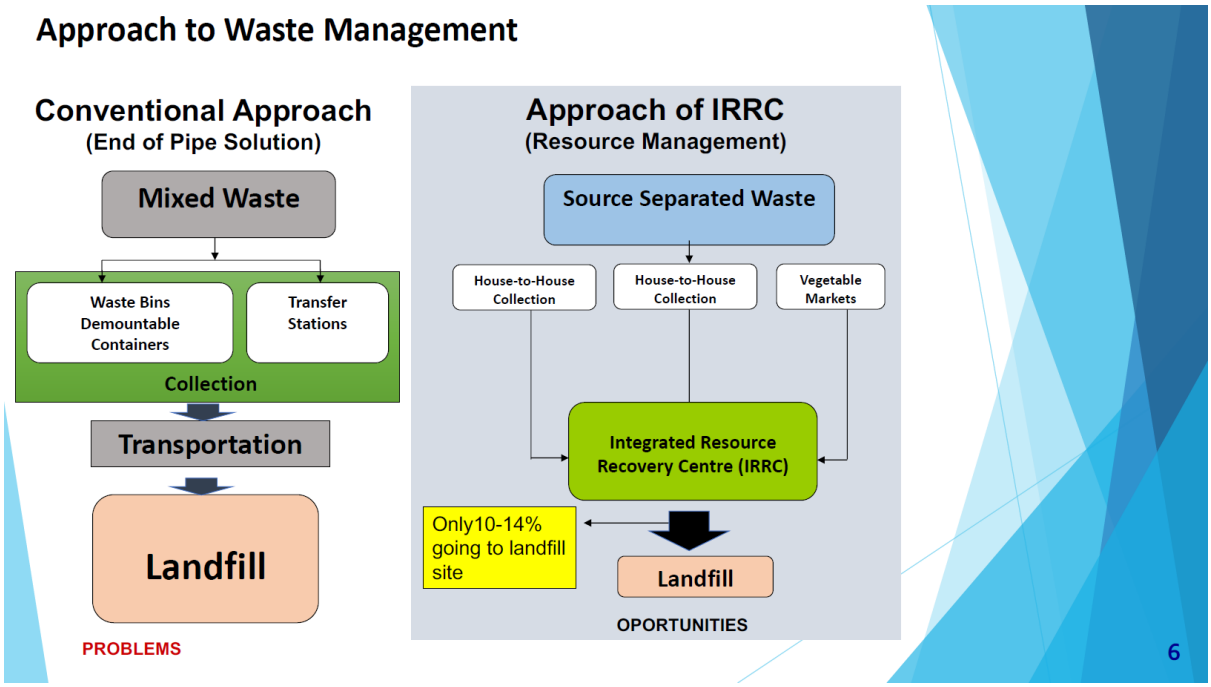
Evaluation criteria	**Weight**
1. Expertise of the individual consultant/consulting firm/organization	
Understanding of the ToR	20
Experience in conducting relevant assignments	20
2. Methodology	
Appropriateness of methodology	45
Quality assurance	15
Total	**100**

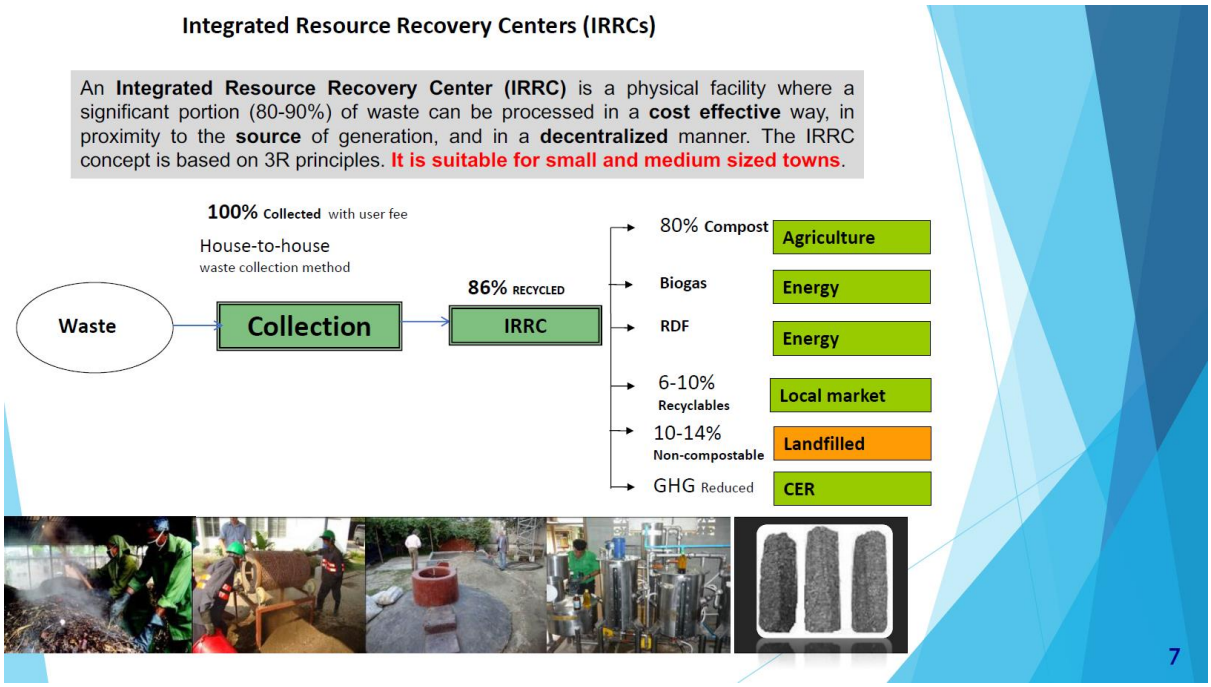
Contact information

Refer to the detailed TOR for this assignment please contact Sanjida Jahan Ashrafi, Consortium Coordinator, Dhaka CALLING Project, Dushtha Shasthya Kendra (DSK), House-741, Road-09, Baitul Aman Housing Society, Adabor, Dhaka- 1207. Or email at sanjida@dskbangladesh.org by May 19, 2022.

Annex B: The Waste Concern IRRC Model

From – (Enayetullah, IRRC Lessons Learned: Contribution to Urban Resource Efficiency, Circular Economy and Sustainability in the Asia Pacific Region, 2018)



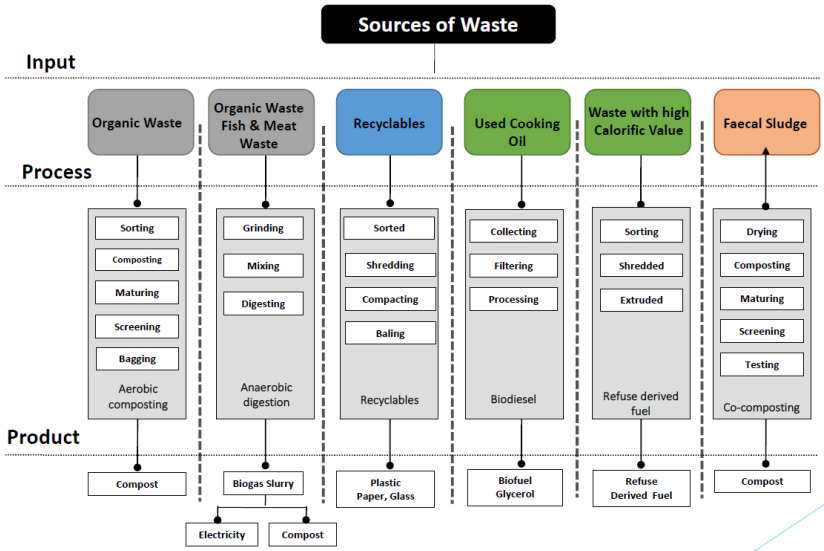


Integrated Resource Recovery Centres (IRRCs)

- Based on 3R principles
- It is a physical facility integrated with social system
- Recovers 80 percent of waste as resources (both organic and inorganics)
- Promote separation at source (organic/inorganic)
- Decentralized, close to generated waste
- Capacity can range from 2-20 tons/day (manual)
- Uses appropriate technologies
- Employs waste pickers and other urban poor
- Reduces GHG emissions

9

Recycling Options Used in IRRC Approach



11

Annex C: MSW Management in Bangladesh Cities and Town

Waste Segregation and Collection

Segregation of wastes at the household level is the best way of dealing with the problem of wasted resources and failing to achieve 4R. Pilot programs on waste segregation have not been successful in Bangladesh. Source segregation implies that waste collection and transportation must also be segregated. The segregated wastes must remain segregated until final treatment. From a survey of practices around the world, it has been found that segregated wastes in many instances get mixed up at the Transfer Station. Such practices are a clear waste of effort. In the context of Bangladesh, it has to be first decided what will be the ultimate fate of organic wastes. If either Composting or Biogas Production is the final treatment processes, then it is very productive to have source segregation. On the other hand, if mass burn (incineration) technology is the final treatment, then there is no advantage in source segregation.

Source Segregation can play a big role in managing MSW of small towns especially those that have low priced land around the town for setting up composting/biogas plants. In that case, the segregated organic wastes can be easily transported to the nearest treatment facilities. Such treatment facilities will not work for big cities. However, in many cases, at the outskirts of cities if there are pockets of dense habitation such as slums, then these can be sources of segregated wastes to operate small/medium sized compost/biogas plants.

The main nuisance created by MSW is the low rate of collection. As may be expected the uncollected wastes create all kinds of problems including stench, health problems and clogging of drains. The frequent water logging after rainfall is caused by these clogged drains. MSW management would amount to very little if the collection cannot be increased to 100%. All other steps of the MSW value chain accomplished very well would not yield the desired result of creating a clean city, if wastes are found strewn all over the city. Thus, the number one thing that any Roadmap would try to achieve is 100% collection.

Wastes collection from slums

In most urban centers of the developing world, there are slums. Along with people who actually live on the streets, slum dwellers are the most marginalized section of the urban population. These marginalized people have to undergo untold sufferings of various kinds and the nuisance created by MSW is one of the main ones.

MSW collection from slums is erratic. Slum dwellers are completely left on their own to manage their wastes. As may be expected, the management implies dumpling in

any open space near their homes. Sometimes they dump their wastes right in front of their dwelling.

NGOs have extended support in helping to manage the MSW of slums. They have evolved several good ways of managing the wastes. But whatever steps NGOs take to help, ultimately it depends on the city authorities responsible for MSW management. The city authority must agree to allow the collected wastes to be stored somewhere and to be transported to the ultimate disposal site. Often the city corporation does not facilitate collection; they do not even permit slum dwellers to deposit their wastes in government designated community bins because the slum dwellers have no legal status. This quandary implies that 100% of waste will never be collected in large cities where there are slums. The city authorities must change this practice and find a way of managing slum solid wastes.

It is only recently that solid wastes from slum households have begun to be managed in an organized manner through the efforts of NGOs. Before that, solid wastes was found littered all around and periodically dumped in low lying land surrounding the slums. The municipal services was not extended to slums for two main reasons –

1. The slum dwellers did not have a holding number
2. Slum dwellers did not have the capacity to pay for the services

Municipal authorities were unable to provide services because the slum dwellers did not have any legal rights of residing in the slum land. Even though in many instances, Municipal authorities were interested to collect the solid wastes from slums, they were unable to do so because that would give the slum dwellers a squatting right, which may create problems if the government decided to take over the land. The more important reason, however, was that it was perceived that slum people will not be able to pay for the services.

It is worth pointing out that in Bangladesh, the city corporations do not provide door-to-door collection service. This is provided by a third party for a fee. The fee charged is determined by negotiation. Thus, all households have to pay a fee for their solid household wastes to be taken away.

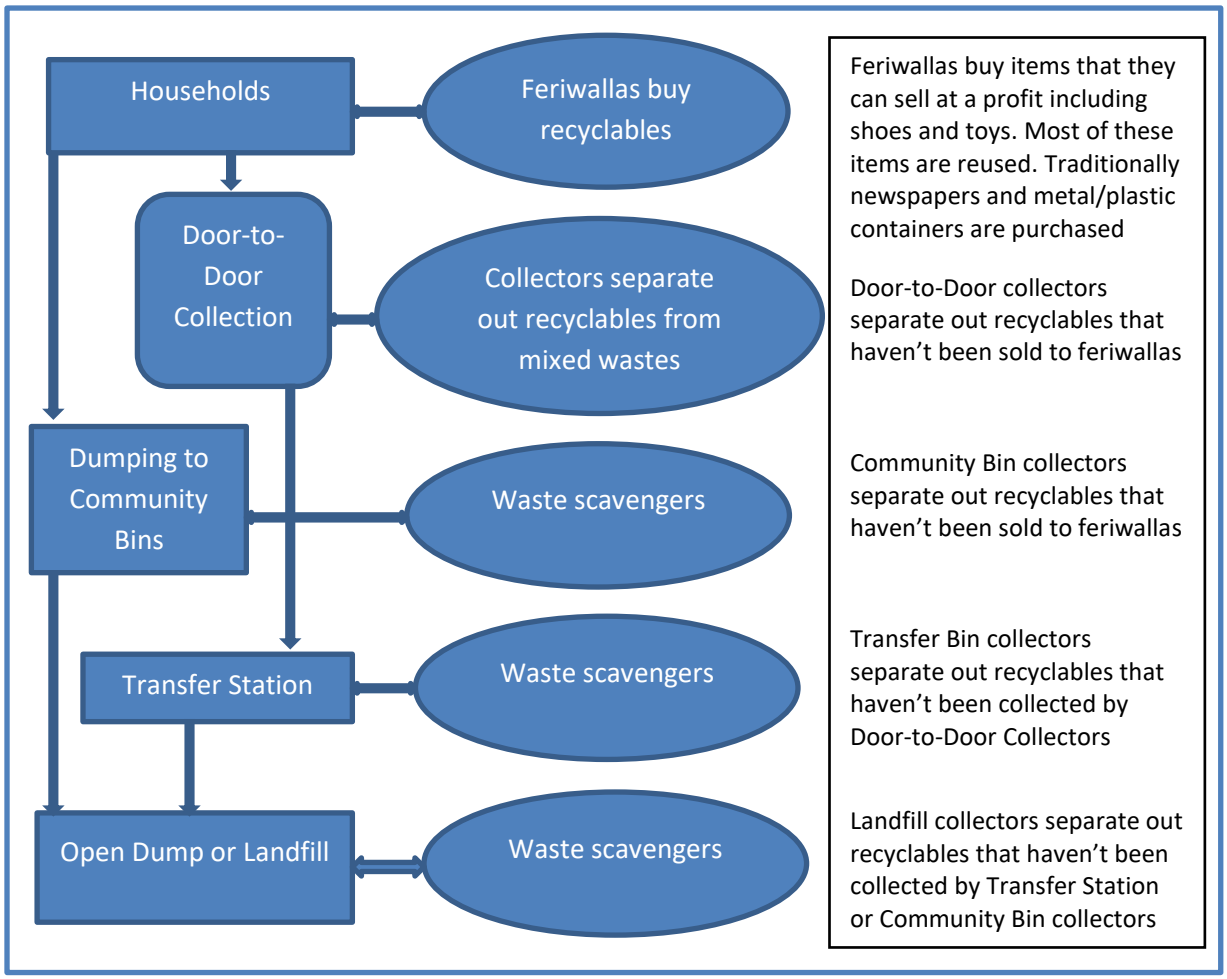
In slums, the people have organized themselves through CBOs with assistance from NGOs to perform the waste collection. This has resulted in fairly orderly collection of waste, but the issues of using the Transfer Stations have not been fully resolved. The NGOs are working hard to convince the municipal corporations to allow the solid wastes of slums to be dumped in transfer stations just like those of rest of the city. Some progress has been made in this regard, and it is expected through negotiation a permanent solution will emerge.

It is important for the City Corporations to realize that without waste collection from slums and other such areas were marginalized groups of people reside in large cities, they will not be able to achieve 100% collection status.

Recycling

Recycling of material recovered from MSW is probably the most productive step of the 4R process. This is because the achievements of all other steps are generally low unless of course a full 4R management of MSW is present. In theory most material can be recycled, but the collection difficulties and the steps involved in getting it back to the usable form (which in turn determines the cost of the operation) determines to what extent it can be recycled. For example, plastic can be easily recycled but only if can be collected in an unsoiled condition.

Bangladesh and indeed most developing countries are very fortunate in terms of waste recycling because a series of actors are involved on their own initiative in support of their livelihood. Thus through these waste collectors nearly 100% of metals are collected and recycled. This group of collectors and recycling facilitators in theory could recycle all that can be recycled but cannot do so because of mixed wastes discarded mainly by households. As soon as dry and wet wastes are mixed, recycling not only becomes extremely difficult, but also the value of the material is reduced to such as extent that waste pickers are demotivated from collecting the material.
Figure shows the waste recycling value chain. In Bangladesh there is considerable amount of reuse in households. People generally do not throw away household items if it has any use. Most households reuse containers both metal and plastic for as long as they can. Many other items are sold to waste buyers called Feriwallas. This group of waste collectors purchases the items from households. In most cases these are reused by others.



Collection of Reused and Recycled waste materials in Bangladeshi Cities

Waste Treatment and Final Disposal

According to 4R management of Solid Wastes, only inerts, or that which possibly cannot be recycled should go to the final disposal site, which is usually a Landfill. Bangladesh is far from that because at present, nearly all the collected waste minus what is reused and recycled as shown in Figure 2, ends up in open dumps or landfills. In the 4R principle this needs to change. To deal with the final disposal of wastes the following treatment procedures are available. In the context of Bangladesh, gasification and biomethanation are not appropriate, nor is chemical recovery. In the context on Bangladesh COMPOSTING is the most desirable option. However, because of shortage of land the government has opted for Waste-to-energy (WtE) as a trial case for Dhaka city. While this process is very effective in reducing the quantity of material that need to be landfilled, it is not compatible with the 4R principle mainly because it destroys the resource value of the waste material especially the organic waste. It is worth mentioning that organic waste is an extremely valuable resource in Bangladesh because the soils of Bangladesh are getting depleted of organic content because of over farming. Whereas there should be more than 3% organic content Bangladesh soils have less than 2%; one-third of

the soils have less than 1%. This alarming situation can be reversed by using organic fertilizer, which is the output of Composting.

Summary of the the Elements of the MSW value Chain in Bangladesh

From an in-depth study of primary and secondary literature and using expert knowledge, the Bangladesh situation of the following eight elements of the MSW value chain was analyzed.

Source segregation – All source segregation pilot projects have failed to produce positive results. Feriwallas (door-to-door purchasers), collect on payment items from households, and as such prevent materials going to the waste bin. These items are mostly reused

Collection – In most towns the proportion of solid wastes collected is less than 50%. The main reason is that in all urban centers*, slums and poor communities are incompletely served by the municipal waste collection services*

Transportation – From households to transfer stations, rickshaw vans are used. From roadside dustbins and transfer stations to landfills, garbage trucks are used, but all the trucks are not proper garbage trucks designed to carry MSW

Sorting (MRF) – Waste pickers from the informal sector perform a function at several levels to extract recyclables from MSW (dustbins; secondary transfer stations; landfills). Only 3-4 pilot project MRF for sorting mixed wastes exists in the country; so very little scope of RDF or Pyrolysis plants

Composting – Composting of MSW is a relatively new practice in the country; being implemented in few towns under either CDM projects of the MoEFCC or IRRC piloting. In small scale the private sector are trying to get involved in this activity

Anaerobic digestion – No practice of anaerobic digestion (AD) using MSW

Incineration – No incineration of MSW being practiced but a project for Dhaka and one for Narayanganj have been initiated

Disposal – Landfills and Open Dumps; only one sanitary landfill at Dhaka

Annex D: Analysis of MSW Value Chain Components for Bangladesh

For the analysis of 4R sustainable solid waste management of urban centers of Bangladesh, eight components of the MSW management value chain have been chosen. These eight components are shown in Table below. Using expert knowledge and data and information gathered from KIIs and the FGDs, the activities that would be required are determined. The targets of the goals set are also shown in Table. The activities set for each component has been determined by comparing what is the present status of that component and what is suggested in the IRRC model and global best practices in this regard. Most important consideration was the 4R principles; that many high-level 4R actions are not achievable in Bangladesh even by the end of the long term timeframe, i.e., 2041 were kept in mind.

Analysis of the MSW Management Value Chain Components for Bangladesh

	Components	Activity or Target	Remarks
1.	Source segregation	Households have to be provided at least 2 bins	Difficult in Bangladesh, but some sort of incentive scheme can be devised
2.	Collection	100% collection should be the primary goal Community participation in source segregation and collection	If this can be achieved, then slum dwellers will be automatically accounted for Since this will be difficult to achieve, special measures will be required to address the present barriers and difficulties faced by marginalized groups with respect to MSW management
3.	Transportation	Motorized covered vehicles	Rickshaw vans have to be phased out in the door-to-door collection Proper covered garbage trucks have to be deployed from transfer stations to landfill
4.	Sorting	Material Recovery Facility (MRF) need to be incorporated in the chain	Refuse derived Fuel (RDF) can be promoted to deal with soiled plastic wastes
5.	Composting	Small and big composting facilities need to be created to deal with organic wastes	A high value fertilizer is obtained; marginalized people can get involved in this activity
6.	Anaerobic digestion	If investors can be found then biogas plants can be considered in place of composting	More expensive option; both greater funds and technology required
7.	Incineration	Experience with the proposed Dhaka incinerator will dictate further decisions	Expensive; foreign investment with technology required
8.	Disposal	Open dumping MUST be stopped. Sanitary landfill if organic waste not diverted for either Composting or Anaerobic Digestion, otherwise ordinary landfill	If all the 4R steps have been followed very little landfilling would be required. The target should be – only INERTS will go to the Landfill

From the analysis of issues, and the activities and targets, the short, medium and long term actions for Collection Efficiency, Sorting and Treatment are indicated in Table below.

The Setting of Actions and Targets for the Short, Medium and Long Term

	SHORT	MEDIUM	LONG
Collection Efficiency	80%	100%	100%
Sorting (to separate out materials to produce RDF when the Treatment process is not WtE)	MRF in 25% of towns	MRF in 50% of towns	MRF or Incineration in 100% of towns
Treatment	WtE in Dhaka and Chittagong Composting in 25% of the other cities/towns	WtE in Dhaka and Chittagong Composting in 50% of the other cities/towns	WtE/Composting/Biogas depending on local factors
Notes – 1. 100% *Collection Efficiency* implies that all wastes generated **MUST** be collected. This includes wastes generated in slums and other poor communities 2. It is assumed that recyclables are collected by the existing actors, and only those that either cannot be collected or have no value are left in the wastes 3. The MRF will sort out combustible material and produce RDF 4. When the Treatment Process is WtE, the waste will be transported straight to the WtE facility and not to the MRF. The MRF will only be for Composting and Biogas treatment process.			

Waste Treatment Process for Bangladesh

There are several waste treatment processes available. While some are mature technologies others such as gasification, pyrolysis and biomethanation are new technologies that are being perfected and have not reached full commercialization. Moreover, the latter technologies tend to be expensive when judged on the basis of per Ton of wastes treated. In developing countries funds for MSW management is very limited, therefore aspiring for expensive technologies is not a realistic way forward. The actual choice of technology will however depend to a large extent by the constraints imposed by funds and land availability. In populous countries such as Bangladesh, land is at a premium. The municipal corporations are often not given access to sufficient land so as to choose the appropriate technology. Table below shows the evaluations of the technologies for a set of parameters.

Evaluations of Treatment Technologies for a Set of Parameters

	Sanitary Landfill	Waste-to-Energy (Incineration)	Composting (aerobic digestion)	Biogas (anaerobic digestion)
Land Requirement	Very high	Low	Moderate	Moderate
Preserving resource value of waste	Low	Destroys	High	Very high
Emission	Methane emission unless GHG collection	High; unless expensive pollution control is used.	None; some smell in the locality	None; very little smell in locality
Initial Investment	Moderate if land cost is excluded	High	Moderate	High
Cost per Ton	Low	Low	Moderate	High
Other Benefits				
Technology + Operation	Not difficult	Complicated	Not difficult	Complicated

The following conclusions can be drawn regarding the suitability of each of these four treatment technologies from Bangladesh perspective –

- Sanitary or any kind of Landfill in Bangladesh is not a suitable technology because of the scarcity of LAND
- Waste-to-Energy (incineration) is good in terms of LAND requirement, but is a technology that completely destroys the resource value of the waste, and it can produce harmful emissions unless expensive pollution control equipment are installed
- Biogas or anaerobic digestion is an excellent technology; its outputs are liquid fertilizer and biogas, which is a fuel, but in the context of Bangladesh is difficult to implement for two reasons (i) high cost and (ii) complicated technology and operation
- Composting or aerobic digestion is by far the best technology for Bangladesh. Its investment cost is reasonable compared to WtE and Biogas technologies and produces an excellent solid fertilizer so critically needed in Bangladesh.

Dealing with packaging wastes and single-use plastics

Plastics packaging and other single-use plastics such as coffee cups, plates, cutlery, straws, and takeaway food containers are an important constituent of municipal wastes. With brand manufacturers using different kinds of packaging to attract consumers, and the growth of food stall culture, discarded plastic materials are becoming a significant portion of MSW. One problem with these plastic wastes is that these are prone to being littered, and thus create huge nuisance by blowing in the wind, covering ground and clogging drains. The fraction that rounds up in the municipal bins, are responsible for making the MSW difficult to manage. Plastic packagings are generally small and light, and when mixed with wet wastes are not collected by waste pickers. The recent trend in packaging is **multilayer packaging material**, which in most cases cannot even be recycled. Governments around the world have started to tackle single use plastics and packaging wastes. The following are some of the ways governments around the world are tackling packagings wastes and single use plastics –

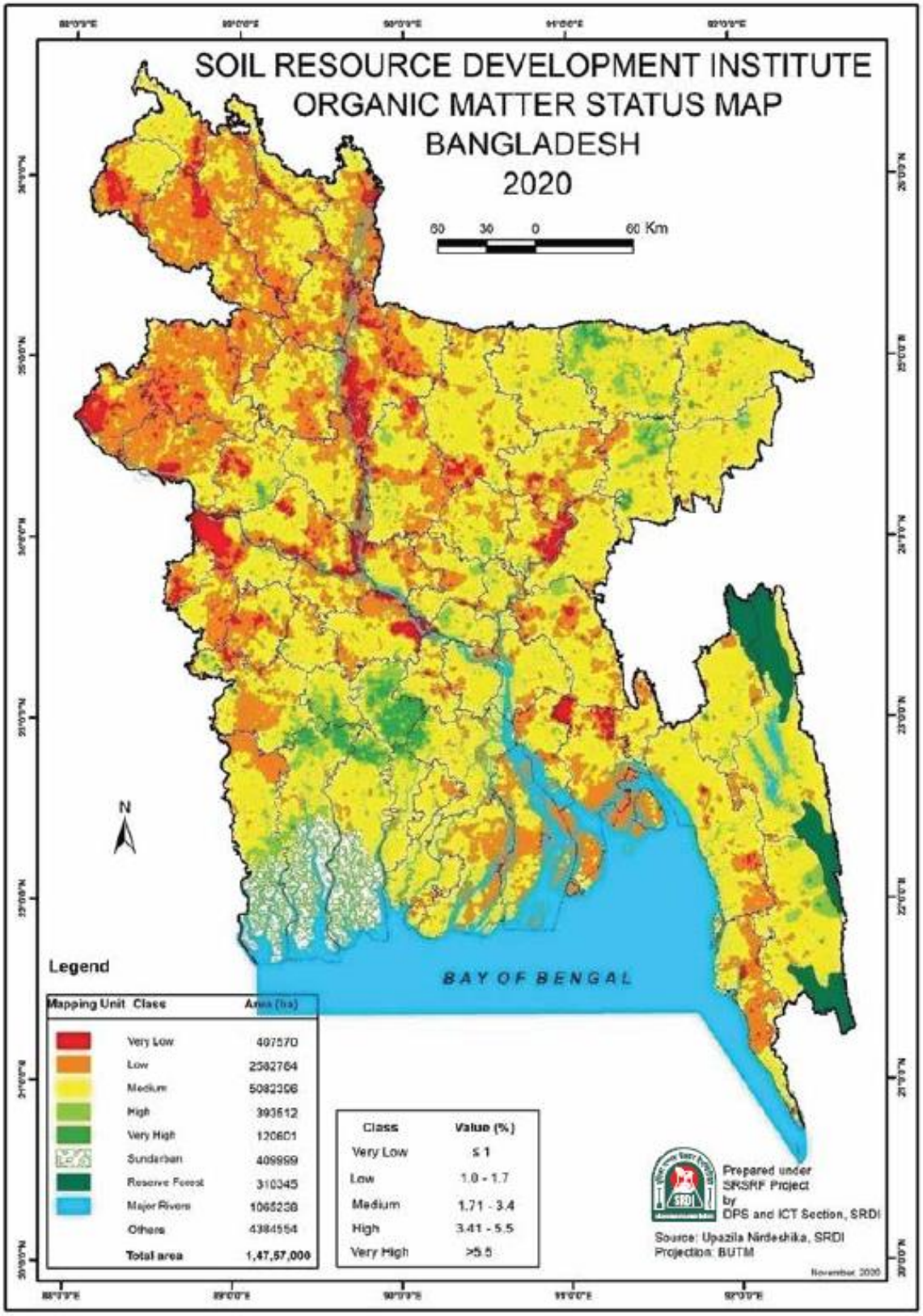
1. Inducing manufacturers to use less or biodegradable packaging
2. Using Extended Producer Responsibility (EPR) making brand manufacturers responsible for discarded packaging
3. Imposing restrictions on multilayer packaging – must be recyclable
4. Control on single use plastics
5. Multilayer packaging ban
6. Single use plastics ban

If product manufacturers could be convinced to sell their products with minimum packaging, that would be ideal. Since that is not very feasible in the real world, the best alternative would be to force them to take responsibility for the discarded wastes. EPR is used to make brand owners pay for directly or indirectly for collection and management of the discarded packaging. EPR can take many forms and each will depend of the conditions prevailing in a country. The discarded packaging can be brought back to the manufacturer through the chain of distributors by inducing the users in return for a small reward to collect the packaging instead of discarding, which can be one free item for 10 packagings. Alternatively, the packaging can be collected through waste pickers from the different points where waste pickers are active. The incentive for the waste pickers would be some sort of a financial or non-financial reward. In a program in India waste pickers are given a free meal if they are able to collect 1 kg of plastic wastes from mixed wastes. Developed countries have been using EPR for some time now, and many models for EPR have been developed.

The problems created by single use plastics especially due to littering is becoming such a burden on MSW management that many countries are considering banning single use plastics. Short of that the next best approach is to control the use of these items. There are several ways of bringing in controls. For example, in Singapore food stalls have been prohibited to use single use plastic items. The serious problems created by single use plastics and difficulty to enforce control have forced many counties to ban single use plastics. EU has banned top 10 single use plastic products, while Canada is banning single use plastic products including grocery bags and straws from the end of the year. Recently, India has banned 19 single use plastic items. Of course the total elimination of these items from MSW is the most desirable state, thus promoting 4R at the highest level, i.e., Reduce, but the consequences of such a ban need to be carefully studied.

Packaging cannot be totally eliminated therefore the GoB must take proactive action to both limits its use and to manage it when it appears in the MSW. The GoB has initiated talks with brand owners regarding the introduction of EPR. This process need to be speeded up to improve MSW management. Similarly not all single use plastic items can be banned. The GoB need to take decisions on matters of plastic packagings, multilayer packaging material, and single use plastics.

Annex E: Organic Content of Soil in Bangladesh



Soil Organic Matter Status Map, Year 2020
(Hasan, Bari, & Lutfar, 2020)

Annex F: Financial Viability of a Composting Plant

		Fertiliser Production		250	kg/day																
		Capital Investment		3,000,000	Tk		Discount Rate									Cost of Land					
		Other expense		0				0%			Tk/$	100				33,000,000	Tk				
		Total Initial Investmen		3,000,000	Tk																
	Y-0	Y-1	Y-2	Y-3	Y-4	Y-5	Y-6	Y-7	Y-8	Y-9	Y-10	Y-11	Y-12	Y-13	Y-14	Y-15	Y-16	Y-17	Y-18	Y-19	Y-20
Expenses	-3,000,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000	-3,665,000
Earnings		3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000	3,815,000
	-3,000,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
				Price (Tk/kg)		41.81															
				Operation (Tk/T)		1,000															
				Waste Delivery (Tk/T)																	
				Sales (Tk/T)																	
				Others (Tk/T)																	
PV	-3,000,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000	150,000
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
																		PV of Cash Flow			0

4R Road Map on Solid Waste Management

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