Progressive Formalisation of Household Solid Waste Source-Segregation in Khulna City, Bangladesh: A Transition towards Inclusive Circular Economy

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ABSTRACT

Integrating circular economy into solid waste management is challenging for the local government authorities in Bangladesh, though its necessity is well recognised. The absence of household waste segregation in overcrowded urban areas is an obstacle for achieving the Sustainable Development Goal of reduced waste generation by 2030. This research in Khulna city found that recyclable and reusable products are separated informally by grassroots people in seven stages, instead of a source. Relevant stakeholders and grassroots people working at different level of solid waste governance were interviewed to find out the current status. The thematic analysis reveals that policy gaps, limited budgets, inadequate facilities, social constraints, behavioural inertia, non-engagement of private organisations and insufficient community participation are significant challenges to circular economy transition. Stakeholders have proposed a series of actions, beginning with proper policy formulation, followed by facility provision, awareness building and enforcement in the event of excessive public ignorance.

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1. INTRODUCTION

Solid waste management is a significant challenge in countries like Bangladesh, with a population of 170 million. Urban areas in Bangladesh generate more solid waste compared to rural regions, attributed to factors such as population growth, rapid industrialisation and increased product consumption. The cities of Bangladesh produce around 25,000 tons of solid waste daily (Alam and Qiao, 2020; Islam, 2021) and the primary source of this municipal solid waste (MSW) is domestic activities (Sujauddin et al., 2008). The increased demand for waste management creates immense pressure on public sectors, frequently leading to poor services (Ahmed and Ali, 2006; Bhuiyan, 2010). As a result, collaboration with non-government organisations (NGOs) and community-based organisations (CBOs) – in other words, public-private-partnership (PPP) – has been promoted and practised to reduce the burden of waste collection, transportation and disposal on government authorities (Ahsan et al., 2012; Haque et al., 2020; Zahur, 2007). However, the conventional linear model of production, consumption and disposal is still followed by the waste management authorities and the haphazard disposal in open landfills without sorting household waste remains unchanged. Disposal of household solid waste is a cause of concern for Bangladesh because burning and open dumping are causing air, water and soil pollution and posing a threat to the environment and public health (Jerin et al., 2022).

Nowadays, the concept of circular economy (CE) in solid waste management is gaining popularity over the traditional linear model. CE keeps the materials in circulation as long as possible by involving the processes of refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle and recover (10R) until the value of the material completely diminishes, so as to minimise energy flow and to mimic nature where nothing is wasted ultimately. The concept is aligned with the early principle of 3R (Reduce, Reuse and Recycle), which evolved into 10R strategies with time. It is an environmentally viable, socially practicable and financially feasible concept essential for achieving Sustainable Development Goal (SDG) 12 of reduced waste generation by 2030. It is also an important part of sustainable solid waste management that ensures both public and environmental safety. Therefore, adopting CE principles is crucial for Bangladesh, considering its growing urban waste. Nevertheless, various social, economic and environmental barriers can hinder communities from transitioning to a CE (Neves and Marques, 2022).

Differences can be observed in the practice of CE between the countries of the global north and south. Engineering, technology, resources, governance and community are the main drivers of CE in the global north (Halog and Anieke, 2021), whereas waste pickers play the central role in CE in countries of the global south (Barford and Ahmad, 2021; Gutberlet and Carenzo, 2020; Morais et al., 2022; Velis, 2017). Like other developing countries, solid waste management is labour intensive in Bangladesh and household waste is not sorted at source. Initial sorting of waste at the source of generation, also known as source-segregation, is an important step of solid waste management that facilitates the process of reuse to recover and thereby enables CE. Grassroots-level workers like door-to-door collectors, sweepers, waste pickers, drivers and recyclable materials collectors or vendors play critical roles in segregating and collecting recyclable solid waste, thus contributing significantly to the CE. They are regarded as the main driving force performing the basic level of waste management activities in contrast to the policymakers at the top of waste management governance.

Waste segregation activities in Bangladesh are dominated by informal sector workers and are mostly done informally following unregistered practices, even by the formal sector workers. The formal sector consists of public or registered private service providers such as door-to-door collectors, sweepers and drivers, while the informal sector consists of individuals or small unregistered service providers such as waste pickers and itinerant vendors (Katusiimeh et al., 2013). Millar (2018) suggests seeing these people as independent environment protectors who value materials discarded by others and handle them with underrated local knowledge and skills in the absence of other suitable options. This informal practice is saving time and money by reducing operating costs and is effective for developing countries with high collection and material recovery rates (Alam and Qiao, 2020; Katusiimeh et al., 2013). Fredericks (2021) highlighted that waste pickers not only generate surplus value from waste materials by returning them to the money exchange loop but also expose themselves to the numerous vulnerabilities of landfill sites, the value of which is intangible. Besides, they do not benefit as much as small or large dealers of recycled materials because of the increasing values of recyclables with each exchange, as found in a study on Cape Town (Perez, 2021). These people are taking the burden away from the authorities without being included into the existing formal system and their contribution remains unrecognised by the government of Bangladesh.

Formalisation approaches and their impacts can vary from country to country. Formalising waste segregation service, mainly through PPP, can shrink the domain of informal sector workers and violate basic human rights as seen in a case study on Indore city of India (Tiwari and Sharma, 2024). According to Matter et al. (2013), implementing formal engineering solutions for sustainable waste management, incorporating mechanical segregation systems as

in industrialised countries, is impractical in developing countries like Bangladesh. Informal practices of waste segregation create a livelihood opportunity for the urban poor and have the potential to improve their income (Alam and Qiao, 2020). A comparative study of Malaysia and Indonesia has shown that waste picking at landfills can be a feasible source of income even for higher middle income countries without formalised and so-called efficient source-segregation (Watanabe, 2018). A study on the waste pickers of China has revealed that informal waste picking not only generates significant profit but also provides opportunities for entrepreneurship, freedom of work and opportunities to live in cities (Wu and Zhang, 2019). Another study in Lahore has observed the dissatisfaction of many informal waste workers regarding formalisation because of limited freedom and decreasing amount of work (Butt, 2020). Ignoring these core implementers of the waste segregation system may lead to a less progressive and less equitable waste management system and create a barrier to successful CE transition and profit generation by the government. In contrast, an unsupervised informal service often involves unhygienic waste separation methods and open dumping of unwanted waste that threatens the environment and public health. As seen in Nigeria, substandard processes of waste segregation used by informal workers create occupational risk and results in low quality recovered material (Oguntoyinbo, 2012). Formalising partnerships between waste picker organisations and governments through policy-making is proved to be effective for transitioning towards CE in Brazil and Argentina (Gutberlet and Carenzo, 2020). It can potentially improve informal workers' lives by means of a social safety net, legal recognition, secured working environments and impartial negotiation opportunities.

As the idea of integrating formal and informal sectors for inclusive CE transition is relatively new in Bangladesh, there is a lack of central databases or records of available circularity-driven firms. Matter et al. (2013) have discussed separately the roles and viewpoints of authorities, households, door-to-door collectors, waste pickers and recyclable material collectors in Dhaka, the capital of Bangladesh. Some researchers have discussed the acts, rules, policies, strategies, guidelines and plans regarding solid waste management overall in Bangladesh (Alam and Qiao, 2020; Jerin et al., 2022; Shovon et al., 2022). CE-based waste management practices in agriculture, livestock farms, garment industry, shipyards, biomedical industries and leather industries are analysed separately in multiple research studies (Ahmed et al., 2022; Azizuddin et al., 2021; Islam et al., 2021; Moktadir et al., 2020; Saha et al., 2022), though practices of CE in managing household solid waste management in cities have so far not been discussed. Some researchers have prioritised compost production, particularly from organic solid waste for agricultural use (Roy et al., 2013), waste-to-energy conversion (Habib et al., 2021) and the reuse potential of inorganic waste (Ahmed et al., 2023b; Bari et al., 2012; Moniruzzaman et al., 2011; Moniruzzaman et al., 2012), though they have not suggested a human approach recognising the informal contribution of grassroots workers. In the context of Bangladesh, resource and technology oriented top-down approaches that do not address the complex socio-economic settings are not enough for a successful transition to a CE.

This article investigates the current practices of waste segregation and CE in Khulna city, the country's third largest city, with an area of 45.65 square kilometres and a population of 751,237 in 177,852 households (Bangladesh Bureau of Statistics, 2011). The city generates 420–520 tons of household waste daily, of which only 13.5 per cent is recycled (Islam and Moniruzzaman, 2019) and only 7.2 per cent reused (Moniruzzaman et al., 2011). The study focuses on two questions: What are the challenges of formalising household solid waste segregation at the source? What are the potential solutions for the inclusion of CE while managing household solid waste?

2. METHODOLOGY

2.1 DATA COLLECTION

Sixteen grassroots people from five different groups – namely truck drivers, door-to-door collectors, sweepers, recyclable material collectors and waste pickers – were interviewed, as shown in Table 1. The interviews were based on a pre-defined semi-structured questionnaire. The rationale for targeting these groups was their critical role in solid waste management and CE. Among these people, three were women and thirteen were men. All these people have education below the primary level. Landfill supervisors, drivers and sweepers are mainly working under government organisations. Door-to-door collectors were part of two different NGOs in Khulna. The rest of the people were working individually and informally. In addition to grassroots workers, sixteen stakeholders performing different roles in solid waste management sectors in different public and private organisations were interviewed. Group interviews were performed for all categories of actors except for officials, conservation officers, large dealers, experts, consultants and development practitioners.

This empirical research meticulously collected data by observing the behaviours of households and grassroots workers dealing with solid waste collection, segregation and disposal. The paper uses annual data of KCC budgetary allocation from 2016 to 2022 and reviews twenty policy documents of the Bangladesh government. The study also utilised the results attained from the online knowledge

Table 1. Respondents and participants

ID	Roles		Affiliation	Number
GRASSROOTS AND STAKEHOLDER INTERVIEWS				
1	Official		Department of Environment (DoE)	1
2	Official		Department of Public Health (DPHE)	1
3	Conservancy Officer		Khulna City Corporation (KCC)	2
4	Conservancy Supervisor (Door-to-door Collection)		KCC	2
5	Conservancy Supervisor (Sweeping)		KCC	1
6	Landfill Supervisor		KCC	2
7	Grassroots Workers	Landfill Worker	KCC	2
8		Vehicle Driver	KCC	2
9		Door-to-door collector	NGO-Bangladesh Resource Improvement Center (BRIC) and Prantik	6
10		Sweeper	KCC	2
11		Waste Picker	Informal	2
12		Recyclable Material Collector	Informal	2
13	Junk Shop Owner/ Small Dealer		Private Organisation	2
14	Large Dealer		Private Organisation	1
15	Individual Consultant		Private Organisation	1
16	Expert & Researcher		University	1
17	Development Practitioner		NGO-SNV and Prodipan	2
WORKSHOP				
17	Expert & Researcher		Universities	5
18	Official		KCC	2
19	Official		DoE, DPHE	3
20	Development Practitioner		NGOs- SNV, NGO Forum, RUSTIC, PRISM, Rupantor and Nabolok Parishad	6

sharing workshop on CE Transition in Khulna, organised by Khulna University of Engineering and Technology, Bangladesh, and Intellectual Centers, Nepal on 25 July 2023. As shown in Table 1, the workshop was attended by sixteen stakeholders from related organisations in Bangladesh. The workshop was based on the Delphi approach in the form of semi-structured interviews where multiple rounds of questions were asked to a panel of interviewees and the answers were aggregated in the end by them. The approach allowed participants to rethink their ideas and alter their responses to coincide with the majority's perspectives, which was effective in reducing the diversity of opinions on challenges and recommendations, as well as summarising the findings. In the workshop, the research team shared the existing policies and initiatives on CE and the key findings from consultations. Later, the participants shared their opinions on the preliminary findings, challenges and recommendations. They also recommended other strategies that did not come up in the initial discussions with grassroots workers and stakeholders.

2.2 DATA ANALYSIS

This study followed a qualitative method to achieve the objectives. Policies were preliminarily selected for review considering their relevance to MSW as suggested by stakeholders and mentioned in multiple studies (Alam and Qiao, 2020; Azizuddin et al., 2021; Jerin et al., 2022; Shovon et al., 2022). Non-statistical content analysis was employed to review policies that have inclusively or exclusively discussed household solid waste and to examine the motivation of and gaps in the policy for CE transition. Data collected from grassroot people and stakeholders were triangulated using various sources like published articles, policy documents, documents from official websites and direct observation. The findings of the interviews and workshops were reviewed in detail by systematically assigning codes to contents and themes using NVivo software. The existing situation was portrayed and analysed under five predefined categories, namely relevant legal frameworks, different levels of actors, existing facilities, existing processes of segregation and relevant initiatives. A thematic analysis was performed to identify the challenges of waste segregation and possible

solutions. Afterward, the results were generated by aggregating the findings from the interviews, workshops and observations.

2.3 ETHICAL CONSIDERATION

In order to get access to information from grassroots workers, they were regularly visited in their workplace, on the streets and at disposal sites. Comfortable and easily accessible places were chosen for interviewing. All visits were made according to prearranged schedules that were convenient for them. The times of the interviews were fixed after consulting with the participants and did not conflict with their working hours. The participants were given a brief description of the research before starting the interviews. The purpose of the research was clearly stated before each interview. Written consent was obtained from all participants. It was explained to the participants before interviews that their participation was voluntary and that they could withdraw at any time. All participants are kept anonymous in the article.

3. RESULTS AND DISCUSSION

3.1 EXISTING SITUATION ANALYSIS

Compared to the past situation, the country has improved greatly in the waste management sector, though it still a long way to go to achieve comprehensive waste segregation, particularly at source. Bangladesh still follows a traditional top-down approach to managing MSW generated at the household level. Many policies formulated to improve this sector specify the roles of authorities, promote PPP and encourage community-based initiatives. Still, bottom-up approaches ensuring citizen engagement and responsible participation of root-level workers are yet to be implemented. Additionally, the technologies and methods used by the city authorities in Bangladesh are traditional and similar to those in other developing countries, which are highly labour-intensive. National government, local government and other private sectors are involved in the process, but few are engaged in recycling activities. The term CE is still unknown to general citizens, grassroots workers and even higher officials. This section discusses the existing policies related to CE, multilevel actors playing roles in CE, existing facilities, ongoing processes of informal segregation by grassroots workers and initiatives taken following CE concepts in Khulna city.

3.1.1 RELEVANT LEGAL FRAMEWORK

Several policies and action plans have been formulated to improve solid waste management systems, but the notions of CE and source-segregation are discussed explicitly only in a few. Most of these policies are not in practice yet. Table 2 represents a chronological review of twenty policy documents that promote MSW management. Seventeen directly promote household solid waste management and four are for managing specific types of waste like organic, e-waste, plastics and batteries. Ten of these legal frameworks encourage PPP, whereas only one inspires women's participation and one is concerned about the health of child waste pickers. However, fourteen documents mention recycling, i.e. production of compost from organic waste and energy generation from MSW. Six policies introduce concepts of 3R (reduce, reuse, recycle) or 4R (reduce, reuse, recycle, recover). Besides, source-segregation is promoted in eight documents, though comprehensively discussed only in one, namely Solid Waste Management Rules 2021. Unfortunately, none of these policies acknowledge the roles of grassroots

Table 2. Existing policies promoting CE

Date	Name	Objectives related to CEand citizen engagement	Section	Reference
1995	Bangladesh Environment Conservation Act	Recommends standards for disposal based on categories and engagement of citizens. Provides restrictions on manufacture and sale of wastes injurious to environment.	6A	MoEFCC, 1995a
1995	National environmental management action plan	Discourages dumping in water, drains and open spaces.	4.7, 4.9	MoEFCC, 1995b
1998	National Policy for Safe Water Supply and Sanitation	• Promotes recycling, particularly use of organic waste for compost and bio-gas. • Promotes engagement of local government, other government organisations, NGOs, and CBOs for behavioural advocacy through social mobilisation. • Promotes participation of women in decision making regarding urban sanitation.	8.2.7, 8.4.9 8.4.3, 8.4.6-8 8.4.4	MoLGRDC, 1998
2004	Bangladesh Private Sector Infrastructure Guidelines	Encourages private sector involvement in urban solid waste management.	2.1	BERC, 2004

Date	Name	Objectives related to CEand citizen engagement	Section	Reference
2005	Solid Waste Management Action Plan for Eight Secondary Towns	Focuses on the promotion of source-segregation and 4R principle.		MoEFCC, 2010
2009	Fertilizer Management Act	Promotes bio fertiliser production from organic matter.	2.7, 2.20.b	MoA, 2009
2009	Renewable Energy Policy of Bangladesh.	Promotes biomass, biogas and other green energy production from municipal waste.	1.3.3, 1.3.4	MoPEMR, 2009
2010	National 3R Strategy for Waste Management	Promotes source-segregation, 3R principles, PPP and supports informal sectors.	Chapter 2 & 5	MoEFCC, 2010
2010–2021	National Sustainable Development Strategies	• Encourages community initiatives, source-segregation and adoption of 3R related projects by the Government. • Promotes PPP and protecting human rights.	5.4.3 8.3	MoP, 2010
2011	National Urban Sector Policy	• Supports improving the health of child waste pickers. • Promotes recycling, especially composting, as a means to reduce the cost of managing solid waste. • Encourages PPP and community participation.	5.14.1, 5.14.7 5.8.4 5.8.5	MoLGRDC, 2011
2013	Mandatory Jute Packaging Rules	Promotes the use of jute packaging to reduce the amount of hazardous plastic packaging.	T1	MoTJ, 2013
2014	National Strategy for Water Supply and Sanitation 2014	Promotes source-segregation, recycling and composting of organic waste and encourages biogas and fuel production from waste. Promotes 3R principles and PPP.	Strategy 6	MoLGRDC, 2014
2018	National Environment Policy	• Promotes PPP. • Promotes sanitary landfill sites in suitable locations. • Recommends electricity production from waste in large housing projects.	2.9 3.4.7, 3.7.4 3.7.1	MoLGRDC, 2018
2020–2025	8th Five Year Plan July 2020–June 2025	• Prioritises 3R practices while disposing of urban domestic waste. • Encourages production of power and compost from urban waste. • Introduces fiscal reforms like Beneficiary Pays Principle, Polluters Pays Principle at household level for reducing illegal disposal of household waste. • Promotes CE and Extended Producer Responsibility (EPR Policy in plastic management. • Promotes government authority to provide financial incentives, tax rebates for production of recycled materials. • Encourages citizen engagement and PPP.	4.6.3, 9.8.5 5.3.1, 9.8.5 8.4.1 8.4.6 8.5 9.8.3, 9.8.5	BPC, 2020a
2021	Solid Waste Management Rules	• Prioritises segregation, reuse, recycle and recover principals. • Promotes the storage of household solid waste in three separate containers of different colours. • Encourages PPP to provide the appropriate source-segregation facilities and to handover these wastes to the licensed waste collectors or recycle shops or organisations. • Encourages composting of organic waste. • Encourages local authority to raise public awareness and ensure regular monitoring. • Has provision for punishment in case of violating these rules.	10.2, 19 7.2, 10.6, 14-18 8.4, 10.4, 14 8.5 10.7, 8.4 1 0.6, 15	MoEFCC, 2021a
2021	Hazardous E-waste Management Rules	• Promotes partial cash refund to the user by the producer for returning used electrical and electronic products. • Promotes individual users selling e-waste to the producer, repair shop, recycle shop, junk shop or recyclable material collectors. Users have to pay a fine if they fail to return e-waste. • Encourages city corporations to provide separate places for e-waste in waste dumping sites.	3.10 7.1, 7.2, 21.3 23.2	MoEFCC, 2021b
2021	Battery Recycling and Management Rules	Promotes safe disposal of old and used batteries and encourage users to safely hand over or sell these batteries to the recycling shop.		MoEFCC, 2021c
2023	Bangladesh Environment Conservation Rules	Considers landfill sites, plastic producing and plastic recycling industries as red category industries that are highly hazardous. A compost plant with production capability of 5,000 kilograms, paper and e-waste recycling industries have been considered as the orange category. STSs and industries producing easily recyclable solid waste have been considered the yellow category, whereas organic waste producing industries are considered under the green category.	T1,T14	MoEFCC, 2023

Date	Name	Objectives related to CEand citizen engagement	Section	Reference
2021–2041	Perspective Plan of Bangladesh	• Promotes conversion of waste-to-energy to supply low-cost energy. • Encourages PPP for solid waste management. • Encourages local government tax resources to help finance operating costs and promotes cost recovery through initialising self-financing.	8.5 11.6.1 11.11	BPC, 2020b
2023–2050	National Adaptation Plan of Bangladesh	• Promotes community based solid waste management. • Encourages PPP for waste management and recycling.	3.3.6 3.3.8, 4.7	MoEFCC, 2022

workers in source-segregating solid waste and their contribution to CE. No acts, rules, policies, plans, or strategies exist to guide the workers, which contradicts the human-based approach. Different government organisations like the Ministry of Environment, Forest and Climate Change (MoEFCC), Ministry of Planning (MoP), Ministry of Health (MoH) and Ministry of Local Government, Rural Development and Cooperatives (MoLGRDC) are responsible for the formulation of policies regarding sustainable solid waste management. The Ministry of Power, Energy and Mineral Resources (MoPEMR), Ministry of Agriculture (MoA) and Ministry of Textile and Jute (MoTJ) deal with some crosscutting policies.

3.1.2 DIFFERENT LEVELS OF ACTORS

Waste segregation services cannot be rolled out in a centralised manner like some other infrastructure services. It depends ultimately upon the actions of a full range of independent actors without any single institution taking full responsibility. Governance of household solid waste management incorporating CE takes place at multiple levels and includes a range of stakeholders. Different actors involved in this multilevel governance can be categorised under four levels – macro, meso, micro and pseudo as shown in Figure 1.

Macro level: Acts, rules, plans, policies, guidelines, standards and strategies are formulated at the macro level. Various ministries under the national government, along with local government authorities, design the policy and play decision-making roles in managing MSW. International development organisations and NGOs provide advocacy for policy-making and technical support. The Department of Environment (DoE) and the Department of Public Health (DPHE) regularly provide feedback regarding waste management activities in monthly consultation meetings with city corporations.

Meso level: This level includes the web of actors ranging from government employees to private sectors, formal and informal service providers and civil society organisations. Policies are interpreted, communicated and executed by these actors. The Local Government Engineering Department (LGED) typically oversees the design and construction of infrastructural facilities. KCC supervises and operates the system following devised policies. International organisations provide financial support and NGOs assist local authorities in implementing the guidelines. The conservancy department is in charge of collecting, transporting and disposing of solid waste without causing any environmental hazards. The department is also tasked with the sustainable management of accumulated wastes and city-wide monitoring. The engineering department of KCC assists in maintaining motorised waste vehicles, transporting waste and landfill development. Figure 2 shows the setups of solid waste management under KCC.

KCC struggles to provide full coverage of door-to-door waste collection services in 31 wards of Khulna city. In some areas, this system is entirely operated or supported by NGOs or CBOs, referred to as a community-based system. Khulna city produces 470 tons of daily waste, with only 250 tons collected by KCC (Rafew and Rafizul, 2021; Rafi et al., 2020). About 374 tons are transported to landfill sites (Islam and Moniruzzaman, 2019), leaving approximately 124 tons of unmanaged waste. Around 1,100 grassroots workers (Halim, 2021), mainly door-to-door pickers, van drivers and sweepers, operate under KCC and sixteen per cent of them are outsourced from NGOs and CBOs. Twenty-two NGOs and CBOs are involved with waste collection in 23 different wards covering 23,612 households out of 172,000 households in Khulna city (Ahsan et al., 2012)). The key NGOs are Clanship Association, Muktir Alo, RUSTIC, BRIC, Rupayan, Nabarub Sangsad, SEIAM, CHD, SPS and Samadhan. Interested organisations have to consult with the respective ward commissioner of KCC to obtain permission from the conservancy department of the city corporation. These organisations mainly provide services in exchange for residents' monthly subscription fees (50–100 Bangladeshi Taka). The conservancy inspectors and supervisors (see Figure 2) usually monitor allocated wards under them and the activities of NGOs providing services on those wards. Informal workers like waste pickers, who are primarily children and women, are also important actors playing roles in waste segregation. KCC lacks a strong formal system for waste segregation, relying on grassroots workers for informal source-segregation at the household level.

Micro Level: The actual implementation of the formal institutions on the ground is done mainly by households at the micro level. Users of waste management services are mainly taking part by paying taxes and subscription fees. Additionally, household owners and maids, as general citizens, play roles in

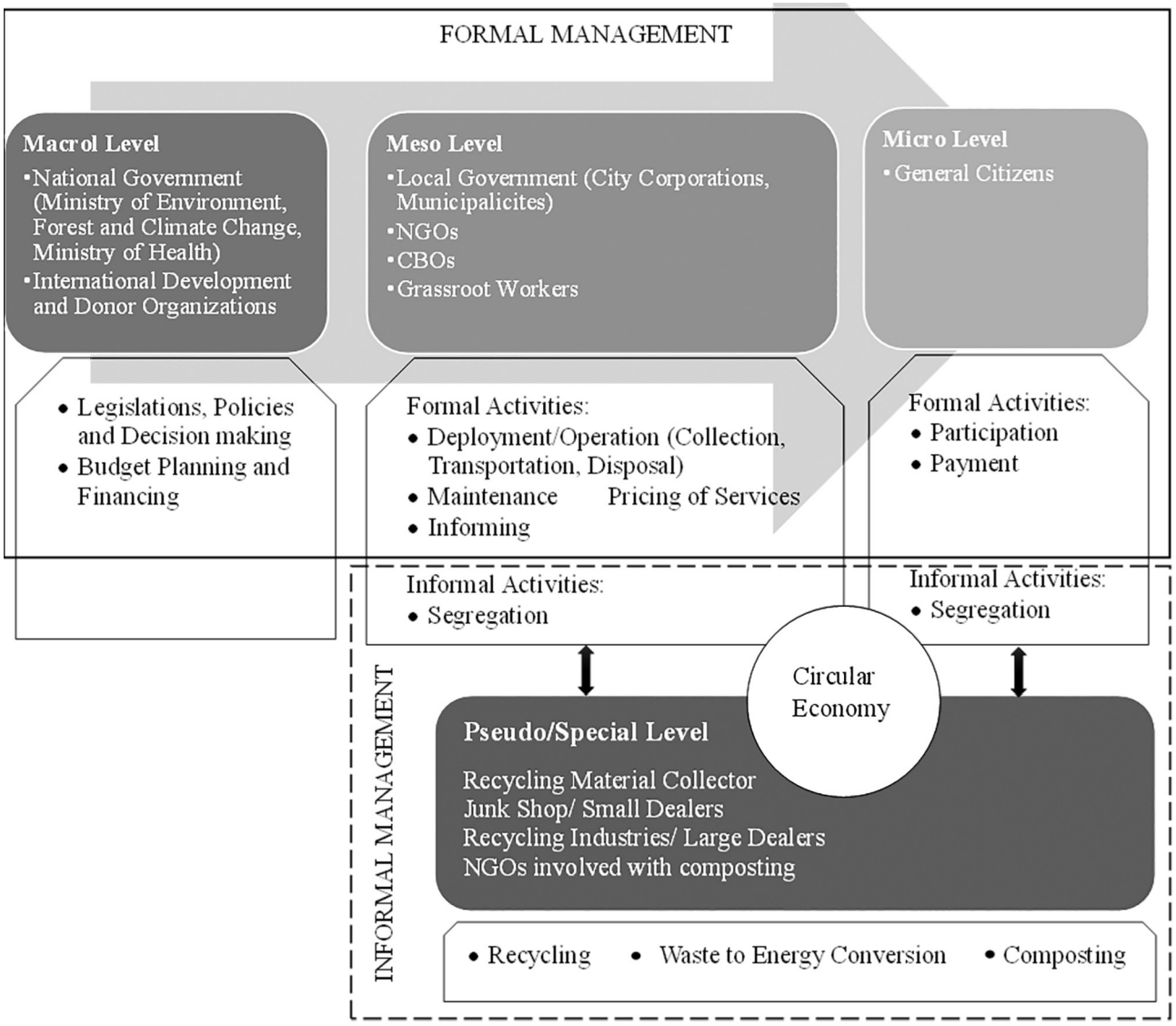

Figure 1. Actors' involvement in different level of solid waste governance. Created by the authors.

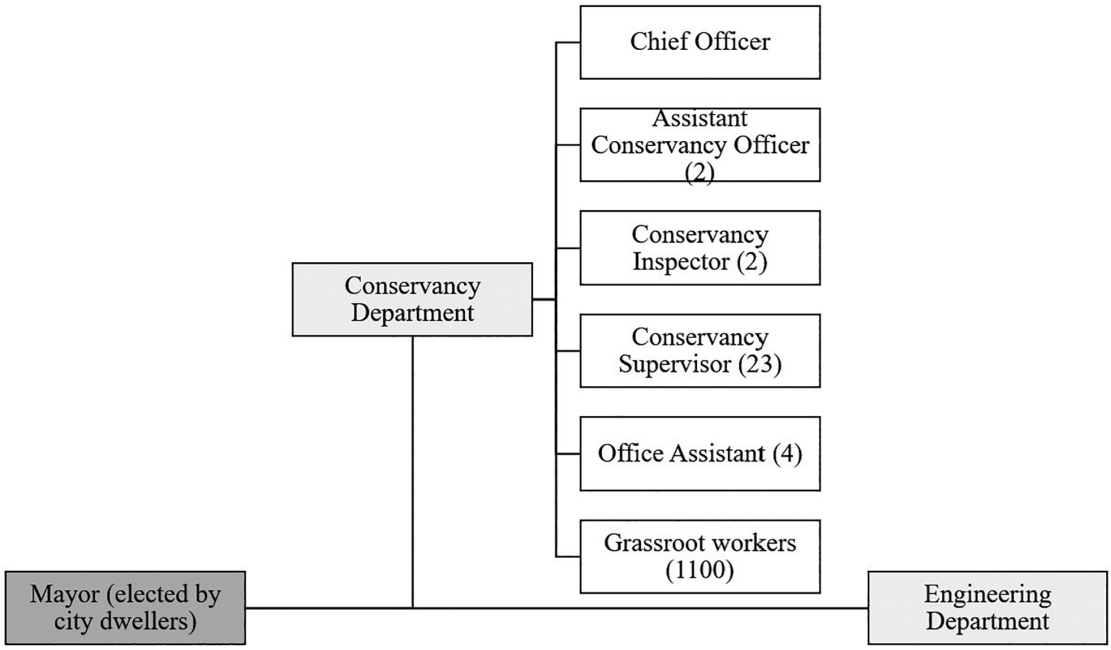

Figure 2. Setup of solid waste management under KCC (Data source: KCC).

recognising the value of waste and separating valuable products.

Pseudo level: Actors involved with this special level are playing a role in rotating the economy. All grassroots workers, junk shop owners or small dealers, recycling industries or large dealers are part of this level as they play significant roles in the final implementation of policies related to CE. Money rotation mainly takes place between pseudo level, micro level and meso level. In the past, only five NGOs, namely Prodipan, PRISM RUSTIC, SPS and Samadhan, were involved with composting organic waste separated from solid and other waste. Recently, only RUSTIC has been producing compost from its own plants in Khulna city. Approximately 859–3,713 persons are engaged in buying and selling reusable and recyclable materials (Alam and Qiao, 2020). About 310 junk shops are involved with direct or indirect recycling of inorganic used materials like plastic bags, jute bags, cartons, paper, books, garments and mixed waste (Alam and Qiao, 2020; Bari et al., 2012). About four recycling industries are dedicated to recycling organic materials (Alam and Qiao, 2020), while 35 are involved in recycling inorganic materials. Many of the recycled products are being sold to local and international markets.

3.1.3 EXISTING FACILITIES

Khulna city has seventeen Secondary Transfer Stations (STSs) or Secondary Disposal Sites (SDSs), 27 large hauled containers (each having a daily capacity of five tons), eleven small hauled containers (each having a daily capacity of three tons) and twelve distinct collection routes (Islam and Moniruzzaman, 2019). KCC owns 35 motorised trucks and 216 non-motorised vans for waste collection and transportation (Halim, 2021). Community containers are mostly located along the roadsides. Neither the STSs nor the containers have separate chambers. Khulna city has three ultimate disposal sites at Rajbandh (twenty acres), Sholua (seventeen acres) and Mathavanga (24.7 acres), all located ten kilometres from the city centre, as shown in Figure 3. Unlike in the past, separate dumping and treatment of medical waste and faecal sludge are practiced, though no formal or mechanical system exists for separating organic and inorganic waste from solid waste. According to the local government authority, the sites still do not fulfill the criteria to become landfill sites. Only eighteen tons of solid waste from the dumping sites are directly used by NGOs for composting purposes (Islam and Moniruzzaman, 2019). KCC has no separate cells for monitoring waste dumping by households, though it has a system of giving and receiving feedback from citizens. It maintains registrar books to monitor the daily trips the waste trucks make. NGOs have their own monitoring system and usually submit a monthly report to KCC.

3.1.4 EXISTING PROCESS OF WASTE SEGREGATION

The formal system of solid waste management in Khulna city involves conventional activities of collection, transportation and disposal, though it lacks integration of solid waste segregation and the CE, which is mainly carried out informally by the labour force and general citizens.

Two types of waste are typically generated at the household level – organic and inorganic. According to Alam and Qiao (2020), 78.9% of collected MSW in Khulna is organic. Inorganic waste consists of paper (9.5–9.9%), plastic & polythene (2.8–3.1%), textiles and woods (1.3–2.1%), rubber and leather (0.5–1%), metals (1.1–2.2%), glass (0.5–1%), and others (2.3–5.1%) (Ahmed et al., 2023b; Alam and Qiao, 2020). Nowadays, households generate a considerable amount of e-waste. Reusable and recyclable metals, plastic, rubber, leather, wood, textiles, glass and paper are often segregated in informal ways. Figure 4 illustrates the different tiers of waste segregation, primarily undertaken by grassroots-level workers.

The first tier involves the preservation of recyclable and reusable products with good market value by aware household owners, who then sell them to recyclable material collectors or junk shops. The second stage of segregation takes place when owners give away reusable materials like textiles, plastic, glass, or e-waste to housemaids who either use those products or sell them to recyclable material collectors or junk shops. However, certain recyclable but not reusable products, such as small or broken plastic products, plastic packaging and damaged items, often end up mixed with organic waste. This mixed waste is given to the door-to-door collectors who collect waste using non-motorised vans. In this stage, collectors separate the usable materials that are visible. Many houses are not accessible by the vans. Besides, some homeowners are unwilling to pay for waste collection services. Consequently, houses without door-to-door services either dispose of their waste in community dustbins if available nearby, or beside roads or in drains. After primary collection from the house, door-to-door collectors or van drivers dump the waste into the nearby community dustbins or STSs, where they separate more materials. They sell all the accumulated waste to junk shops. Waste from community containers or STSs is further transported to landfill sites using waste trucks provided by KCC. The fourth stage of recyclable waste separation is done by waste pickers who collect waste from community dustbins and STSs and sell this waste to recyclable material collectors or vendors. Recyclable waste that remains unseen by waste pickers is eventually sorted by landfill workers in the next stage, although achieving complete separation is difficult. A significant portion of this waste is polythene, which is sold for use in construction. In the sixth tier of segregation, street sweepers collect spilled recyclable solid waste

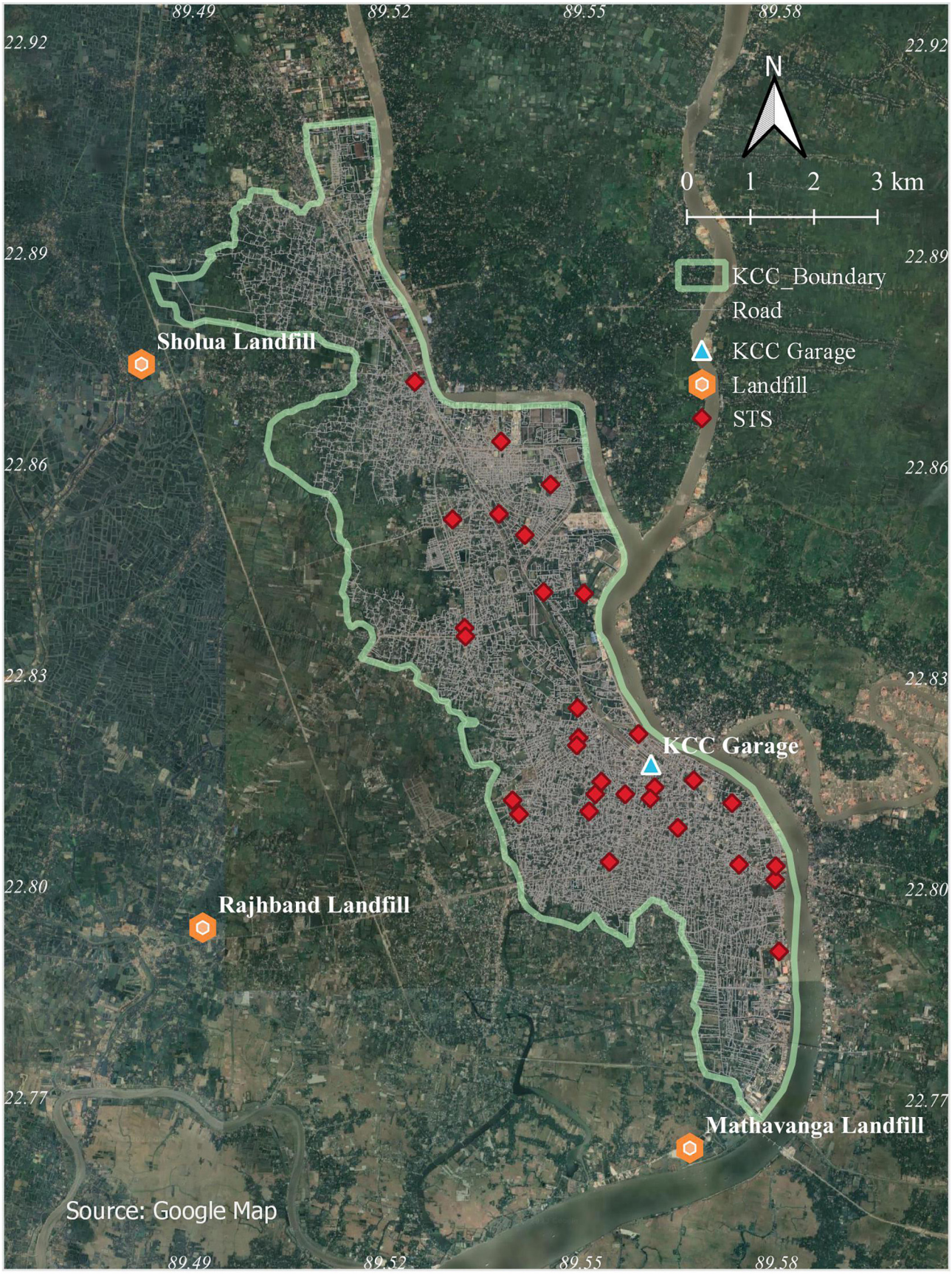

Figure 3. Location of Secondary Transfer Stations (STSs) and Landfill Sites in Khulna City Corporation (KCC).

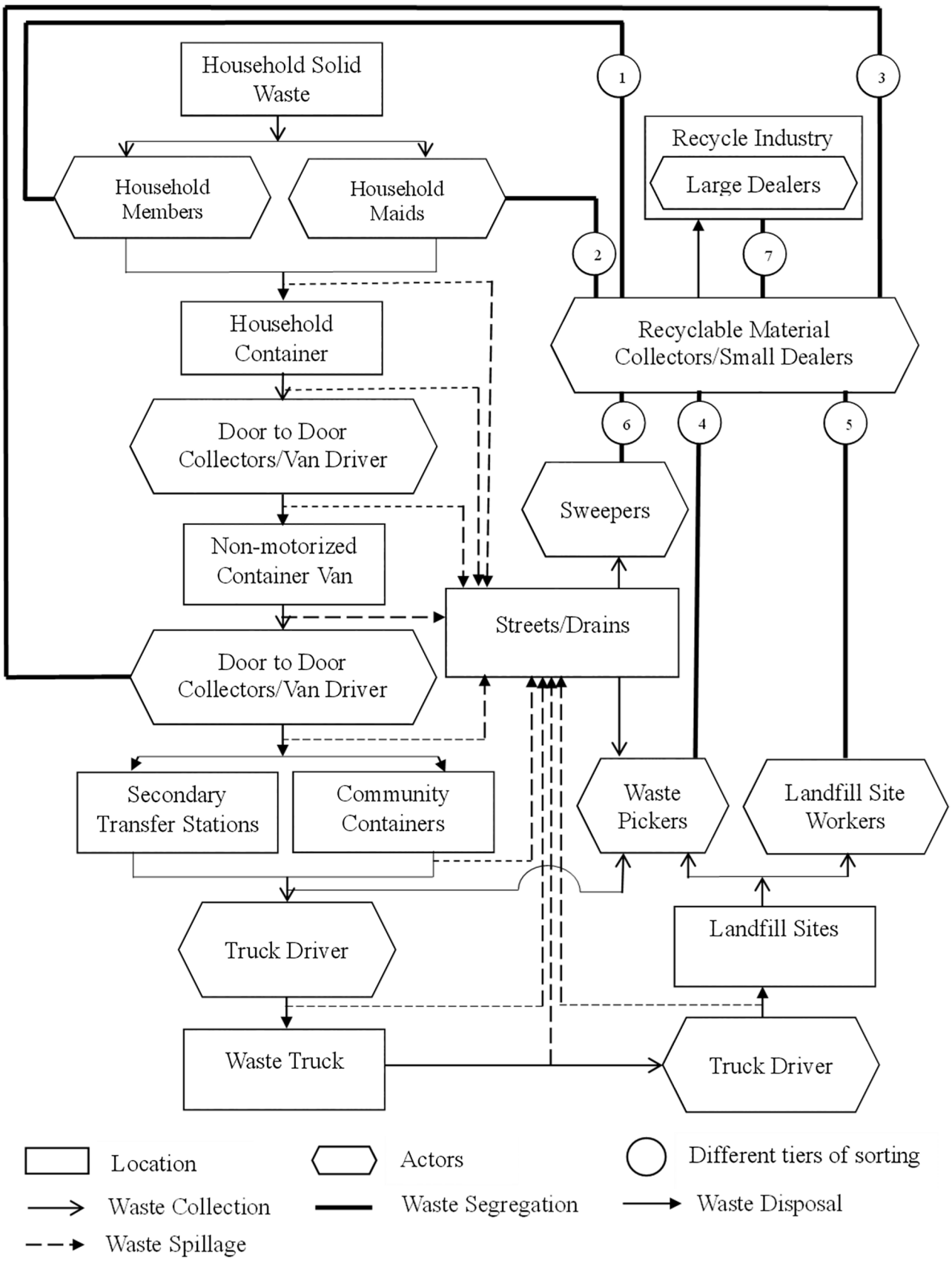

Figure 4. Solid waste segregation by grassroots workers at different tiers. Created by the authors.

and sell it to recyclable material collectors. Spillage commonly occurs during the transportation and dumping process to community containers, STSs and landfill sites by door-to-door collectors, household owners, maids or truck drivers. In the last stage, recyclable material collectors, who generally work for small dealers, sort the materials based on type (i.e., hard plastic and soft plastic) and quality and sell them to large dealers, wholesale companies or recycling industries.

3.1.5 RELEVANT INITIATIVES BY PUBLIC AND PRIVATE SECTORS

In March 1997, a compost plant was built by KCC in partnership with a local NGO called Prodipan, under the water and sanitation programme (WSP) of the World Bank (Ahmed and Ali, 2006). Prodipan was the first NGO to produce compost fertiliser, which had high market demand in Khulna. Currently, the NGO does not produce any compost. RUSTIC started a small-scale composting initiative in 2001 with funding support from Canadian International Development Agency (CIDA) under Bangladesh Environment Management Project (BEMP). In 2004, production stopped because of public complaints about the bad smell. At present, the NGO continues producing approximately thirty tonnes of compost fertiliser monthly on their own 0.47-acre site at KCC's Rajbandh landfill site (Roy et al., 2013). They follow the process of vermicomposting using worms and microorganisms that produce less smell. From 2002 to 2004, SPS had a compost plant in partnership with another NGO, PRISM, under the Sustainable Environment Management Programme (SEMP). Samadhan started another organic compost fertiliser preparation plant during 2007–2010. The project was co-financed by the European Commission's Asia Pro Eco Program and Khulna University of Engineering and Technology (KUET) under the project 'Integrated Management and Safe Disposal of MSW in Least Developed Asian Countries', WasteSafe for short. The NGO stopped composting due to disapproval from the MoA. A national 3R workshop was held in February 2007 to minimise MSW. The workshop showed case studies from Japan to design domestic policies for implementing 3R principles. The workshop had 56 participants from different government organisations like MoEFCC, MoLGRDC, MoP, LGED, KCC, Narayanganj City Corporations, Chittagong City Corporation and Kusthia Municipalities; and non-government organisations like Waste Concern, RUSTIC, PRISM and ESDO. Government medical officers and news reporters also attended the workshop. The Urban Public and Environmental Health Sector Development Program (UPEHSDP), funded by the Asian Development Bank (ADB), supported the construction of four STSs, provided two waste trucks to KCC, and distributed 12,500 waste bins to city dwellers.

At present, multiple projects are ongoing in Khulna city for the overall improvement of solid waste management systems, incorporating the CE concept. The 3R innovative pilot Project Phase 1 at Mathavanga, initiated by KCC under the Climate Trust Fund, focuses on MSW treatment to prevent environmental pollution. KCC has an awareness training centre under ongoing Sustainable Capacity building to reduce Irreversible Pollution by Plastics – in short, SCIP Plastics Project. The campaigns are mainly about source-segregating organic and inorganic waste, particularly plastic, to prevent ocean pollution. KCC has also started placing awareness stickers on walls and distributing leaflets to houses, schools and offices. The City and Regional Development Project-2 involves the construction of trenching grounds at Rajband and a controlled dumping station at Sholua, with plans for compost, energy and electricity production from dumped waste. Besides, Bangladesh Power Development Board (BPDB) is attempting to implement waste-to-energy (WTE) projects in various city corporations and major municipalities. The WTE project proposal for Khulna City Corporation is in progress. Lastly, DPHE is working for the treatment of solid waste without polluting the environment and DoE is planning to produce oil and octane from waste according to officials from these organisations.

3.2 CHALLENGES OF HOUSEHOLD SOLID WASTE SOURCE-SEGREGATION

The analysis of interviews and workshop reveals a variety of constraints, which are classified under five broad categories: policy, institutional, environmental, financial and social or behavioral. Table 3 gives the significance of these challenges, calculated based on number of comments made by various participant groups. The highest number of comments were found under the behavioural constraint theme. Social and institutional constraints were respectively the second and third significant constraints.

3.2.1 POLICY GAP

The study reveals a lack of emphasis on formal waste recycling in Khulna, contrary to policy promotion. Organic waste is never separated at source from inorganic and composting is still done by private NGOs with little or no support from the government. Strict licensing policies and the absence of recognisable incentives from the governments (Ahmed et al., 2022; Matter et al., 2015) are causing limited formal participation by private shops and industries in recycling activities. A junk shop owner commented,

> We are helping the government to protect the environment and in return, we are making little profit, but sometimes that is also hindered by government restrictions. Recycle

Table 3. Significance of various themes according to the participants.

Participants/Stakeholders	Challenges						Recommendations				
	Policy Gap	Institutional Constraints	Environmental Constraints	Financial Constraints	Social Constraints	Behaviourial Constraints	Appropriate Policy Design	Providing Services and Facilities	Raising Awareness	Legal Action and Enforcement	Total Comments by participants
Official, DoE	0	1	1	0	1	1	1	1	2	0	8
Official, DPHE	0	2	1	2	1	2	1	2	2	0	13
Conservancy Officer 1, KCC	0	4	0	1	3	3	2	2	1	1	17
Conservancy Officer 2, KCC	0	1	1	2	1	5	0	1	4	1	16
Conservancy Supervisor (Door-to-door collection), KCC	0	1	1	0	3	2	0	2	0	0	9
Conservancy Supervisor (Sweeping), KCC	0	0	0	0	0	0	0	1	1	0	2
Landfill Supervisor, KCC	0	0	1	0	1	1	0	1	2	0	6
Small Dealer	1	0	0	2	1	0	1	0	0	0	5
Large Dealer	1	0	0	1	0	1	0	2	0	0	5
Individual Consultant	1	1	0	2	0	0	3	2	1	0	10
Expert and Researcher, University	1	1	1	0	0	1	3	1	2	3	13
Development Practitioner 1, SNV	0	2	1	0	2	2	3	1	2	1	14
Development Practitioner 2, Prodipan	2	4	0	1	1	0	4	0	4	1	17
Landfill Worker	0	1	2	0	1	2	1	3	1	0	11
Vehicle Driver	0	1	0	0	2	2	0	1	0	0	6
Door-to-door collector	0	2	0	1	3	2	1	1	0	1	11
Sweeper	0	0	0	0	1	1	1	2	1	0	6
Waste Picker	0	0	0	0	3	2	0	0	0	0	5
Recyclable Material Collector	0	0	0	0	0	0	1	1	0	0	2
Workshop	1	1	0	1	1	1	3	1	3	2	14
Total comments under themes	7	22	9	13	25	28	25	25	26	10	190

> shops like ours don't have favourable conditions for work.

According to two stakeholders, most policies do not clearly define the roles of waste generators alongside waste managers. Existing policies also overlook the roles of grassroots workers and women in segregating solid waste. Grassroots workers are also not aware of the existing policies. The Bangladesh Labor Act 2006 prioritised the taking of safety measures by formal workers while disposing of wastes (MoLE, 2006). Insufficient guidance and protection measures for child and female informal waste workers are also a cause of concern. All these aspects contradict the five fundamental principles of the human rights based approach (HRBA) – namely meaningful participation, access to decision-making, non-discrimination, accountability for all and transparency of information. Furthermore, waste management-related policies are not revised regularly.

3.2.2 INSTITUTIONAL CONSTRAINTS

The major reasons for mixed dumping of solid waste by citizens are unavailability of separate communal dustbins, irregular waste collection services and inaccessibility of waste vehicles. A development Practitioner pointed out, 'Sometimes, waste overflows from these dustbins as they are not regularly

transferred to the STSs.' Another stakeholder stated that, 'Inefficient use of STSs only for transferring waste instead of as material recover facilities is another shortcoming of the sustainable waste management system.' Currently, only 950 waste workers are employed under the conservancy department of KCC, serving 177,852 households with a worker-household ratio of 1:188 (Bangladesh Bureau of Statistics, 2011; KCC, 2018). Despite this workload, only 17.36 per cent of workers are outsourced from private organisations (KCC, 2018). Government bodies like KCC, DoE, and DPHE also lack the workforce to adequately monitor waste collection. The lack of a comprehensive and reliable database regarding door-to-door waste collection at the city level makes monitoring more challenging. Inadequate collaboration and integration among organisations poses barriers to funding and responsibilities, causing unnecessary delays and hindering effective monitoring. Stakeholders highlight problems such as the lack of warnings, inadequate law enforcement and rare monitoring of recycling sectors. Awareness campaigns by government organisations are not part of regular activities. The lack of a training and awareness programme for waste workers and general citizens is another shortcoming of the existing system. Lastly, most waste recycling and composting projects in cities rely on support from donors, NGOs or CBOs. Challenges persist due to undisclosed issues stemming from the lack of initial capacity assessment, jeopardising the sustainability of these projects.

3.2.3 ENVIRONMENTAL CONSTRAINTS

Electricity generation from waste is common in dry regions as waste can be quickly dried and burned for fuel production in hot weather. Humidity and excessive rainfall in Bangladesh make it difficult to remove moisture from waste. Moreover, the country's humid weather is responsible for the quick decomposition of organic waste (Roy et al., 2022). As pointed out by an expert, 'Insufficient dumping facilities and long-term storage of household waste during humid weather create odours and effluents, making it difficult for waste collectors and grassroots workers to separate inorganic and organic waste.' Sometimes, waste pickers are not allowed in landfill sites in view of the threat to their health, which is a cause of concern for their livelihood. A landfill supervisor mentioned, 'Sometimes we do not allow them in the site considering their health risk. Now they collect the remaining wastes after dressing.' Many stakeholders agreed that this indirectly minimises the practice of CE by restricting informal waste segregation.

3.2.4 FINANCIAL CONSTRAINTS

KCC's primary income sources include development funds, taxes, fees, fines and tolls for various activities. From 2016 to 2022, an average of 6.48 per cent of the total budget was invested in the conservancy department, with only 0.45 per cent spent on development activities like solid waste management (see Table 4). The remaining amount is spent on establishment sections like salaries and official bills. The conservancy department manages MSW, human waste, street sweeping, drain cleaning, waterlogging prevention, mosquito extermination and detention of stray animals. Managing these activities with limited tax money is a challenging task. A conservancy officer stated, 'Due to lack of funds, it is very difficult for us to provide separate bins in every household and design community containers and STSs accordingly. Providing appropriate facilities requires money and no taxes are paid by the households for many of the services we provide.' Moreover, many households, particularly low-income people in slum areas, are unwilling to pay monthly subscription fees for waste collection services. Inadequate financial benefit also discourages grassroots workers from providing a quality service, making waste separation a challenge. An expert

Table 4. Budgetary allocation for the conservancy department (2016–2022) in million Bangladeshi taka (BDT).

Year	Proposed Total Budget for KCC	Actual Total Budget for KCC	Total Budget for Conservancy Department		Budget for Conservancy Establishment		Budget for Conservancy Development	
			Amount	%	Amount	%	Amount	%
2016–17	4678.466	2645.247	182.952	6.92	176.600	6.68	6.352	0.24
2017–18	4407.988	2557.929	196.462	7.68	188.554	7.37	7.908	0.31
2018–19	6370.986	2988.314	251.307	8.41	243.160	8.14	8.147	0.27
2019–20	8655.403	5827.157	235.827	4.05	224.924	3.86	10.903	0.19
2020–21	5043.122	3624.674	246.435	6.80	240.222	6.63	6.213	0.17
2021–22	6080.256	4506.491	225.420	5.00	157.900	3.50	67.520	1.50
Average	5872.703	3691.635	223.067	6.48	205.226	6.03	17.840	0.45

Data sources: KCC, 2017; KCC, 2018; KCC, 2019; KCC, 2020; KCC, 2021; KCC, 2022.

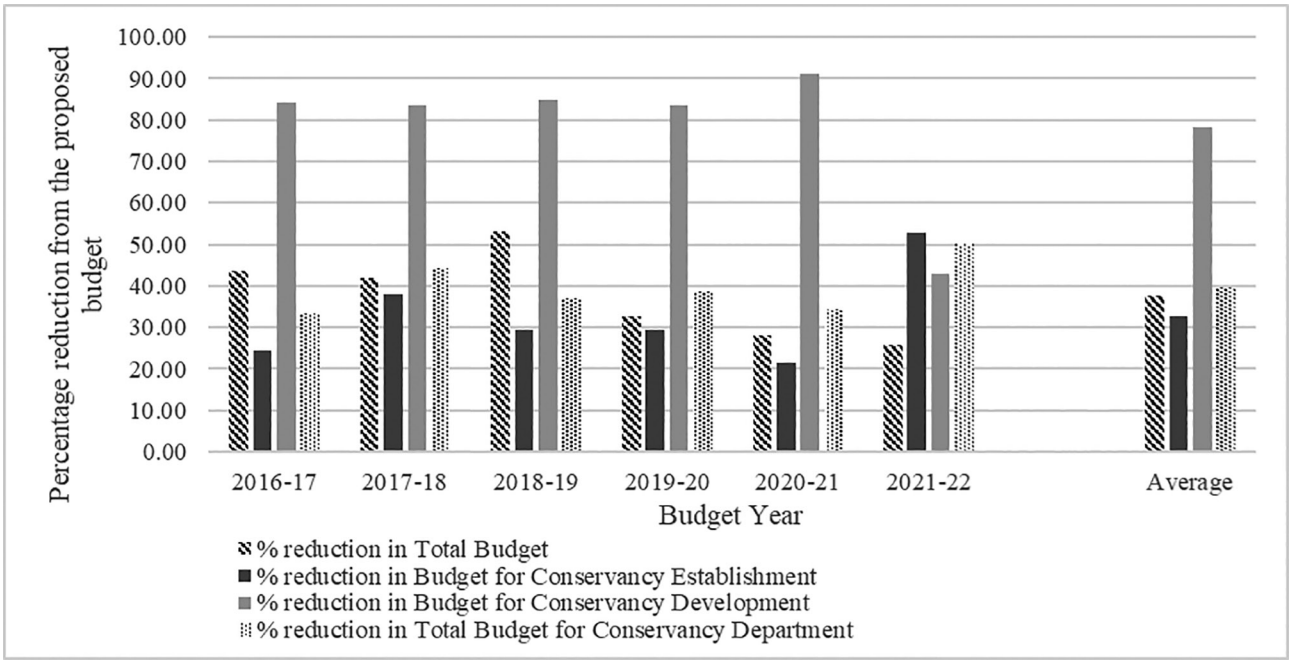

Figure 5. Percentage reduction from proposed budget allocated for KCC. Data sources: KCC, 2017; KCC, 2018; KCC, 2019; KCC, 2020; KCC, 2021; KCC, 2022.

highlighted, 'the amount of service charge claimed by NGOs from the households is not often reasonable, creating an extra burden for people already paying taxes. In addition, there is no fixed rate and no government control over the service charges and salaries of workers fixed by NGOs.'

According to a consultant, another reason for financial deficits is budget shrinkage due to insufficient development funds from donor organisations. Projects initiated by different international organisations and NGOs in collaboration with City Corporations have failed due to lack of funds for continuation. KCC experiences an average annual reduction of 37.54 per cent in its proposed total budget. Figure 5 reveals a seventy per cent reduction in the proposed budget for conservancy development annually, except for the 2021–2022 budget year, indicating the direct impact of budget narrowing on development and waste management sectors.

Small dealers claimed that zero incentives from the government and an increased tax burden on recycling firms are major reasons for many people taking waste recycling lightly. Smaller net profit by recycling firms due to inappropriate business model is considered to be a significant reason for less interest in waste segregation. A development practitioner said,

> it is often not suitable and feasible to produce material from waste and there is no certainty of profit generation from producing fuel or fertiliser using solid waste. So, initiatives for running CE frequently fail to continue.

3.2.5 SOCIAL CONSTRAINTS

In Bangladesh, the crucial role of women in source-segregation is undeniable, given their predominant involvement in household activities, including waste disposal. Interviewees of this study agree that women can significantly contribute to household solid waste source-segregation and policy decision-making. However, the waste management sector lacks female representation, with only two female officers currently working under the conservancy department of KCC. A female stakeholder stated, 'It is hard for many people to accept a female leader in this sector.' Stereotypes regarding the perceived work ethic of female grassroots workers further hinder their recruitment, contributing to gender-related disputes in policy implementation. Less female participation in community meetings dominated by males is another reason behind household women's lack of awareness regarding waste source-segregation.

New methods of formal waste segregation using separate bins and collection of recyclable materials in a registered way are causes of concern for poor grassroots and small dealers as there will be fewer recyclable materials for them to collect and sell. It will threaten their livelihood because selling recyclable waste is a source of income for them. A recyclable material vendor claimed 'It will be a loss for us as a middle-man and our occupation will no longer exist. Then, people will directly sell the sorted items to large dealers or the government. It will benefit them, but we all will lose our jobs.' This study also reveals a dispute among stakeholders regarding formalising the solid waste source segregation

process. While some experts emphasise the difficulty of relying solely on a workforce for segregating all types of waste, others believe formal segregation may lead to environmental pollution as grassroots workers have made considerable contributions for the last forty to fifty years in maintaining the value chain.

3.2.6 BEHAVIOURAL CONSTRAINTS

Stakeholders have identified significant path dependencies or behavioural inertias at macro, meso, and micro levels, posing obstacles to CE practices. Halim (2021) has stated that even educated people do not follow the rules, despite knowing the benefits of waste segregation. An officer from KCC said,

> Households are not interested in buying separate bags or bins as it will cost them extra money. They are unwilling to keep bins nearby or in front of their houses. They even do not want to pay the monthly service charge for waste collection. They want a clean environment but believe everything is the responsibility of the government. But, the waste generators should mainly be responsible for waste segregation.

According to a consultant, people tend to return to their old behaviour even when resources are provided and even after the successful completion of projects. Therefore, resource-oriented initiatives ended in failure and were not sustainable in the long run. Residents' unsafe disposal of sharp and hazardous materials complicates waste separation for door-to-door pickers as they have to touch or handle the waste directly. Some garbage also contains water content, which makes the separation more challenging for collectors. A door-to-door collector mentioned,

> I do not think household residents can segregate waste. Where they think they don't even have time to dump waste, waste segregation is a far cry. Sometimes, the garbage contains broken glass that causes injuries to us regularly even though we have requested them to segregate this.

3.3 KEY RECOMMENDATIONS FOR INCLUSION OF CE

This research gathered valuable insights from experts and grassroots people, suggesting key measures to stimulate a CE through policy design, separation facilities, awareness raising, and legal measures. Table 3 illustrates the relative importance of each key recommendation and shows that all are almost equally significant except Legal action and law enforcement, which the stakeholders suggested less frequently.

3.3.1 APPROPRIATE POLICY DESIGN

At first, operational guidelines detailing the entire segregation process (dumping to selling) with a clear description of the waste generator's roles should be formulated, as suggested by a consultant. Secondly, the involvement of private organisations should be encouraged for waste segregation and CE practices through supporting policy environments and incentives as recommended by all development practitioners from different NGOs. Large and small dealers mentioned that a simple licensing or certification system and reduced registration fees may ease the process of CE. Thirdly, the production of compost fertiliser from organic waste should be explored as a viable business model in the climatic and local context of Bangladesh (Alam and Qiao, 2020; Roy et al., 2013). Biofertilisers created from organic waste have more market value worldwide compared to chemical fertilisers, which are harmful to health, soil and the environment. A researcher interviewed for this study highlighted, 'We can make successful business plans for compost plants that must declare the after-use policies, basic purpose of utilisation, target customer, value chains, price, ingredients and components.' As argued by an expert, initial project assessments and feasibility analysis are also essential. Fourthly, strategies have to be taken to enhance citizen participation, regardless of gender, age, occupation, religion and race, in decision-making and implementation. All stakeholders stated that the active involvement of women in policy and decision-making processes needs to be ensured. Lastly, grassroots workers should be incorporated into the institutional process without disrupting the existing value chain, recognising their essential roles in the material recovery. A formal system for adequately benefiting these marginalised people for waste management should be introduced to reduce the gap between policy and action (Halim, 2021). Like Matter et al. (2013), many stakeholders have suggested generating alternative employment for waste pickers by employing them in recycling centres where further separation or composting takes place.

3.3.2 PROVIDING SERVICES AND FACILITIES

Institutional capacity building using advanced technologies and human resources is mandatory for transitioning toward CE. Interviewees suggest maximum utilisation of Solid Transfer Stations (STSs) as material recovery facilities, fostering stakeholder collaboration and providing well-designed communal dustbins with separate chambers. Regular household surveys and preparing a comprehensive citywide database are essential to monitor the regularity and the quality of the services. An expert recommended, 'Local government authorities should regulate service charges and grassroots workers' salaries provided by NGOs.' As shown in a study, high-income people in Dhaka, the capital of Bangladesh, are willing to pay 13 Bangladeshi Taka per month (Afroz et al., 2009), whereas residents of Khulna city pay 50 to 100 Bangladeshi taka monthly. However, a national coordination committee should

be responsible for examining reports on generated and recycled waste and issuing licenses. They will provide incentives and ensure recycling industries take proper risk control measures. An online monitoring system must be introduced, and emergency hotline numbers can be circulated among citizens as suggested by KCC officials. According to an expert, a weekly scheduled collection system could be introduced for easy segregation of different types of waste. Jerin et al. (2022) suggested to collect organic waste daily and non-degradable waste four or five days a week. There should also be a provision for citizens to provide feedback regarding their satisfaction level with the services, which will increase the level of transparency and accountability.

3.3.3 RAISING AWARENESS

According to a government official, Ministry of Commerce (MoC) and Ministry of Information and Communication Technology (MoICT) alongside with MoE, DPHE and KCC should augment source-segregation practices. Regular and extensive awareness campaigns by KCC, social media campaigns, local committee meetings, public consultations and public hearings can help provide information and increase knowledge regarding waste segregation. Leveraging diverse media and engaging leaders and teachers in public speeches can reshape social norms. A development practitioner highlighted, 'The concept of behaviour change regarding solid waste source-segregation should be incorporated into primary education because children can also play significant roles in changing the family's behaviour.' This is also suggested by Ahmed et al. (2023a). Targeting both citizens and grassroots people, especially with gender-focused training on waste segregation and safety measures, is crucial for effective awareness, as mentioned by many stakeholders. Establishing precedents and illustrating the community's profit potential can motivate widespread adoption. According to an expert, a concept of tax rebate for separating solid waste could be introduced.

3.3.4 LEGAL ACTIONS AND ENFORCEMENT

According to a participant, strict execution of Solid Waste Management Rules 2021, National 3R Strategy for Waste Management 2010 and Mandatory Jute Packaging Act 2010 is necessary at the household level. The government should ensure exemplary punishments for law violations, publicising them through newspapers, television or social media. A development practitioner recommended, 'Prominent figures like actors, players, or politicians can participate in role-playing events to underscore the importance of compliance.' Small-scale pilot projects with closed-circuit television (CCTV) cameras could be initiated to identify the rule breakers. Polluters Pay principles can be applied for non-biodegradable waste, according to a researcher. An expert said that strict laws should be imposed on households and shop owners to reduce generation, consumption and disposal of single-use plastics.

4. CONCLUSION

CE is widely accepted because it brings both environmental and financial benefits. It is aligned with SDG 12, which encourages justifiable consumption and production through reduced waste generation, reuse and recycling of products. Implementing a CE in managing household solid waste can prevent pollution and offer financial gains for the government. Source-segregation is one of the essential steps for implementing CE. Like other cities in Bangladesh, Khulna faces the challenge of separating household solid waste, which is most of citywide collected waste. The findings of this research show that different actors at macro, meso, micro and pseudo levels of solid waste governance are involved in the process from operation to implementation. Only a few actors are actively participating in decision-making. Local government operates waste collection, transportation and disposal with the help of grassroot workers, but responsibility for reusing, recycling or recovering is not assigned yet. Recently devised Solid Waste Management Rules 2021 have motivated private organisations to get involved with recycling and composting. Local NGOs and CBOs have taken some measures focused on composting organic waste. Grassroots workers like door-to-door collectors, sweepers, recyclable material collectors, waste pickers and truck drivers play informal but significant roles in segregating reusable and recyclable solid waste. This segregation occurs not at source but in seven different stages. Many policy instruments have been devised over the last 25 years that promote recycling but they have not acknowledged the contribution of these workers in saving time and money in operation. Recycling organisations are not getting incentives from the government because of the informal nature of the process, resulting in limited benefits for these workers. Policy instruments alone are insufficient for sustainable solid waste management without appropriate facilities and services.

This research also finds that inadequate budgetary allocations, limited facilities, technological limitations, weak monitoring systems, institutional inefficacy and manpower shortages within local authorities impede complete source-segregation. Additionally, societal constraints, such as lack of awareness, behavioural inertia and dependence on older systems, need addressing to achieve sustainable waste management. Moreover, the formalisation of source-segregation may threaten the livelihood of grassroots workers, which is another major humanitarian challenge for the government. Given the necessity of circular practices in Bangladesh, this study is expected to help stakeholders make

productive and long-term decisions. Stakeholders interviewed for this study suggested progressive formalisation of source-segregation, incorporating all stakeholders. Beside designing effective policy instruments, considering the social and environmental context of the region, it is recommended to increase institutional capacities, provide appropriate facilities, raise public awareness and enforce legal measures as a last resort.

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