Asia-Pacific
Economic Cooperation

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Enhancing Labor-intensive Separate Waste Collection and Utilization in APEC Economies

APEC Ocean and Fisheries Working Group

January 2023

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IMPLEMENTATION GUIDE

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APEC Project: OFWG 08 2020A

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APEC#223-OF-03.1

Contents

Text boxes

LIST OF TABLES

LIST OF FIGURES

Abbreviations

APEC	Asian Pacific Economic Cooperation
CBC	Community Based Contractors
CBO	Community Based Organizations
CH4	Chemical formula for methane – powerful greenhouse gas
CO2	Chemical formula for Carbon Dioxide – greenhouse gas
EPR	Extended Producer Responsibility
IEC	Information, Education, Communication
NGO	Nongovernmental Organization
PET	Polyethylene Terephthalate – plastic often used for single-use bottles
RDF	Refuse Derived Fuels
UNEP	United Nations Environmental Program
WWF	Word Wide Fund for Nature

1. Why this Guide?

Land-based sources of marine litter, including plastics, have been identified by the Asia-Pacific Economic Cooperation (APEC) and the broader international community as a major problem plaguing our oceans and cities. The vast majority of the plastics entering the sea stem from land-based sources. As much as 75% of land-based sources of marine plastic litter comes from uncollected and/or improperly disposed of waste on land[1] .

Rivers and waterways are the most important entry paths as they transport waste thrown or flushed into the rivers and dumped at their shores into the oceans. Even plastic and rubbish disposed of in an uncontrolled way in the hinterland can end up in the sea. This uncollected waste causes significant socio-economic costs to municipalities, impacting public health, economic development, and tourism to APEC economies.

The main causes of land-based marine litter are insufficient or even non-existent waste management systems inland in combination with increasing sales of single-use plastic products, mainly packaging. 'Economic development, population growth, increasing consumerism, movement from rural to urban areas and the prevalence of a disposal culture has resulted in growing levels of waste, often without the infrastructure in place to collect and manage it'[2].

To reduce marine pollution, action is needed at both the domestic level and at local and regional levels. At a domestic level, measures to prevent waste generation, such as requiring producers and distributors of packaging products to contribute to the costs of environmentally sound waste recovery and disposal, are needed. Such 'Extended Producer Responsibility' schemes necessitate legislative action by governments. At the local and regional level, cost-effective waste collection systems and disposal infrastructure must be implemented or enhanced that are affordable for the population and manageable for local and regional administrations.

The APEC wants to bring attention to the marine litter issue caused by inadequate waste collection, with a focus on small and medium-sized cities. Besides rural and peri-urban areas, these urban and semi-urban settlements have the lowest waste collection rate and the highest per capita leakage rate. Apart from collectors and itinerant buyers of recyclables and maybe some private-to-private arrangements for waste management services, there is often

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1 Ocean Conservancy and McKinsey Center for Business and Environment, Stemming the Tide: Land-Based Strategies for a Plastic Free Sea, 2015 https://oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf

2 Danielson, J.: Leave no trace; Vital lessons from pioneering organisations on the frontline of waste and ocean plastic; Published in 2020 without date; https://hasirudala.in/wp-content/uploads/2020/12/Leave-No-Trace.pdf

no regular orderly waste collection service. Lacking or inadequate waste collection schemes represent a key gap in establishing effective solid waste management infrastructure that is commensurate with the rapid increase in population and purchasing power of APEC economies.

There are meanwhile innumerable activities and projects conducted worldwide to combat marine litter, most of which focus on collecting plastic and trying to recycle as much as possible to render collection activities financially viable. Although some of the plastic is designed for single use then recycling, some is designed for multiple use, refilling or recycling, the vast majority of discarded plastic is not recycled and ends up as waste. Even plastics that could be recycled is frequently incinerated in an uncontrolled manner, generating considerable air emissions, or deposited in inadequately secured and operated dump sites, especially if the quantities collected are too small and logistics too cumbersome[3] for commercial recycling. A stable supply-chain for the recycling companies cannot be guaranteed by such irregular actions.

Besides plastic collection activities, volunteers carry out beach cleanups, diving for ghost gear, fishing for trash, and other actions at little cost. Such actions undoubtedly raise awareness and demonstrate that it is more difficult to cleanup than to avoid, reduce or collect plastics regularly. However, such activities are mostly unsustainable because they cannot be institutionalized and there is no sustainable funding. It leads to frustration and demotivation when plastic waste is laboriously collected or retrieved from the sea, but then there are no adequate facilities for its proper treatment and disposal. Far be it to criticize such actions, on the contrary, it is admirable how many people are actively fighting for the health of the seas. They do what is in their power; however, their possibilities are limited without institutional structures. The government and institutions must take responsibility and work to establish effective measures against marine litter and include diverse stakeholders and the general public to the greatest extent.

[3] Which is often the case with archipelagos and small island, e.g. in the Philippines

The strategy outlined in this Guide follows a fundamentally different approach. It is guided by the conviction that combating marine plastic pollution at the municipal level cannot be achieved by establishing plastic waste collection and recycling systems. Rather, plastic waste management must be embedded in reliable waste collection and disposal systems -- in combination with market-led separate collection of recyclables -- that encompass all waste types and waste generators, both for environmental and economic reasons, as shown below. To this end, labor-intensive, low-tech collection concepts are presented and recommended, which are flexible and easy to adapt to changing frame conditions, e.g. if an EPR scheme comes into play. Labor-intensive methods are mostly better suited to the context in many APEC economies than large waste collection trucks, especially in low- and middle-income economies and in densely populated cities where large waste compactors cannot be utilized. This Guide targets a key gap in APEC economies that is often overlooked, namely the need for low-cost, easily applicable, flexible methods of waste collection and separation.

1.1. Municipalities and their financial struggle with waste

'Municipalities often struggle with limited financial resources, a lack of waste system training and other administrative setbacks which make managing waste both an expensive and challenging proposition. Further, many regions lack essential waste management infrastructure, including proper landfills and established recycling processors. Residents and businesses are met with poor collection services and often resort to dumping their waste away from their homes, or in the water. Without proper collection systems, waste recyclers and processors do not have a consistent supply of quality feedstock'[4].

The Guide takes the perspective of a municipality whose task is to ensure the proper management of all municipal waste generated in its territory in an environmentally sound and cost-efficient manner. The challenge is to organize a reliable, user-friendly, affordable waste collection service that ensures the greatest possible recovery of waste. The Guide supports municipalities and communities to identify tangible and cost-effective options for comprehensive separate collection and waste utilization that can be easily implemented and replicated in small to medium sized-cities in the APEC region.

Rather than reducing collection services to cut costs, the Guide encourages establishing waste collection systems that provide reliable and regulated waste disposal services to all residents and waste generators at an affordable cost. This guide outlines ways to establish this type of system.

[4] Danielson ibid.

The Guide is led by the conviction and experience that municipalities can institute cost-effective waste management systems that serve the entire population using low-tech and labor-intensive means. Source segregation and separate waste collection is key to resource recovery and high waste utilization rates, as well as generating revenues that could help cover the cost of waste management services. Enhancing separate waste collection will contribute to the development of waste infrastructure that benefits the local economy while providing material for secondary markets to establish and flourish.

The primary focus of this Guide is household waste and waste generated in small quantities like shops, restaurants, small businesses[5]. Waste generated by households accounts for the largest share of municipal waste (e.g., about 60 and 80%, depending on the structure of the district, originate from private households). Other than household waste generators – so-called 'commercial waste' – can be included in the collection system if the quantities generated are manageable with the labor-intensive collection methods as described. For large waste generators such as schools, hospitals, office buildings, large commercial operations, stores, and wholesale markets, individual solutions are necessary to address this waste stream.

Removal of littered waste from roads, public areas, and open drains requires different approaches and is therefore not included in this Guide. However, it must be emphasized that a regular, reliable and user-friendly waste collection service leads to a significant reduction in the amount of waste disposed of on streets, roads, public squares and areas, or in open drains. Collecting litter from streets and from storm water drains, is much more expensive than collecting waste directly from residents and commercial businesses. Therefore, the introduction of a regular waste collection service significantly reduces the cost of removing these types of waste by preventing the occurrence of litter in the first place.

Likewise, construction and demolition waste is not included, as its collection and disposal requires entirely different collection methods and equipment.

1.2. The role of private recycling entities

For waste collection and disposal to be successful and sustainable, it generally needs a reliable cost recovery system. Even if waste is recycled to the greatest extent possible, the revenues generated from the sale of the secondary raw materials obtained, the energy generated and goods produced - such as compost or Refuse Derived Fuels (RDF), are insufficient to cover the costs of the waste management system. Thus, without reliable cost recovery schemes, waste management does not provide incentives for private companies to

[5] In this Guide referred to as 'other waste generators'

develop business models that cover the entire waste management chain. Only in selected areas are cost-covering private sector activities possible, particularly in the collection of recyclable waste or by collection services paid for by waste producers, as is often the case with commercial waste generators.

There are a wide variety of low-technology approaches for the separate collection of recyclables and recyclable waste worldwide. They are mostly carried out by private value chain actors – supplemented in some cases by nongovernment organizations (NGO) and community based organizations (CBO) – and focus on those recyclables that generate a high revenue. As welcome as these activities are in terms of their social impacts, these limited collections generally achieve low rates of diversion from landfills and result in limited benefit to the community and to the environment.

From the perspective of the municipality, private recycling activities have both benefits and costs. On the one hand, these private recycling activities reduce the amount of waste and thus the amount of effort required by the municipality to dispose of the remaining waste. On the other hand, selective collection of high value recyclables by private recycling activities deprive the municipality of potential revenue that could help cover the costs of the waste management system. This does not mean that such private activities are undesirable; on the contrary, municipal waste management needs private entrepreneurial involvement to ensure proper waste disposal. Services provided by the private sector tend to be more flexible, efficient, and cost-effective than those provided by public entities. It is, however, the responsibility of the municipality to coordinate and control these waste management activities so that they are carried out in the best possible way for the benefit of both the community and the environment. Municipalities are usually better advised to contract out the services instead of providing those services using own staff and equipment.

1.3. Informal recycling – bane or blessing?

In principle, recycling activities of the informal waste sector also represent a kind of 'cherry-picking', or a selective form of waste collection because the collection of recyclable waste is often the only source of income for these people. This should not be a reason to ostracize or condemn them, rather it is an opportunity to make the best use of the expertise and skills of this sector and involve them into the community's waste management system in a way that best serves the interests of both the community and the informal waste pickers.

1.4. Objective of this Guide

The objective of this Guide is to support the development of locally adapted low-tech solutions for the comprehensive separate collection and recycling of waste. This Guide will:

- encourage to evaluate feasible options in your municipality
- assist in identifying and leveraging the potential that exists locally
- provide guidance through the planning and implementation process

The descriptions in this Guide are largely based on the findings of a pilot project conducted in the city of Tan An, the capitol of Long An Province located in the Mekong Delta in Viet Nam. The project was implemented by the World Wide Fund for Nature / Viet Nam (WWF) in cooperation with the city of Tan An in the years 2020 and 2021[6]. The project was highly successful, and as a result, the People's Committee of Tan An and the People's Committee of Long An Province have decided to extend the collection concept to the entire city and later to the entire Province. A more detailed account of the pilot project and its results can be found in Annex 2.

In addition, experiences of similar projects in other APEC economies have been included. These are presented as case studies in Annex 1.

Although the project in Tan An was very successful, this Guide cannot and is not intended to present ready-to-implement solutions. Each municipality must develop the locally most appropriate solution given its framework conditions. To facilitate this, the Guide outlines the principles of reliable waste collection, gives guidance and provides tools on the design, planning and implementation process of such an approach. Also presented are organizational models and cost recovery opportunities that can take to increase the quantities and qualities of materials needed for the creation or upgrading of secondary material markets. Besides the model of the city of Tan An, which is particularly recommended for replication, the Guide presents other examples of successful labor-intensive collection concepts using low-tech equipment.

The Guide is intended to address primarily low- and middle-income economies, also referred to as 'developing economies'. However, since low-tech approaches to waste collection can also be more cost-effective in high-income economies, the guide is likely to be useful for any economy.

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6 For details see: WWF Viet Nam: Technical Progress Report Period 01 July 2020 – 31 December 2020, Ho Chi Minh City 15 January 2021 (not published)

Pfaff-Simoneit, W.: Reduction of Marine Litter by Improved Waste Management in the Mekong Area, Viet Nam, Pilot Project Separate Collection, Final Evaluation Report, Darmstadt / Germany October 2021 (not published, available from author)

2. Success factors for comprehensive waste recovery

Reliable waste collection is the foundation of any waste management system and the most effective measure to keep plastics and other waste out of the environment. However, many municipalities are reluctant to offer a more comprehensive collection service because the more waste they collect, the higher the expenditures for fuel, vehicle maintenance and salaries for collection staff, and the shorter the lifespan of the landfill. In many communities in low-income economies, the expenses for waste disposal and street cleaning take up 20 – 50% of the municipal budget[7].

Additionally, the collection and administration of waste management fees is politically sensitive, difficult, time-consuming, and costly for the municipalities. Municipalities and their political representatives are often reluctant to introduce waste fees that cover costs; on the one hand because of social considerations, since a large part of the population is often not willing or even unable to pay the fees; and on the other hand because they fear that such supposedly unpopular decisions could impair their chances at the next elections. However, examples around the world show that paying fees for waste management and street cleaning often creates a virtuous circle of clean communities inhabited by satisfied residents who are willing to pay people or small businesses from their own communities to collect and manage waste. They are both sides of the same coin: Residents' satisfaction with the city administration is directly related to its ability to provide clean, healthy living conditions in the city. Citizens, even if low-income, are willing to pay a fee for a service, provided it is performed reliably and at a reasonable and affordable cost. ‘It is, however, evident in low-income communities, where population densities are high and awareness of the hazards of uncontrolled refuse disposal is low, that the need for the service is greatest. The poor are often willing to pay for a waste collection service because it so difficult otherwise for them to get rid of their solid wastes’[8].However, the implementation of socio-politically sound concepts for cost recovery requires good preparation, such as surveys on public perception and expectations of the service 'waste management', assessment of capabilities and willingness to pay, good information and communication as well as creative implementation strategies.

The challenge for the city administration is to develop economically viable waste collection systems that cover the entire community and are capable of keeping waste out of the environment. In parallel, strategies are needed to generate income through various revenue sources and to minimize costs by improving operational efficiency and labor productivity.

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7 World Bank Group: What a waste 2.0 - A Global Snapshot of Solid Waste Management to 2050, Washington D.C.2018, https://datatopics.worldbank.org/what-a-waste/

8 Danielson, J. (2020) ibid.

Municipalities and organizations around the world, in particular in low-income economies, have found ways to make waste collection economically viable. Cost-effective waste management systems are possible in your community. The Guide presents appropriate technical and organizational concepts to increase revenue and reduce costs of municipal waste collection, which shall provide inspiration and assist in developing the right concept for your community.

Proper waste collection is essential to achieve a clean, healthy and livable city. This can be accomplished at affordable cost also in your municipality. All it requires is some enthusiasm, firm political will, time and patience. As a side effect, your community will be rewarded with hundreds of green jobs, a clean city, a proper environment, and satisfied residents.

2.1. Comprehensive waste recovery and utilization – the key to success

The key to minimizing the costs of waste management and to maximize revenues from other sources than fees is simple: It lies in the materials that end up in the waste, assuming they are properly handled. The more waste that is prevented from entering the waste system and is managed by or sold to the value chains and therefore does not have to be disposed of in landfills or waste treatment plants, the higher the revenues and the lower the costs of its disposal. As a 'side effect', recycling reduces the use of primary raw materials, protects the environment, avoids greenhouse gases, preserves landfill capacity, and creates numerous jobs in an evolving green economy. Of course, it cannot be ruled out that the operational costs of comprehensive recovery and recycling are high, but recovery and recycling avoids expensive investments in disposal facilities and creates a large number of jobs, which in turn contribute to economic stimulation.

2.2. Low-technology waste collection is smart – and cost-effective!

In low-income economies, existing approaches developed in high-income economies to source-separate collection have mostly failed. A main reason being that systems typically use large-volume containers ranging from about 120 liters for household collection to several cubic meters for drop-off containers. The large volumes are to keep the collection effort and operational costs of collection (i.e. trucks, fuel, personnel etc.) low. In many ways, the separate collection systems deployed in industrialized economies are less suitable under the conditions prevailing in low- and middle-income economies, for both technical and organizational reasons.

The collection of waste and recyclables in large-volume standardized waste bins that are individually allocated to households and other waste generators is rare in most APEC economies and at best used only in the commercial sector. Predominantly, household waste is placed for collection in rather small quantities in bags or other disposable receptacles such as cardboard boxes, shopping bags and cans etc. Collection times, as far as they exist at all,

are hardly respected. People usually take their waste out of their homes for removal whenever necessary.

In suburban zones, waste is not usually collected on a daily basis. Waste generators in developing economies have minimal experience in pre-sorting reusable materials within the household and subsequently providing them for separate collection. High-income households have personnel available for such work or it is the duty of the householders, sometimes children. Hence, the collection systems practiced in industrialized economies, which require the active involvement of the waste generators, are usually less suited to people's habits and living conditions in developing economies. Furthermore, urban residential areas in APEC economies are often densely populated, side roads and paths are narrow and unpaved, meaning they cannot accommodate large waste compactor trucks.

Collection systems applied in high-income economies have primarily been developed with the goal of reducing personnel costs, the highest cost factor in waste collection systems. Container volumes were increased, collection intervals were extended, and process steps of waste collection were transferred to waste producers[9]. In this way, personnel expenses were increasingly reduced and replaced by capital expenses[10].

In contrast to high-income economies, personnel costs in low- and middle-income economies are low, whereas foreign currency capital, which in most economies is required to purchase standardized waste bins and refuse compaction trucks, is expensive. From a development perspective, it is highly desirable to create meaningful long-term employment for as many people as possible. Therefore, labor-intensive collection systems are preferable to capital-intensive ones. This requires replacing capital cost by operational cost to create jobs and provide services to the entire community.

Labor-intensive waste collection systems using low-technology equipment are better suited in low- and middle-income economies, achieve higher diversion-from-landfill rates and are in most cases cheaper than systems applied in high-income economies. However, it must be considered that not all households and waste generators will segregate their waste at source properly. A significant portion of the population will only gradually understand and comply with the new requirements of waste segregation at source. In addition to good communication to raise awareness and change behavior, the collection concept must provide measures to ensure a high quality of the separately collected materials.

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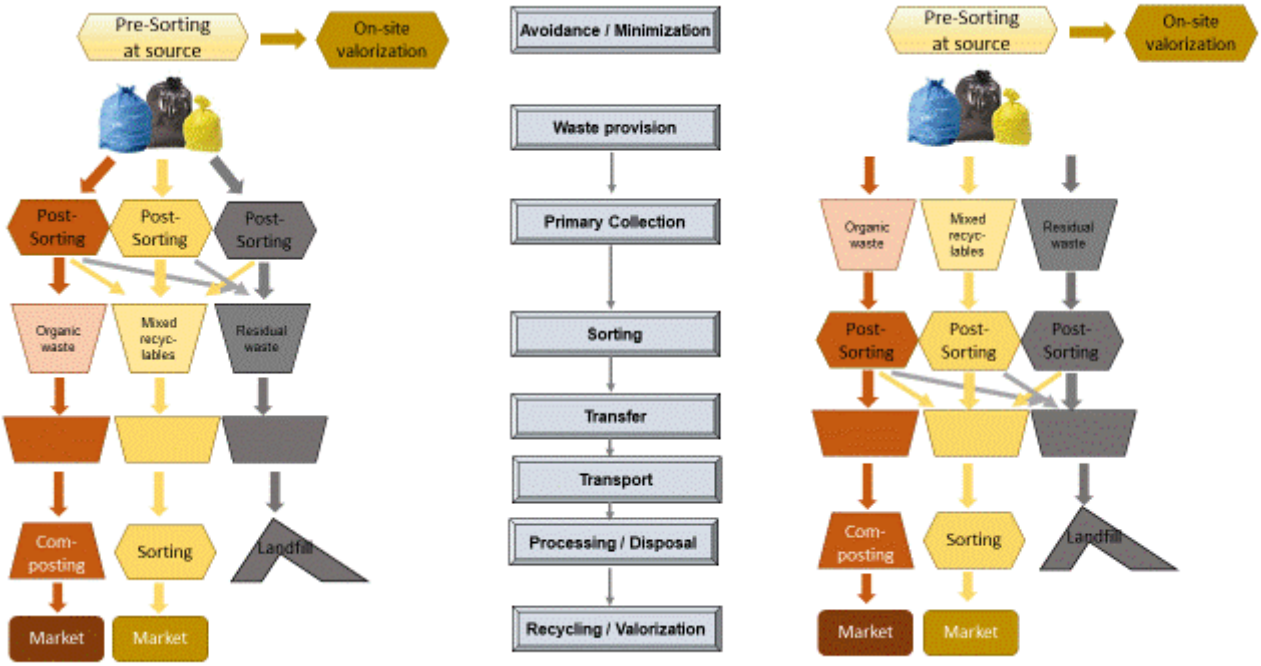
9 e.g. bins must be moved to specific collection points or recyclables brought to containers

10 e.g. for more and larger containers, for bigger and more sophisticated trucks etc.



Post-sorting at cart **Central post-sorting**

Figure 1: Elements and process steps of a labor-intensive separate collection scheme

Figure 1 presents the elements and process steps of a labor-intensive separate collection scheme. Basically, it consists of the following elements resp. process steps:

Waste prevention

Regardless of the collection system, residents should be encouraged to avoid waste wherever possible or to recycle it themselves, such as feeding food waste to livestock or home composting. However, it is important to restrain residents from environmentally harmful practices such as burning or disposal at and in water bodies or in the landscape.

Waste provision

Households and other waste generators are asked to separate their waste into different fractions and provide them separately for collection.

Primary collection

Primary collection is the key element in a collection concept that aims at comprehensive recovery and recycling of waste. It constitutes the interface between customers and waste collection service. A high service level, based on the principle of door-to-door collection, and immediate quality check of the collected materials are key features of the approach. Technically simple collection and transport techniques, such as handcarts, tricycles, tuk-tuks, etc.,

	which can drive right up to the dwellings, even if the roads are narrow or unpaved, are much better suited for this purpose than large collection vehicles.
Post-Sorting	Post-sorting of the collected waste is critical to ensure a high quality of the separately collected materials. Post-sorting can be done directly during the collection process or at a sorting station. In any case and as a basic rule, sorting the materials before they are compacted is crucial for the success of the approach.
Transfer	Transfer is the process step from primary to secondary collection / transport. Depending on the equipment used, the waste can be transferred directly or at a small, fixed transfer point in the city.
Transport	The different fractions – mixed recyclables, organic waste and residual waste – are transported to the respective destinations. Experience and model calculations suggest that such concepts require only 15-20 % of the truck capacity compared to typical waste collection schemes applying trucks for the collection of mixed waste.
Recycling / Disposal	Recyclables are transported to sorting facilities for further processing and refinement, organic waste to a composting or digestion plant and residual waste to the landfill.

The combination of flexible, low-tech primary collection means with efficient waste collection trucks that can efficiently transport large quantities of waste even over longer distances bear several advantages. Such concepts can:

- Be flexibly adapted to the unique structural conditions
- Offer a high service level for waste producers
- Enable source separation (with corresponding staff organization and training),
- Create employment opportunities even for less qualified workers
- Offer opportunities to involve the informal sector

Figure 2 shows the spatial organization of the concept in a city.

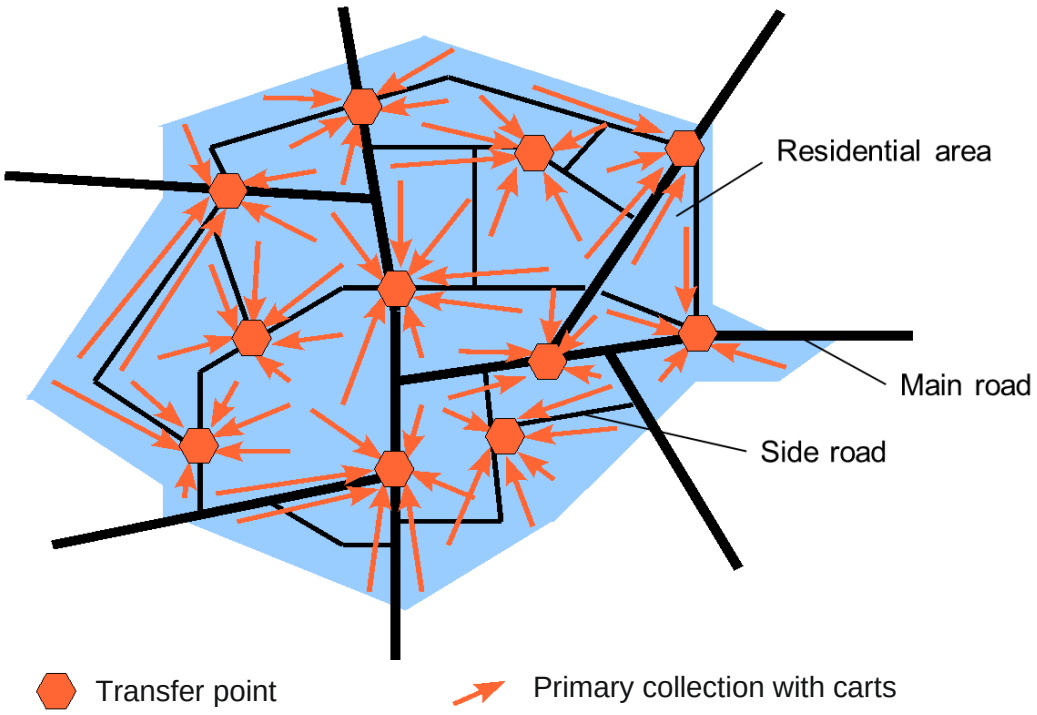


Figure 2: Spatial organization in a municipality[11]

2.3. How to deal with organic waste?

While the separation of recyclable materials such as paper, cardboard, PET or metals is quite common at least for parts of the world, the separation of organic waste and the knowledge that it represents a valuable raw material is not widespread. Organic waste smells bad, attracts rodents, flies and vermin, it is understandable that – without better information – the ordinary citizen does not see a valuable material in it. In less densely populated areas, organic waste is partly fed to animals, or it may be used to compost it and fertilize plants, but in urbanized areas, the physical constraints don't permit such in-house utilization.

Organic waste usually comprises the largest portion of the municipal waste composition. In particular kitchen waste is moist and heavy, transporting it over longer distances to the landfill and paying fees for its disposal is costly. When disposed of in a landfill, it decomposes under uncontrolled conditions, thereby releasing methane – a very powerful greenhouse gas – and contaminated leachate and bad odors. Operating a landfill where high volumes of organic waste are deposited is significantly more difficult and costly.

[11] Pfaff-Simoneit, W: Adapted selective waste collection concepts for developing and emerging economies, Waste-to-Resources International Conference, Hannover / Germany 2017

Sustainable municipal waste management requires proper solutions for the disposal of organic waste. However, organic waste has no value until it is processed. A cost-effective method of valorization is composting. Even if the revenues for the products do not cover the costs of the composting process, the total costs of the waste management system are usually at least not higher, since the costs of transportation are reduced and those for landfilling are avoided. Regardless of whether there is not yet a well-developed market for compost and compost products, it is generally preferable to collect organic waste separately for both economic and environmental reasons. Experience shows that, over time, a notable demand for compost and compost products can be developed, provided the products are of high quality and a professional, target-group-oriented marketing is carried out.

2.4. The revitalizing carbon markets – promising prospects for valorization of organic waste

Separate management of organic waste is a source of CO2 offsets. When kept out from landfilling, valorization activities can provide substantial opportunities to benefit from carbon markets. Composting organic waste instead of landfilling reduces significantly the greenhouse gas generation. These avoided emissions can be sold as carbon credits on the international offsetting carbon markets. However, prices for carbon offsets are still rather low. In contrast, carbon credit prices in closed carbon markets[12] are much higher and are on a steady rise since about mid-2021 due to the intensification of greenhouse gas mitigation measures in many industrialized economies. There is much to suggest that offset credit prices will also rise with a certain time lag.

It can roughly be estimated that for every ton of organic waste that is valorized in a composting plant instead of being disposed of in a landfill, between about half and one ton of CO2 equivalents is saved[13]. It is not unlikely, that the prices for emission credits will rise to such an extent that the costs of composting can be almost completely covered by the revenues from carbon credit trading, as this was the case at the height of the so-called 'Clean Development Mechanism'[14], when prices of USD 20 per ton of CO2 and more were paid, provided that

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12 E.g. the European Carbon Credit Market, where the so-called EUA – European Union Allowance – which is equivalent to one metric ton of CO2 meanwhile achieves prices above 60 EUR, or the California Carbon Credit Market, known as ‚California Cap and Trade Program' with prices at around 30 USD per ton of CO2.

13 The calculation of actual emission savings, and thus emission credits, must follow methodologies approved by the UNFCCC. Due to the complex methodological and procedural requirements, the involvement of a consultant experienced in these issues is recommended. For further reading visit: https://cdm.unfccc.int/methodologies/index.html

14 The Clean Development Mechanism (CDM) allows an economy with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing economies. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets. For further information

technically simple, cost-effective composting processes are used. Together with revenues from the sale of compost and the savings due to reduced transportation and landfill costs, especially when composting facilities are decentralized, there are thus significant cost benefits to the municipality from the separate collection of organic waste.

2.5. Jobs creation through labor-intensive waste management

Collection, separation, and processing of waste and reusable materials provide enormous potential for employment and contribute to developing a green economy[15]. Within the waste management chain, waste collection offers the greatest employment potential. Although less personnel is needed for sorting of waste than for collection, it also creates substantial employment opportunities even for less educated or illiterate people. Low-skilled workers with limited, if any, education can be trained for simple tasks. The informal waste sector, while low skilled, can provide a wealth of knowledge and experience with respect to waste identification and recovery of recyclable materials and should be included when developing waste collection schemes. While advanced technologies such as biological treatment, energy recovery from waste and disposal may sound enticing to policymakers, they offer few employment opportunities. Additionally, the operation of these facilities requires qualified and high-skilled personnel for their management with respect to technical and commercial direction, often lacking in a developing economy context.

Table 1 shows the staffing requirements for different waste-management services and processes. In the upper half of the table advanced technologies are reported, in the lower half labor-intensive processes are referred to. The figures underline the statement that labor-intensive collection concepts based on technically simple processes generate vast employment opportunities. The personnel required for low-technology waste collection systems can be estimated at 7 – 14 people per 1,000 metric tons of waste per year collected and processed, depending on the type of collection concept and the urban structure. By comparison, the personnel needed for technically highly developed collection and logistics systems is about 0.7 – 2.5 people per 1,000 tons per year collected and processed, depending on the structure of the collection area, the technical system as well as the type of materials collected. From these figures, it can be concluded that labor-intensive collection concepts can employ 6 – 10 times more people than capital-intensive collection systems. Nevertheless, model calculations[16] show the collection costs of low-technology collection

visit: https://unfccc.int/process-and-meetings/the-kyoto-protocol/mechanisms-under-the-kyoto-protocol/the-clean-development-mechanism

[15] United Nations Environmental Programme: Green Economy Report - Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication, PART II: Investing in energy and resource efficiency; Chapter 'Waste'; 2011; www.unep.org/greeneconomy

[16] Pfaff-Simoneit, W. (2017) ibid

systems are less than those of capital-intensive systems in economies whose GDP lies below around 8,000-10,000 US$ per capita per year.

Table 1: Staffing requirements for different waste-management services and processes[17]

Advanced Processes and Technologies	**Staffing requirements** [Persons/1.000 tons/a]
Waste collection using technically advanced equipment	0.7 – 2.5
Composting of organic waste (‘bio-waste’)	0.3 – 1.0
Digestion of organic waste (‘bio-waste’)	0.3 – 0.6
Mechanical-biological treatment (MBT)	0.3 – 0.5
Thermal treatment / waste incineration	0.4 – 0.6
Labor-intensive processes using low-tech equipment	
Collection of commingled waste	7 – 11
Separate collection of dry recyclables and residual waste	8 – 12
Separate collection of dry recyclables, bio-waste and residual waste	10 – 14
Sorting of recyclables for material utilization	3 – 6
Sorting of high calorific value fractions for RDF	2 – 4

But the conceptual and cost advantages of low-tech logistics systems are also increasingly being recognized in high-income economies. Due to frequent traffic jams and parking problems, such systems are increasingly used by postal and delivery services on the so-called 'last mile' (when delivery is made), especially in inner cities, because they are more reliable and less expensive than using large vehicles. What is considered the “last mile” for the delivery of goods and mails is correspondingly the 'first mile' for waste collection, otherwise known as ‘primary collection’.

The following chapters present the principles and examples of labor-intensive, low-technology separate waste collection and describe the steps involved in developing and implementing locally adapted solutions. It goes without saying that Environmental and Social Safeguards (ESS) must also be complied with in labor-intensive practices, especially with regard to limiting loads to be lifted or moved[18].

[17] The values in the upper half were compiled on the basis of: Umweltbundesamt (German Environment Agency), Best Practise Municipal Waste Management, Dessau-Roßlau 2018, http://www.umweltbundesamt.de/publikationen
Figures in the lower half are based on: Pfaff-Simoneit, W., 2017 (ibid.)

[18] Compare e.g.: https://unhabitat.org/environmental-and-social-safeguards-system-version-3-esss-31

3. Principles of Comprehensive Utilization of Waste

The strategy of comprehensive utilization of waste is only successful if the sale of the separated materials is ensured. Sustainable market demand for secondary raw materials and products derived from the waste stream, as well as high revenues can only be achieved if high product quality and a reliable supply is guaranteed. The source separation of waste collection concept is the crucial element to successfully implementing this strategy. The challenge is to collect a large quantity recyclable waste while maintaining a high level of quality with limited contaminants of these materials. At the same time, the concept must ensure that non-recyclable waste is also collected reliably and disposed of in an environmentally sound manner. Jane Jacobs stated in her famous publication 'The Economy of Cities' already in the year 1970[19]:

> *"The more highly developed waste recycling becomes,*
> *the more valuable is this very diversity of materials.*
> *The aim must be to get all the waste possible into the system -*
> *not only those that are already valuable at a given stage of development*
> *but also those that are only beginning to become useful and those that are not useful*
> *but may become so.*
>
> *A type of work that doesn't now exist, if thus necessary:*
> *services that collects all waste, not for shunting into incinerators, gulches,*
> *but for distributing to various primary specialists*
> *from whom the material will go to convertors or re-users".*
>
> *- The Economy of Cities by Jane Jacobs -*

3.1. Quality matters

Sustainable sale of secondary raw materials and products derived from waste – in particular compost – can achieve high revenues only if the supply chain is reliable and high product quality is guaranteed. Source separation and, to the greatest extent possible, selective collection of recyclables and organic waste at households, administrations, businesses etc. are essential for proper resource recovery. Only clean, unmixed and uncontaminated fractions and products selected out of the waste stream (e.g. compost) will find a sustainable demand and generate revenues from their sales. Segregation and separate collection of organic waste also helps to prevent the contamination of both materials, which adversely effects their value.

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[19] Taken from: Pinky Chandran, Kabir Arora, Marwan Abubaker and Nalini Shekar: Valuing Urban Waste – The need for comprehensive material recovery and recycling policy; Hasiru Dala, June 2018

3.2. The challenge of behavior change

Achieving high material quality requires the cooperation of households and other waste generators. They should aim to keep the different materials separate already during generation to avoid mutual contamination. Segregation at source requires a significant change in the habits of residents in the way they handle their waste. 'Waste management literature is littered with failed behavior change case studies. So much that the consensus is that models which rely on community behavior change – like waste separation at source – will fail. It is assumed that it is just too difficult to get people to care enough to sort their waste.'[20]

Essentially, two approaches or philosophies can be distinguished to recover recyclable materials from wastes:

(1) Subsequent sorting out of recyclable materials from commingled waste, or

(2) Segregation at source and separate collection.

Approach (1) builds on the belief that behavioral changes can only be achieved to a limited extent and that substantial amounts of recyclable materials can only be recovered through technical solutions, i.e. in a Material Recovery Facility (MRF). The waste is collected commingled, recyclable components are recovered by means of various separation processes and, above all, by manual sorting. The materials obtained in this way are usually more or less highly contaminated and have only a low or even no market value. Although separation from commingled waste is technically possible, the financial sustainability of these approaches is often unknown. Around the world, there are countless MRF investments that have failed and are not operating due to a lack of profitability and sustainability.

Approach (2) builds on the experience in many economies and projects that behavior change is possible, and this even within a relatively short period. The actual challenge is to apply the right tools, especially locally appropriate and relevant communication, information and motivation strategies, identify important stakeholders and ways to involve them, and to well coordinate the information and motivation campaigns with the waste collection organization. It is decisive that the separate collection system is actually implemented when people are called upon to segregate and provide their waste separately.

This Guide clearly advocates the strategy of segregation at source and separate collection of the various materials (Approach 2), for ecological reasons, but above all for economic reasons. This Guide describes step-by-step how to prepare, design, plan and implement a labor-intensive separate waste collection system using low-tech collection equipment.

[20] Danielson, J.(2020) ibid

3.3. Behavior change – the Tan An experience

That behavioral change is not only possible but can even be achieved in a very short time, has been evidenced in the pilot project in Tan An, Viet Nam. The key feature of this project is the immediate check of the sorting quality when picking up or collecting the waste. This measure has proven to be very effective. In the event that the household users /(the waste producers have not sorted the materials well or not at all, the collection staff has the duty either to post-sort the waste immediately at the collection cart, or to discard the non-sorted waste to the residual waste fraction.

Figure 3: Type of collection cart used in the pilot project in Tan An, Viet Nam

The collection cart is equipped with a small sorting platform large enough to take the volume of the largest waste container used by waste generators to provide it for collection. However, the volume of the waste receptacles should not exceed 50 liters, since the weight of a full receptacle would become too heavy for manual handling. Figure 3 shows the collection cart with simple sorting platform used in Tan An.

Besides collection and post-sorting, the waste collectors have the responsibility to give feedback and instructions to the households in case they have not well pre-sorted their waste. In this way, they are simultaneously waste educators/advisers to households and waste producers, avoiding the need for the task to be performed by special employees

In Tan An, the quality of the pre-sorting by the households has improved very rapidly. While at the beginning of the pilot project only about 1/3 of the households had their waste well sorted, this figure has risen to over 90% within only 2 weeks, as Figure 4 shows. On the one hand, this is due to the very committed and intensive public relations work of WWF and the

local institutions involved, such as the Women's Union and the Neighborhood Association. The other crucial success factor is the one-on-one conversations between the waste collectors and the households and other waste generators. The waste collectors are not perceived as representatives of the local administration – to whom residents often tend to act reservedly – rather they are perceived as an average citizen. In this way, trust is built and advice on waste segregation at source is more likely to be accepted than can be achieved through typically used methods like leaflets, notices or radio spots.

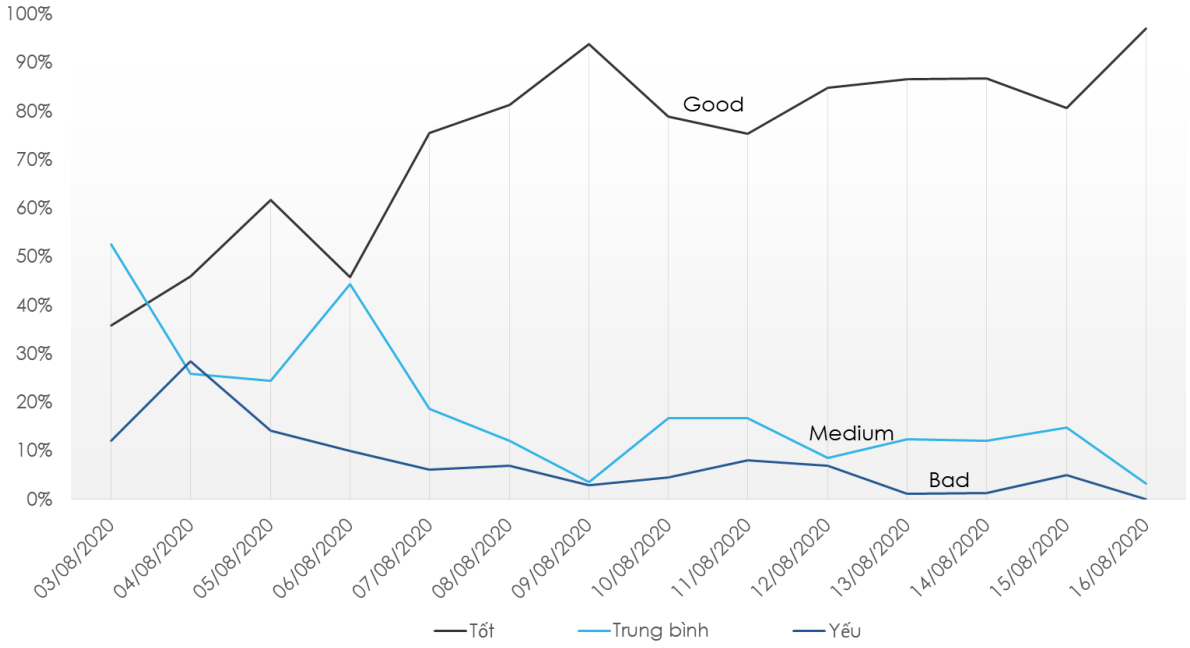

Figure 4: Development of the pre-sorting quality in the pilot project in Tan An, Viet Nam[21]

The fact that the system gives immediate feedback is an effective approach to shifting the practices of the users and helping them adjust to the demands of the new collection concept. The use of small collection vehicles also has a positive psychological aspect: system users can see directly what happens to their separately provided recyclables and organic materials. This would probably be less the case if their waste were collected by large compaction trucks. Users would see their waste disappear and they might conclude that there is no point in separating it.

[21] WWF Viet Nam: Technical Progress Report Period 01 July 2020 – 31 December 2020, Ho Chi Minh City 15 January 2021 (not published)

Pfaff-Simoneit (2021) ibid

3.4. No compaction before sorting!

Sorting needs to take place before the waste is compacted – at best before it is collected! When waste is collected in a mixed form by compaction trucks, organics and liquids will be squeezed into the voids and contaminate the recyclable components. Especially sensitive materials such as paper and cardboard, but also plastics, packaging material and textiles, lose considerable market value as a result of contamination and can even become unmarketable. For this reason, the materials sourced from compacted mixed waste, e.g., in a so-called ‘dirty’ Material Recovery Facility (MRF), are of significantly lower quality, which leads to sales problems and low or nonexistent revenues. If the organics are mixed with other waste, the organic waste could come into contact with contaminating substances such as glass splinters, cigarette butts, cotton swabs, etc. and with harmful pollutants. Heavy metals, which enter the waste via batteries, fluorescent tubes, electrical waste, etc., are easily dissolved due to the acidic decomposition phase, which organic waste undergoes very quickly, and thus contaminate the waste and can result in high heavy metal loads. Moreover, liquids containing pollutants such as waste oil, solvents, paints, varnishes or outdated medicines, cosmetics, etc. mix with the organic waste can also be a source of contamination if they are not separated.

3.5. Provide a high service level

To recover large quantities, the collection system must be easy and convenient for households and other waste generators. Door-to-door collection systems generally achieve considerably higher collection rates and are preferable to drop-off systems, which require waste generators to bring their waste to a defined common collection point. The additional advantage of door to door collection is that it is clear to the collectors – at the point of collection – which "door" their waste has come from, allowing targeted feedback with immediate effect.

3.6. Integrated Collection – crucial for collection performance and cost efficiency

Collection accounts for the highest share – between about 50% and 80% of total waste removal costs, depending on the design of the waste management system. Some crucial factors are decisive for the collection cost in a labor-intensive collection scheme[22]:

[22] Additional criteria apply to more mechanized collection systems. Due to their high capital costs, such systems are not considered here.

- Collection performance, i.e., the average amount of waste that a worker can collect per day: The higher the performance, the lower the cost.
- Amount of waste per collection point: The lower the amount of waste to be collected per collection point, the higher the collection costs.
- Specific weight of materials: The lower the specific weight of the materials to be collected, the higher the cost (given in cost per ton):
- Collection of lightweight materials, such as plastic or cans, is significantly more expensive than the collection of heavy materials such as glass or organic waste.

To reduce collection costs, the amount of materials collected at each collection point needs to be increased. This can be accomplished by

- Integrated collection: The different materials to be collected separately – recyclables, organics, and the residual waste – preferably, should be collected by the same service.
- Extension of collection frequencies.

However, there are limits to the increase of the amount of materials per collection point. Firstly, due to the loading capacity of the collection vehicle, and secondly for hygienic reasons: Waste, especially organic waste, can be stored only for a short period of time – especially in tropical climates, otherwise unpleasant odors and even hygienic problems may occur.

To better understand the impact of collection frequency and integration on performance and cost, it may help to compare it to shopping: Shopping can be compared to collecting waste, as it is also a process of gathering different products or materials. The more of different products you can buy in one place, the less time it takes. If, on the other hand, you have to go to the bakery for bread, to the harbor or fishmonger for fish, to the market for vegetables, etc., the travel times are significantly longer, unless these stores are located close together. If you can buy all the goods in one store, you only have to go there once. This is why supermarkets are becoming attractive to more and more people. However, the amount of shopping is limited by how much you can carry or load in your vehicle. And you should only buy as much perishable goods such as vegetables or fish as you can consume within a reasonable time or keep fresh at home.

From this simple comparison, we can learn:

> The more integrated the collection concept and the longer the collection frequency, the lower the collection cost. However, for physical, hygienic and acceptance reasons, the quantity of materials per collection point and the length of the collection intervals are limited. The appropriate collection frequency must be determined individually in each city quarter.

4. Stakeholder Involvement

Though the design of waste management concepts is largely an engineering task, it consists of much more than the technical components of collection and disposal. It largely depends on cooperation, information, communication and interaction of households and other waste generators, actors and stakeholders of the waste management process chain, in particular when priority is given to minimization and recycling of waste. The feasibility of concepts depends largely on social, cultural, and ethical factors. Indigenous groups, in particular, are to be included where present. It is therefore incredibly important to involve the locally relevant persons, organizations and stakeholders in the development of waste management concepts in order to arrive at locally appropriate solutions. At the same time, of course, the physical conditions of the municipality must be taken into account, such as settlement structures, transport distances, topography, waste quantities and compositions, and other factors.

The comprehensive separate collection and recycling of waste requires cooperation and willingness of the households and other waste generators to participate. Waste recovery and recycling generate more material flows than conventional waste disposal concepts. Dealing with secondary raw materials requires operating in markets, with changing prices, quantity needs and quality requirements. Such changing conditions are difficult to align with the regulations and usual processes of a public administration. Waste recovery and recycling comprise numerous, often specialized process steps, that a municipality's administration usually finds difficult to handle. Cooperation and interaction with other actors – private persons, businesses and organizations – is necessary and key to sustainable and resilient waste recovery and recycling concept.

Local government officials tend to believe that they know and understand the wishes of their communities without gathering public input. Thus, they often assume it is their job to make decisions for the community with the best intentions; they often do this without prior consultation with the public[23]. However, comprehensive separate waste collection and recycling requires a cooperative, open, and transparent approach with the public and stakeholders. Many factors in the waste management concept affect the public as well as stakeholders and can have significant economic impacts on them. Their participation and understanding is the key to whether a program is successful. Their opinion should therefore inform decision makers especially regarding their wants and needs for the program. If their wishes cannot be met, it is important to explain why. Open communication channels with the public and stakeholders can provide valuable ideas and be very effective in achieving cooperation and support that will lead to a successful program.

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[23] Manus Coffey & Adrian Coad: Collection of Municipal Solid Waste in Developing Countries; UN Habitat (Editor), 2010; https://unhabitat.org/sites/default/files/2021/02/2010_collection-msw-developing-countries_un-habitat.pdf

The waste management concept should not adversely impact the interests and business of affected parties and stakeholders. This especially applies to the informal sector. Where this is not possible, those adversely impacted must be compensated with equivalent or even better opportunities to compensate for their losses. Labor-intensive separate collection and recycling offers numerous business opportunities and options for employment. Broad support for the concept is better achieved if the municipality communicates early and often to stakeholders so they can be involved in shaping the concept and can prepare for a successful implementation.

In the following typical stakeholders and their probable interest and roles in a waste recovery and recycling strategy are shortly presented. A more detailed presentation and discussion of the roles and interests of the different groups can be found at Coffey/Coad (2010)[24].

4.1. Private sector

The private sector encompasses a wide range of economically active persons and companies that play different roles in waste management. On the one hand, they appear as waste generators, which – depending on the type and size of their business – can generate large quantities of waste. On the other hand, there are numerous individuals and companies, which contribute by manufacturing products needed for the execution of waste management operations such as containers or vehicles, or who are providing services, may it be consulting and planning, construction services or waste disposal services.

The private sector is thus not a homogeneous group with uniform roles and interests. Different types of ventures are considered in detail below. In principle, however, private companies can provide services more efficiently and are more flexible to adapt to changing conditions because of their ability to change their procurement and investment structures. They make financial decisions quickly and often do not have the same cumbersome procurement rules and other regulations that apply to public administrations.

Private companies are often specialized in a small number of services and have considerable expertise in these fields. They have easier access to capital and can purchase the most suitable equipment. In other words, in most cases it is more advantageous to involve the private sector and delegate certain tasks to private individuals and companies rather than to perform them with the – usually limited and less suitable – means of the municipality. Identifying the possibilities and potentials for involving the private sector is a key task in designing the waste management concept.

[24] Coffey & Coad, 2010, ibid

4.2. Informal sector / waste pickers

In contrast to formal businesses, which operate within the legal and tax framework and are officially registered and licensed, the term 'Informal sector' refers to economic activities that are not officially registered, operate without a license, and do not pay taxes for their business. Informal economic activities are present in all sectors of the economy. In waste management, they are primarily involved in solid waste collection and recycling, mostly called ‘waste pickers’. The term refers to a person who picks reusable or recyclable materials discarded by others out of the trash and sells that material for a profit or reuses it.

Informally working waste pickers can be found in almost every city of the world, mostly in developing economies. ‘It is estimated that up to 2% of the urban population in low- and middle-income economies work in the informal waste sector. Informal workers in solid waste management (SWM) are often ignored or seen as hindrances to efficient waste management processes. It is little known that these informal actors often contribute significantly to resource recovery and recycling of waste materials and can thus have a very positive impact on waste management systems, especially in low- and middle-income economies’[25].

‘Waste pickers are very efficient at collecting “high value” recyclable waste and, based on their location, specialize in certain types of waste. Some waste pickers buy waste directly from households and organizations to guarantee clean, high-value waste. Others salvage from households, business, streets, or public waste bins. Once waste has been collected by formal collection vehicles, another group of waste pickers are sometimes inside the hauling trucks separating out recyclables en route. If waste is delivered to a transfer station, then another group might sort material before it goes to a landfill. Finally, the largest number of waste pickers are found sorting and collecting waste at landfills and dumpsites’[26].

The informal waste economy is heterogeneous and multi-faceted. It incorporates a range of activities, which compare to a pyramid: From waste-picking and itinerant buyers at the bottom, to the marginal operations of petty scrap dealers, to those linked with large-scale enterprises. Waste pickers are deeply entrepreneurial, hardworking, independent, and skilled at identifying valuable waste and their livelihoods depend on it. Mostly they operate without significant legal recognition or protection. Entry into this sector for newcomers is usually a last resort survival strategy, and for some a family legacy passed down from generations.

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[25] German International Cooperation / giz: Recovering resources, creating opportunities - Integrating the Informal Sector into Solid Waste Management; Eschborn / Germany 2011 https://www.giz.de/en/downloads/giz2011-en-recycling-partnerships-informal-sector-final-report.pdf

[26] Danielson, J. (2020) ibid

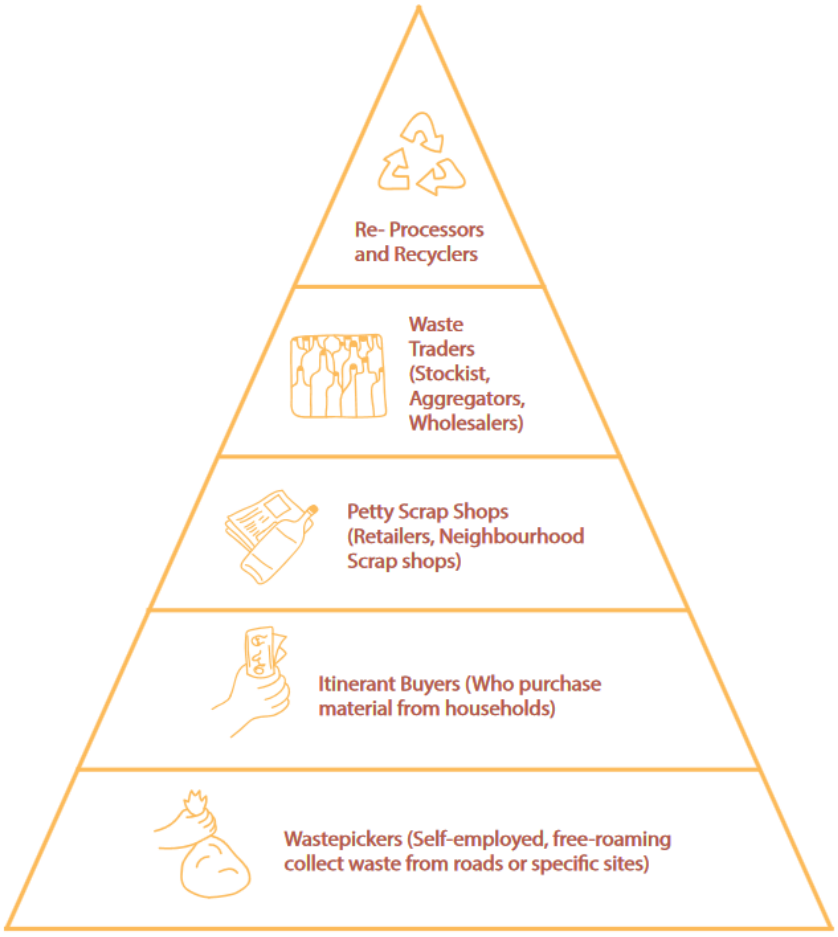

Figure 5: The pyramid of informal recycling[27]

Further up the ladder, entrepreneurial drive is the hallmark of scrap dealers/traders. These economies are socially constructed based on market principles. Often unregistered, these entrepreneurs have limited access to credit, infrastructure, and other facilities, although their economic output is much higher.[28] In some areas/economies, junkshops petty scrap dealers are classified as 'semi-formal' (e.g. with business registration, paying taxes, etc.) as they form the link between the real informal waste sector and the formal economy.

It would be negligent to ignore the informal waste economy and not to involve them in the design and the operation of a waste management concept. If they are not included, their

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[27] Source: Hasiru Dala (2018) ibid.
A more comprehensive description of the structures of the informal waste sector is available from KKPKP/SWACH in Pune, or similar organisations in Delhi/New Delhi, Mumbai and Kolkata. https://swachcoop.com

[28] Source: Chandran, Pinky et al. / Hasiru Dala: Valuing Urban Waste, June 2018
https://hasirudala.in/wp-content/uploads/2020/09/Valuing-Urban-Waste-2019.pdf

extensive experience and knowledge is lost as well as the risk of causing considerable social upheaval that would result in resistance and ultimately lead to the failure of a solid waste concept aimed at comprehensive utilization of waste.

Figure 6: Stakeholder involvement[29]

It must, however, be conceded that 'it can be challenging to incorporate them into the formal waste system. They generally earn more than minimum wage or earnings found in comparable low-skilled professions (e.g., domestic work, manual labor, fishing, farming) and prefer to work independently with flexible schedules (rather than reporting to a manager with fixed timelines and deliverables).'[30] Universal recipes and ready-made solutions for how this can be accomplished do not exist and often rely on current conditions. This incorporation of the informal waste sector into the formal waste sector can only happen in an open, early consultation process together with the informal sector. Yet the labor-intensive separate collection and extensive recycling of waste offers enormous potential for permanently improving the living conditions of these people and creates opportunities for self-determined, entrepreneurial activities in a formal economy. Locally unique and relevant perspectives must be identified at an early stage through a transparent constructive dialogue with the informal sector. Organizational models for cooperation between municipalities and informal sector are

[29] Source: GIZ (2011) ibid
[30] Danielson, J., (2020) ibid.

shown in this guide. Numerous successful examples of informal sector involvement / integration / cooperation can be found in the literature provided.

The inclusion of waste pickers in waste management systems and a recognition of their importance is crucial not only for their own health and livelihoods, but for the economies of municipalities as well. The key is to thoughtfully include waste pickers into the formal waste system in ways that recognize their value and empowers them, rather than pushing them out as new programs are launched.

4.3. First buyers

Waste traders, scrap dealers and retailers are the first buyers of materials collected by waste pickers and itinerant buyers. They operate at the transition or 'semi-formal' zone between the formal and informal economies. They maintain economic relations with both sectors and, for the most part, exert control over local secondary raw material flows and often have a significant turnover. Mostly they are highly respected and have great influence both in terms of their social authority and in local politics.

The first buyers have a little-understood financial position in the recycling value chains. They are the bridge between informal cash economy and formal commodities trading. They have to pay cash every day to their suppliers, but they are paid net 90 to net 180 days, meaning that they have to wait up to half a year to get paid themselves. Often they also pre-pay their informal collector suppliers, lend them money, provide them equipment, or pre-finance the transport. All these contribute to their operating costs, which is why they pay considerably less per kilo than the next larger trader in the chain.

It is also true for this group of stakeholders, in the same way as for informal waste collectors that municipal waste management can benefit considerably from their experience, know-how and economic contacts that these companies have. However, scrap dealers, middlemen etc. may be skeptical to dismissive of new approaches to separate collection for fear of losing the basis of their economic activity. Due to their political influence, this group must therefore be involved early in the process and with a fair amount of sensitivity. The early consultation and communication should avoid language that could cause or exacerbate such concerns but rather highlight the opportunities that a comprehensive recycling strategy brings to the sector in the form of expansion of their business model. Specifically, systematic, institutionalized separate collection will significantly increase and ensure the quantity and quality of recovered secondary raw materials, providing growing and additional opportunities for their businesses. The challenge is to define clearly the tasks, roles and responsibilities of the parties involved. Once the roles are agreed, adequate organizational models need to be developed that are adapted to the local conditions and that take into account the interests of these important

stakeholders, such as residents, municipalities, waste collectors, waste pickers, scrap dealers, and the first buyers.

4.4. Potential operators for composting plants

Organic waste accounts for the highest proportion of municipal waste, at around 50-80%. Valorization of this fraction is a central and the most effective element in a strategy of comprehensive separate collection and recovery of waste. The most efficient way to deal with organic waste is at the source, notably by feeding it to livestock or home composting. However, the possibilities for this are limited, especially in cities because of lack of space, hygienic and odor problems, possible attraction of rodents, vermin and flies, lack of time and know how.

For cities in particular, it is necessary to find other solutions for the valorization of organic waste than home-based utilization. The most obvious and usually most cost-effective form is composting However, facilities that process organic waste are the exception rather than the rule. Where they exist, they mostly process mixed household waste and produce only low-quality compost. These facilities are not well respected by the industry and the compost is difficult to market.

However, composting is a commonly found process often used by farmers, tree nurseries and gardeners, wineries, and similar sectors. These sectors generate large quantities of organic waste and simultaneously have a high demand for soil substrates and organic fertilizer. By composting their organic residues, they achieve a twofold benefit: They get rid of their organic waste at a low cost and produce compost at the same time, a high-quality material they need for their business. However, the amount of organic waste they generate is usually not enough to produce the amount of substrate and fertilizer they need.

In addition, the soil substrate producing companies, which often use peat as raw material, could be also be an interested sector. Peat cutting which results in the destruction of peatlands is increasingly being criticized because of the importance of peatlands in climate protection. This is why such companies are becoming interested in finding substitutes for peat. High-quality organic waste is a very suitable option for this.

All of these enterprises are potential candidates for operating a composting facility. The challenge is to convince stakeholders that the proposed concept of labor-intensive separate collection will ensure a high purity (low contaminated) of collected organic waste. The concept cannot be compared to household waste composting that they may have in mind. To be successful, it is important to interest the private sector/stakeholders in the concept and involve them in its implementation. The private sector must be able to experience first-hand that the separately collected organic waste is of high purity and quality. Through utilization of

this organic waste, opportunities are created to produce their own substrate needs, and to start additional related economic activities.

4.5. Community-based organization and nongovernmental organizations

Comprehensive waste recovery requires good participation, cooperation and understanding of the public. Nongovernmental organizations (NGO) and community-based organization (CBO) can be very useful to help provide the necessary information and motivation to the general public and other waste generators to participate and support the waste management approach. In the project in Tan An, Viet Nam, the CBO's 'Women's Union' and 'Neighborhood Association' provided very valuable information, public awareness activities that persuaded the public. In addition, WWF as a worldwide active NGO has brought in experience and given the project high credibility and public attention.

'CBOs are generally less specialized than NGOs and linked to one particular community. In most cases CBOs are likely to have little knowledge of solid waste management, so their value lies in their links with local people and officials and with their experience in promoting community involvement and participation.'[31]

CBO participation may include other activities depending on their interest and opportunities. It can range from monitoring and identifying opportunities to improve a collection system from operation including performing collection services. At least individuals could become community waste collectors or contractors (CBC) of the municipality. The waste collectors play a vital role in the comprehensive waste recovery strategy. CBC work towards motivating and convincing the households and waste generators to gradually improve source separation. The key to this is the personal contact between residents, waste generators and the collection personnel. CBCs are particularly suitable for this task.

4.6. Large waste generators

Large waste generators are those that cannot be reasonably served by the small-scale, labor-intensive collection systems used for servicing households and other small waste generators. This includes, for example, larger companies, shopping markets, administrative buildings, hospitals, schools and so forth. Their share in the total volume of municipal waste is on average about 20-30% and ranges from about 10% in peri-urban areas to 50% and more in inner-city areas. Customized solutions must be developed for waste generators that cannot be served by low-tech equipment because, for example, the volumes are too large or handling the waste would be too impractical. Examples for such solutions, which are at the

[31] Coffey & Coad (2010), ibid

same time compatible with the labor-intensive separate collection concept, have been developed in the project in Tan An, Viet Nam[32].

4.7. Industries utilizing Refuse Derived Fuels

Many industries (e.g., cement industries) require large quantities of fuels for their production. Energy costs account for a very high share of production cost and is the reason industries are searching for cheaper alternatives. So called 'Refuse Derived Fuels' (RDF) are such an alternative. RDF are obtained from waste and consist mainly of the high calorific value fractions such as plastics, wood, paper, etc. Thus, although RDF production competes with the material recycling of these materials, it can be an option in situations where there is not enough demand for secondary raw materials (collected recyclables) or the material quality is not sufficient. For example, mixed plastics often cannot be recycled in a meaningful way.

In principle, material recycling should always have priority over energy recovery, for ecological but also for economic reasons. Material recycling saves much more energy in production than energy can be gained from burning these materials. Accordingly, the greenhouse gas savings are much greater with material recycling. The revenues are also many times higher with material recycling, because many industries (e.g. cement) want to reduce its energy costs as much as possible.

RDF can also be produced from residual waste. However, the initial monetary investments are not financially possible for most municipalities. In instances where industries (e.g., cement) have invested in such facilities or intends to do so, shipment of the non-recyclable materials and residual waste may be a viable option for this waste fraction. However, it cannot be overstated that proper air quality control systems should be installed at facilities that use RDF, especially plastics to avoid emitting hazardous air pollutants into the atmosphere.

[32] Pfaff-Simoneit, W., (2021) ibid.:

5. Baseline assessment

So far, a lot about principles, stakeholders, and other issues important to waste management have been discussed. But how can this be implemented? The following chapters will guide step-by-step through the preparation, planning and implementation process.

5.1. Who should do the preparation and design work?

It is quite common that the responsibility of municipal waste management lies with the municipal medical or health officer or some other administrative official who has no technical background in waste management. Much of solid waste management is a technical issue. It is therefore advisable to assign a person with technical expertise, or even better a team, to develop the waste management concept.

If a person with the appropriate technical background, sufficient time and resources cannot be found within the municipal administration, an effort should be given to obtaining an expert from a specialized authority, a nearby city, an NGO, or from a consultancy. However, the work cannot simply be delegated to an outside person, it requires close cooperation and support from the municipal administration and its political leadership to be successful.

Once the project expert is identified and the team established, they can start the project.

5.2. Assessing the framework conditions

First, it is necessary to get an overview of the status of waste management in your municipality and to figure out the framework conditions. The enabling and hampering factors for the establishment of a comprehensive system of separate collection and recycling are to be identified and assessed, and some basic data need to be compiled.

5.2.1. Evaluation of the market for secondary raw materials and recycling

The only fractions of waste that generate value are those types that have demand in secondary markets or for which demand can be created. Persons who are active in the secondary raw materials market in this regard can provide expert assessments. The following are initial actions you can take to evaluate the market for secondary raw materials and recycling purposes:

- Identify companies like scrap shops and dealers, retailers, traders, wholesalers etc. of secondary raw materials. Waste management service providers in your municipality should know most of them. Information can also be gathered by searching in the telephone directory and internet, by inquiring directly with waste pickers, scrap dealers etc. Also if waste associations or relevant organizations and lobby groups exist, they can be excellent resources for market information. After identifying these stakeholders seek to prepare the following:

- List of the companies and the materials they do business with
- Prepare an interview guide with topics to discuss:

  ** What materials do they trade?*
  ** What are their sources?*
  ** Who are their clients?*
  ** What quantities do they trade per month on average?*
  ** What, if anything prevents them from trading more quantities?*
  ** What would have to be met for more volumes to be recycled?*

  Keep in mind that some of these questions may be sensitive and involve trade secrets of your interview partner. It is therefore better to conduct the interview as an open conversation rather than using a prepared questionnaire.

- Interview them about the secondary raw materials market and their activities.

  ** Explain the background of your visit and your interest*
  ** Briefly explain the envisaged collection concept*
  ** Make it clear that the municipality is looking for cooperation with secondary raw material dealers and does not want to take the materials away from them*
  ** Show the prospects for their business and solicit their views*
  ** Try to find out their interests and willingness to cooperate*
  ** Try to find out their willingness and capability to invest, e.g. in a sorting facility and equipment*

- Compile a list of the companies showing interest to cooperate and assess their interests
- Develop first ideas what role they could play in the future concept

5.2.2. Existence and role of informal sector

People in the informal sector who (have to) make their living by collecting recyclable waste will be strongly affected by the implementation of a comprehensive waste separate collection scheme. Here, it is vital to approach the issue with sensitivity to allay their fears from the outset that the municipality does not intend to displace them.

In outreaching to this sector, make it clear that the goal and interest is to involve the people that make up the sector in the best possible way. Be sure to point out opportunities of what role they could play in the future concept, whether as an employee, small business owner, member of a cooperative or other organizational models. Explain that the forms of collaboration will be developed in a participatory process and encourage them to participate.

- Try to identify the people informally working in the sector:
  - in the streets and residential areas
  - on the collection trucks
  - at transfer stations, dumpsites or the landfill

- Identify who else is currently making an earning from recovering recyclables, e.g. custodians, domestic servants, waste collectors, itinerant buyers
  Such persons do not necessarily depend on the revenue they earn from recovering recyclables, they do it on occasion, or when they have time, or when prices are high. Nevertheless, it is important to identify them in order to develop a role for them in the future concept. For example, custodians could play an important role in schools, office buildings, apartment houses and the similar places of business.
- Interview a representative sample of waste pickers.

  ** What materials do they collect?*
  ** Where do they find these? How do they collect?*
  ** Which means do they use (carts, bags, working clothes…)?*
  ** To whom do they sell the materials?*
  ** Are they working on their own behalf or for an organization?*
- Determine people's age, gender, and assess their health status.
  Some of them are elderly people who have to earn extra money because of their low pensions. Show them options how they, too, could earn money in the new system (waste concept), for example, by monitoring the collected quantities, supervision, organization, fee collection, advising households, etc.
- Show empathy and ask for their input and suggestions on how to facilitate the work of people in their sector. Often, even small things can help considerably, such as providing work clothes, gloves, a handcart, but also a free health check-up and medicine or vaccination, if necessary. Providing such services and equipment can help to build trust and increase willingness to collaborate.

The goal of this investigation is to get an overview about the number, type, structure (age, sex, physical condition) and situation of the informally working waste pickers in order to develop a collection concept that meets the needs and capabilities of these people in the best possible way. The collection concept should be developed in close cooperation with the informal waste pickers in the subsequent design phase.

5.2.3. Evaluation of demand for compost and soil substrates

First, get an overview of the companies and actors in the municipality and the region that need fertilizers, soils, soil substrates and the like, as well as companies that deal with them.

- Search for farmers, horticultural enterprises, tree nurseries, vineyards, and similar industries.
- Check if there are associations, lobbying organizations, advice centers for these groups, who could play an important multiplier role.
- Discuss the matter with the department responsible for parks, green areas, cemetery
- Search for dealers of fertilizers, agricultural and horticultural supplies
- Search for producers of soils and soil substrates

- Select a reasonable sample of these groups and interview them:

  1) Farmers, horticulturists, etc.
  ** What products do they use for the preservation of soil fertility?*
  ** Do they apply compost? Do they produce compost by themselves?*
  ** How much do they spend for fertilizers and other soil fertility conservation products?*

  2) Dealers and producers:
  ** How do they assess the opportunities for marketing compost?*
  ** What would they need – in terms of quality and quantity – to develop such a market?*
  ** Would they be ready to participate and/or cooperate in the development of the collection concept?*

- Additionally, it would be helpful to ask whether the interviewees could imagine operating a composting facility on behalf of the municipality:

  ** Explain the envisaged collection scheme and the difference to a composting facility processing commingled waste.*
  ** Explain the envisaged quality assurance measures.*
  ** Refer to the good experiences in other projects, e.g., the project in Tan An.*
  ** Offer to be involved in the development of the collection concept and to have access to the experience gathered.*

5.2.4. Evaluation of demand for Refuse Derived Fuels

Although the probability of finding an industry or facility (e.g. cement plant) willing to accept even small quantities of waste is unlikely, this option should not be discarded from the outset. The research does not require too much effort and, if necessary, further options may result from the discussions.

- *Find out if there are any facilities like cement plants in your region that could use RDF.*
- *If so, contact them and ask if they use RDF or intend to do so.*
- *If yes, inquire about the delivery conditions and minimum quantities*
  Note that it in most cases there is no option for the use RDF. Only if the industry (cement facility) is interested in accepting residual waste or leftovers from sorting of recyclables, RDF could be an option.
- *Check the cost to transport the waste to the facility and compare with other options for disposing of residual waste and sorting residues.*
- *Ensure that adequate air pollution control systems are in place where RDF will be used.*

5.2.5. Treatment and disposal facilities

While the focus of this guide is on the collection system, attention should be given to the disposal of residual waste when designing or redesigning the waste management concept. Even with very extensive utilization, a fraction of waste is generated that cannot be recycled. Furthermore, the residues from the sorting of recyclable materials and from the processing of organic waste must be disposed of in the most environmentally sound manner possible. Therefore, it should be examined whether the significant reduction in the volume of residual

waste offers the opportunity to improve the environmental standard of residual waste disposal. Due to the lower quantities to be transported and the associated lower transport costs, more distant plants with a better environmental standard can also be considered.

- *Find out which disposal facilities exist in your region.*
- *Assess the environmental standard and whether information is available at the responsible Ministry or Environmental authorities.*
- *Check whether disposal at these facilities is accepted by the owner/operator of this facility and legally possible.*
- *Ask for the gate fee, tipping fee, and the delivery requirements.*
- *Check the cost of transport to the disposal facility.*
- *Compile the total cost and compare with other options for disposing of the residual waste.*

5.3. Basic planning data

Many guides and manuals recommend first conducting extensive surveys of the types, quantities and compositions of waste generated. However, such surveys are of limited value for the purposes discussed in this Guide. They are at best a snapshot in time and can have many potential sources of error. Moreover, the values change over time and are affected by the waste collection system. So, rather than spending time and money on extensive waste surveys, it is more advisable to think carefully about how these data can be collected and monitored during implementation and later during ongoing operations. Ways to do this are presented in the following chapters.

For the design of the collection system, it is initially sufficient to rely on estimates based on experience and approximations. It is much more relevant to get to know the number and type of residential buildings, households and residents than determining the 'exact' amount and composition of waste. On this basis, the quantities of waste can be roughly estimated, and to get an overview of the different types of waste generators in the municipality, in particular the large waste generators.

Required activities of basic data planning:

- *Determine the number of inhabitants, households, and residential buildings.*
- *Create a map with the different types of buildings*
  (One and two family households, villas, small apartment buildings, large multi-story apartment buildings etc.).
- *Approximately estimate the number of residents and households living in the different types of residential buildings.*
- *Mark on the map the districts with high rates of business and commercial activity.*
- *Identify the large waste generators and mark them on the map*
  (Markets, schools, administrations and office buildings, big supermarkets, and traders, commerce and trade…).
- *Compile a list with the collected data, differentiated for the different districts.*

6. Conceptual considerations and decisions

For the design of the collection system, the following conceptual issues are to be discussed and decided upon:

- Number and type of separately collected fractions
- Alternating or simultaneous collection
- Collection frequencies
- Point of collection
- Post-sorting at cart or central post-sorting

The alternatives of the system should be discussed with the policy makers and the stakeholders to be involved. These are influenced by the previously identified framework conditions and opportunities, but also by the goals and expectations towards the collection concept. Nevertheless, be aware that decisions initially made may need to be revised as the implementation moves forward. Although this is not pleasant, it is quite common in the course of a planning process.

6.1. Number and type of separately collected fractions

The determination of the number of fractions to be collected separately depends on various factors. In general, the more differentiated the separation at source, the better the recyclability. However, there are limits to the number of fractions due to manageability and comprehensibility for households and waste generators, as well as due to limited space for placing the collection receptacles.

- **Two Fractions**

At a minimum, separation into organic and non-organic or wet and dry waste is necessary. This implies that recyclables need to be sorted out of the non-organic fraction at a nearby sorting facility. The achievable material qualities are limited. Paper and cardboard in particular are contaminated by liquids and other residues contained in bottles, cans, as well as by non-recyclable waste components such as refuse, ash, nappies and used hygiene papers, batteries etc.

A variant for the 2-fraction collection concept is to leave the collection of recyclables to the informal sector. Public collection would be limited to organic waste and residual waste[33]. However, this approach has some disadvantages:

[33] This concept was finally applied in the Tan An project, since it turned out during the pre-test that households continued to sell or hand over the recyclables to the informal sector – compare: Pfaff-Simoneit (2021) ibid.

- The revenues from the sale of recyclables do not contribute to covering the costs of collection.
- Collection quantities fluctuate depending on demand for secondary raw materials, because some informal waste pickers only become active when certain revenue margins are achievable.

- **Three Fractions**

Better results in terms of material quality and recyclability are achieved if three fractions are separated:

- Recyclables (paper, cardboard, metals, plastics, glass…)
- Organic waste
- Residual waste

However, even in this collection concept, the quality of paper and cardboard is limited due to food and liquid residues remaining in bottles, cans and the like. It is therefore advisable to keep paper and cardboard separate as well and to collect them separately.

- **Four Fractions**

The optimum compromise between manageability for households and waste generators on the one hand and recyclability on the other is the separation into four fractions:

- Paper and cardboard
- Other recyclables (metals, plastics, glass…)
- Organic waste
- Residual waste

As needs or opportunities arise, other fractions such as hazardous waste generated in small quantities in households and electrical and electronic waste can also be integrated into the separate collection system at a later stage of concept implementation. Likewise, additional services such as the collection of bulky waste can be offered, depending on demand and the willingness of the population to pay for this additional service.

Recommendation

A strategy aiming at the comprehensive recovery of waste should provide for the most differentiated separation at source and separate collection. Preferably, four fractions should be distinguished, regardless of whether they are collected by the same collection service or by different collectors, e.g., informal waste collectors.

6.2. Alternating or simultaneous collection

The different fractions can be collected either alternately or simultaneously.

- Alternating collection: The different fractions are collected on different days of the week according to a schedule that must be communicated to the residents
- Simultaneous collection: All fractions are collected simultaneously on all collection days

The advantage of simultaneous collection is its greater flexibility and ease of use for the residents. They can make their waste available for collection as needed at any time, which probably increases the system's acceptance. Alternating collection imposes a greater obligation on waste generators to pre-sort waste because only one fraction is collected at a time.

If all fractions are to be collected simultaneously in one operation by the same service, the loading platform of the collection vehicle needs to be divided into several compartments to keep the different fractions separated from each other. Separate unloading must also be ensured. In case of alternating collection, the platform of the collection vehicle does not have to be divided into several compartments, so that the eventually existing collection trolleys can be used. However, the vehicles need to be equipped with some extra receptacles to store the impurities sorted out by the collectors.

Alternating collection forces households to separate organic waste more carefully. If residual waste and recyclable materials are collected only once or twice a week, any organic waste still contained in these waste containers could develop unpleasant odors, in particular in hot climates. Waste generators are likely to take more care to separate organic waste so that it can be collected within a short time. The disadvantage of alternating collection is that fractions that are not collected on the designated day, but are put out for collection by households and other waste generators will remain and not be collected. This increases the risk of scattering of waste and littering which leads to greater dissatisfaction among residents and unwillingness to cooperate in the waste management concept.

In summary, alternating collection is technically simpler but organizationally more demanding. The concept is therefore more suitable if a greater willingness to cooperate can be expected from the general population. Simultaneous collection suggests a higher acceptance and is suitable for connecting people to the collection system who do not show a great willingness to cooperate. In terms of cost and collection performance, there is not much difference between the two options. In this regard, the collection frequency is much more decisive.

Recommendation

The decision on the collection concept can be taken based on practical considerations and personal preferences. Alternating collection is technically simpler but organizationally more demanding. Simultaneous collection probably leads to higher acceptance.

6.3. Collection frequency

Determining the collection frequency is a very controversial issue. For cost reasons, the collection intervals should be as long as possible, while hygienic aspects and the acceptance of the residents favor short collection intervals. Figure 7 shows the cost impacts of different collection frequencies for a labor-intensive separate collection system for three fractions. The cost of weekly collection is only about 60% of the cost of daily collection. By extending the collection interval from daily collection to two days, the cost savings are already about 20%.

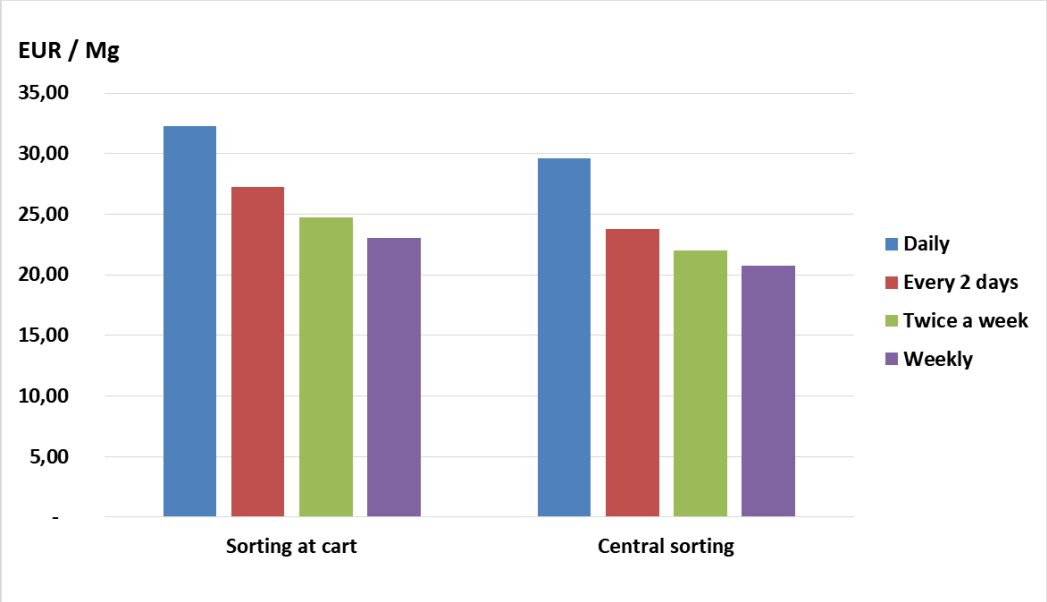

Figure 7: Impact of collection frequency on collection cost[34]

In terms of hygiene, organic waste is of primary importance. Organic waste should be collected at least twice a week, in hot, tropical maybe even every second day in order to avoid bad odors. Since a high quantity of organic waste is probably generated on the weekends, organic waste should be collected at the start of the week, on Mondays.

In contrast residual waste and recyclables can be stored over longer periods. The limiting factor regarding the extension of the collection frequency is the volume of the receptacle to store the waste. However, the volume should not exceed about 50 liters to ensure that it can still be handled manually and does not require additional floor space. 50 liters volume is sufficient to store the recyclables and residual waste of an average household for more than one week.

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[34] Infrastruktur & Umwelt: Development of a Waste Management Concept for Long An Province / Viet Nam Darmstadt / Germany, March 2019 (not published – available at author)
1 EUR was equivalent to about 1.12 US$ in the year the study was conducted
1 Mg = 1 Megagram = 10^6 grams corresponds to one metric ton

In many economies, people are used to having their waste collected daily. An extension of the collection frequencies will therefore probably meet with protests. In fact, however, most households only put their waste out for disposal every 2-3 days. The frequency and convenience of the waste collection service that is expected by the population cannot be ignored when planning collection systems.[35] The appropriate collection frequency must be determined individually in each community, taking into account existing criteria and practices.

Recommendation

Try to start with three collection days if you have opted for simultaneous collection. In case of alternating collection, organic waste on Monday and Thursday, residual waste and recyclables on another day. A strong argument for this collection scheme is the lower cost for residents/households. If there is no acceptance, start with daily collection and monitor carefully, how often households use the collection service per week. After some point in time the collection frequency could eventually be extended. There is also the possibility of providing financial incentives to extend the collection frequency by shaping the fees or the service charge: Households that want daily collection pay more than households that are served only on three days per week or even less.

6.4. Point of collection

The collection system must be easy and convenient for households and other waste generators if the full participation is to be realized. In addition to the increased effort caused by separation at source, residents should not be expected to walk long distances to the collection point. Therefore, the recyclable and the non-recyclable waste should be collected, wherever possible, as close as possible to the waste generators, preferably at the front door or in the immediate vicinity of the residential buildings.

In the case of apartment buildings, individual solutions must be found. Residents can either take their waste to drop-off points in front of the building, or this task can be handled by the janitor or cleaning staff. The public waste collection service can also collect the waste in front of each apartment. Although this is very labor-intensive, it has proven to be very effective when collected by the Zabbaleen people in the middle-class areas of Cairo[36].

Handing over the waste at the door opens up the possibility for the waste collectors to give immediate feedback to the households if they have not pre-sorted the organic waste or recyclables properly. This measure has proven to be extremely effective in the Tan An / Viet

[35] Manus Coffey & Adrian Coad (2010) ibid.

[36] See text box in chapter 6.6.3

Nam project in changing the behavior of residents with regard to their waste disposal and is highly recommended.

Recommendation

All fractions should be collected as close as possible to households and other waste producers. The service should be convenient, easy to use and understand for the residents. If socially accepted, waste collectors should have contact to the customers to advise them on how to segregate their waste in their home (at the source).

6.5. Post-sorting at cart or central post-sorting

To ensure a high-grade purity and quality, the collected organic waste and recyclable materials waste fractions will likely require post-sorting if households and waste generators have not sorted their waste well.

Post-sorting of the waste can be accomplished directly during the collection process or in a small sorting station. In case of central post-sorting approaches, workers other than the collection staff perform this task.

Sorting directly during collection has the advantage that the waste collectors can see directly which households sort their waste well and which do so less well or not at all. They have an opportunity to address the households that do not sort well and give them advice on how to improve segregation at source. Experience in Tan An shows that advice by collection staff is well accepted. The sorting quality of the households has improved considerably in a short time.

Note: The purpose of post-sorting is to ensure a high quality of separation of the waste into the different fractions. In this process, unwanted materials and impurities in the fractions, such as mixed recyclables, paper and cardboard, and organic waste, are sorted out (so called ‘negative sorting’ = unwanted materials are sorted out).

It is true that mixed recyclables, paper and cardboard have to be further sorted into the different materials and specifications. However, this process should be the responsibility of the purchasers of the recyclable materials.

Post-sorting of residual waste can be taken into consideration to sort out recyclable materials still contained in it (positive sorting = wanted materials are sorted out). This measure only makes sense if higher shares of recyclables are found in the residual waste. However, sorting out organic waste from the residual waste fraction is only feasible for larger accumulations such as garden waste.

Direct sorting also has advantages with regard to the possible introduction of fee incentives for households. Waste collectors know very precisely which households sort well and would have to pay lower fees or service charges and which do not, if such payment schemes were implemented. Possible payment schemes are discussed in chapter 9.

If post-sorting cannot or shall not take place directly at the collection vehicle, the waste must be transported to a nearby sorting facility without trans-shipment or compaction, because this would significantly affect the quality of the materials and the possibility of being further sorted. Centralized post-sorting is more efficient than post-sorting at the collection cart. In addition, the time required for waste collection is less, so centralized post-sorting is somewhat cheaper. However, it requires higher initial investments for a large open area or covered area along with sorting belt or table and equipment.

Recommendation

The decision on where and who shall perform post-sorting of the collected fractions should be made on the basis of practical considerations, taking into account the overall collection and logistics concept. Immediate post-sorting at cart is slightly more costly, but is better suited for achieving changes in waste disposal behavior. Centralized post-sorting is more efficient, but requires investment for sorting infrastructure and the availability of suitable land near the collection area.

6.6. Logistics chain

The proper collection and disposal of a city's waste requires a chain of process steps and combination of techniques and equipment to make this happen reliably and efficiently. The logistics chain must be designed consistently for all separately collected fractions from the source to the final destination. All transfers in the chain must technically and organizationally fit together well. Loading, trans-shipment and unloading procedures are crucial for efficiency, hygiene, and occupational health and safety. Time-consuming and strenuous waste transfer procedures should be avoided, the standards for occupational health and safety have to be met[37]. In particular, the transfer from primary collection vehicles to onward transportation or treatment must be efficient and should not place an excessive burden on the collectors. Long waiting times should be avoided, especially where capital-intensive equipment and vehicles are used. The longer, for example, refuse collection vehicles transporting waste to the landfill take to be fully loaded, the less time they have available for their actual task of 'transportation'.

The individual elements of the process chain influence each other and cannot be combined without thought for how one element impacts another. Decisions on the following topics should be taken:

[37] For further reading see e.g.: https://unhabitat.org/environmental-and-social-safeguards-system-version-3-esss-31

- Sorting at cart or centralized post-sorting
- Direct trans-shipment into transport trucks or transfer points
- Human-powered, animal-pulled or motorized primary collection vehicles

Decisive parameters are transport distances, topography, site availability, type of transport vehicles and traffic situation. In addition, the type and equipment of existing refuse collection vehicles must be part of the considerations.

The logistics concept depends largely on whether the waste is sorted directly at collection or centrally afterward. If the separately collected materials are post-sorted directly at the collection cart, they can be transferred directly for further transport to the different destinations. Trans-shipment can be done either directly from the primary vehicle to the secondary vehicle or in a special transfer station. The following options of the logistics chain are possible:

6.6.1. Option A: Sorting at cart – direct trans-shipment into transport truck

The collected and already post-sorted materials are transported in the collection vehicle to meeting points, where they are loaded into compactor trucks for onward transport to the different destinations. The collection cart and the compaction truck must be mechanically compatible. The cart must be compatible with the lifting device of the truck.

Figure 8: Direct transshipment from collection cart to compaction truck

This approach is likely to cause waiting times for waste collectors, primarily due to traffic congestion that impedes the timely arrival of the transport vehicle. They can be reduced or avoided entirely if full collection carts can be exchanged for empty ones at the meeting points. However, this requires having more collection carts on hand than trash collectors and sufficient parking capacities for the carts at the meeting points.

The meeting points must be staffed to organize and monitor the operations. The staff responsible for organization record and document the quantities of waste delivered by the different waste collectors. The staff will need to visually check the delivered materials to control the work quality and diligence of the waste collectors. More thorough checks should be performed on a random basis. To do this, the contents of the carts are tipped out onto a tarpaulin and pulled apart. Subsequently, they are shoveled back into the cart.

Advantages	**Disadvantages**
• No infrastructure investments / transfer stations needed • Meeting points can be flexibly adapted • Short transport distances for waste collectors allowing use of human-powered collection carts	• Strong dependence on the punctuality and reliability of the garbage truck • High organizational and coordination effort • Waiting times of collectors reduce collection performance and increase cost • Heavy, large compactor vehicles with strong lifting devices required • Quality control of delivered waste difficult • Households located near the meeting points may feel adversely impacted

6.6.2. Option B: Sorting at cart – trans-shipment at fixed transfer point

Trans-shipment at a fixed transfer point decouples the process steps ‘primary collection’ and ‘transport’ and forms a buffer between these. It avoids high organizational and coordination effort and the dependencies on the punctuality and reliability of the transport truck. While waste collection may be performed during the day, transports may take place at night or when there is less congestion.

The collected and already post-sorted materials are transported in the collection vehicle to a small transfer point located as close as possible to the collection area. There, weight or volume is registered, and the carts can be easily unloaded even manually by simply tipping the materials into a lower placed larger container. For this purpose, the transfer point must have two levels, an upper delivery level and a lower level for onward transport. The height difference between the two levels must be sufficiently large so that the transport containers used can be easily filled from the upper level. When unloading the carts, the quality of the delivered materials can be easily inspected.

A structurally simpler solution is the transfer by waste compactor trucks. The full primary waste collection carts are exchanged against empty ones and stored in the transfer station. Emptying and transport of materials is carried out by waste compactor trucks equipped with a lifting device. It is the same principle as in Option A, with the difference that the transfer takes place at a fixed location. Structurally, only a fenced area, or preferably a covered area, is required.

Advantages	Disadvantages
• Organizational decoupling of primary collection and transport • Time bypassing of traffic congestions • Easy quality control and monitoring of delivered materials	• Suitable site within the municipality is required • Investments for a fenced area, preferably covered, are required • Depending on location, longer distances from collection area to transfer point • Maybe motorized collection vehicles are required

6.6.3. Option C: Central post-sorting and trans-shipment

From a logistical point of view, central post-sorting of the collected fractions in a small sorting facility represents an extension of Option B. Sorting merely precedes the transfer of waste; both operations take place at the same location. The requirements for the site are comparable, but the space requirement is somewhat larger. Advantages and disadvantages are comparable to option B.

The Zabbaleen – world champions of recycling[38]

The Zabbaleen are a community in Cairo / Egypt who manage the waste of about one third of the city's population. Zabbaleen literally means 'garbage people' and they are generally considered to be the world champions of recycling. Over 80% of the waste they collect is valorized. Thea collect trash door-to-door from the residents of Cairo for nearly no charge. They use handcarts, donkey-pulled carts and small pick-up cars to collect and transport the waste to their homes in Mokattam Village, which is also called 'Garbage City'. There the waste is sorted into different fractions by family members. Structurally, it is a door-to-door collection with central post-sorting. Recyclables are sold to middlemen or recycled in own facilities, in particular plastics, organic waste is fed to pigs they breed. Pigs play an essential role in their recycling system, as they recycle most of the waste and the sale of the meat forms a significant part of their income. No doubt, the conditions in which the Zabbaleen work and live are absolutely unsanitary, and the working conditions in no way meet the minimum standards for occupational health and safety. This is absolutely not the approach to labor-intensive separate collection and recycling that the Guide intends to propagate. However, we can learn a lot from the fact that the Zabbaleen recycle 80% of the waste they collect using simple processes and low technology. The key success factors for this extremely high recovery rate are:

- High service provision – the waste is collected waste at the front doors, which makes participation for residents easy and convenient! Residents appreciate the work of the Zabbaleen very much.
- They first sort the waste and then compact! Modern waste collection systems do it exactly the other way round to save collection and transport costs.
- Utilization of organic waste, which accounts for the largest share of municipal waste. This measure alone contributes to more than 50% to the recycling rate.
- Integrated collection – the Zabbaleen collect all waste! This keeps collection cost low.

[38] See also: https://www.youtube.com/watch?v=phpDOvkEZZk;https://www.youtube.com/watch?v=Zy4sj4ggpSY https://www.youtube.com/watch?v=fwrZfZPFIV0; https://en.wikipedia.org/wiki/Zabbaleen

7. Design Parameters

7.1. Collection performance

The design of the collection system is decisively determined by the collection performance of the waste collectors. Although there are a large number of projects worldwide applying labor-intensive low-tech collection, they have not yet been systematically evaluated from an engineering point of view. Model calculations[39] suggest that a waste collector can collect and post-sort about 500-700 kg of waste per day, depending on the type of housing, settlement density and waste volume. Empirical experience from the project in Tan An, Viet Nam[40] shows that these values can be higher and reach up to more than 1,000 kg per collector per day. However, local factors such as population density, topography, road and path conditions, transport distances, collection concept, remuneration system for waste collectors, etc. have a considerable influence.

The collection performance also depends on waste quantities produced and the settlement density, which determines the walking distances and thus the time required to go from collection point to collection point. Areas with low population density are usually home to wealthier residents who tend to produce more waste, especially recyclable waste. All in all, the two factors roughly balance each other out. However, it is difficult to calculate how much waste a collector can collect per day without extensive preliminary research.

To save both the time and cost of preliminary studies, it makes sense to implement the collection system in phases. The aim of the first phase is to determine the collection performance under the locally given framework conditions and the selected collection concept. On the basis of the findings in the pilot phase, it can be rolled-out to other districts.

Recommendation

As a figure of scale, the following preliminary performance figures can be applied for the lay-out of the pilot phase:

- Post-sorting at cart: 1,000–1,500 residents per collector
- Central post-sorting: 1,500–2,000 residents per collector.

[39] Pfaff-Simoneit, W. (2017) ibid

[40] WWF / Pfaff-Simoneit, W. (2021) ibid

7.2. Specific waste generation quantities and volumes

For the design of the primary collection, the waste quantities and the composition should be approximately known. If no information is available, the system can initially be designed with default values. Usually, the specific waste generation is in the range between 0.5 and 0.8 kg per capita per day. The actual values must be determined during the monitoring of the project implementation.

If information on specific waste quantities is available or has been estimated, these must be converted into volumes. Likewise, the approximate share of the fractions in the waste generation must be estimated. To this end, the default values given in Table 2 can be provisionally applied for preliminary design of the collection system.

Table 2: Default values for weight and volume shares of the different fractions

Fraction		**Mixed recyclables**	**Paper and cardboard**	**Organic waste**	**Residual waste**
Weight share in total waste	Weight %	8-12%	5-10%	60-70%	10-20%
Density in collection cart	kg/liter	0.08-0.12	0.10-0.15	0.3-0.4	0.25-0.3
Volume share in total waste	Volume %	20-25%	15-20%	35-40%	20-25%

7.3. Phased implementation

The collection scheme should be implemented in phases starting with a pre-test phase, followed by a pilot phase and then roll-out to the entire municipality

7.3.1. Pre-test phase

In the pre-test phase, the primary collection system is tested to determine planning parameters and, most importantly, to evaluate the acceptance and functioning of the approach. Basic parameters like waste quantities and collection performance are determined empirically, and the feasibility of the collection concept can be tested. In particular, the following data and insights are intended to be gained during the pre-test phase:

- Collection performance: The quantities of waste collected per collector and day is a decisive parameter for the collection cost and strong route planning. Measure, document and evaluate the type and quantities of waste collected per collection round and per day for each collector. If applicable differentiate the settlement structure and transport distances.
- Process flows and suitability of equipment: Before procurements are made on a large scale, check the suitability of vehicles and equipment used in the pilot phase.

- Quantities and composition of collected waste: The separately collected fractions must be weighed separately. If feasible and staff available, analyze the composition of the fractions. For this activity, the involvement of informal waste-pickers has proven to be very effective.
- Willingness of the households and other waste generators to cooperate: The experiences in the pre-test phase are very valuable to improve strategies for raising environmental awareness, testing of communication and information dissemination methods and stimulating the willingness of waste generators to cooperate.
- Acceptance of waste advice by waste collectors: The control of the sorting quality and advice to households by waste collectors is a key feature of the recommended approach to comprehensive separate collection and recycling of waste. The pre-test provides indications of where this concept may meet with low acceptance, so that appropriate precautions can be taken or alternative measures conceived at an early stage.
- Interaction of the various participants and processes: The processes and roles of the different participants can be tested and optimized, in particular, cooperation with involved NGO and CBO who support public relations and who can motivate waste generators to participate and cooperate.

The pre-test area should have a population of at least about 3,000 to obtain performance data from multiple collectors. No major investment is required to perform the pre-test except for a few collection carts and equipment for monitoring.

7.3.2. Pilot phase

In the pilot phase, the entire collection and logistics concept is subject to a practical test. The objective is to identify weaknesses and coordinate the various process steps with each other, as well as to optimize the interfaces.

The pilot area should have a minimum size of about 20,000 residents. It should form an administrative unit such as a city district with clear administrative responsibilities or be geographically well delineated.

The pilot phase should be sufficiently long to test as many possible influences and different operating conditions in practice as possible, such as the impact of rainy, dry and other seasonal variations, festive seasons such as Ramadan or Diwali, harvesting seasons, labor migration, turn of the year, etc. Thus, the net duration should be at least 12 months. In addition, there is the time required for preparation and organization. During this time, equipment procurement, route planning, training of collection personnel, preparation of information materials and user explanation and education will be carried out.

After the execution of the pilot project, the results are to be evaluated and conclusions are to be drawn. If the pilot phase was successful and a decision is made to expand the collection concept to the entire municipality, the pilot must not be interrupted under any circumstances. Otherwise the confidence and co-operation of the users will be destroyed and the credibility of the planners and organizers negatively affected. It will then be extraordinarily difficult to start a similar project at a later date.

If the pilot project was successful, the planning and preparation to permanent operation and scale-up to the whole municipality area follows. If it's not, the pilot needs to be phased-out or improvements have to be implemented, which again require a sufficiently long field test.

7.4. Delimitation of collection districts

The final zoning of the collection districts and the delineation should be based on the findings of the pilot phase. Differences to the characteristics in the pilot areas, especially with regard to topography, condition of roads and paths, distances to the transfer point are to be taken into account accordingly.

The collection districts for primary collection must have clear boundaries from each other. In the case of roads and paths that form the boundary between two collection districts, it must be clearly designated which sides of the road belong to which collection district.

It is advisable to implement the new collection concept in stages. In this way, mistakes in the planning or further findings from practice can be taken into account when designing the collection system for other districts in the future.

8. Equipment and Facilities

8.1. Waste receptacles

The type of containers used by households and other waste generators for storing waste between collection days and providing it for collection is often not given much attention. Yet this has a significant influence on source separation, collection performance and the overall costs. Furthermore, waste properties, urban hygiene and occupational safety are aspects to be taken into consideration when discussing about pros and cons of using standardized set-out containers. Recyclables, organics and waste is often stored in temporary containers such as cardboard boxes, cartons, baskets, jugs, plastic bags and other types of receptacles. Plastic bags, especially shopping bags, are very popular because they are thrown away anyway; they are easy to handle for the households, relatively clean and are suitable for wet waste. However, they can easily be torn open by scavenging animals like dogs, cats or birds, scattering the waste and thus requiring a lot of time for the waste collectors to sweep up. In addition, they can be easily punctured by sharp objects and injure the waste collectors. Opening the plastic bags, emptying them and disposing of them separately is more time consuming than emptying reusable containers, so collection performance is reduced, and costs are higher. In the long run the use of standardized containers is therefore more cost-effective.

Cardboard boxes lose their strength when they hold wet waste or get wet from rain or soil moisture. Metal containers such as tins or cut open canisters have sharp edges on which the waste collectors can cut themselves. Disposable receptacles or households' own containers mostly do not have lids, which leads to hygienic problems. Flies have easy access to the waste and can breed in it, animals and birds search for food and scatter the waste. Rain not only increases the weight, it also leads to a high amount of water that can run out of the collection vehicles. Likewise, the amount of leachate in the landfill increases.

Disposable receptacles or households' own containers mostly do not have handles. This makes lifting and emptying the receptacles more difficult and costs valuable collection time. When collecting organic waste and recyclables, disposable containers must have their own box on the collection cart so that they can be transported away separately.

For all these reasons, it is highly recommended to use standardized bins for the collection of the wastes. These should have lids to isolate waste from access for flies, animals and rainfall, and handles for easier handling.

For example, one person generates about 2 – 3 liters of waste per day, depending on the specific waste generation and its composition. If the waste is collected twice a week, a

volume of 20 liters per fraction is sufficient for a household consisting of 5 up to 8 persons[41]. In case of larger households, either more or bigger receptacles are required. However, the volume of the receptacles should not exceed 50 liters, so that the bin can still be lifted by hand when it is completely filled with heavy waste such as organic waste.

When using small waste containers up to a volume of about 20 liters, they can be used both for the collection of waste in the house and for providing it for collection. In this way, they facilitate separation at the source. Various models are available for this purpose. Stackable containers are particularly space-saving; Figure 8 shows suitable types of waste storage bins for households and other small waste generators.

Bins used in pilot project Tan An
Source: WWF (2020) ibid.

Stackable in-house trash bins
https://trashcansunlimited.com

In-house pre-sorting bins
www.thebetterindia.com

Figure 9: Waste storage bins for households and small waste generators

Whether the bins are to be purchased by households themselves or provided by the municipality must be decided according to local criteria and the available budget. If the containers are procured in larger quantities by the municipality, the unit price is significantly lower. Depending on the design, the costs are in the order of $6-15 per household. The provision of such containers is particularly suitable as a starting signal for the new collection system in the context of public relations work and motivates households to participate. Whether or not these receptacles will be replaced by the municipality if damaged or lost should also be stipulated in advance and communicated to the users accordingly.

[41] The organic waste determines the maximum number of persons. It has a share of about 35 – 40 vol.-% (s. Table 2), which is between 0.7 and 1.2 liters per capita per day or 5 – 8 liters per capita per week. Two collections per week of a 20 liter bin correspond to 40 liters, which is sufficient to store the organic generated by 5 – 8 persons.

Recommendation

Wherever possible and financially feasible or affordable for residents, standardized containers with lids and handles should be used for the collection of recyclables, organics and residual waste. If the financial resources do not allow for this, improvisations are also feasible as a temporary solution. However, households and waste generators should be encouraged to use at least coverable receptacles as part of public outreach campaigns. In the long term, such temporary solutions of waste provision should be progressively replaced by standardized bins.

8.2. Primary collection vehicle

8.2.1. Type of vehicle

The choice of the type of vehicle for primary collection is decisively determined by the distance between the collection quarter and the unloading point. In addition, topography is important, i.e., the gradients that exist in the collection area.

To achieve high collection performance, the time required to transport the collected waste to the collection points should be as short as possible, it should be not exceed 10 minutes for transporting the full collection vehicles. If handcarts are used, the average distance should not exceed 0.5 km. Load-carrying tricycles have a range of around 1.5 km since they are faster even when loaded, if well designed. For motor-driven vehicles, even longer distances up to about 5 km are possible.

Simultaneous collection
Source: https://www.indiamart.com

Alternating collection
Source: WWF 2021 ibid.

Figure 10: Waste collection hand carts

If steep slopes have to be overcome, handcarts and cargo rickshaws / tricycles cannot be moved with muscle power due to the high transport weights. In such cases animal carts can be an option. ‘Donkeys, mules, horses and buffaloes are used for pulling loads in many economies. Attention must be paid to the design of the carts and the harness to minimize the loads that the animals must support and to simplify tipping. In steep-sloping communities with unpaved access roads, donkeys and mules can carry waste in panniers (a container on either side).’[42] Due to the higher possible loads, the distance to the unloading point can be greater, up to 2 km.

Handcarts and tricycles, just like animal carts, have the advantage that the driver does not need to have a driver's license. They can be operated by either men or women, although cultural aspects must also be taken into account, as it might be not appropriate for women to ride tricycles, for example.

Source:https://globalrec.org/2016/12/01/hasiru-dala-turns-3/#jp-carousel-35912

Source: https://sigmasquaretech.in/tricycles-cart/

Figure 11: Tricycles for separate waste collection

If, due to local conditions, primary collection can only be carried out by motorized vehicles, models should be preferred that are widely used locally due to low maintenance costs and good reliability. A particularly advanced solution can be tricycles with supportive drive by an electric motor – so called ‘E-cargo bikes’. However, this requires solutions for daily charging of the batteries to be conceived as well.

Valuable advice and criteria for the selection and design of suitable primary collection equipment can be found at Coffey/Coad (2010) and Diaz / Bakken (2005)[43].

[42] Coffey / Coad (2010) ibid.

[43] Diaz, Luis F., Bakken, Per: Solid Waste Management, UNEP / CalRecovery (Editors), 2005 https://wedocs.unep.org/20.500.11822/30733

8.2.2. Size / Volume of the collection vehicles

Basically, the larger the load volume of the collection vehicle, the higher the collection efficiency. However, the volume is limited by the maximum weight that can be transported with the vehicle. The maximum load of a hand-pulled cart should not exceed 100 kg, provided the cart is well designed with smooth running wheels and easy to maneuver. Poorly designed or badly maintained handcarts result in physical stress for the collectors and thus low labor productivity.

Tricycles with pedal drive can load up to 200 kg, whereas the load of motorized vehicles is limited by its design permissible payload. The maximum load may need to be reduced in case of bad road and path conditions or due to bad weather.

The volume of the collection cart should be large enough so that no more than about 6 – 8 trips per day per collector are required to fully serve the collection district. Table 3 shows an example how to calculate the required collection trips per week resp. per collection day for the different fractions and the impacts on the collection frequency. The calculation is based on the following assumptions:

- specific waste generation: 0.6 kg per capita per day
- cargo volume: 600 liters
- 1,000 people served per collector

The example calculation shows that each collector must walk up to 8 times per day to empty the collection carts. The distance should therefore not exceed approx. 500 m, which takes approx. 20 – 25 minutes for each round to the transfer point, unloading and going back. This reduces the net collection time by up to 3 hours per working day.

Table 3: Required collection trips per week using a cart with a cargo volume of 600 l

Fraction		**Mixed recyclables**	**Paper and cardboard**	**Organic waste**	**Residual waste**
Total weight district	kg/week	450	250	2,700	800
Total volume	liter/week	4,500	2,000	7,500	3,000
Limiting factor		Volume	Volume	Weight	Weight
Trips per collection day		7-8	3-4	6-8	6-7
Collection frequency	**days/week**	**1**	**1**	**3**	**1**

Note: The values given in the table are only to be understood as indications for the initial design. They also depend on the sorting discipline of the waste producers and the care taken in post-sorting. Since it cannot be assumed that recyclable and organic waste is completely separated, the quantities of residual waste actually collected tend to be somewhat higher and those of the other fractions lower. The actual values must be determined in practice through careful monitoring.

It becomes clear that with alternating collection, the possible collection frequency is limited. It must be determined for each fraction, taking into account the number of working days per week and the working hours per day.

8.2.3. Special devices of the collection vehicle

Depending on the chosen concept for collection – alternating or simultaneous, and sorting, or sorting at cart or centrally – the collection vehicle must be equipped with special devices, such as a sorting tray.

Sorting tray

In case of sorting at cart, the collection vehicles must be equipped with a tray onto which the contents of the waste receptacles can be tipped and spread out. The size must be large enough to accommodate the waste of the biggest bin collected. For a 50 liter bin, the size of the tray should be at least about 60 by 80 centimeters. To prevent the waste from falling out, the tray should have a rim about 5-10 centimeters high. This allows emptying of receptacles with a volume of up to 50 liters. The tray should be tiltable, so that the waste can be easily tipped into the waste collection vehicle after having sorted out impurities.

Figure 12: Hand cart with sorting tray used in Tan An

Compartments or different bins

If all fractions are to be collected simultaneously, the loading platform of the collection vehicle needs to be equipped with appropriate compartments or different bins to keep the different fractions separated from each other. The shares of the volumes should be about

- Paper and cardboard: 15 – 20%
- Other recyclables: 20 – 25%
- Organic waste 35 – 40%
- Residual waste 25 – 30%

If standardized trash containers are used for collection, the following arrangement would be recommendable:

- Paper and cardboard: 1 bin
- Other recyclables: 1 bin
- Organic waste 2 bins
- Residual waste 2 bins

It is advisable to fold and stack cardboard and not to collect it in bins or boxes, otherwise it requires too much loading volume.

Separate unloading must also be ensured. If different containers are used, they can easily be unloaded one after the other separately by fraction. If the materials are stored on a platform in different compartments, the platform should be tiltable to the side and the compartments must be able to be opened independently of each other.

Receptacles for sorted out materials

In case of alternating collection, the platform does not need to be separated in several compartments. However, the vehicles need to be equipped with some extra boxes to store the impurities sorted out by the collector from the main load. A simple solution can be hooks on which to hang bags. However, bags get dirty quickly and some materials do not empty well. Durable bins or boxes can be washed out and are easy to empty. They should have a volume of about 10% of the cargo volume of the collection vehicle.

8.3. Central sorting facility

For central post-sorting, preferably a covered area is needed that can be easily reached from the various collection districts. It must be large enough to accommodate all functions:

- Delivery area for primary collectors
- Weighing or volume determination, quantity recording
- Unloading area, maybe ramp to an upper level
- Chute or feeding belt to convey onto the sorting table / belt
- Sorting area, either small sorting belt or table
- Storage area for container for storing post-sorted materials
- Storage area for full container
- Loading area for onward transport

The area must be easily accessible for large refuse collection vehicles, and there must be sufficient space to maneuver. Depending on the number of collectors delivering to the sorting facility and the waste quantities processed, the area must have at least about 200 m².

The sorting performance depends on the design of the facility. In particular, the method of feeding the waste to be sorted and the modes of internal transport influence the personnel requirements. Conveyor and sorting belts reduce the work force needed, but require investments and a reliable energy supply to operate the belts. As a rule of thumb, one person can sort the following quantities of the different materials:

Recommendation staffing for central post-sorting

Negative sorting – sorting out of impurities and unwanted materials:

- Mixed recyclables: 200-300 kg per person per hour (Input)
- Paper and cardboard: 300-400 kg/person*hour (Input)
- Organic waste: 600-1,000 kg/person*hour (Input)

Positive sorting – sorting out of wanted materials:

- Residual waste: 400-600 kg/person*hour (Input)

Further staff is required for waste acceptance, weighing and recording of delivered waste, internal transports, feeding of sorting belt or table, exchange of containers, cleaning and other auxiliary duties. The exact number of staff can only be determined based on the design of sorting facility and the operational plan. Roughly it can be estimated, that in total about 5-8 persons per 10,000 residents serviced by the facility are required, of which 3-4 for sorting.

8.4. Transport to destinations

For transporting the different fractions to the respective destinations, trucks with high loading capacity are preferable. Since the vehicles do not have to perform waste collection, they can be used very efficiently. The entire load is collected at one location or at a few locations, no time-consuming door-to-door trips with stops in between are necessary, while at the same time significantly reducing fuel consumption and exhaust emissions.

Depending on the type of materials and the type of trans-shipment, waste compactors and trucks with interchangeable containers can be used. If the trans-shipment is carried out directly from the primary collection vehicle, waste compactors with lifting equipment are mandatory. The same applies if the fractions are provided for transport in standardized waste bins.

Organic waste and residual waste can also be transported very efficiently in containers without compaction. Due to their high material density further compaction is not necessary and would have no advantages. Hook lift trucks, skip loaders or front-end loaders are more robust than refuse compaction trucks and require less repairs and maintenance. However, this requires a fixed transfer point, where the materials delivered by the primary collectors are either unloaded directly from a higher level into the containers, or a centralized post-sorting facility where the sorted materials are stored in large containers.

The type of vehicles to be used for the transport of mixed recyclables and paper / cardboard strongly depends on the transport distance. This should not be long distance, as secondary raw material dealers can be found in almost every city, who are likely to be interested in accepting the materials. In case of longer transport distances the use of on-site balers or compaction trucks is recommendable for cost efficient transport.

The type of vehicles to be used is essentially determined by local conditions. If possible and reasonable, the existing vehicles should be used. These can be successively replaced by vehicles that are better suited to the new collection concept and which are more efficient.

Coffey and Coad (2010)[44] state in their very worth reading publication ‘Collection of Municipal Solid Waste in Developing Countries‘: ‘There is a very wide range of vehicles to choose from, so the selection should be made after careful consideration by open-minded technical experts who are prepared to consider new types of vehicles if there are good reasons for using them. The final decision regarding vehicle type should include comparisons of the cost of collecting each ton of waste. Simple vehicles based on chassis (both manufacturer and model) that are widely used locally are preferable because they offer low maintenance costs and good reliability. Real benefits can be expected from investing in local manufacture of well-designed bodies.

A key element of sustainability in any solid waste management system is the rapid supply of spare parts and access to maintenance facilities for the vehicles and other equipment that is used. Inevitably, if complex and specialized imported vehicles are used, there will be long delays and high costs in the procurement of spare parts as these vehicles wear or break down in the future. In almost every economy, simple, locally manufactured bodies on commonly available truck chassis provide the most sustainable collection systems, as well as benefiting the domestic economy and local industrial sector.’

[44] Coffey / Coad (2010) ibid.

9. Organizational Models

Different organizational models are discussed below[45]. In addition to the 'classic' form of employing waste collectors by the municipality or by a private waste service provider, models are also illustrated that could considerably reduce the administrative effort and the financial burdens and risks for the municipality associated with waste collection services. At the same time, they open possibilities for entrepreneurial activities on the part of waste collectors and are suitable for mobilizing the specific skills of many people in the informal sector.

All models have advantages and disadvantages, which are discussed below. However, the selection of the most suitable model can only be made in consultation with the actors and stakeholders.

9.1. Municipal service provision

In most economies, responsibility for waste disposal lies with the municipalities. Employing their own personnel to carry out the tasks is a widespread model. The costs are covered by general tax revenue or fees. In addition to the organization of the waste disposal service and personnel management, the levying of fees result in a high administrative effort, also many citizens are not willing to pay the fee for the service.

Figure 10 presents the material and the financial flows of this model. It becomes clear that the municipality has a high organizational and administrative burden and must bear all the expenses and risks associated with waste management.

[45] More detailed presentations and discussions of operator models can be found in:
Operator Models. Respecting Diversity Concepts for Sustainable Waste Management, published by GIZ (2013) https://rwm.global/utilities/documents/giz2013-swm-operator-models-sourcebook-en.pdf
Whiteman, Webster and Wilson: *The Nine Development Bands: A conceptual framework and global theory of waste and development*, https://davidcwilson.com/publication/nine-development-bands-a-new-theory-of-waste-and-development/

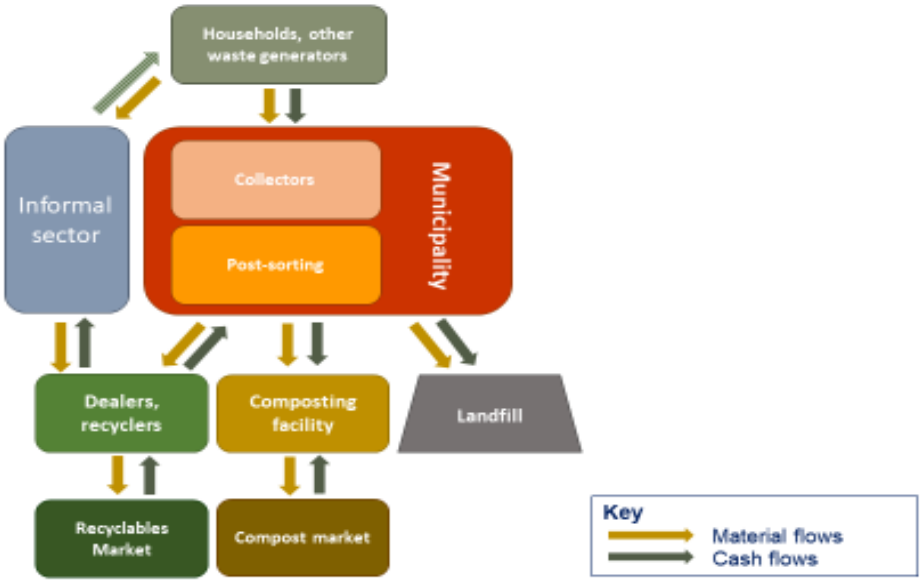

Figure 13: Municipal service provision

The cost and the financial risk for the municipality is very high, since costs must be largely covered by fees or municipal taxes. Municipal employees are not always highly motivated for a variety of reasons, and paying financial incentives to improve job performance is usually not allowed. At the same time, administrative law hinders entrepreneurial activity. Municipal administrations also lack the experience to operate in the secondary raw material markets, so they will usually earn low revenues from the sales. Another challenge is that people from the informal sector will likely not be interested in working as a public employee.

Furthermore, it should be considered that recyclable materials are still collected by the informal sector, and these materials are even sold by some of the households and waste generators. Consequently, the revenues can hardly contribute to covering the costs of the municipality for waste management. This scenario is exactly what was experienced in the model project in Tan An, Viet Nam. The municipality has therefore decided to stop collecting recyclables[46]. All these aspects represent rather unfavorable conditions for motivating waste collectors to perform their tasks with dedication.

The classic organizational model of municipal service provision thus appears to be less suitable for a strategy of comprehensive waste recovery. Table 4 summarizes the assessment of this model.

[46] Pfaff-Simoneit (2021) ibid.

Table 4: Assessment of municipal service provision

Municipal service provision	Assessment	
Administrative effort	Very high	– –
Organizational effort	Very high	– –
Cost and cost risks for municipality	Very high	– –
Financial incentive for households and waste generators to segregate waste	Very low	– –
Incentive for waste collectors to perform well	Very low	– –
Suitability to involve informal sector	Medium	o

Key: ++ Very positive
+ Positive
o Neutral / Medium
– Negative
– – Very negative

9.2. Private services company

Contracting a private service company relieves the municipality of operational tasks and administration for waste service personnel. However, municipal staff will be needed for tendering, contracting, performance monitoring and contract management. A private company can grant performance incentives to its personnel and it is familiar with operating in markets. In this respect, such an organizational model is better suited to a strategy of comprehensive waste recycling. However, the financial liability and risks remain with the municipality, including the efforts associated with the collection of fees and taxes. Granting financial incentives to households and waste generators in the form of reduced fees for good presorting at source is administratively complex. Moreover, there may be legal risks since the quality of pre-sorting would have to be assessed by a private third party and not by an employee of the municipality. Additionally, people from the informal sector will only partly be interested in working in a private company as an employee.

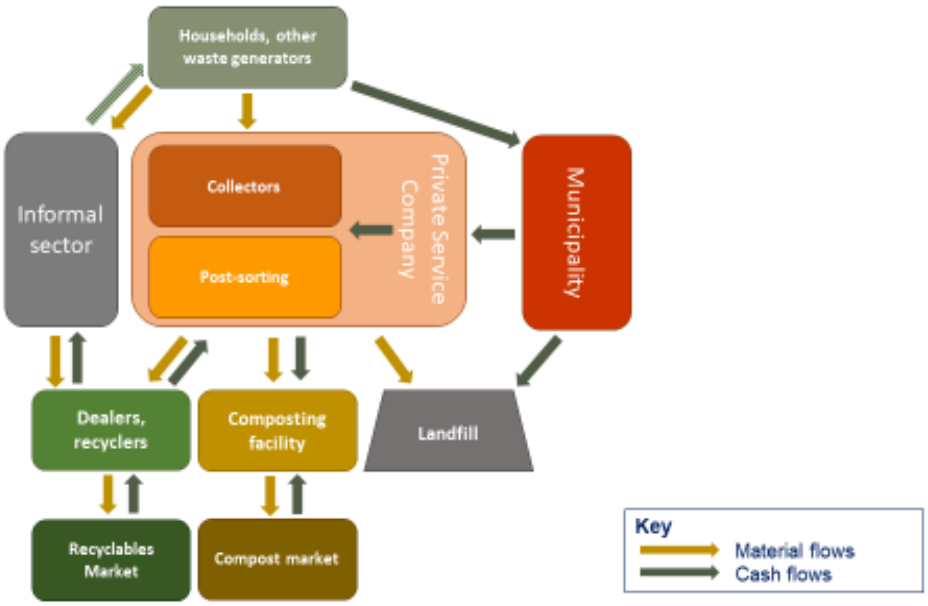

Figure 14: Private collection service company

Table 5: Assessment of service provision by a private company

Private collection service company	Assessment	
Administrative effort	High	–
Organizational effort	Low	+
Cost and cost risks for municipality	Very high	– –
Financial incentive for households and waste generators to segregate waste	Very low	– –
Incentive for waste collectors to perform well	High	+
Suitability to involve informal sector	Medium	o

9.3. Service provision by micro enterprises

The delegation of waste collection services to microenterprises seems to be particularly suitable for involving people from the informal sector. This model allows them to deploy their entrepreneurial skills and continue to work largely independently. For each collection district, one microenterprise is responsible. The task of the municipality is to commission the services and to control the proper execution, which requires a certain organizational effort.

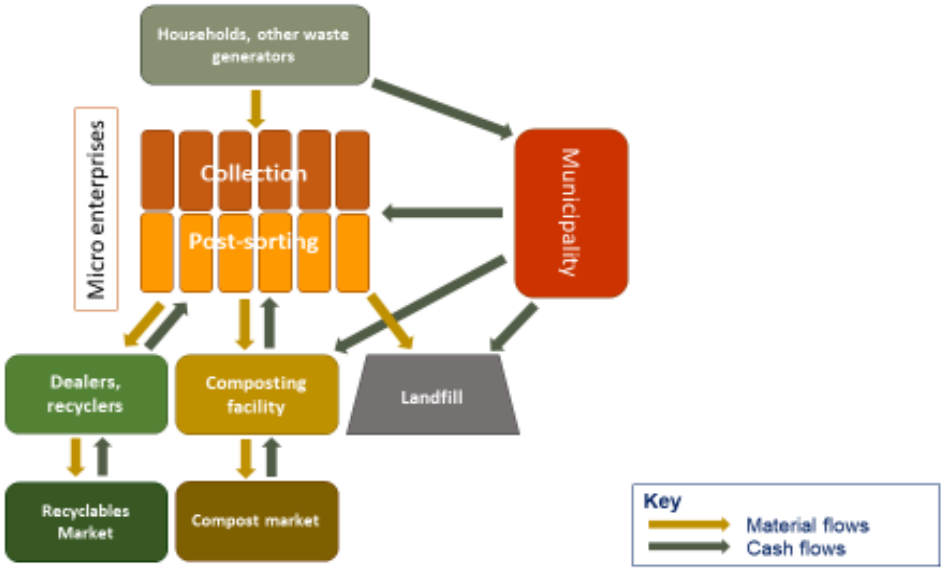

Figure 15: Waste collection service provision by microenterprises

Payment of the collectors for the services is based on performance according to the amount of the different fractions collected. The contracted microenterprises should be allowed to market the recyclables themselves as part of their compensation and as an incentive for good performance. For the collection of organic waste and residual waste, they should receive remuneration per ton delivered, the amount of which should be determined according to local conditions. Significantly higher payments should be granted for clean organic waste in order to provide incentives for separating organic waste. To prevent micro-enterprises from collecting only the most profitable materials, quotas for each of the different fractions can be set that specify a range of percentages of organic and residual waste that collectors must collect.

The particular advantage of this arrangement is that the collectors have a strong interest in collecting the largest possible quantities of clean secondary raw materials and organic waste. The municipality covers its costs from waste disposal fees or from general tax revenue. It remains responsible for the financial administration and the associated expenses. Granting financial incentives to households and waste producers in the form of reduced fees for good presorting at source is administratively complex and involves legal risks. It is a matter of negotiation as to whether the municipality or the microenterprises are responsible for providing the collection equipment.

The municipality must manage a large number of contracts, control the work of the micro-enterprises, monitor the work performance and remunerate them accordingly. Thus, the model causes a high administrative and a very high organizational effort.

Table 6: Assessment of service provision by microenterprises

Service provision by micro enterprises	Assessment	
Administrative effort	High	–
Organizational effort	Very high	– –
Cost and cost risks for municipality	High	–
Financial incentive for households and waste generators to segregate waste	Low	–
Incentive for waste collectors to perform well	High	+
Suitability to involve informal sector	Very good	++

9.4. Service provision by collectors' association

The high organizational burden of managing a large number of service contracts with individual microenterprises can be significantly reduced if the collectors can be organized into a cooperative. The municipality can encourage this by providing appropriate legal advice and support. For the other criteria, the same assessments apply as for the provision of services by micro-enterprises.

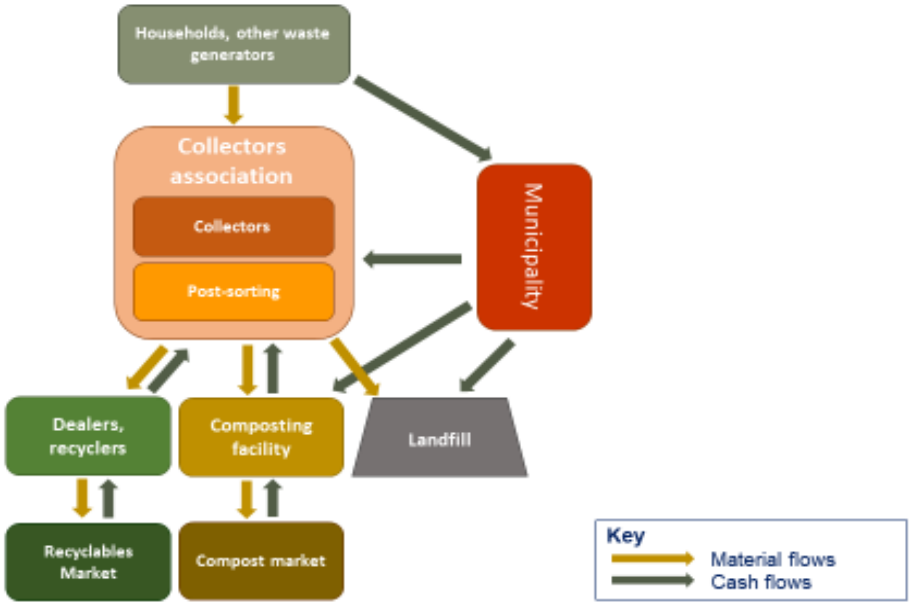

Figure 16: Waste collection service provision by an association of waste collectors

Table 7: Assessment of service provision by an association of waste collectors

Service provision by micro enterprises	Assessment	
Administrative effort	High	–
Organizational effort	Low	+
Cost and cost risks for municipality	High	–
Financial incentive for households and waste generators to segregate waste	Low	–
Incentive for waste collectors to perform well	High	+
Suitability to involve informal sector	Very good	++

9.5. Direct payment of waste collection services by residents and clients

The models presented above have in common that the financial responsibility for waste disposal remains entirely with the municipality. The collection and administration of service fees usually represents a high burden for the municipality. Moreover, many citizens are unwilling to pay sovereign fees. This problem could be significantly reduced if residents and other waste generators would have to pay for the waste collection service directly to the service provider. Collection costs account for up to 80% of the total waste disposal costs. In this way, the financial burden for the municipality and the risk associated with fee collection are lowered substantially. The payment would thus no longer be a sovereign fee, but rather a private service charge. The municipality remains responsible for the cost of landfilling and possibly required subsidies for the processing of organic waste. These costs may be recovered through municipal taxes, primarily property or real estate taxes, or as a surcharge on the water or electric bill, if permitted by law.

Through direct payment for the services of waste collectors, the polluter pays principle is applied very effectively. The service charges contribute to foster behavior change. The rate of the service charge depends on the diligence in waste separation of the customers. Those that produce little waste and sort well pay little or nothing, those that do not, pay significantly more. The garbage collectors know very well how much garbage a customer generates and how accurately it is pre-sorted. This provides a strong incentive to households and other waste generators to minimize the residual waste by segregation of organics and recyclables.

The municipality must control whether the service fees are also reasonable and fair and whether the waste collectors perform their work reliably and correctly. This includes supervision that the financially less lucrative fractions 'organic waste' and 'residual waste' are also reliably collected and transported to the designated places. To bolster this, consideration can be given to paying waste collectors a (small) fee for delivering this waste, based on the quantities delivered. The costs have to be borne by the municipality.

Figures 14 and 15 show such an organizational model in case of service provision either by micro enterprises or by a collectors' association.

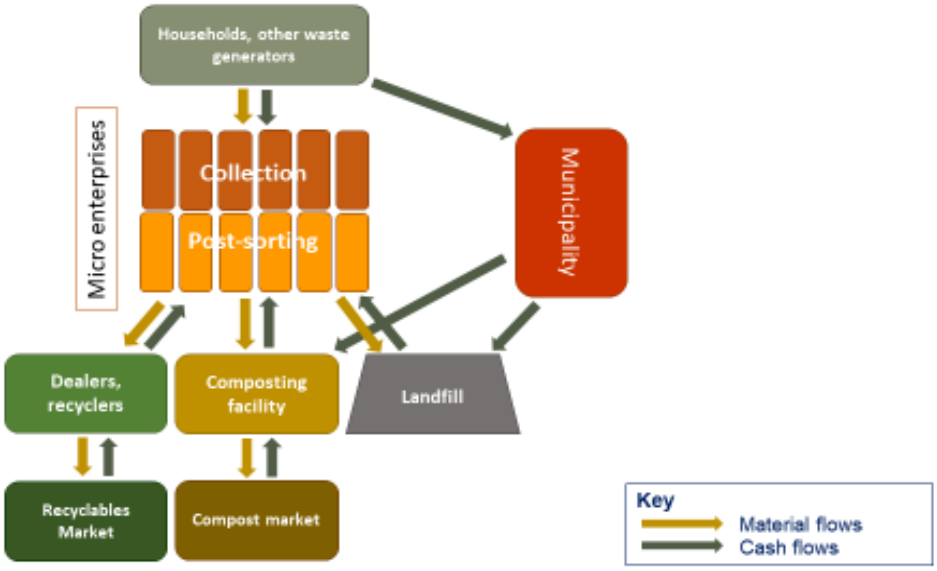

Figure 17: Private service charge for micro enterprises

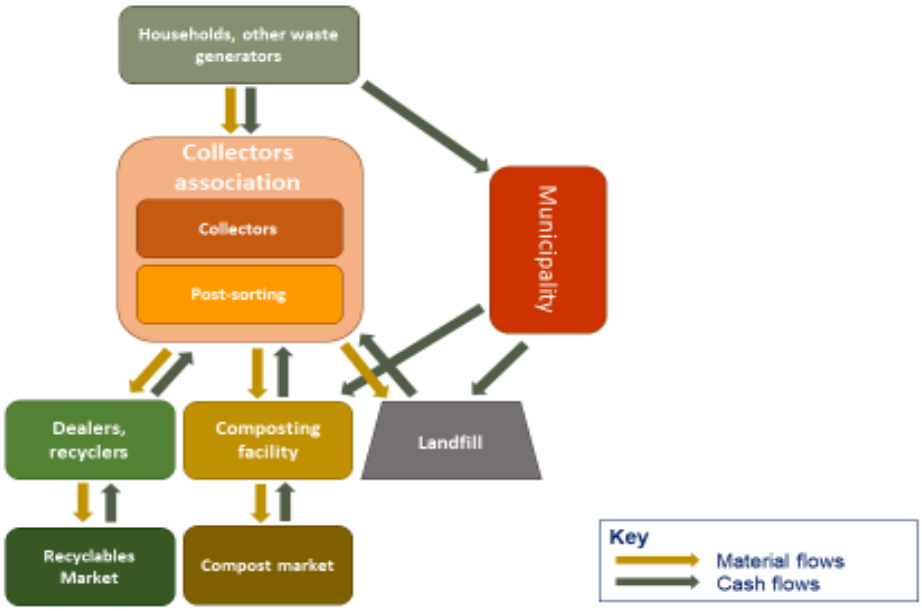

Figure 18: Private service charge for collectors' association

The concept may seem very revolutionary, but it is already practiced very successfully for example by the Zabbaleen in Cairo or by Hasiru Dala in Indian cities. Experience shows that residents are more willing to pay a service charge that is raised in direct relation to the

service, rather than a public fee that is more likely to be perceived as anonymous and non-transparent.

Hasiru Dala – variable pricing model for waste service charges

Hasiru Dala Innovation, who provides waste collection services to apartment complexes and condominiums in Bengaluru, India uses a variable pricing model as a powerful incentive to promote behavioral change. Each of three classifications of waste: organic, non-organic, and reject (e.g. sanitary pads and diapers), are given a different price. Rejected waste that goes to landfill is charged the highest price followed by organic waste, which is composted while recyclable, non-organic waste is collected for free. In addition, they regularly increase the price for residential waste. Each category of waste is opened and weighed at the time of collection for transparency. An appointed building manager watches the weighing process and signs off on the final weight if satisfied. This ensures people do not put reject waste into other waste categories and that final cost is transparent and aligned. Because the final price is divided between all residents in the building, there is little incentive for illegal dumping, as they do not have the choice to "opt out". (Source: Danielson (2020), ibid)

The rate of the service charge depends on the diligence in waste separation of the customers. The waste collectors know very well which households and waste producers cooperate well and which do not and can therefore set the service charge accordingly. The model therefore creates significant financial incentives for behavioral change and careful separation of waste.

Table 8: Assessment of waste collection service against private service charge

Waste collection service against private service charge	Assessment	
Administrative effort	Medium	o
Organizational effort	Low	+
Cost and cost risks for municipality	Low	+
Financial incentive for households and waste generators to segregate waste	Very high	++
Incentive for waste collectors to perform well	Very high	++
Suitability to involve informal sector	Very Good	++

9.6. Comparison of organizational models

Table 9 compares the ratings of the different organizational models. It can be understood that the provision of the 'waste collection' service for a private service charge has clear advantages and appears to be the most suitable for a strategy of comprehensive waste recycling.

Table 9: Comparison of organizational models

	Criteria					
Organizational model	Administrat. effort	Organizat. effort	Cost and risks	Incentives households	Incentives collectors	Informal sector
Municipal service provision	– –	– –	– –	– –	– –	o
Private service company	–	+	– –	– –	+	o
Micro enterprises	–	– –	–	–	+	++
Collectors' association	–	+	–	–	+	++
Private service charge	o	+	+	++	++	++

Key:
- ++ Very positive
- + Positive
- o Neutral / Medium
- – Negative
- – – Very negative

10. Conclusion

Implementation of proper waste management systems carries the stigma of being almost unsolvable, especially in less industrialized economies with widespread negative consequences for human health and the community, for the environment, the climate and the protection of the oceans. Decision makers and practitioners in economies with less developed waste management schemes often focus on technological solutions for recycling, treating and disposing of waste. However, such technologies have been mostly implemented in industrialized economies where collection is widespread and the affordability is not a barrier. What is less appreciated, however, is the vital importance of household waste collection approaches that can be reliable, affordable, and easily adaptable to local communities in developing economies. The successful projects start at the source – with waste collection. The secret of their success lies in the waste itself. These projects utilize the resources contained in the waste as secondary raw materials and as feedstock for sought-after products. Only a small proportion of the generated waste, usually less than or around 20%, is not recyclable and requires disposal in an environmentally sound manner as possible. This reduces the high expense of transport and landfilling.

The utilization of the resources contained in waste require these fractions to be collected reliably, continuously and in high quality. Only when the supply of these materials is sustainably secured and they reach the quality standards of the purchasers, companies start to invest in recycling capacities and economic relationships can be established so that a stable demand develops.

It cannot be overstated that the key to success lies in the first part of the waste management chain – the collection phase. It is not only the most often ignored part of the chain but also the most costly. It is estimated that 60-80% of disposal costs are related to collection. Mistakes made here result in high costs that cannot be compensated for by any technology, no matter how sophisticated. This is exactly where this guide is helpful in sharing successful examples that use technologically simple means to manage the generated waste very efficiently and cost-effectively. Moreover, it provides practical instructions on how such systems can be developed, implemented, and operated.

Cities and municipalities in low- and medium income economies are well advised to structure their waste management to maximize the strengths in their communities: the potential of people who, with their skills, talents and creativity, can achieve much more than any technology, no matter how sophisticated. In almost all low- and middle-income economies, there are people working in this field, sometimes for generations, as is the case for workers in the informal sector, or waste pickers, as they are often disparagingly referred to. The informal sector encompasses people who operate outside the formal economic system and earn their living by recycling waste fractions that would not be possible in the formal labor market. Their skills and experience in dealing with waste, as well as their entrepreneurial

skills, have received far too little attention in the design of waste management systems. The examples of Zabbaleen in Cairo, Egypt, who recycle over 80% of the waste they collect, or Hasiru Dala in Bangalore, India which provides a comprehensive and cost-effective waste disposal service to over 30,000 households on a purely private-sector basis and recycles around 90% of the dry waste, and several other examples all over the world show that these approaches can be very successful[47] .

However, the solution does not lie in simply transferring the tasks of waste disposal to the informal sector. This would overestimate the capabilities of these people and disregard their social status. The challenge is to integrate these people into the municipal waste management system in a way that allows them to make the best use of their skills while contributing to the well-being of the individual worker, the community and the environment. This requires active management and input by the communities. They must develop, organize and regulate the waste management system with the participation of the informal sector and other actors in the waste market. This Guide provides guidance on how to do this and presents organizational models that consider the different framework conditions in the municipalities.

Sustainable, environmentally sound, resource-efficient waste management is feasible through simple technical means, and can be cost-efficient and affordable. This Guide offers inspiration and guidance to empower as many communities as possible with the knowledge to seriously consider and implement a reliable waste collection system that is aimed at separate collection and recycling. These communities will be rewarded with hundreds of green jobs, a clean city, a proper environment, and satisfied residents.

[47] An impressive compilation and description of such projects can be found at: Danielson, J.: Leave no trace; Vital lessons from pioneering organisations on the frontline of waste and ocean plastic; Published in 2020 without date; https://hasirudala.in/wp-content/uploads/2020/12/Leave-No-Trace.pdf

Glossary

Extended Producer Responsibility	Extended Producer Responsibility is a concept where manufacturers and importers of products should bear a significant degree of responsibility for the environmental impacts of their products throughout the product life cycle, including upstream impacts inherent in the selection of materials for the products, impacts from manufacturers' production process itself, and downstream impacts from the use and disposal of the products. Producers accept their responsibility when designing their products to minimise life-cycle environmental impacts, and when accepting legal, physical or socio-economic responsibility for environmental impacts that cannot be eliminated by design (Definition by OECD) https://www.oecd.org/env/waste/factsheetextendedproducerresponsibility.htm
Household waste	Household waste refers to waste material usually generated in the residential environment. Waste with similar characteristics may be generated in other economic activities and can thus be treated and disposed of together with household waste.
Marine litter	Any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; accidentally lost, including material lost at sea in bad weather (fishing gear, cargo); or deliberately left by people on beaches and shores (Definition by UN Environment) https://www.unep.org
Post-sorting	Measure to improve and ensure the quality of sorting waste into different fractions by the waste disposal service
Pre-sorting	Sorting of waste into different fractions at the place of generation by the waste generator
Primary collection	Collection of waste by the disposal service from the waste generator - First process step in the disposal chain.
Recycling	Recycling is defined as any reprocessing of material in a production process that diverts it from the waste stream, except use as fuel. It includes both reprocessing as the same type of product, i.e. of an identical nature, and reprocessing as products of similar nature but for different purposes (Source: OECD Library) https://www.oecd-ilibrary.org
Source segregation	Segregation of specified waste at source by the waste producer, in such a way to make it suitable for separate collection by avoiding such specified waste from being mixed, combined or contaminated with other potentially polluting wastes, products, materials or packaging
Transfer	Transfer, as an operation, is the moving of waste from a primary collection vehicle to a larger and/or faster vehicle in order to save transport costs. This operation often takes place at a transfer station (Coffey / Coad 2010)

Waste generators	A waste generator is a person or organisation which decides that an item is of no further use and therefore wishes that it is taken away. (The word “producer” is not used since this infers some type of industrial production process.) (Coffey / Coad 2010)
Waste provision	Process in which waste is made available by the waste generator for collection by the disposal service at a defined location or in receptacles specified for this purpose

Annex 1 Case Studies that relate to enhancing collection and segregation of waste to reduce marine litter in the APEC economies

The Guide presents a step-by-step approach to establishing cost-effective waste manage systems that serve an entire population in a community using low-tech and labor-intensive means. While the Guide is based off of an approach taken in Tan An City, Viet Nam, Annex 1 below highlights case studies presented at the APEC Waste Symposium in July 2022 that offer similar methods to the Tan An case study from the Guide for developing waste collection and separation systems in small to medium-sized and densely populated urban areas as well as tools for conducting feasibility studies and assessing solid waste capacity for municipalities. The case studies were prepared with a template that prompted the lead project officer to describe the project and provide the project objectives, lessons learned, strengths and weaknesses, obstacles to success, and any advice given to the reader.

These case studies are designed to provide readers with additional practical information that highlights how low-cost techniques for solid waste collection can be optimized and applied within municipalities based on the geography and demographics of the location.

Case Study #1: USAID's Solid Waste Capacity Index for Local Governments (SCIL)
USAID's SCIL tool, as described below, is a good complement to the Guide, as it deals with the improvement of the enabling environment and provides tools for this purpose. Specifically, the tool can be used to assess local government capacity for waste management services and help identify areas for improvement. This tool could be used to help the user of the Guide with the baseline assessment.

Case Study #2: Hasiru Dala's Dry Waste Collection Centers in Bengaluru, India
Hasiru Dala's work in Bengaluru, India provides a good example of the benefits of involving waste collectors early and often in the design process for waste collection services. Waste pickers, in particular, have become a major player in the recycling market. The case study exemplifies how a steady, reliable supply of recyclables stimulates demand.

Case Study #3: Rethinking Recycling Academy in Denpasar, Bali, Indonesia
Delterra's project on a Rethinking Recycling Academy (RRA) in Bali demonstrates a good example that small-scale, low-technology approaches are cost effective and viable.

In addition to this Annex, the user of this Guide can also refer to the Tan An case study in Annex 2 that is paired with this Guide.

USAID's Solid Waste Capacity Index for Local Governments (SCIL) Tool

Project Name: Building Capacity in Solid Waste Management under US Agency for International Development's (USAID) Clean Cities, Blue Ocean (CCBO) Program

Description of Project

USAID's Clean Cities, Blue Ocean (CCBO) program provides technical assistance to local governments to build their capacity to develop and implement robust solid waste management systems, so they can effectively manage waste in their cities. Local governments have an important role of providing on-the-ground services to control waste and prevent ocean plastic pollution, but often they do not have the institutional capacity (skills, resources, infrastructure, knowledge and ability) to successfully plan, build and operate these systems.

Local governments need to be strong, empowered, and capable to implement domestic solid waste management regulations, plans, and operate effective and efficient local systems. CCBO works in ten economies and more than 25 cities across Asia, the Pacific Islands, Latin America, and the Caribbean.

Objectives

- Assess local government capacity and identify specific areas for improvement through Clean Cities, Blue Ocean's Solid Waste Capacity Index for Local Governments (SCIL) assessment tool.
- Address SCIL results through tailored technical assistance to build sufficient capacity to implement robust SWM systems and advance local circular economies.
- Provide tools and resources to address identified capacity gaps, such as CCBO's Cost of Service Analysis(part of SCIL), which helps local governments determine the costs of its current and future SWM programs, and the Rapid Appraisal Facility Tool (part of SCIL), which enables partners to gather data on and assess waste facilities' capacity and performance.

Lessons Learned

- **Identifying capacity gaps can be a knowledge building opportunity:** Local governments have built capacity through the Solid Waste Capacity Index for Local Governments (SCIL) assessment process. The self-assessment leads a committee of staff across local government agencies through a six step SWM process: (1) Planning; (2) Policy and Legal Frameworks; (3) Financial Management; (4) Service Delivery; (5) Human Resources; and (6) Community Engagement. These six steps help local governments to evaluate their current capabilities in these areas. This allows staff to

develop a report and roadmap highlighting priority improvements in key capacity areas, particularly those that are critical to the development of Solid Waste Management Plans–a learning experience in and of itself.

- **The SCIL process fosters cross-government collaboration:** Since the assessment is locally-driven, conducted as a committee, and with representation from all agencies responsible for the six component areas, it introduces the importance of each component to staff across local government agencies and raises awareness about the linkages between them. This encourages more regular collaboration between agencies in the SWM system.

- **Local governments tend to score highest in the areas of policy and legal frameworks; lowest in the areas of financial management, community engagement and planning:** In several economies, domestic legislation has been established that local governments have replicated, leading to higher scores in this area. However, although these frameworks have been established, local governments lack the financial resources and technical capacity to design, implement, and enforce the systems and services to comply with these policies. Community engagement and planning also frequently scored low, with few instances of cities involving the community or methodically planning waste services before launching them.

Strengths

- **Presents local governments with a methodical, systematic way to examine their SWM capacity:** The SCIL has enabled local governments to work as a team and break down extremely complex systems into workable parts through the tool's six-component approach. The resulting SCIL scores and committee-developed recommendations help government officials to methodically and collectively determine what is most critical for the overall system.

- **Provides a roadmap for incremental improvements:** Although completing the SCIL is just the first step in building a more robust local SWM system, the assessment helps local governments to prioritize areas where they lack capacity, providing a roadmap to make the process of strengthening the city's waste system less overwhelming.

- **Empowers local staff as leaders of change:** The SCIL is voluntary and locally led, which not only builds institutional capacity through the assessment process but empowers local staff to develop recommendations, ensuring they are locally-relevant and championed by agency staff.

- **Measures improvement over time:** The SCIL is replicable and can be done annually to measure and track improvement year over year. Being able to monitor and track these

improvements can be beneficial for local leaders to advocate for additional resources and funding.

Weaknesses

- **Requires continued effort and local government commitment:** It is important to remember that the SCIL only identifies areas of weakness that need to be addressed. It does not solve the problems itself. Local governments must be committed to following through on resulting recommendations to reach solutions.
- **SCIL results are only as good as the inputs:** As with any assessment, the result is only as good as the data it is based upon. Local governments must be committed to providing honest data that will yield accurate scores. Results are confidential and there are no "right" or "wrong" scores.

Factors for Success

- **Local government support and commitment:** Because the SCIL is locally led and internally driven, the buy-in, leadership, and engagement of local governments is essential, not just from one government agency but from all of the agencies involved in the solid waste management system.
- **Honesty and transparency:** The ability to be honest, transparent, and self-critical are essential for the assessment to successfully and accurately diagnose the key issues.
- **Continued collaboration:** For the SCIL to deliver results, continued collaboration is required to address identified gaps (e.g. facilities, financial management). Uptake of CCBO-developed tools can yield continued growth, such as the Cost of Service Analysis to support financial capacity and the Rapid Appraisal Facility Tool to optimize facility operations.

Obstacles

- **Reliance on documentation:** Documentation is required to validate responses but can be difficult or not possible to locate. This can slow the process and even impact resulting scores.
- **Navigating data sensitivities:** Staff can be reluctant to reveal agency financial data as part of their SCIL documentation.
- **Identifying the appropriate participants:** Having representatives participate across local government agencies that are responsible for the six components of the SCIL is essential to achieve accurate scoring and recommendations that are relevant and locally tailored.

Advice and recommendations

- **Technical guidance is available for this process:** Clean Cities, Blue Ocean has established a library of free technical trainings on topics including local capacity building. You can access this and other trainings through the program's virtual learning hub.

Hasiru Dala in Bengaluru, India

Project Name: Inclusive, innovative and sustainable Dry Waste Management Collection

Description of Project:

The city of Bengaluru has built a model of a decentralized waste collection network called the Dry Waste Collection Centers (DWCCs). The DWCCs receive domestic inorganic waste from the neighborhood to sort which is then sent for processing and recycling. They were set up following the Lok Adalat's intervention directing the municipal corporation to set up these centers to enable ward level recycling. The infrastructure cost of these centers (space, shelter, electricity, water, collection vehicles) are paid for by the city's urban local body (BBMP).

Of the 198 wards in the city, 141 have functioning DWCCs. The management of the DWCCs have been given to waste pickers and self-help groups; thus the model runs as a public private partnership model. About 46 centers are run by the waste pickers and Self-Help Groups supported by Hasiru Dala. The waste pickers have now become entrepreneurs hiring anywhere between 5-20 waste pickers depending on the quantum of waste received. As a resource organization, we support 38 DWCCs. Hasiru Dala's role as a Resource Organization (RO) is to oversee the collection, the data transparency, validation, value creation, grievance redressal, and social inclusion of the informal waste workers especially the waste pickers.

Objectives

- To promote inclusive, innovative, and sustainable livelihoods for the waste picking community & other informal collectors in Bengaluru, Karnataka
- To enable waste pickers to become entrepreneurs and integrate into the waste management system in the city
- To provide quality services to the citizens
- To encourage and facilitate innovation in both technology and business models to sort waste, and find alternative uses of waste that hold value
- To integrate waste pickers into social welfare schemes and support the waste pickers to formally organize so they can represent themselves in forums
- To carry out research to measure the reduced carbon footprint on account of the new systems

Lessons Learned

- Collaborative effort - zero waste as well - decentralized collection - professionalization - timeliness - traceability - data and tech adaptation for the waste picker operator

Strengths

- The integration of the informal waste pickers to operate the DWCC creates predictable income and job security for thousands of street-based waste pickers.
- Efficiency in dry waste management is possible due to the knowledge and skills of the waste pickers who operate the DWCC, ensuring that recyclable waste does not reach landfills.
- DWCCs became one of the primary suppliers of a robust recycling circular economy.

Weaknesses

- The lifeline of the DWCCs depends on the political will of the urban local body and the state despite the institutionalization of the practice in SWM policy of the state.
- The quality of waste arriving at the DWCC depends on the proper implementation of the SWM policy and efficiency of source segregation by the residents.
- The economic viability of the DWCC operations depends on receiving a high quantity of waste. If there is a disruption due to policy changes, like an exclusionary tender process, or monopoly of waste collection by big waste management companies, then the DWCC operations cannot be economically viable.

Factors for Success

- **Integration of informal waste workers:** Hasiru Dala is working with the waste pickers who have years of knowledge and skills for resource recovery from waste. Their inclusion in the dry waste management at the local level ensured higher levels of resource recovery from dry waste. The efficient micro-planning and routing of the DWCC designed by the waste pickers also reduced the black spots. Not only did it help in reducing the quantum of waste reaching landfills but also helped in ensuring predictable incomes and livelihood for the workers. Most of the waste pickers who operate the DWCC have generated employment anywhere between 4-10 jobs. The professionalization of their service also brings with it social security benefits of formalization for the workers.
- **Information, Education, Communication (IEC):** Educating communities to successfully segregate their waste and changing traditional beliefs of caste-based

occupations and notions of purity and pollution. It required intense and persistent citizen engagements sessions to address the stigma, taboos among the citizens and to bring the behavioral changes of source segregation of waste and for them to give waste to the waste picker-operators of DWCC. It brought in higher rates of segregation as well as changed the perception of the citizens about the waste pickers, as professionals who contribute to making the city clean. Our endeavor has impacts not just on the environment but also on the sociocultural beliefs of the city.

Obstacles

- The biggest obstacle has been the resistance from within the system. For a SWM system that has been centralized for decades, accepting the decentralized model of waste management, more importantly inclusion of the informal waste pickers in it was beyond the conventional norms. It took years of advocacy and the waste pickers conducting door-to-door collection without pay to show that they can manage the dry waste effectively for policymakers to include them in the operations of the DWCC.

- The obstacles can be overcome with the support of the other stakeholders like the elected representatives and administrative officials. When we proved that the informal waste pickers were saving the Bengaluru urban local government INR 84 crores per year in transportation and collection charges alone, the city issued Occupational Identification cards to the waste pickers, thereby recognizing their contribution to the system.

Advice and recommendations

- **Stakeholder engagement and institutionalizing practices:** Hasiru Dala works with the existing formal advocacy for the creation of inclusive policies and successful institutionalization of our good practices ensures the sustainability of livelihoods for the workers as well as our project.

- **Market connectivity:** By establishing the DWCCs as one of the primary suppliers in the circular economy of recycling was an essential part of ensuring their economic viability.

Rethinking Recycling Academy (RRA) in Denpasar, Bali, Indonesia

Project Name: Rethinking Recycling Academy (RRA)

Description of Project:

The Rethinking Recycling Academy (RRA), a Delterra initiative, partners with villages in Bali, Indonesia to transform their Material Recovery Facilities (MRFs), known locally as TPS3Rs, by working hand-in-hand with government officials, waste collectors, local implementation partners and multinational industry players.

The Academy provides capability building programs coupled with up-front capital support (when available) and on-the-ground operational support. Today, Delterra is operating in two geographies, Indonesia and Argentina, with the goal of developing solutions that will eventually scale domestically and globally.

Delterra does this by delivering support in four focus areas:

- **Institutional capability building** – enabling villages to have waste management regulation, a waste management entity, an annual village budget planning and a waste management task force.
- **Community behavior change** – top-down and bottom-up educational approach for communities to separate their waste.
- **TPS3R operational optimization** – optimizing capacity of small-scale MRFs through infrastructure upgrades and machinery support and optimizing processing and collection system.
- **Use of digital tools** – enabling waste data monitoring and control, enabling easier collection of waste fees, using a chatbot to promote source separation.

Objectives

- The objective of the project is to develop and scale sustainable solutions to waste management and recycling, focused on the full waste stream including harder to recycle materials, like organics and plastics.
- On the supply side, Delterra aims to develop and scale self-sustaining, community-led recycling programs that capture the full value of all waste.
- In addition, Delterra works to demonstrate that a full value chain approach, from institutional capacity building to digital enablers, and the development of offtake markets for materials, enables long-term sustainability.

Waste collection with motorized cargo tricycles

Impact to date in Indonesia

- **Environmental impact:** Achieve a target of 50-80% household coverage in the village (according to waste that can be processed in the village TPS3R) to be served with source-separated waste collection (organics, recyclables, and residue) to enhance recycling potential and divert waste from landfills.
- **Social impact:** Engage and support six local communities through job creation and upskilling for 83 essential waste workers with ethical treatment (e.g. health insurance) and basic standard operating procedures (SOPs) to collect, sort, and process waste in a safe environment.
- **Economic impact:** Develop efficient and financially sustainable waste management systems that maximize quality and quantity of recovered waste across villages and that can be managed by the village stakeholders.

Lessons Learned:

- End-to-end approach: Provided some key bottlenecks in the value chain are addressed, self-sustaining models can be achieved at a community level. In this case, the primary bottlenecks included the development of institutional capabilities, the participation of households in waste segregation, efficient operations at the local MRFs and the collection of user fees.

- High participation rates from households (60-90%) can be achieved, but mass communication is not enough. Personal face-to-face engagement and commitment to system design change (e.g., scheduled collection) is what drives real change. Delterra's approach for education is door-to-door, while also exploring lighter touch channels (e.g. Whatsapp chatbot and online training).

- Digital solutions can have a significant impact on key performance e.g., with payments for collection and longevity of adoption of source separation. For example, the use of digital RRA Operations Platform in the villages has improved payment collection from ~30% to 80+%, whilst reducing financial bureaucracy, time needed for financial consolidation, and increasing transparency.
- Larger TPS3Rs with a size of 1000+ sqm are more cost effective to transform. Sites smaller than <400 sqm are inadequate for managing the whole waste stream of a village, particularly given organic waste represents 70% of the waste stream and requires space to process.
- Government commitment and top-down village support (e.g., government decree) is required to enforce change (e.g., drivers not picking up mixed waste), unlock resources (e.g., village educators) and to overcome challenges (e.g., incorporating informal waste collectors into the system).
- Investing in human resources is as important as investing in infrastructure and equipment. Capability building is integral, particularly in areas such as financial management and business management where the starting point is usually very low.

Strengths

- The bottom-up / community-based approach of the program has enabled strong buy in and trust from the village government to transform their waste management system.
- The small-sized operation has enabled the system to run at relatively low cost, making it easier for a village to run it themselves, implement a low waste management fee (around $USD 2 – 3 dollars/household per month), and allocate a reasonable amount in their yearly village budget for the operational cost.

Weaknesses

- The ‘1 village - 1 MRF’ model is limited by the capacity of the MRF. Even after optimization, a MRF of around 1500m2 is commonly still not able to process the waste from the whole village (20,000 – 30,000 people) therefore needing additional solutions at regency level, such as centralized organics processing or additional processing sites.
- While the bottom up, full value chain approach is very effective, it is harder to scale in a decentralized setting such as Bali and must therefore be combined with a more top-down, state or regional approach, from which a broader user base can be impacted.

Factors for Success

- Right sizing for the community and avoiding highly technical solutions works best: simple treatment solutions, with low-cost collection, and a strong focus on behavior change will be more sustainable in the long term
- Government buy-in is absolutely necessary for the program success as, in the end, waste management is a municipal competency, and the local / regional government is the one making all of the decisions and allocating the necessary resources (assignment of a waste management taskforce, allocation of village funds, ratification of regulation, etc.)
- High participation rates from the community and drivers’ adherence to the scheduled waste collection are also key to enable the TPS3R workers to also process the waste streams properly and not have to deal with the high amount of mixed waste / residue.

Since collection fees are the largest source of revenue, the village needs to charge an adequate but appropriate fee, to promote both high payment collection rates and financial sustainability.

Post-sorting of organic waste

Obstacles

- One of the biggest obstacles is the size of the TPS3R, which may not be large enough to accommodate the waste from the whole village. Simple and cheap composting solutions are needed as 70% of the waste is organic; however, current methods require considerable processing space which is difficult to secure in densely populated areas.
- The infrastructure and waste flow design often are not optimal, necessitating upgraded infrastructure, equipment, and ways of working for workers to ensure that the TPS3R can run as effectively and efficiently as possible.
- Most waste collection services are run by independent waste collectors, which are informal, privately owned entities and not clearly known or organized by the village. The numbers and coverage sizes of these independent waste collectors vary; there could be 10-20 in a village and the small ones may service only around 20 households. This fragmented collection service poses obstacles when it comes to being integrated into the newly-formed system for a number of reasons – they need to be clearly identified and mapped, the village needs to negotiate with them to reach a standard collection fee and they need to be trained in line with source separated collection systems.

Advice and recommendations

In our experience, an end-to-end program encompassing the four focus areas at the same time (institution and financial sustainability, behavior change, operations, and digital enablement) is very important to ensure that the whole system is transformed fully. They are all interlinked and therefore, a program focusing on only these parts will threaten the sustainability of the whole waste system.

Annex 2 Case Study WWF pilot project Tan An / Viet Nam

1. Background

As part of its global commitment to the conservation of natural resources and biodiversity, World Wide Fund for Nature (WWF) is strongly involved in the international negotiations on marine plastic litter and plays an active role in shaping the policy environment. On a domestic level, WWF supports Governments in the development and implementation of legal measures to minimize plastic production and consumption and promote so-called "extended producer responsibility" schemes, which oblige manufacturers and distributors of plastic products, especially packaging, to contribute to the costs of environmentally sound disposal of plastic waste. These activities conducted on a domestic level are complemented by initiatives on a local level. Arising from the finding that a major cause for marine pollution, in particular with plastic waste, is a lack of sufficient waste management systems inland. Therefore, WWF has launched a pilot project to find out and to demonstrate how the causes of marine litter can be combated on a local level by improving waste management services even with limited financial resources.

A significant amount of plastic waste entering the oceans is stemming from only a few economies in Southeast Asia, of which Viet Nam is one. The Mekong River is amongst the most important entry paths for marine litter worldwide. WWF has therefore selected the Province of Long An in the Mekong Delta as a model area. Long An is a typical province for this region with predominantly rural structures, some urban agglomerations, and its capital Tan An. More than 80% of the 1.5 million inhabitants live in rural areas, while about 10% live in the capital Tan An.

To prepare the project, WWF has commissioned a feasibility study[48] in which the present waste management system was analysed and various alternatives for the improvement of the waste management in Long An Province were developed and assessed. Key findings were:

- The central causes for the input of waste, especially plastic waste, into water bodies were identified to be poor or even absent of collection systems on the one hand, and the inadequate disposal of waste in unsecured dumps on the other. This is especially the case in rural areas. Only about two thirds of the population in the Long An Province are connected to a regular waste collection system.

[48] Infrastruktur & Umwelt: Development of a Waste Management Concept for Long An Province / Viet Nam Darmstadt / Germany, March 2019 (not published – available at author)

- There is a high demand for all types of recyclable materials contained in the waste including for compost and compost products.

- At the local level, the main challenge is to ensure regular waste collection at reasonable cost. At the provincial level, environmentally sound disposal facilities are to be realised and the environmental standard of existing facilities needs to be improved, respectively.

2. Collection Concept

The comprehensive recovery and recycling of waste turned out to be the most suitable option in terms of both ecological and economic criteria. Segregation at source and separate collection are essential for such a strategy. However, experience in many economies shows, that the desired quality of segregation at source is often not complied with by a sufficiently large number of households and waste generators. The collection concept must take these weaknesses into account. For this reason, the collection concept implemented a method to enhance quality control of collected waste. The waste collection staff conducts an immediate check of the sorting quality and post-sorting of the collected fractions in the event that households and other waste generators have not sorted the materials well or not at all. This quality control step was to prevent unsorted waste from being mixed with the pure recyclables and the organic waste. Resulting from this method, a high quality of the collected waste was achieved, which is particularly crucial for sustainable demand and high revenues.

Figure 1: Type of collection cart used in the pilot project

Post-sorting can be either carried out by the waste collector directly during collection, or in a centralised sorting facility to which the waste is transported without being compacted. In Tan An City the administration opted for the ‘sorting at cart’-model. The waste collectors were provided with trolleys equipped with a sorting table on which receptacles provided by the

households for collection can be emptied and waste can be sorted. Figure 1 shows the type of collection cart used with sorting table.

3. Objectives of the Pilot Project

The main objective of the pilot project was to test the feasibility, effectiveness and efficiency as well as social acceptance of the separate collection concept in practice. In particular the cost and revenue balance aimed to evaluate whether high collection costs can be compensated by revenues and other cost savings, in particular landfilling cost. For example, the personnel requirements for such a labor-intensive collection concept are significantly higher compared to conventional collection concepts. At the same time, however, meaningful additional employment opportunities are created. The strengths and weaknesses of the approach were to identify in order to optimise the concept and adapt best to the local framework conditions.

Accompanying monitoring and evaluation measures were undertaken to derive parameters like collection performance and waste composition, and to learn about the interaction of the persons involved in the collection process. Interviews were conducted with residents, waste collectors and informal sector people to obtain their attitudes and experiences with the collection concept and other information relevant for planning of similar projects. The following parameters were monitored and evaluated:

- Collection performance and planning data
- Willingness of the residents to cooperate
- Interaction of the various actors and process steps
- Opportunities and willingness of the informal sector to participate
- Cost and revenue balance

The pilot project forms the central basis for optimising the collection concept and its roll-out to the other quarters of the city and the throughout the Province of Long An.

4. Pilot Area and Project Execution

The pilot project was carried out in Ward 3 of Tan An City, the capitol of Long An Province in the Mekong Delta in the south of Viet Nam. The project was launched on 1 August 2020 and is still ongoing.

A pre-test was carried out in the Binh Dong 2 quarter to help authorities examine the feasibility of the concept and suitability of the waste collection equipment. Figure 2 shows an aerial view on the pilot area; Table 1 depicts the basic data of the pilot areas.

Figure 2: Aerial View of Ward 3 (blue line) and Quarter Binh Dong 2 (red line)

(Source: https://satellites.pro/Vietnam_map#Y10.533899,106.412330,16)

Table 1: Basic data of Ward 3 and Bin Dong 2

Parameter	**Ward 3**	**Quarter Binh Dong 2**
Population	**19,017**	**1,855**
Number of buildings	**4,823**	**432**
Number of households	**4,775**	**430**
Commercially used buildings (shops, restaurants, administrations…) number / share thereof used only for non-residential purposes mixed use (residential and non-residential)	1,175 / 24% 48 / 1%* 1,127 / 23%	83 / 20% 4 / 1%* 79 / 19%
Total length of streets [m] (passable with a truck)	**17,698**	**2,376**
Total length of alleys [m] (not passable with a truck)	**24,196**	**3,682**

The purpose of the pre-test was to evaluate the practicability and procedures and to gain basic data. Three fractions were collected separately:

- Organic waste
- Recyclable waste
- Residual waste

The separate collection of organic waste was very effective with over 80% recovered and a very high purity. The share of impurities was below 1% by weight. The recovery rate for organic waste and the diversion-from-landfill rate could have been higher if the composting plant would invest in a suitable shredder, so that the households could be instructed to also give the coconut shells to the organic waste fraction. Coconut shells account for up to 10% of the waste composition and had to be discarded together with residual waste.

In contrast, the results for recyclables did not show as high a collection rate. Only 18% of the recyclable materials were recovered. This is mainly due to the fact that households retained their habits and sold the recyclables to itinerant collectors from the informal sector or left it to them for social reasons.

The initial intention when designing the collection concept was to contribute significantly to covering the costs of waste collection through the recovery and sale of dry recyclables as part of public waste collection. The informal recyclables collectors were to be offered employment and income opportunities within the public waste management system. Due to the additional human resources required, this would have been easily possible. However, this would have required a significantly longer preparation time for the project and met with reservations from the city. In view of the very low quantities of separately collected recyclables and the weak recovery effectiveness it was decided to reduce the number of separately collected fractions to two – organic waste and residual waste. In parallel, people were encouraged to hand over recyclables to the informal sector. The organizational concept finally looked as presented in Figure 3.

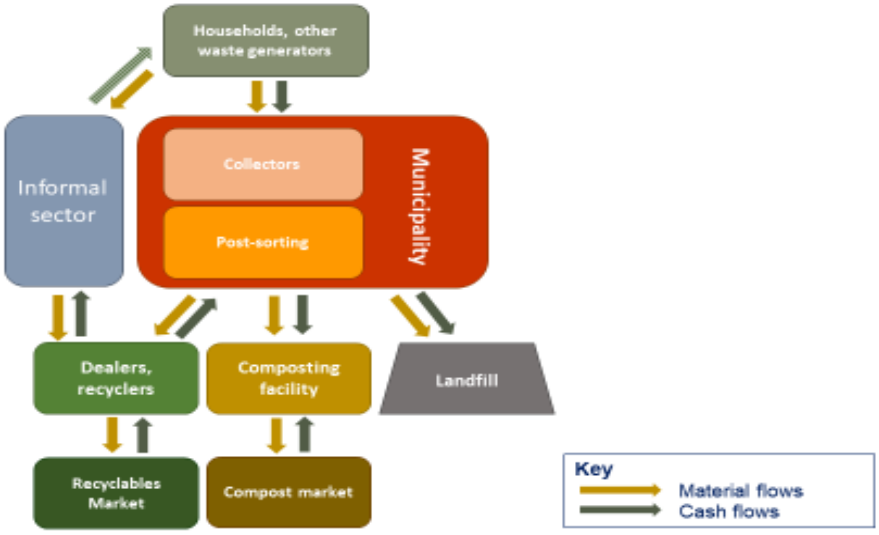

Figure 3: Organization model in the pilot project

5. Findings[49]

Labor-intensive separate collection with immediate post-sorting has proven to be very suitable for residential areas with predominantly private households and small businesses. The separately collected and directly post-sorted fractions have a very high-grade purity and quality. High collection and recovery rates of more than 80% were achieved, especially with organic waste fractions. Depending on the actual possibilities to recyclable different waste fractions, more than 60% of the total waste could be diverted from landfilling.

Hand-pushed trolleys can be very suitable to collect waste within densely populated flat areas with short walking distances and paved roads and paths. In thinly populated areas with long walking distances and in regions with steeper inclines and declines, however, the use of hand-pushed trolleys is less suitable. Here, the use of motorized collection equipment is necessary; otherwise, collection would become too time-consuming, inefficient and costly. The high weight of the filled trolleys cannot be handled manually if the slope was too steep.

For waste collection in rural areas, which are usually considerably more sparsely populated than urban areas, collection with hand-pushed trolleys is not an option. Motorized vehicles are needed to efficiently cover the longer collection and transport distances. Motorized cargo tricycles have already been identified as particularly suitable. These can be driven either by a combustion engine or electrically.

All waste workers considered the workload of collecting and post-sorting waste to be manageable. None of the workers found the job to be too strenuous or difficult. Overall, the interview results indicate a high level of commitment and satisfaction of the waste collectors with their work. This is a very encouraging result since they have a crucial role and contribute significantly to the success or failure of the separate collection approach. Even higher motivation and job satisfaction could most likely be achieved through rewards or financial incentives for good performance.

In commercial areas and at other non-household waste generators the quantities of the separately collected materials were lower. In particular, for sites generating large waste quantities such as big office buildings, hotels, schools and the like, the relatively small handcarts are less suitable. Emptying, checking and, if necessary, post-sorting large quantities of waste is not very practical with the trolleys. For such sites, other solutions are needed, e.g. collection of waste with small pick-ups or tricycles without compaction, The

[49] For details see: Pfaff-Simoneit, W.: Reduction of Marine Litter by Improved Waste Management in the Mekong Area, Viet Nam, Pilot Project Separate Collection, Final Evaluation Report, Darmstadt / Germany October 2021 (not published, available from author) The Evaluation Report contains recommendations for the roll-out to the whole city and for separate waste collection in rural areas.

post-sorting is to be carried out in a nearby simple sorting plant. Besides, in large buildings with several waste generation points, in-house systems for separate collection need to be implemented. Approaches for separate collection in commercial areas were proposed, but not implemented in the frame of the pilot project.

6. Cost and Revenue analysis

Although the costs of the separate collection combined with immediate post-sorting are considerably higher compared to the currently applied collection system, the total waste management cost could be significantly reduced. This is mainly due to the reduction of gate fees to be paid for the disposal of residual waste. If the city of Tan An were to implement the separate collection concept in the whole city, it is estimated that the amount of waste to be disposed of on the landfill could be reduced by more than 50% and cost savings in the range of 10% could be achieved as Table 2 shows. Further contributions to cover the waste management cost would be possible through the sale of recyclables and organic materials. However, such sales could not yet be realised within the scope of the pilot project.

Table 2: Waste management cost in Tan An in case of rolling-out of the collection concept

[EUR]		Organic waste			Residual waste			Total cost
		Quantity [tons/day]	Specific cost [EUR/ton]	Cost per day [EUR/day]	Quantity [tons/day]	Specific cost [EUR/ton]	Cost per day [EUR/day]	Cost per day [EUR/day]
Collection	Trolley	37	17,31	640,47	41	7,03	288,23	928,70
	Tricycle	1	17,70	17,70	1	17,70	17,70	35,40
	Box truck	2,5	9,50	23,75	8,5	9,50	80,75	104,50
Post sorting		2,5	9,00	22,50	8,5	9,00	76,50	99,00
Transport		40,5	16,74	677,97	50,5	16,74	845,37	1.523,34
Disposal					50,5	14,81	747,91	747,91
Total				1.382,39			2.056,46	**3.438,85**
					Current cost			**3.741,01**

Note: 1 EUR was equivalent to about 1.12 US$ at the date of the evaluation

Further cost reductions in the range of about 5% could be realised if coconut shells were collected together with organic waste, another 10% could be reduced through sorting out nylon bags and sell them for recycling. If Tan An were ready to invest in more efficient transport trucks, another around 10% of cost savings could be realised.

In total, the achievable cost savings and contributions to cost recovery through recycling are in the order of 30 – 35% compared to the current system

7. Impacts on local solid waste policy

Given the very positive experience and encouraging results of the pilot project, the People's Committee of Long An Province has in its announcement No: 313/TB-UBND from January 27, 2022, which:

- acknowledged the outcomes of the project and appreciated the support of WWF;
- assigned the People's Committee of Tan An city to continue to maintain the separation of domestic waste at source in Ward 3, develop an appropriate plan and roadmap to deploy and replicate the model throughout the city;
- assigned the Department of Natural Resources and Environment to monitor and urge the implementation of waste separation at source in districts, towns and cities; resolve difficulties and problems within their competence and make reports according to regulations,
- assigned People's Committees of districts and towns to study, develop plans and implement waste separation at source in accordance with the actual situation of the locality.