Work Plan for Reduction of SLCPs from Municipal Solid Waste Management in Medan City, Indonesia

2019 - 2025

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Yayasan Pendidikan Graha Kirana: Tengku Kemala Intan

Design and Layout

Institute for Global Environmental Strategies (IGES): Shino Horizono

Published by

Institute for Global Environmental Strategies (IGES) and Climate and Clean Air Coalition – Municipal Solid Waste Initiative (CCAC-MSWI)

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Citation

IGES, CCAC-MSWI (2019) Work Plan for Reduction of SLCPs from Municipal Solid Waste Management MSWM in Medan City, Indonesia: 2019-2025. Institute for Global Environmental Strategies.

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FOREWORD

All praises and thanks be to The One Almighty God, for His generosity so that the book of Work Plan for Reduction of SLCPs from Municipal Solid Waste Management in Medan City, Indonesia: 2019 – 2025 can be completed on schedule.

The increase of population, the growth of economy and the development in Medan City often causes various externalities, one of which is related to environmental sanitation, especially the issue of waste management. These externalities must be addressed immediately, as mandated by the RPJMN 2015-2019 that the target of residential area development is achieved through a target of increasing access of the citizen toward proper sanitation (domestic wastewater, waste and environmental drainage) into 100 percent.

It is fully realised that a comprehensive and integrated waste management system from upstream to downstream is needed. At the decision-making level, waste management must be seen as a challenge as well as an opportunity to change people's behaviour into a clean and healthy life. Therefore, partnerships are needed in order to increase capacity and mobilise resources.

We do not pretend to be seen different, but this work plan is slightly different from what we have had so far, by the involvement of multi stakeholders through Focus Group Discussions (FGDs) and in-depth field observations to further optimise the availability of data and information which finally results in a list of excellent proposed activities to be implemented in Medan City.

Of course, the effort to finalise this book will not be achieved without the cooperation and support of various parties. We owe thanks to various parties including (I) CCAC – Municipal Solid Waste (MSW) Initiative and the Institute for Global Environmental Strategies (IGES), which are our main partners in completing this great work. We will always support IGES to be an agent of change in realising the global transition towards sustainable development; (II) Graha Kirana Foundation as a local partner who has also contributed to providing an understanding of solid waste problems in Medan City; (III) Resource persons who have taken the time to provide valuable information that we need; and (IV) many parties that we cannot mention one by one.

Finally, I hope this work plan can improve our capacity to develop work plans and priority programmes in a clearer framework. We believe that all of our hard work will benefit for the performance improvement of residential development in Medan City.

Ir. Wiriya Alrahman, MM
Regional Secretary of Medan City

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EXECUTIVE SUMMARY

Waste management has been one of the major issues in many cities especially in developing countries. Municipal solid waste landfills are the third largest source of global anthropogenic methane emissions. Meanwhile, open burning of garbage and incomplete combustion of fossil fuels from waste trucks emit black carbon. These substances have a relatively short lifetime in the atmosphere but have significant influence in warming the near-term climate, and are called Short-Lived Climate Pollutants (SLCPs). The Climate and Clean Air Coalition (CCAC) is one of the global efforts committed to improve air quality and protect the climate by reducing SLCPs across different sectors. With support from CCAC's Municipal Solid Waste Initiative, a rapid assessment was conducted during 2017-2018 to understand the status, challenges and opportunities of waste management in Medan City in North Sumatra Province of Indonesia. A Work Plan has been prepared considering the findings of the rapid assessment and organisation of multi-stakeholder consultations with relevant local agencies and key stakeholders to improve waste management and to reduce SLCPs in Medan City on a mid-to-long term basis.

This Work Plan provides comprehensive and up-to-date analysis on the status, challenges and opportunities of waste management in Medan City, including relevant regulations and policies, administrative structure, waste management cost, waste quality and quantity, waste collection, 3Rs (reduce, reuse, recycle), and final disposal. Based on such findings and the results of a series of consultation workshops held with relevant stakeholders, a set of new targets was suggested. They were made consistent with the national target set force by the Presidential Regulation No. 97/2017 on National Policy and Strategy on Management of Household Waste and Waste Similar to Household Waste to achieve 30% waste reduction and 70% waste treatment by 2025. In order to achieve those targets, the Work Plan suggests focusing on six specific areas, and detailed activities were proposed under each strategic goal. The Work Plan also shows strategies and a path toward achieving the targets as well as providing key performance indicators to monitor and evaluate the progress of implementation.

It was estimated that, if Medan City continues the current waste management scheme (business-as-usual or BAU scenario), the net greenhouse gas (GHG) emissions including SLCPs could reach up to 1,200 kg CO_2-eq/ton. However, if Medan City can achieve 100% waste collection and 10% reduction of waste, GHG emissions could be reduced by 29% compared to BAU scenario. If it can achieve a further 30% reduction in waste, GHG emissions could be 41% less compared to BAU scenario. In addition, the Work Plan also identified that various co-benefits, such as improved sanitation, a cleaner and more liveable city, waste management cost reduction, efficient use of resources, raised public awareness, etc., can be achieved through the application of proposed strategic actions.

However, success depends on the effective implementation of the Work Plan. For this, it is suggested that Medan City should take this Work Plan forward by applying it as the Regional Policy and Strategy (*Jakstrada*) on Waste Management and use it as a tool to involve a wide range of stakeholders, including public, private and civil society, to work together in improving waste management. In the long run, it is hoped that Medan City will become a leading clean and green city representing not just the cities and regencies in North Sumatra Province, but as the key mega city in Indonesia.

1. INTRODUCTION

Today, more than half of the global population live in cities, and the increase in urbanisation and a rise in income levels invite further waste generation. In many cities, waste takes up a disproportionate and unsustainable share of municipal budgets, leaving many communities without basic collection and disposal services. Municipal solid waste landfills are the third largest source of global anthropogenic methane emissions, and open burning of garbage and incomplete combustion of fossil fuels from waste trucks emit black carbon and other greenhouse gases (GHGs) as well as other air toxins. Methane and black carbon in particular are powerful Short-Lived Climate Pollutants (SLCP), substances with a relatively short lifetime in the atmosphere that carry a significant warming influence on near-term climate[1].

The Climate and Clean Air Coalition (CCAC) is one of the global efforts that unites governments, civil society and private sector, committed to improving air quality and protecting the climate by reducing SLCPs across different sectors. In 2012, the governments of Bangladesh, Canada, Ghana, Mexico, Sweden and the United States, along with the United Nations Environment Programme (UN Environment) joined together to launch the CCAC. The current membership consists of 61 state partners and 71 non-state partners including International and Bilateral Agencies and Non-Governmental Organisations (as of October 2018). Due to the significance of SLCP emissions from the municipal solid waste sector, CCAC established the Municipal Solid Waste Initiative to foster partnerships, political will and technical capacity that directly support cities to take action on methane and black carbon reduction and management[2].

The Institute for Global Environmental Strategies (IGES), one of the implementing agencies of the MSW Initiative has been assigned to coordinate and implement the project on behalf of the Initiative in Asia, and has provided technical assistance to municipalities in Cambodia, Indonesia, Myanmar, Philippines, and Thailand. Under its current project activities, the CCAC MSW Initiative has selected Medan City in North Sumatra Province, Indonesia as one of the pilot cities of the initiative to give support in developing a Municipal Solid Waste Management (MSWM) Work Plan to improve waste management and reduce SLCPs.

The project applied an integrated approach and included: (I) waste separation at source and collection at community level; (II) waste reduction through waste banks and composting using both decentralised and centralised mechanisms; (III) proper landfill operations and future advanced technology application; and (IV) training and capacity building for institutional strengthening and partnership building.

Based on this background, during 2017-2018, a rapid assessment was undertaken to increase understanding of the status, challenges and opportunities of waste management in Medan City. A rapid assessment was conducted based on a literature review, technical interviews with relevant departments and stakeholders, and extensive site visits. For some key areas where secondary data were lacking, a primary data collection was undertaken including waste bank surveys and composting surveys. In addition to the rapid assessment, various consultation meetings and thematic workshops on waste banks and composting were organised with relevant departments and key stakeholders to discuss and identify the key challenges and direction of the Work Plan development[3]. Furthermore, a city exchange

1. Climate and Clean Air Coalition – Municipal Solid Waste Initiative: http://www.ccacoalition.org/en/news/municipal-solid-waste-initiative
2. Climate and Clean Air Coalition: http://www.ccacoalition.org/
3. IGES (2018) Status of Municipal Solid Waste Management (MSWM) in Medan City, Indonesia. Quick Review of Status, Challenges and Opportunities. IGES.

learning programme was undertaken in Kitakyushu City and other neighbouring cities in Kyushu, Japan; four key representatives from Medan City participated in the exchange to build capacity through peer learning with the local governments in Japan[4] (Table 1).

Table 1. Developing process of the Work Plan

Activities	2017				2018			
	JAN	JUN	JUL	DEC	JAN	JUN	JUL	DEC
1. Literature review								
2. Consulting meetings								
3. Small workshops								
4. Field visits and interviews								
5. Waste bank survey								
6. Composting survey								
7. City exchange learning programme (Japan)								
8. Analysis and finalisation of the Work Plan								
9. Follow-up activities								

This Work Plan was developed based on the results of the rapid assessment[3] with objective analysis as well as close consultation with, and feedback from, key local stakeholders in order to incorporate local context and priorities. It is therefore expected that this Work Plan will provide the most up-to-date information on the status and challenges for municipal solid waste management in Medan City, and it is hoped that the Plan will serve as the basis for waste management policy to be implemented and followed-up in the near future.

During the development of the Work Plan, the Presidential Regulation No. 97/2017 on National Policy and Strategy on Management of Household Waste and Waste Similar to Household Waste was enforced in a timely manner in 2017. This new regulation is referred by the term "*Jakstranas*", which is the abbreviation from "*Kebijakan dan Strategi Nasional* (National Policy and Strategy). The *Jakstranas* requests all the provincial and municipal governments in Indonesia to develop a Regional Waste Management Policy and Strategy, which is referred by the term "*Jakstrada*" as the abbreviation from "*Kebijakan dan Strategi Daerah*" (Regional Policy and Strategy). The suggested timeline for development of *Jakstrada* by municipal governments is to be completed within a minimum of one year after the issuance of the *Jakstranas* while *Jakstrada* at the provincial level is requested to be in place earlier which is a minimum of six months after the issuance of the *Jakstranas*[5]. However, neither North Sumatra Province nor Medan City have developed a *Jakstrada* (as of December 2018). Therefore, this Work Plan could serve as a basis to develop a *Jakstrada* for Medan City to fulfill its responsibilities as a municipal government.

4. IGES (2018) City Exchange Report: Building City Capacities through Peer Learning. City Exchange Learning Programme in Kyushu, Japan. IGES.
5. Kementerian Lingkungan Hidup dan Kehutanan (2017) Peraturan Presiden Nomor 97 Tahun 2017, Kebijakan dan Strategi Nasional Pengelolaan Sampah Rumah Tangga dan Sampah Sejenis Sampah Rumah Tangga.

2. BACKGROUND

City profile

Medan City is the capital of North Sumatra Province and has an area of 265 km². It is the fourth largest city by population in Indonesia after Jakarta, Surabaya and Bandung. With a total population of 2.2 million people in 2016, Medan City remains as one of the largest cities outside Java Island[6]. The city is located on the north eastern coast of North Sumatra Province and has direct and easy access to the Straits of Malacca, an international seaway that could connect to neighbouring countries such as Malaysia, Singapore and Thailand (Figure 1).

Figure 1. Geographical location of Medan City in Indonesia (Blue area indicates territory of Indonesia)

The city was originally formed from a rapidly growing tobacco plantation industry in the 1800s. Since then, it attracted many labourers and business traders from outside the region including Javanese, Tamils, Chinese, Mandailing, Minang, Aceh and Arabs. This mixed ethnic diversity created the unique characteristics and dynamism that is evident in Medan today[7]. In recent years, the city has also undergone rapid urban development, resulting in some large-scale infrastructure development projects including a new airport, seaport, railway, and toll road. The economic growth rate of Medan City has always been above the regional and national average. According to the Medan City Medium Term Investment Program Plan 2013-2017, the rate of economic growth was 8% in 2011[8]. Medan's Gross Domestic Product (GDP) was Indonesian Rupiah (IDR) 186,049 billion (USD 13.8 billion[9]) in total or IDR 83 million (USD 6,148) per capita in 2016, which is the fourth largest for a city in Indonesia after Jakarta, Surabaya and Bandung[10]. This rapid economic growth

6. Badan Pusat Statistik Provinsi Sumatera Utara (2017) Jumlah Penduduk Menurut Jenis Kelamin dan Kabupaten/Kota Sumatera Utara 2011-2016.
7. Siregar et al. (2018) Cultural Assemblage as Genius Loci: Character Analysis of Medan City Centre District. SHS Web of Conf. Volume 41, 04011.
8. Badan Perencanaan Pembangunan Daerah Kota Medan (2012) Rencana Program Investasi Jangka Menengah (RPIJM) Kota Medan 2013-2017.
9. All IDR to USD exchange rate in this document will use USD/IDR = 13,500 reflecting the mean rate in 2017.
10. Badan Pusat Statistik Provinsi Sumatera Utara (2017) Produk Domestik Regional Bruto menurut Kabupaten/Kota Atas Dasar Harga Berlaku 2014 – 2016.

largely depends on various commercial activities of more than half a million units of small, medium to large-scale industries.

The population is largely concentrated within the south-to-central part of the city. The development in the northern part is lagging behind and some public services including waste collection are partly limited. In order to achieve more balanced development and by taking advantage of the geographical location with good access to the Malacca Straits, the Medan City government is planning to push development towards the northern area including development of an international port as set out in their Medan City Spatial Planning 2010-2030[11] (Figure 2).

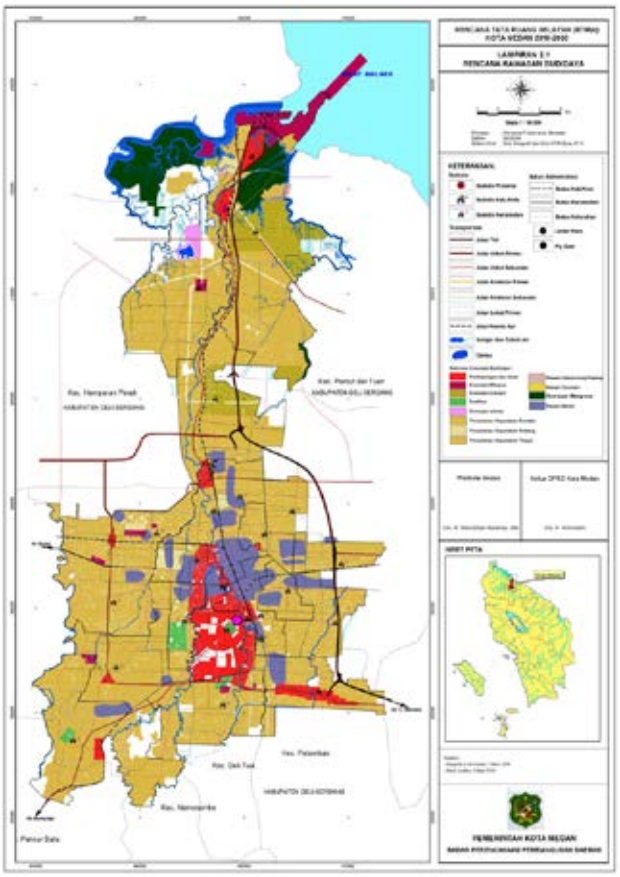


Figure 2. Spatial planning map of Medan City
(Rencana Tata Ruang Wilayah (RTRW) Kota Medan 2010-2030)

Local governance framework

In Indonesia, there is a distinct hierarchy of administrative structure in local governance. Provinces comprise of several cities and regencies where the mayors or regents are elected by popular vote, and each has its own legislative body to administrate local governance. Cities or regencies are divided into sub-districts (*kecamatan*), and sub-districts are further divided into administrative villages (*kelurahan*). Both sub-districts and administrative villages are governed under the city or regency government and their heads are unelected civil servants chosen by the mayor or regent. Each administrative village is then divided into community associations (RW: *rukun warga*), and RW are further divided into smaller units of neighbourhood associations (RT: *rukun tetangga*) which are the lowest level administrative hierarchy for local governance in Indonesia. RT typically consists of 30-50 households and RW consists of five to ten RTs based on the Ministry of Domestic Affairs No. 7/1983 on the Establishment of Community Associations[12]. The leaders of RW and RT are directly chosen by the community members and entitled to receive some incentive or honorarium from the local governments for their services. Medan, however, is a rather unique case since there is no differentiation between RT and RW, and these are formally referred to only as "*lingkungan*". The word "*lingkungan*" literally means "the environment", but in this context, it could be referred as "the neighbourhood". There is no specific reason for this unique terminology other than to be perceived as local wisdom and legalised by Medan City. At the national level, *lingkungan* is formally recognised as one type of the smallest city administrative units. These smallest administrative units serve some positive roles not just in social aspects for self-help and mutual cooperation but also for improvement of neighbourhood environment including waste management[13]. Medan City consists of 21 sub-district, 151 administrative villages, and 2,000 *lingkungan*[14].

11. Badan Perencanaan Pembangunan Daerah Kota Medan (2009) Rencana Tata Ruang Wilayah (RTRW) Kota Medan 2010-2030.
12. Yoseph-Paulus R (2014) Perspectives of planners on adaptation to climate change in Indonesia. Asian Cities Climate Resilience Working Paper Series 9: 2014.
13. Yuliastutia and Saraswatib (2014) Environmental Quality in Urban Settlement: The Role of Local Community Association in East Semarang Sub-District. Procedia - Social and Behavioral Sciences 135, 31–35.
14. Badan Perencanaan Pembangunan Daerah Kota Medan (2012) Rencana Program Investasi Jangka Menengah (RPIJM) Kota Medan 2013-2017.

3. STATUS AND CHALLENGES

3.1. Waste Management Policies and Regulations

Waste Management Policies

The Law No. 18/2008 (Undang-Undang No. 18/2008) on Waste Management stipulates responsibilities of national, provincial and municipal governments in Indonesia. The responsibilities of municipal governments at the city and regency levels are to: a) stipulate policy and strategy for waste management based on national and provincial policies; b) conduct waste management; c) provide guidance and supervision to other parties based on their waste management performances; d) establish temporary disposal sites, integrated waste treatment sites and final disposal sites; and e) conduct monitoring and evaluation of final disposal site every 6 months for 20 years. The Government Regulation No. 81/2012 on Management of Household Waste and Waste Similar to Household Waste stipulates further details on what the municipal governments should do to manage the waste including: a) sorting; b) collection; c) transportation; d) processing; and e) final disposal.

The existing available municipal policy that addresses the waste management issue is the Medan City Sanitation Strategy 2017-2021[15] which was issued in 2016. This is a revised version of the former Sanitation Strategy that puts more emphasis on the implementation of medium-term programmes and activities. It was developed in line with the existing city planning documents, including: Medan City Spatial Planning 2011-2031[16], Medan City Long Term Development Plan 2006-2025[17], and Medan City Medium Term Investment Program Plan 2013-2017[18]. In the Sanitation Strategy, there is only limited coverage of waste management. However, there are five stipulated targets related to waste management as shown in Table 2. Although the Sanitation Strategy is not a dedicated waste management strategy, given the conformity with the existing legal documents, these targets were taken into account in the current Work Plan.

Table 2. Targets in Sanitation Strategy of Medan City 2017-2021, current status & relevant national regulations

Targets in the Medan City Sanitation Strategy 2017-2021	Current status in achieving targets in Medan City	Relevant targets set in national regulations
100% of city area is covered for waste collection	No accurate data available on collection coverage	
Waste that goes to landfill is reduced by 10%	Waste dumped at landfill in 2016 was approximately 1,577 ton/day	Presidential Regulation No 97/2017 sets targets to reduce waste by 30% and proper handling of waste by 70%
City budget allocation to waste management will be increased up to >5%	Current city budget allocation to waste management is 4.4% (FY2017)	
Initiate operation of controlled landfill by 2021 and sanitary landfill after 2022	Open dumping (TPA Terjun)	Waste Law No. 18/2008 requires to operate environmentally sound landfill
Stop illegal dumping in drainage, rivers and open areas	No accurate data available	

15. Kelompok Kerja Sanitasi Kota Medan (2016) Pemutakhiran Strategi Sanitasi (SSK) Kota Medan tahun 2017-2021.
16. Badan Perencanaan Pembangunan Daerah Kota Medan (2010) Rencana Tata Ruang Wilayah (RTRW) Kota Medan 2011-2031.
17. Badan Perencanaan Pembangunan Daerah Kota Medan (2005) Rencana Pembangunan Jangka Panjang Daerah (RPJPD) Kota Medan Tahun 2006-2025.
18. Badan Perencanaan Pembangunan Daerah Kota Medan (2015) Rencana Pembangunan Jangka Menengah Daerah (RPJMD) Kota Medan Tahun 2016-2021.

Waste Management Regulations

Based on this national guidance including other relevant laws and regulations, Medan City has issued several Local Regulations (*Perda*) and Mayor Regulations (*Perwali*) regarding waste management as shown in Table 3. In Indonesian local governance, *Perda* is the highest level local ordinance that requires decision at the local assembly and *Perwali* is a lower level ordinance which can be issued by the decision of the mayor. Although details are not available, the provisions in the currently existing *Perda* and *Perwali* seem to be covering the basic roles, responsibilities and procedure of waste management at the municipal level. Upon development of the *Jakstrada* for Medan City following the Presidential Regulation No. 97/2017 with renewed policies and strategies, it is expected that these local regulations (*Perda* and *Perwali*) will also be updated for consistency.

Challenges and Opportunities: Basic local policy and regulations on waste management seems to be in place, but the actual implementation remains questionable. In terms of law enforcement, *Perda* No. 6/2015 stipulates a fine of up to IDR 5,000,000 (USD 370) for illegal dumping which is one of the major problems for waste management in Medan City. According to Medan City's Cleansing and Landscaping Department (DKP), however, there are a limited number of cases of imposition of fines for illegal dumping. There are no systematic inspection activities or reporting systems to identify illegal dumping. Furthermore, *Perda* No. 6/2015 does not specify any illegality on open burning.

Table 3. Major regulations related to waste management issued by Medan City in recent years

Relevant regulations	Outline of contents
Perwali Kota Medan No. 73/2017 on Implementation of Partial Transfer of the Responsibility on Waste Management from the Mayor to the Head of Sub-district	Optimisation of partial waste management responsibility including cleansing workers management and wages, and also cleansing equipment procurement and maintenance.
Perwali Kota Medan No. 1/2017 on the Position, Organisational Arrangement, Responsibility and Role, and Working Procedure of Regional Government	Regulation of the organisational structure along with the duties and responsibilities of all agencies within Medan City Government.
Keputusan Walikota No.15/2016 on the Merger between DKKM and Dinas Pertamanan into DKP	Merger of DKKM (Cleansing and Aesthetic Department) and Dinas Pertamanan (Landscaping Department) to form DKP (Cleansing and Landscaping Department).
Perda Kota Medan No. 15/2016 on Regional Institutional Arrangement for Medan City	Arrangement of the regional institutional structure for Medan City.
Perda Kota Medan No. 6/2015 on Waste Management	The local government is responsible for ensuring the implementation of appropriate and environmental sound waste management. This regulation stated that the local government could establish a public company to provide waste service (BLUD Persampahan). Furthermore, this Perda supports possible cooperation with third parties for waste management. It also has a clause on illegal dumping and fining such conduct. There is also an incentive-disincentive approach and introduction of Kecamatan's involvement.
Perwali Kota Medan No. 14/2014 on Establishment of Cleansing Service Technical Operating Unit (UPT Pelayanan Kebersihan) and Waste Bank Technical Operating Unit (UPT Bank Sampah) within DKP Medan	UPT Pelayanan Kebersihan is responsible to assist DKP on providing cleansing services within its territory by coordinating with Kecamatan and Kelurahan. UPT Bank Sampah is responsible to assist DKP on conducting waste bank activities.
Perwali Kota Medan No. 56/2012 on the Implementation of Perda Kota Medan No. 10 Year 2012 on Retribution for Cleansing Service	Implementation of Perda Kota Medan (Regional Regulation of Medan City) No. 10 Year 2012 on Retribution for Cleansing Service.
Perwali Kota Medan No. 45/2012 on the Transfer of the Responsibility on the Collection of Retribution for Cleansing Service and Partial Cleansing Service to the Head of Sub-district	Transferring responsibility on the collection of retribution for cleansing service and partial cleansing service to the Head of Sub-district.
Perda Kota Medan No. 10/2012 on Retribution for Cleansing Service	Cleansing service covers: a) waste collection and transportation from source to temporary waste collection points; b) waste transportation from temporary waste collection points to landfill; and c) establishment of landfill. The local government charges a retribution fee to all cleansing services receivers, except for public facilities, based on quality, function, and size of the buildings, location, road classification, and waste volume.
Perwali Kota Medan No. 31/2010 on Waste Separation in Residential, Commercial, Trading, Industrial, Hotel, and Hospital Areas.	Waste separation in residential, commercial, trading, industrial, hotel, and hospital areas.

3.2. Administrative Structure for Waste Management

Administrative Reforms

There have been several transitions of responsibility on waste management including waste collection and transportation among municipal government agencies in Medan City. In the beginning, waste management of Medan city was under the responsibility of *Dinas Pekerjaan Umum* (Public Works Department) before the establishment of the first *Dinas Kebersihan* and *Keindahan* (Cleansing and Aesthetic Department) in 1975. But from 1988 until 2001, waste collection and transportation was managed by a local government-owned company (*PD Kebersihan*: PDK). PDK was established based on the recommendation of the Medan Urban Development Project 1 (MUDP1), a master plan project supported by the Asian Development Bank (ADB) and legalised with *Perda* No. 2/1988. Further, based on the enactment of *Perda Kota* Medan No. 4/2001, PDK was transformed back again into *Dinas Kebersihan Kota* Medan (Cleansing Department of Medan City) or DKKM[19]. The responsibility of DKKM on municipal waste management was further determined by *Perwali Kota* Medan No. 10/2002 and then renewed by *Perda Kota* Medan No. 3/2009 and *Perwali Kota* Medan No. 10/2010[20]. At that point, responsibility for waste management was shared with the Environmental Department (DLH) whereby DLH was responsible for supporting the waste banks, composting, awareness raising and education, evaluation of performances including *Adipura*[21] and *Adiwiyata*[22] awards, environment assessment related to waste, hazardous and toxic (B3) waste management, and coordination with other departments on waste if necessary. However, under the issuance of *Keputusan Walikota* (Mayor Decree[23]) No. 15 in 2016, DKKM was then merged with *Dinas Pertamanan* (Landscaping Department) to form the *Dinas Kebersihan* and *Pertamanan* (Cleansing and Landscaping Department) or DKP.

In addition, based on *Perwali* No. 1/2017, responsibility for waste banks and composting was transferred from DLH to DKP so as to achieve comprehensive waste management services[24]. However, to date, there has been no formal handover of responsibilities from DLH to DKP on waste banks. In fact, within less than a year, the Mayor Regulation (*Perwali*) No.73-2017 indicated that the responsibility of waste collection and transportation and other day-to-day implementation of waste management at the sub-district level should be handed over to each sub-district in 2017 (Table 4). This new administrative reform on waste management in 2017 resulted in a major change in the waste collection and management system. 2,454 staff, 225 units of trucks and 164 units of motorised tricycles were handed over from DKP to sub-districts depending on their population (= expected amount of waste generation)[25]. However, information on detailed responsibilities and procedures has yet to be clarified.

Challenges and Opportunities: These recent repeated administrative reforms regarding waste management in Medan City are an indication of an unstable and inconsistent waste management service and are causing a great deal of confusion. The transition of responsibility to sub-districts may have some positive effects such as enabling provision of more tailored services depending on local conditions. However, differences in the motivation and capacity among sub-districts can cause gaps in the quality of waste management services. For instance, if a truck breaks down in a sub-district, waste collection services may stop immediately because each sub-district cannot afford to secure back-up trucks. Thus, a central coordination and support system is necessary to some extent.

19. Setyowati L (2008) Evaluasi Kinerja Dinas Kebersihan dalam Pelayanan Persampahan di Kota Medan.
20. Perwali Kota Medan No. 10/2010: http://pemkomedan.go.id/hal-dinas-kebersihan.html (Accessed in 29 June 2018)
21. *Adipura* award: Adipura programme is an award for cities in Indonesia that are successful in cleanliness and urban environmental management. It was started in 1986 and is organised by the Ministry of Environment and Forestry.
22. *Adiwiyata* award: *Adiwiyata* programme is an award to encourage the creation of knowledge and *keasadaran* school community in environmental protection.
23. Mayor Decree (*Keputusan Walikota*) is a legal tool made individually by the Mayor to formalise specific arrangement and/or one-time decision while Mayor Regulation (*Peraturan Walikota/Perwali*) is for more general and city-wide regulation for routine public activities. Meanwhile, Local Regulation (*Peraturan Daerah/ Perda*) requires approval from the local House of Representative.
24. Nafishah P (2013) Peranan Pegawai dalam Melaksanakan Fungsi Pelayanan pada Kantor Dinas Kebersihan dan Pertamanan Kota Medan.
25. Muda News (05/10/2017): Walikota Medan Serahkan Pengelolaan Sampah kepada Camat: http://mudanews.com/regional/2017/10/05/28526/

Table 4. Transition of responsibilities on waste management amongst government agencies in Medan City

<table>
<tr><th rowspan="2">Waste management responsibilities</th><th colspan="5">Year</th></tr>
<tr><th>1975</th><th>1988</th><th>2001</th><th>2016</th><th>2017*</th></tr>
<tr><td>Waste collection and transportation</td><td rowspan="4">DKK
(Dinas Kebersihan dan Keindahan)</td><td rowspan="4">PDK
(Perusahaan Daerah Kebersihan)</td><td rowspan="4">DKKM
(Dinas Kebersihan Kota Medan)</td><td rowspan="5">DKP
(Dinas Kebersihan dan Pertamanan)</td><td>Sub-district</td></tr>
<tr><td>Waste management fee (Retribution) & financing</td><td rowspan="4">DKP</td></tr>
<tr><td>Landfill (TPA) management</td></tr>
<tr><td>Temporary disposal site (TPS) management</td></tr>
<tr><td>Composting</td><td rowspan="6">DLH
(Dinas Lingkungan Hidup)</td><td rowspan="6">DLH</td><td rowspan="6">DLH</td></tr>
<tr><td>Waste banks</td><td rowspan="5">DLH</td><td rowspan="3">DLH</td><td rowspan="3">DKP</td></tr>
<tr><td>Awareness raising and education</td></tr>
<tr><td>Evaluation of performance</td></tr>
<tr><td>Environment assessment related to waste</td><td rowspan="3">DLH</td></tr>
<tr><td>B3 waste management</td></tr>
<tr><td>Coordination with other departments on waste</td></tr>
</table>

*Note: The 2017 transition has not been fully implemented for some responsibilities.

Centralisation of Authority

Government Regulation (*Peraturan Pemerintah*) No. 18/2016 on regional government institutions provides guidance to municipal governments to ensure that waste management responsibility is concentrated within a single agency and that it should be dealt under the environment affairs. Thus, currently, most municipal governments in Indonesia govern waste management under DLH. In North Sumatra Province, waste management responsibilities are concentrated under DLH in most of its cities and regencies except Medan City and a few others where it is mainly managed under DKP. Consolidation of all waste management responsibilities to a single agency will indeed give strength in consistency and effectiveness of services. However an aspect of vertical collaboration between the national level (with Ministry of Environment and Forestry) and provincial level (with Environment Bureau of North Sumatra Province) should also be taken into consideration when merging responsibilities. After the 2017 transition of responsibilities, DKP has become the de facto authority to govern waste management in Medan City, with DLH being left with only coordination, B3 waste management, and some duties including waste banks, awareness raising and education, evaluation of performances, and environment assessment.

3.3. Waste Management Cost

The budget of DKP in fiscal year 2017[26], which is before the transition of some responsibilities from DKP to sub-districts, is shown in Table 5. The total amount of DKP budget was about IDR 224 billion (USD 16.6 million) and a large portion of it, about IDR 213 billion (USD 15.8 million), was allocated to the waste management performance development programme which includes funding for activities such as: procurement of waste transportation vehicles and collection facilities; establishment of integrated temporary disposal sites; wages for waste collectors and cleansing workers; capacity building activities; and improvement of the landfill. The remaining budget was allocated to administration, facilities and infrastructure, and other supporting programmes related to cleansing and landscaping public services. The total city budget in fiscal year 2017 was about IDR 5.1 trillion (USD 378 million), so it can be said that about 4.4% of the city budget was allocated to waste management. This is lower than 5% of the total city budget which is the target in the Sanitary Strategy 2017-2021 (see Table 2) but may not be so difficult to achieve. The important thing is not just raising the total allocation of the budget but how and on what activities will the budget be used to improve waste management. Thus, a strategic allocation of budget is needed to effectively implement the priority activities in this Work Plan or *Jakstrada*. A 5% benchmark, as well as how the budget is used for waste management, can be learned from other cities, such as Jakarta, Surabaya and Bandung, and if appropriate, introduced to the future benchmark.

Table 5. FY2017 budget of DKP, Medan City

No.	Main programme/activity	Amount (IDR)	Percentage (%)
1	Office administration service programme	1,777,250,000	0.8
2	Facility and infrastructure improvement programme	7,536,000,000	3.4
3	Official disciplinary improvement programme	2,333,464,000	1.0
4	Performance indicator and financial reporting system development improvement programme	165,000,000	0.1
5	Waste management performance development programme	212,509,683,245	94.7
6	Religious and important days activity implementation programme	15,000,000	0.0
	TOTAL	224,336,397,245	100

3.4. Waste Quantity and Quality

In Indonesia, the Law No. 18/2008 on Waste Management categorises waste into three types: a) household waste; b) waste similar to household waste (waste generated from commercial area, industrial areas, special areas, social facilities, public facilities, and/or other facilities); and c) specific waste (hazardous and toxic waste, disaster waste, construction and demolition waste, and other waste that requires special treatment). This Work Plan mainly discusses household waste and waste similar to household waste, considering its scope of work. However, this study also identified that specific waste management also has some problems and requires more attention to be improved.

Waste Quantity (City Level)

Table 6 shows the transition of population and waste generation amount between 2010 and 2017 in Medan City. Quantitative monitoring data on the amount of waste dumped in the only formal landfill site in Medan

26. Cleansing and Landscaping Department (DKP) Medan City (2017). The Work Plan of the SKPD for 2017's Fiscal Year.

City (*TPA Terjun*) has been taken by DKP. The data is based on the balance between the weight of each truck measured by the weighbridge at the entrance of the landfill site before and after dumping the waste. There was some period of time when the weighbridge was broken but data was recorded based on visual estimation in volume from the capacity of each type of truck and then converted to weight (using the coefficient of 1m³ = 250 kg). The volume of waste that exceeded the height of the containers was calculated as 1m³ without exception. On the other hand, there is no reliable data on the amount of uncollected waste including that treated under the 3Rs (reduce, reuse and recycle) by informal scavengers, waste banks and composting, and illegally dumped in drainage, rivers and open areas. Therefore, the total waste generation amount was estimated from the daytime population and per capita waste generation (0.7 kg/person) according to the Ministry of Environment and Forestry[27]. It is estimated that about 500,000 daily commuters go to work in Medan City from the surrounding cities[28]. This is about a 20% increase compared to the registered population. Thus, 120% of the registered population was applied as the daytime population to estimate the waste generation amount. Some quick assessments revealed that the total amount of waste generation in Medan City is more than 2,000 tons/day, while other estimates put this at more than 2,500 ton/day. However, since there is no clear evidence on the source of these figures, this Work Plan used the population and per capita waste generation data to estimate the yearly waste generation amount. The amount of uncollected waste was thus estimated from a balance between the estimated total amount of waste generation and the amount of waste dumped at the landfill site.

Table 6. Population and waste generation estimates in Medan City between 2010 and 2025

Parameters	Year (past)							
	2010	2011	2012	2013	2014	2015	2016	2017
A. Registered population*1	**2,109,330**	[2,129,210]	[2,149,278]	[2,169,535]	[2,189,983]	**2,210,624**	[2,231,459]	[2,252,491]
B. Estimated daytime population = [**A** x 1.2]	2,531,196	2,555,053	2,579,134	2,603,442	2,627,980	2,652,749	2,677,751	2,702,989
C. Estimated total waste generation amount (ton/day)*2 = [**B** x 0.7]	1,772	1,789	1,805	1,822	1,840	1,857	1,874	1,892
D. Amount of waste dumped in TPA (ton/day)	1,129	1,218	1,244	1,491	1,314	1,461	1,577	927
E. Estimated uncollected waste (ton/day)*3 = [**C** – **D**]	643	571	561	331	526	396	297	965
Parameters	Year (future)							
	2018	2019	2020	2021	2022	2023	2024	2025
A. Registered population*1	[2,273,720]	[2,295,150]	[2,316,782]	[2,338,618]	[2,360,659]	[2,382,908]	[2,405,367]	[2,428,038]
B. Estimated daytime population = [**A** x 1.2]	2,728,464	2,754,180	2,780,138	2,806,341	2,832,791	2,859,490	2,886,441	2,913,645
C. Estimated total waste generation amount (ton/day)*2 = [**B** x 0.7]	1,910	1,928	1,946	1,964	1,983	2,002	2,021	2,040

*1: The figures in 2010 and 2015 (Bold) are from the Statistics of Medan City (Badan Pusat Statistik Kota Medan: https://medankota.bps.go.id/) and figures for other years (in [ ]) are estimated from the mean growth rate between 2010 and 2015 (=0.94%)
*2: Applied the 120% of the registered population
*3: Applied the 0.7 kg per capita waste generation

27. Ministry of Environment and Forestry (2015) Kebijakan Pengelolaan Sampah, B3, Limbah B3 dan Pemulihan Lahan Terkontaminasi Limbah B3 di Indonesia.
28. Asian Development Bank (2016) Green City Action Plan 2035: City of Medan.

Figure 3 shows the transition of waste generation amount in Medan City from 2010 to 2017 using the same data as shown in Table 6. Due to the nature of population-based estimation, the total amount of waste is increasing year by year, but the amount of waste dumped in the landfill site, which is based on the real data, shows more fluctuations with an increasing trend toward 2016 where it reached up to 1,577 ton/day. However, it suddenly decreased in 2017 to 927 ton/day. The reason for this sudden decrease was speculated to be partly due to lack of trucks, inaccurate data, and/or illegal dumping of waste in the unofficial disposal sites including one in Sunggal, Deli Serdang Regency by the sub-districts after responsibility for waste collection was handed over from DKP to the sub-districts in 2017.

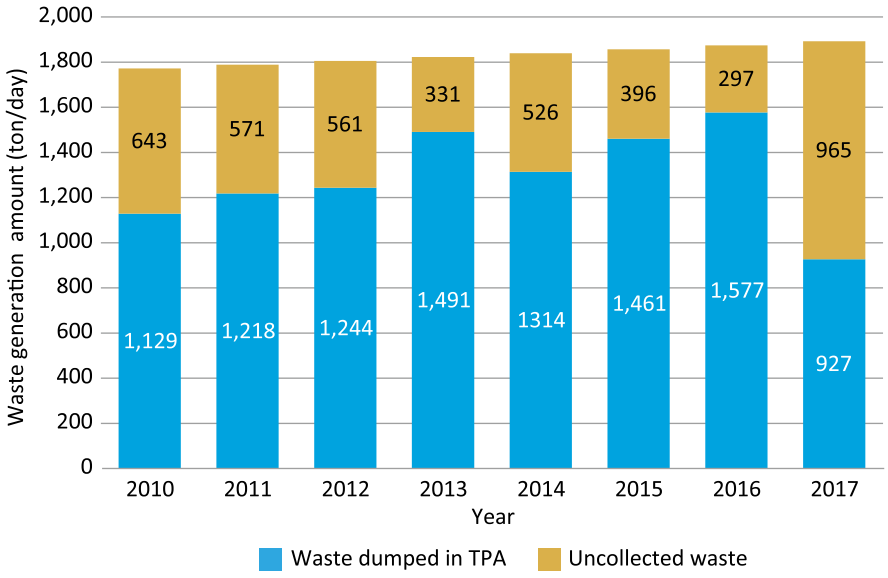


Figure 3. Transition of the amount of waste dumped into TPA Terjun and the uncollected waste estimated from the total waste generation (population x per capita waste generation) in Medan City between 2010 and 2017

Challenges and Opportunities: The current estimation of the amount of waste generation is based on population data. However, the actual waste generation amount in Medan City could be much higher considering its growing population and economy. Even if the same dataset is applied, and under the assumption that the population growth rate is constant and per capita waste generation is the same, the amount of waste generation could reach above 2,000 tons/day by 2023 (2,002 tons/day). This will impose a heavy burden on the city budget as well as impacting the environment negatively. Thus, there is an urgent need to work on waste reduction by introducing the 3R approach. In addition, if assuming that the estimation of total waste generation in 2017 is correct and the data from the TPA Terjun is accurate, it suggests that 965 tons/day of waste, which is a significant amount, could mostly, if not all, be illegally dumped or burnt. This not only suggests that there is a huge impact on the local environment but also shows up a potential conflict with the neighbouring Deli Serdang Regency if the waste is really being dumped at the unofficial disposal site in Sunggal. As 100% collection rate is one of the targets of the Sanitary Strategy 2017-2021 (see Table 2), an investigation and measures to improve the waste collection rate are urgently needed.

Waste Quantity (Sub-district Level)

At the sub-district level, estimated waste generation amount and other parameters from the 2016 data are shown in Table 7. The environmental stress indicator[29] is given from the amount of waste generation divided by its area and expressed in tons/km². This indicator is usually used on a national level, but it was applied at the sub-district level.

29. Waste Atlas Partnership (2013) Waste Atlas 2013 Report. ISSN: 2241 – 2484.

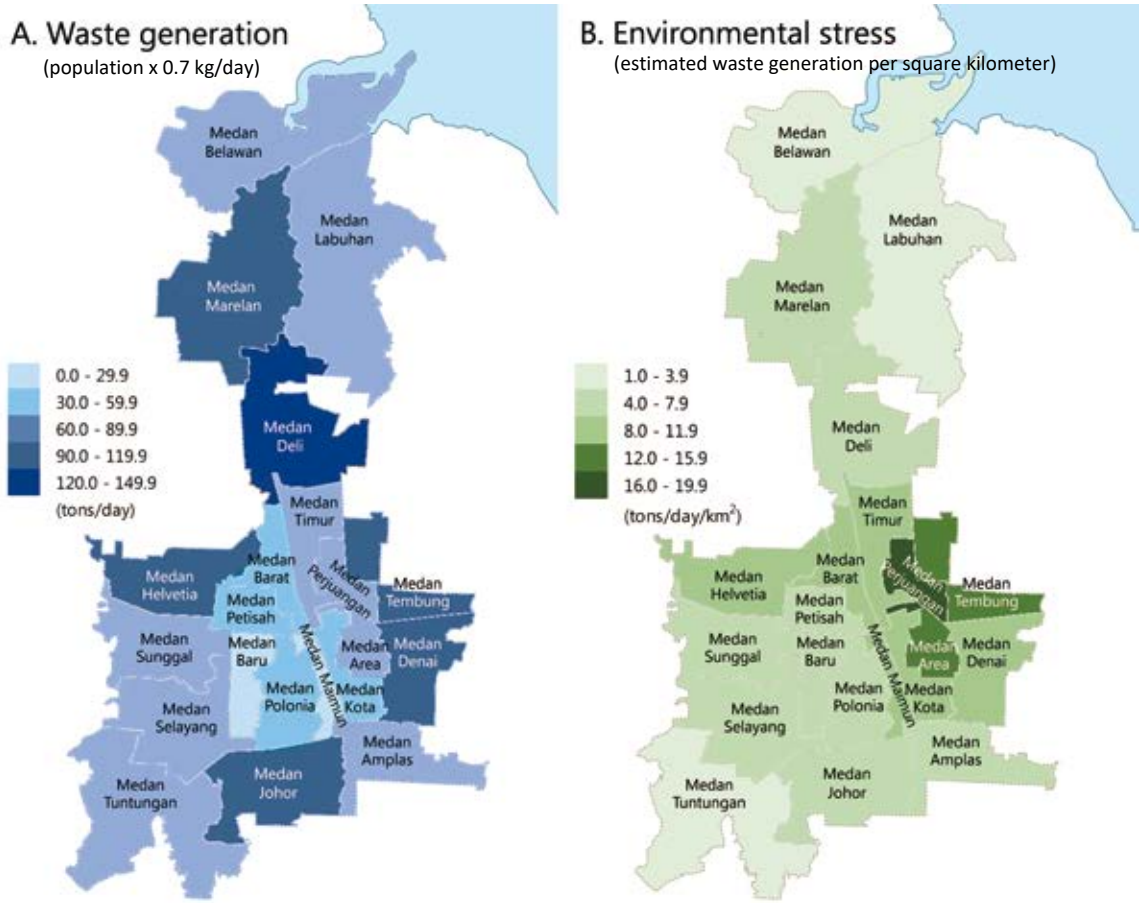
Table 7. Comparison of population, estimated waste generation, and environmental stress in each sub-district in Medan City based on the population and area data of each sub-district in 2016[30]

Sub-districts	A. Population	B. Estimated waste generation (tons/day) [A x 0.7 x 1/1,000]	C. Area (km^2)	D. Environmental stress (tons/day/km^2) [B/C]
Medan Tuntungan	86,425	60.5	20.68	2.9
Medan Johor	133,577	93.5	14.58	6.4
Medan Amplas	126,340	88.4	11.19	7.9
Medan Denai	146,388	102.5	9.05	11.3
Medan Area	99,021	69.3	5.52	12.6
Medan Kota	74,461	52.1	5.27	9.9
Medan Maimun	40,690	28.5	2.98	9.6
Medan Polonia	56,513	39.6	9.01	4.4
Medan Baru	40,560	28.4	5.84	4.9
Medan Selayang	107,831	75.5	12.81	5.9
Medan Sunggal	115,837	81.1	15.44	5.3
Medan Helvetia	151,581	106.1	13.16	8.1
Medan Petisah	63,390	44.4	6.82	6.5
Medan Barat	72,717	50.9	5.33	9.6
Medan Timur	111,438	78.0	7.76	10.1
Medan Perjuangan	95,936	67.2	4.09	16.4
Medan Tembung	137,239	96.1	7.99	12.0
Medan Deli	184,762	129.3	20.84	6.2
Medan Labuhan	118,551	83.0	36.67	2.3
Medan Marelan	167,984	117.6	23.82	4.9
Medan Belawan	98,167	68.7	26.25	2.6
TOTAL	**2,229,408**	**1,561**	**265**	
AVERAGE				**7.6**

The estimated waste generation has applied a per capita waste generation amount of 0.7 kg/person.

Figure 4 shows a comparison of waste generation and the environmental stress between sub-districts in Medan City using the same dataset as Table 7. It indicates that the highest waste generation (=population) could be expected from Medan Deli (129.3 tons/day), followed by Medan Marelan, Medan Helvetia, Medan Denai, Medan Tembung and Medan Johor. On the other hand, the highest environmental stresses (= waste generation per area) could be expected in Medan Perjuangan (16.4 tons/day/km^2), followed by Medan Area and Medan Tembung. These data suggests that areas with higher waste generation and environmental stresses require greater attention on waste collection services. It indicates that these sub-districts need higher allocation of resources for waste collection (e.g., trucks, motorised tricycles, drivers & collectors) and temporary disposal sites (TPS).

30. Kota Medan Dalam Angka 2017: https://medankota.bps.go.id/publication/2017/08/16/71ac9068bbb0b5dfcf4fd2f3/kota-medan-dalam-angka-2017.html



Five levels of ranking in equal intervals were applied to both figures.

Figure 4. Comparison of levels of estimated waste generation (A) and potential environmental stresses (B) between sub-districts in Medan City

Challenges and Opportunities: The sub-districts with high environmental stresses are potentially vulnerable if the waste collection and temporary disposal system is not properly functioning. It has also been suggested that higher efficiency of waste collection at a lower cost could be expected[31]. Allocation of trucks and human resources for waste collection should not be decided only based on the population (or volume of waste generation) but also by considering the potential environmental stress as well as distance to the waste treatment facilities such as temporary disposal sites and landfill site.

Waste Source and Composition

There is no accurate data that shows the amount of waste from different sectors such as households, commercial entities, or industries. According to a rough estimation by DKP, it could be assumed that about 70% of waste is generated by households, 15% is from commercial entities, and 15% from industries. However, accurate waste composition data is important in the development of a waste management plan because future scenarios need to be estimated from the available waste composition data and this could vary considerably depending on where and in what conditions the samples were collected.

A comprehensive waste composition survey in Medan City was undertaken as part of Japan International Cooperation Agency (JICA) funded pilot project on "Project for Capacity Development for Developing National Greenhouse Gas Inventories (Sub Project 3)" in 2011[32]. Waste samples were taken randomly from 33 waste collection trucks that collected waste from 12 sub-districts in southern Medan (Medan Tuntungan, Medan

31. Guerrini A, Romano G, Leardini C (2015) Measuring performance of municipal solid waste collection services. Procedia Environmental Science, Engineering and Management 2 (1) 51-62.
32. JICA (2012) Final Report - Waste Composition Survey and Dry Matter Content Survey in North Sumatra.

Amplas, Medan Area, Medan Kota, Medan Maimun, Medan Polonia, Medan Baru, Medan Selayang, Medan Sunggal, Medan Helvetia, Medan Petisah, Medan Barat), with a total of 1,000 L (559.73 kg) from October to December 2011. The samples were taken at the TPA Namo Bintang landfill site (now closed) when the waste trucks were unloading waste at the landfill site before any collection of recyclables by scavengers. The collected fresh wet waste was immediately separated into nine categories (+ four sub-categories) and weighed respectively. The summary result of the survey is shown in Figure 5. As the samples included waste from 12 sub-districts including household waste, market waste, commercial waste, etc., it could be considered that it represented the overall municipal solid waste composition in Medan City. The result shows that about half of the waste (48%) is food waste, followed by papers (17%) and plastics (14%) which are major recyclable materials.

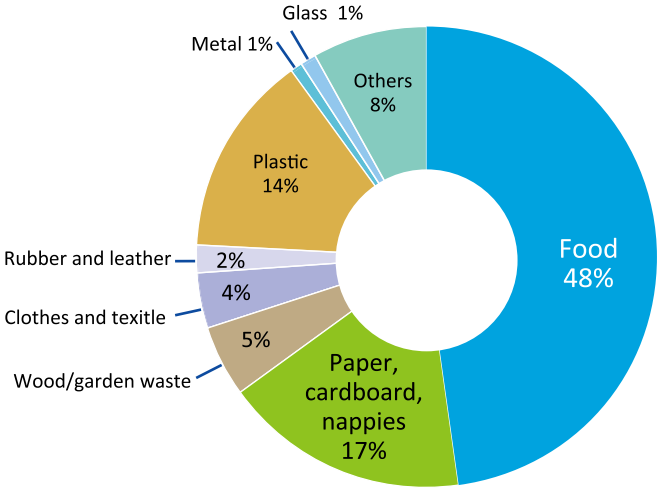


Figure 5. Result of composition analysis on municipal solid waste in Medan City from the JICA (2012) survey[32]

However, this kind of waste composition analysis which takes waste samples at the landfill site may not be accurately reflecting the composition at source. It often happens that scavengers or waste collectors picks up recyclables (plastic, paper, metal, glass, etc.) during the process of waste collection and transportation. In addition, paper waste will be overestimated because it absorbs moisture when mixed with other wet waste. Plastics, including PET bottles, are also overestimated because liquid or leftover food sometimes contaminate the containers. In order to understand the actual waste composition at source, a small study was conducted during the current rapid assessment. Five households (mid-to-high income level communities; average number of family members: 4.0) participated in the study. They separated the waste at source into five types (paper, plastic, glass, organics, others) and weighed them every day for two months from February to April 2018. They were all instructed to dispose of liquid and food from the plastic containers before weighing and to avoid getting paper waste wet. The summary result of this small study is shown in Table 8. The result showed that about half of the waste is composed of organics (47.9%), followed by paper (13.3%), glass (12.5%) and plastic (11.2%). The percentage of glass was large compared to JICA study where it was only 1%. But other major components were within similar magnitude. The average waste generation of 0.91 kg/person was larger than per capita waste generation amount (0.7 kg/person) which is often used in estimating the total waste generation amount in Indonesia. The sample size of five households was small but conformity of the result with the JICA study suggests that the result of JICA study could be used as a representative waste composition data in Medan City.

Table 8. Summary result of source separation and weighing of daily household waste in Medan City

Participants	Average weight of waste per types (kg/day)					TOTAL	Remarks
	Organics	Paper	Glass	Plastic	Others		
A	0.37	0.02	0.54	0.07	0.21	1.22	N = 67 days
B	0.30	0.11	0.00	0.06	0.00	0.47	N = 68 days
C	0.46	0.15	0.00	0.09	0.00	0.69	N = 64 days
D	0.20	0.06	0.02	0.08	0.29	0.65	N = 68 days
E	0.85	0.27	0.00	0.21	0.20	1.53	N = 26 days
Average (kg/day)	**0.44**	**0.12**	**0.11**	**0.10**	**0.14**	**0.91**	
Percentage (%)	**47.9**	**13.3**	**12.5**	**11.2**	**15.3**	**100.0**	

Challenges and Opportunities: The high percentage of food waste suggests that this is an issue of the highest priority within waste category. The reduction of organic waste to be landfilled can contribute to reduction of methane (CH_4) gas production from landfill sites. The high percentage of food waste also implies that introducing an incineration technology as a means of final treatment of waste may not be suited in Medan City due to the low calorific value of waste. In general, lower calorific value of waste should be at least 7 MJ/kg (for reference, calorific value of organic material is 4 MJ/kg) in order to maintain a stable combustion of waste at a high temperature in the incineration plant to reduce risks of producing dioxins and other toxic materials. It is often difficult to maintain such a condition using only municipal solid waste in countries where organic waste occupies a large portion of waste[33]

3.5. Waste Collection

Collection Service Area

Before the 2017 transition of waste collection responsibilities from DKP to sub-districts, DKP divided the sub-districts into three waste collection service areas (Figure 6) and introduced different waste collection strategies[8]. "Medan I" is the urban area within the city centre with a door-to-door waste collection service using trucks which transport waste directly to the landfill (TPA Terjun). "Medan II" is the area surrounding the city centre with a door-to-door waste collection service using push carts and/or motorised tricycles which are used to transport the waste to temporary disposal sites (TPS), where it is reloaded onto trucks, and then carried to the TPA. "Medan III" is a suburban area with a community waste collection system. Members of the communities are advised to bring waste to the communal collection point themselves, and dispose of the waste in the waste containers located at the collection point. The containers are then transported by truck to the TPA. However, the current status of these systems after the 2017 transition of waste collection responsibilities from DKP to sub-districts is unknown.

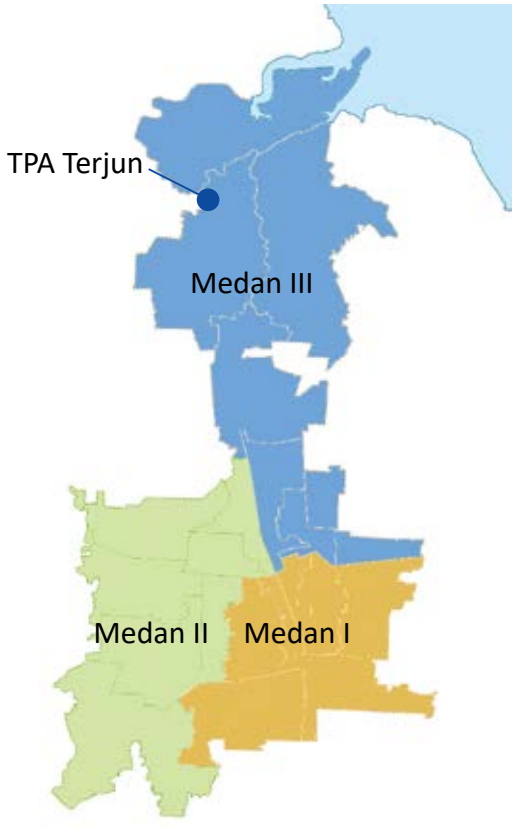


Figure 6. Boundaries of waste collection service area in Medan (RPIJM 2013-2017), applied until 2017

33. International Solid Waste Association (2013) ISWA Guidelines: Waste to Energy in Low and Middle Income Countries. ISWA.

Waste Collection Infrastructures

Before the transition in 2017 of waste collection responsibilities from DKP to sub-districts, DKP provided all the waste collection and transportation services except for some commercial entities and industries which decided to bring waste to the landfill themselves. Table 9 shows a summary of how DKP used the trucks for waste collection in one month before the transition of responsibilities in 2017 (data from June 2016). The maximum number of trucks operated in June 2016 was 212 units and most of them were fully used during the period. Average rotation per truck was 2.5 trips/day but the container trucks (5.6 trips/day) and arm roll trucks (6.5 trips/day) were subject to heavy rotation. An average amount of waste carried per truck suggests that the amount of waste loaded was mostly at maximum capacity or exceeded capacity, especially for container trucks whose capacity is 3.0 tons/unit but that were carrying 4.2 tons/unit in average.

This data suggests how heavily the trucks have been used. However, they were still not enough to accommodate 1,874 tons/day of waste which is the estimated total waste generation in 2016 (see Table 6). This indicates that the limited number of trucks has been the limiting factor to collect all generated waste. The fuel consumption of these trucks is enormous. According to DKP, all waste transportation trucks owned by DKP required a total of 8,500 L/day of diesel oil, costing IDR 1.2 billion/month (USD 89,000/month). DKP also owns 109 units of motorised tricycles, which consume about 2L/day of gasoline. However, all these trucks and motorised tricycles were allocated to the sub-districts following administration reform in 2017 and the current status is unknown.

Challenges and Opportunities: Regardless of whether the waste collection responsibility will be under DKP or a sub-district, in order to increase the collection rate to 100% in accordance with the Sanitary Strategy 2017-2021, it is apparent that more trucks are needed. However, procurement of trucks needs to be carefully considered in combination with the potential reduction of waste by 3R efforts.

Table 9. Summary of waste collection that DKP provided in June 2016 (Source: DKP Medan City)

Types of trucks (carrying capacity)	A. Average number of trucks operated (units/day)	B. Average total number of trips per day	C. Average rotation per truck (trips/day) [= B/A]	D. Actual waste amount carried to TPA (tons/day)	E. Average amount of waste carried per truck (tons/unit) [=D/B]
Typper (2.6 ton)	162	327	2.0	865	2.6
Container (3.0 ton)	14	78	5.6	325	4.2
Compactor (2.6 ton, 4.0 ton)	9	27	3.0	92	3.4
Arm roll (2.6 ton, 4.0 ton)	11	72	6.5	279	3.9
Other	12	13	1.1	34	2.6
TOTAL	208	517	2.5	1,595	3.1

Household Waste Collection

The typical waste collection services at the household level, especially in Medan II service area, are executed as follows. The DKP cooperates with the waste collectors to collect waste from each household and bring it to the temporary disposal sites (TPS). Waste collection and disposal fees (retribution) are defined by the *Perda Kota* Medan No. 10/2012 depending on the size and location of the housing. The retribution for middle income household is about IDR 15,000 (USD 1.1) per month. The retribution is usually collected directly or indirectly by the community leader or the real estate management, either separately or together with other housing expenses such as water charge, electricity, cleaning and security. *Perwali Kota* Medan No. 14/2014 also defines the establishment of Cleansing Service Technical Operating Unit (*UPT Pelayanan Kebersihan*) within DKP to support sub-districts in conducting cleansing activities including collection of the retribution by assigning staffs of this unit to each sub-district (as the Coordinator for *Kecamatan*) and administrative village (as the Coordinator for *Kelurahan*). The retribution collected by the UPT is then transferred to the city general account and mixed with other tax

incomes. The budget for waste management comes partly from the national government budget (APBN) and from the city budget (APBD) and is allocated through DKP to each sub-district and other necessary waste management services such as temporary disposal sites and final disposal sites (Figure 7).

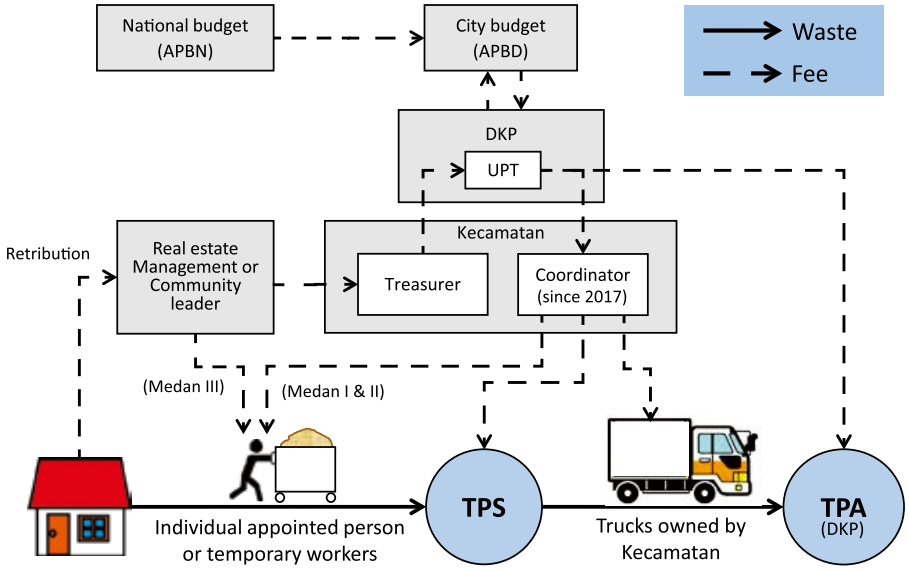


Figure 7. General flow of waste and waste management fees (retribution) at the household level in Medan City

Challenges and Opportunities: Assuming that the total number of households in Medan City is 550,000 (under the assumption that the average family configuration is four among a population of 2.2 million), the IDR 15,000 per (USD 1.1) month of retribution per household will yield only IDR 8.25 billion (USD 0.6 million) which is 27% of the DKP annual budget (IDR 224 billion or USD 16.6 million). Of course, larger houses will be paying more retribution and there is a retribution income from commercial entities and industries as well. According to DKP, the retribution cannot even cover their fuel costs for waste collection and transportation services. This low rate of retribution may be still acceptable under the current status of landfill sites because open dumping does not require much cost for operation and the site is owned and managed by the city, so a tipping fee is not required for city collected waste. However, shifting the landfill site from open dumping to a properly managed sanitary landfill site, and if the new landfill site has to be developed in the neighbouring Deli Serdang Regency adding more distance, the rate of retribution may have to be raised accordingly in the near future. As a tentative solution to raise the retribution income, DKP is planning to review and update the list and number of waste retribution mandatory payers for each sub-district (*Wajib Retribusi Sampah*: WRS).

Commercial and Industrial Waste Collection

For commercial and industrial waste such as from hotels, shopping malls, hospitals, office buildings, government facilities, educational facilities, and manufacturing processes, the retribution is also defined by the *Perda Kota* Medan No. 10/2012 depending on the size and location of the buildings and not based on the waste amount. There are three types of waste collection and fee systems for commercial and industrial waste. In principle, each commercial entity is responsible for bringing waste to the landfill site themselves. However, some entities do not have the capacity to do so, therefore, they commission the work to a third party to collect and bring the waste to the landfill site on behalf of the client. The other type is to pay DKP both retribution and collection fee, thereby ensuring that DKP trucks collect and transport waste to the landfill site.

Challenges and Opportunities: During the rapid assessment, one shopping mall was interviewed and it was revealed that promoting the concept of the 3Rs in the commercial sector would be difficult because there is no incentive to reduce and recycle waste under the current fixed retribution rate. Thus, in order to enhance 3R activities in the commercial sector, introducing a

volume-based retribution similarly with the traditional market (described in the later section) could be effective. This is because the more waste they generate, the more they need to pay. Therefore, they will be encouraged to reduce waste in order to pay a cheaper retribution fee. In addition, there is a suspicion that third parties carry out illegal dumping of waste after they pick up recyclables and there is no tracking system to monitor where the waste is dumped after it is handed to a third party.

Hazardous and Toxic (B3) Waste Collection

The Government Regulation No. 18/1999 on the management of hazardous and toxic waste defines types, handling, and processing of the hazardous and toxic waste materials (B3 waste). In Indonesia, there is only one company that has a business license for B3 waste controlled landfilling which is the PT Prasadha Pamunah Waste Industri (PPLi)[34] located in Cileungsi, Bogor, West Java Province. From the centre of Medan City, it takes about 2,000 km (one way) to PPLi including shipping between Sumatra and Java Islands. Apparently, this long distance transportation is very costly and generates GHG emissions. In North Sumatra Province, it is estimated that about 27,126 tons/year (74 tons/day) of B3 waste are being transported to PPLi. Among them, 816 tons/year of waste is hospital waste[35]. However, there is no reliable data on the percentage of B3 waste that is carried to PPLi and the one that is illegally dumped or treated in Medan City or in North Sumatra Province. Currently there is one company (PT Sumatra Deli Lestari Indah, SDLi) that has a business license to treat B3 waste, and two companies (PT Jasa Medivest, PT Arah) that have a business license to collect and transport B3 waste operating in Medan City. The estimated diesel fuel consumption for transporting 27,126 tons/year of B3 waste to PPLi in West Java using 20 ton trucks is 1,356,300 L/year (or 3,715 L/day)[36] and the estimated CO_2 emissions come to 3,499 t CO_2/year[37].

Challenges and Opportunities: Considering the huge cost for long haul of B3 waste to West Java, constructing and operating a legitimate incinerator and special landfill site that satisfies the specifications for B3 waste treatment in Medan City or nearby regencies could generate a huge impact on the local economy. The impact would not be just limited in Medan City but all around North Sumatra Province and more widely on Sumatra Island. It could directly reduce the B3 waste disposal cost for industries such as hospitals and manufacturing, thereby indirectly reducing the cost burden for patients and consumers. It will also contribute to a huge reduction in GHG emissions from the transportation sector. Considering the scale and potential benefit, this could be something that the Medan City government or North Sumatra Provincial government could take the lead in negotiating with the national government and work together with industries and the private sector to realise the project. The other potential concern on B3 waste is illegal dumping or treatment. There is no accurate data on how much B3 waste is transported to PPLi but some portion could be illegally dumped and/or treated due to the high transportation cost. This could partly be solved if a proper treatment plant was built within North Sumatra Province resulting in substantially reduced transportation costs. Stricter law enforcement to reduce illegal dumping and treatment of B3 waste is needed in any case, considering how hazardous these substances are.

Market Waste Collection

There are 54 traditional markets in Medan City and 31 of these markets are managed by the city-owned Market Corporation (PD Pasar) which have a contract with DKP to collect their waste. The fees for these traditional markets are not determined based on the size or location of the markets like commercial entities but is rather based on the actual volume of waste generated. PD Pasar pays to DKP IDR 38,000 (USD 2.8) per m^3 of waste. The other 23 traditional markets have a contract with private collectors to collect their waste. In this case, the markets pay to DKP IDR 15,000 (USD 1.1)

34. PT Prasadha Pamunah Waste Industri: http://www.ppli.co.id/
35. Shinryo Corporation (2017) Report of the Environment Assessment on Utilization of Efficient Recycling Energies for Hazardous and Toxic Waste (B3 Waste) in North Sumatra Province, Indonesia. Ministry of the Environment, Japan. (In Japanese)
36. Calculation basis: [(27,126 tons/year / 20 tons truck) x (2,000 km x 2 ways)] / 4 L/km
37. Calculation basis: [1,356,300 L/year x 2.58 kgCO_2/L (emission factors for diesel vehicles)] / 1,000

per m^3 of waste. The waste from other smaller informal markets not managed by PD Pasar are dealt together with household waste which is collected by a sub-district together with the retribution.

Challenges and Opportunities: Market waste is generally dominated by organic waste, making it a good candidate source for a small-to-medium scale compost centre which can effectively reduce organic waste from the waste stream and produce compost to assist in the greening of the city. In Surabaya City for example, the city government has been developing and managing 21 small-to-medium scale compost centres using organic waste from traditional markets and garden waste with a capacity ranging between 2-18 m^3/day (about 0.8-7.2 tons/day[38]). The actual amount of compost production from these facilities ranges between 1-8 m^3/day (about 0.4-3.2 tons/day) totalling 66 m^3/day (about 26 tons/day)[39]. The Surabaya City government has been using the compost generated from these compost centres for greening of parks and streets, thus being able to reduce costs for purchasing chemical fertilisers as well as trucks and fuel costs for transportation of the waste to a landfill[40]. Given that the current retribution system applied to traditional markets in Medan is volume-based, it has the potential to encourage reduction and recycling of waste by introducing compost centres by PD Pasar and other markets.

Temporary Disposal Sites

Temporary disposal sites (TPS) function as locations where the waste from households and small businesses is collected by pushcarts and/or motorised tricycles and temporarily dumped, then to be reloaded onto trucks and transported to the final disposal site. In Medan City, the Detailed Spatial Planning (RDTR) document identifies the suggested locations of TPS based on the theory that every administrative village should have at least one TPS. There are 151 administrative villages in Medan City, so in theory, there should be similar number of TPS. However, to date, there are only 82 TPS in Medan City (data obtained from DKP, July 2018), and none of the land belongs to city government. The land belongs to individuals and is temporarily used by the city as TPS. The city has been seeking to promote land procurement to establish permanent TPS, and the Housing, Settlement, and Spatial Planning Agency of Medan City (Dinas Perumahan, Permukiman dan Penataan Ruang Kota Medan) is in charge of this duty. However, land acquisition has not been successful due to protests from nearby residents and land owners who are worried that the land price may decrease due to odors and the negative image of a TPS as a dump site. A typical TPS seen in Medan City is located on bare land with no pavements or facilities, with waste being temporarily dumped directly on the ground or in the waste containers. There might be a presence of some scavengers searching for and collecting recyclables (Figure 8).

Figure 8. Typical outlook of TPS in Medan City (TPS Pulo Brayan, Medan Barat) (Source: IGES, 2017)

There is one TPS that has 3R (reduce, reuse and recycle) functions and it is referred to as TPST-3R (TPST-3R Pasar Tani Medan Berseri, Medan Marelan). It is located adjacent to a traditional market and functions as a waste bank and compost centre for the nearby communities. The community leader who is also a manager of the TPST-3R collects about 1 ton/day of mixed waste from the market and nearby communities and separates this waste into organic waste, recyclables, and non-recyclables. The recyclables are sold to recycling vendors

38. The density of food waste: 400 kg/m^3 was applied for converting data from m^3/day to tons/day.
39. Gamaralalage PJD, Gilby S (2017) Development of Work Plan for Reducing SLCPs from MSWM in Surabaya, Indonesia. Institute for Global Environmental Strategies.
40. Maeda T (2009) Reducing Waste through the Promotion of Composting and Active Involvement of Various Stakeholders: Replicating Surabaya's Solid Waste Management Model. IGES Policy Brief #9 December 2009.

and earns an average of IDR 2,000,000 (USD 148) per month, while organic waste is made into compost and used on the farm owned by the community leader.

Table 10 shows the distribution of TPS and TPST-3R in Medan City in each waste collection service area and sub-district in comparison with the population. Among the waste collection service areas, there is no major difference in the number of TPS (Medan I: 27, Medan II: 25, Medan III: 21) although Medan I is not anticipating the use of TPS[8]. On average, one TPS services 37,691 people (or about 10,000 households) in Medan City but the allocation of TPS is significantly disproportionate between sub-districts. For example, Medan Perjuangan has no TPS, while Medan Baru which has the smallest population among sub-districts has five TPS sites.

Challenges and Opportunities: The fact that not all the lands of TPS are owned by the city government implies unstable TPS management whereby a site could be shut anytime in the future. Given the important function as a site to reload the collected waste onto truck containers, the land should ideally be owned by the city and the TPS functions need to be stabilised. The disproportionate number of TPS among sub-districts and the fact that one TPS is servicing about 10,000 households on average as well as the fact that some sub-districts do not even have a TPS at all suggests that more TPS sites are needed with strategic allocation to ensure efficient waste collection. However, DKP noted the challenge of purchasing land for TPS. Medan City has been granted about IDR 14 billion (USD 1.0 million) from the national government to purchase land for TPS, but the city is having difficulty in using the funds due to protests from neighbouring residents. On the other hand, the TPST-3R Pasar Tani Medan Berseri seems to be a good model and worth replicating. Other TPS sites could also introduce 3R (waste bank and compost centre) functions to reduce the amount of waste transported to the landfill site.

Table 10. Distribution of temporary disposal sites (TPS) and TPS with 3R functions (TPST-3R) in waste collection service areas and sub-districts compared with population in Medan City

Sub-districts	Waste collection service area	Population	Number of regular TPS	Number of TPST-3R	Population per TPS
Medan Tuntungan	Medan II	86,425	4	0	21,606
Medan Johor	Medan I	133,577	5	0	26,715
Medan Amplas		126,340	6	0	21,057
Medan Denai		146,388	3	0	48,796
Medan Area		99,021	2	0	49,511
Medan Kota		74,461	6	0	12,410
Medan Maimun		40,690	1	0	40,690
Medan Polonia		56,513	5	0	11,303
Medan Baru	Medan II	40,560	3	0	13,520
Medan Selayang		107,831	2	0	53,916
Medan Sunggal		115,837	10	0	11,584
Medan Helvetia		151,581	9	0	16,842
Medan Petisah		63,390	2	0	31,695
Medan Barat		72,717	5	0	14,543
Medan Timur	Medan III	111,438	3	0	37,146
Medan Perjuangan		95,936	0	0	–
Medan Tembung		137,239	2	0	68,620
Medan Deli		184,762	3	0	61,587
Medan Labuhan		118,551	6	0	19,759
Medan Marelan		167,984	0	1	167,984
Medan Belawan		98,167	4	0	24,542
TOTAL		2,229,408	81	1	–
AVERAGE		–	–	–	37,691

The population is based on the 2016 data[30] and the data of TPS was obtained from DKP (July 2018).

3.6. 3R (Reduce, Reuse, Recycle) Initiatives

3R Projects and Initiatives

Compared to other large cities such as Jakarta, Surabaya and Bandung, waste management projects and initiatives are limited in Medan City. The most recent waste management initiative was the "Medan Zero Waste City 2020" which was launched by Wahana Lingkungan Hidup Indonesia (WALHI)[41] and Medan City at the commemoration of Earth Day in April 2018. It was officially proclaimed by the Minister of Environment and Forestry, Governor of North Sumatra Province, and Mayor of Medan City. Trying to achieve "zero waste" in just two years is not an easy task but this should be seen as a very important first step where top management at the national, province and city levels have joined together for the first time to commit to addressing the waste management issues of Medan City. Another relatively recent project was the Japan International Cooperation Agency (JICA)'s Grassroots Project: "Improvement of Waste Management in Medan City" from 2013 to 2015[42]. The project supported the establishment of a waste bank centre (Bank Sampah Induk Sicanang) and compost centre in Belawan Sicanang, which is the northern most sub-district. The project contributed to establishing a city-wide waste bank system and became the first initiative to develop a model for organic waste reduction at the administrative village scale.

During the rapid assessment, one of the most notable 3R initiatives identified in Medan City was the waste bank activities supported by the government as well as NGOs and CSR (Corporate Social Responsibility) of the private sector (see below "Waste Banks" section). Projects making handicrafts from waste were also seen at several waste banks and elsewhere. It was hoped that the JICA 2013-2015 project incorporating the compost centre and home composting which distributed 300 Takakura home composting baskets[43] will be replicated to other sub-districts and administrative villages. However, neither of these composting models were replicated within Medan City and the status suggests that they do not have much success for continuation or replication (see below "Composting" section). No other composting initiatives were witnessed during the rapid assessment. There was also no social support system, for example assigning environment leaders/cadres in each community to support community waste management activities which functioned as one of the key factors for success in Surabaya City[40]. In the commercial sector, no business entity except recycling vendors was found to be actively taking part in waste separation and recycling activities.

Public Behaviour and Awareness

In government buildings and public spaces such as parks and pedestrian areas, some locations were equipped with up to 3-4 different types of waste bins encouraging people to separate waste. However, in most cases, waste was mixed and the signs encouraging separation of waste were not being followed. Consistencies in the separation types as well as colour coding of waste bins were also not observed. Even if waste was separated, there is no separated collection system in Medan City, so all the waste would be mixed and dumped in the landfill. The city's current waste management measures are focused on waste collection and final disposal, with 3R measures limited only to waste banks. Thus, public behaviour and awareness on the 3Rs seems to be very low. Some public schools have introduced a waste bank system and have been awarded the *Adiwiyata* prize[22], but there are no formal curricula to educate about the 3Rs in public schools, especially at the high school level.

41. Wahana Lingkungan Hidup Indonesia (WALHI): WALFI (Indonesian Forum for the Environment) was founded in 1980 and joined The Friends of the Earth Indonesia (FoEI) in 1989. WALHI is the largest and oldest environmental advocacy NGO in Indonesia.
42. JICA Kusanone Project: A technical cooperation project funded by JICA during 2014-2016 to promote efficiency of waste management in Medan City. The implementation agencies included Kitakyushu City, Shinryo Corporation, Kitakyushu City Environmental Preservation Association (KEPA), Kyushu Institute for Technology, and Kyushu University. It aimed to establish a community waste management system in model communities, raise capacity of human resources, and develop compost centre to reduce organic waste.
43. Takakura home composting basket: A simple home composting method that was developed in Kitakyushu City, Japan and practiced successfully in Surabaya City, Indonesia. It can accommodate about 1 kg/day of organic waste and contribute to waste reduction in the community level.

Waste Banks

A typical waste bank in Medan City is managed either by the community, organisation or individual and providing service to exchange recyclables into money within a saving system adopting a simple version of a financial bank system and utilising a temporary location owned by individuals or organisations. In most cases, recyclables accepted from the communities are weighed and recorded in the saving books, and an equivalent amount of money will be provided once per three month or longer (Figure 9). Before the JICA project started in 2013, there were only a few waste banks available in Medan City. But since the waste bank centre opened in Belawan Sicanang and obtained additional support from Unilever Foundation, the number of waste bank units have increased to 83.

The waste bank centre is managed by a NGO called Perkumpulan Arta Jaya. The centre also operates a clinic where clinic and healthcare services are provided to the communities using the waste bank savings. It is the only waste bank centre in Medan City and it provides support for opening waste bank units, collecting and purchasing waste from units, organising regular meetings for all the units, and co-organising regular award events to incentivise the units. At the initial stage, DLH of Medan City provided financial support to operate the waste bank centre. However, this funding gradually decreased and was cut when the waste bank responsibility was transferred from DLH to DKP. According to the centre, the number of account holders of the 83 registered waste bank units was 4,928 and the total amount of waste collected from the units was 76,100 kg in 2016.

Figure 9. Waste bank activity (left) and storage (right) (Source: IGES, 2017)

As part of the rapid assessment, a comprehensive survey was conducted to interview all the waste bank units in Medan City in order to deepen the understanding of the status and challenges faced by the waste banks between September 2017 and February 2018. As a result, in addition to the known 83 units, 17 more units were identified and in total 100 units were surveyed. However, 22 waste bank units were found to have closed their activities, so in total 78 waste bank units were considered to be actively operating as of February 2018. Table 11 shows part of the summary data from the comprehensive survey. The number of waste bank units ranged widely among sub-districts. Some sub-districts such as Medan Kota, Medan Barat, Medan Perjuangan, and Medan Tembung had no actively operating units while Medan Belawan had 27 actively operating units. The average population per active waste bank in Medan City as a whole was 44,645, ranging from Medan Belawan which had most number of waste banks per population and Medan Labuhan which had the fewest waste banks per population. The average distance to the waste bank centre was approximately 24 km and the farthest was Medan Tuntungan which was 35 km. The total weight of waste sold by active waste banks (including the waste bank centre) was 63,050 kg/month. However, the amount of waste sold by the waste bank centre equals to the amount of waste they purchased from the waste bank units (about 6,000 kg/month), thus this amount is actually already included in the total weight of all active waste banks in Medan City. Therefore, if this amount is deleted in order to avoid duplication in counting, the total waste sold by all waste banks in Medan would be 57,050 kg/month (approximately 2 tons/day). The geographical location of all the waste bank units (active and closed) plotted using GIS coordinates is shown in Figure 10. Further detailed analysis of the waste bank survey will be provided in a separate publication.

Table 11. Summary status of waste bank units from the rapid assessment conducted in 2017-2018 (Source: IGES, 2018)

Sub-districts	Population	Number of waste bank units		Population per waste bank (active units only)	Approximate distance to waste bank centre (km)*	Total weight of waste sold (kg /month) (active only)
		Active	Closed			
Medan Tuntungan	86,425	3	0	28,808	35	1,500.0
Medan Johor	133,577	2	0	66,789	33	5,127.5
Medan Amplas	126,340	7	2	18,049	31	1,260.0
Medan Denai	146,388	2	0	73,194	31	450.0
Medan Area	99,021	1	1	99,021	28	50.0
Medan Kota	74,461	0	1	–	23	0.0
Medan Maimun	40,690	2	0	20,345	25	650.0
Medan Polonia	56,513	2	1	28,257	29	1,525.0
Medan Baru	40,560	4	0	10,140	28	1,045.0
Medan Selayang	107,831	4	0	26,958	29	935.0
Medan Sunggal	115,837	2	4	57,919	29	220.0
Medan Helvetia	151,581	2	0	75,791	24	1,200.0
Medan Petisah	63,390	2	0	31,695	25	2,000.0
Medan Barat	72,717	0	0	–	22	0.0
Medan Timur	111,438	2	1	55,719	21	1,600.0
Medan Perjuangan	95,936	0	1	–	24	0.0
Medan Tembung	137,239	0	1	–	25	0.0
Medan Deli	184,762	8	0	23,095	17	9,662.5
Medan Labuhan	118,551	1	0	118,551	8	1,400.0
Medan Marelan	167,984	8	5	20,998	10	4,850.0
Medan Belawan (including the waste bank centre)	98,167	27	4	3,636	7	29,575.0
TOTAL	**2,229,408**	**79**	**21**			**63,050**
AVERAGE				**44,645**	**24**	**808.3**

*The distance to waste bank centre was identified from the arbitrary distance from the sub-district office to the waste bank centre (not using the toll road) given by Google Maps.

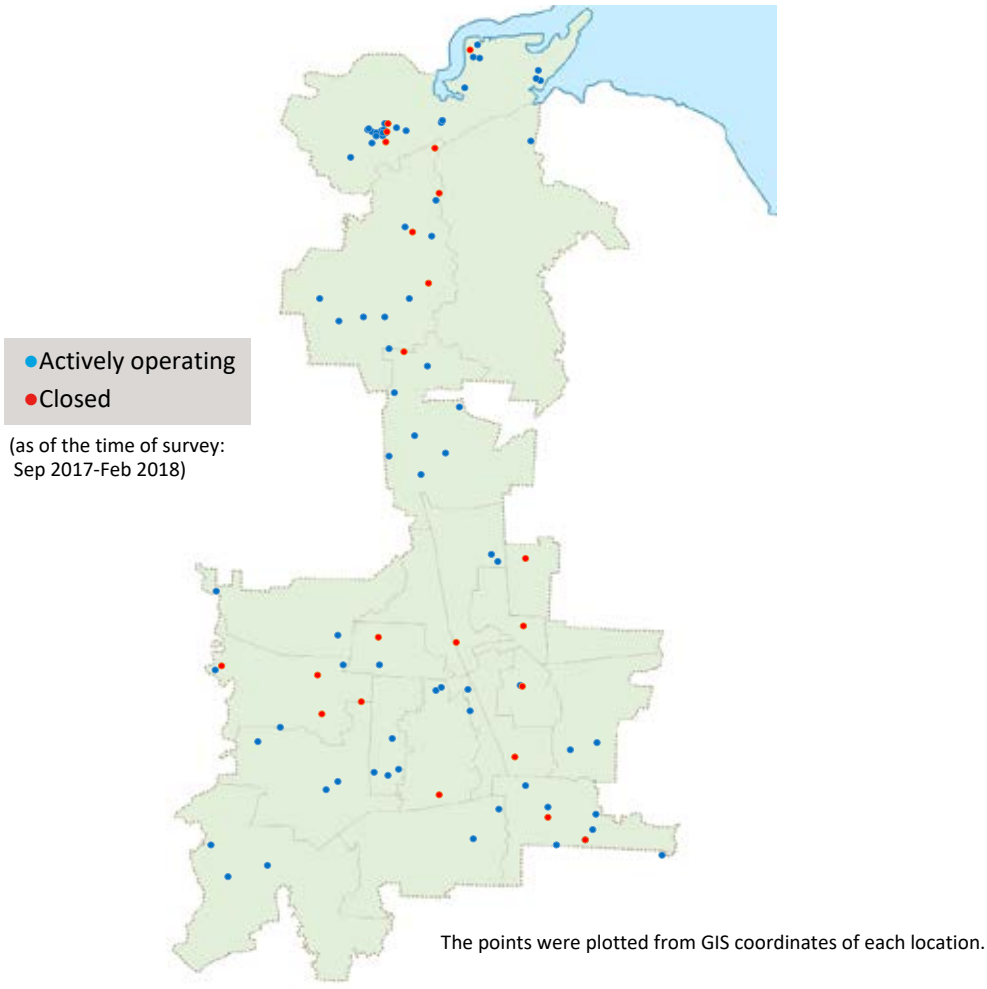


Figure 10. Geographical location of waste bank units from 2017-2018 comprehensive survey in Medan (Source: IGES, 2018)

Challenges and Opportunities: In order to enhance waste banks, and increase participation and waste recovery, the benefits to the end-users (household owners or businesses who provides waste) should be prioritised in the design of the waste bank system. For that purpose, the intermediate processes should be minimal and the processing cost should be reduced as much as possible. In that sense, the current one-centre system in Medan City, which involves high transportation costs, needs to be reconsidered and a more decentralised approach should be implemented. It would also be important that the city government intervenes in the stabilisation of waste pricing. For example, the government of Makassar sets a price and buys the waste to stabilise the waste bank system[44]. Another government intervention could be to exchange an MOU with the recycling vendors to avoid price cheating[45]. One further aspect that needs to be taken into consideration concerning waste banks is the risk of pursuing a benefit-oriented approach. A waste bank is an useful tool to introduce the 3R concept to the public, but it includes the risk that people may stop carrying out waste separation if the price of recyclables drops in the near future in accordance with a rise in average income levels and/or a relative drop in recyclable prices. Thus, the primary purpose of the waste banks should be explained as the means to reduce and recycle waste and not for profit-making. When the city government intervenes in the management of a waste bank centre or system, it should strictly make it a not-for-profit public service, with a transparent accounting procedure. Otherwise, it would be difficult to gain support from citizens.

During the rapid assessment, a small workshop on waste banks was organised by inviting practitioners from 13 key waste bank units. During the workshop, participants were divided into four groups and a facilitated discussion took place to identify the four aspects of the SWOT analysis (strengths, weaknesses, opportunities and threats). The results of the group discussion is summarised in Figure 11. The participants understood and acknowledged several strengths and opportunities with regards to waste banks, while pointing out several weaknesses and threats that needs to be addressed. The lack of transportation, funding, equipment and facilities were the major challenges identified from the small workshop. The strategy to strengthen the waste bank system should prioritise addressing these key challenges and at the same time should aim to enhance the identified strengths and opportunities.

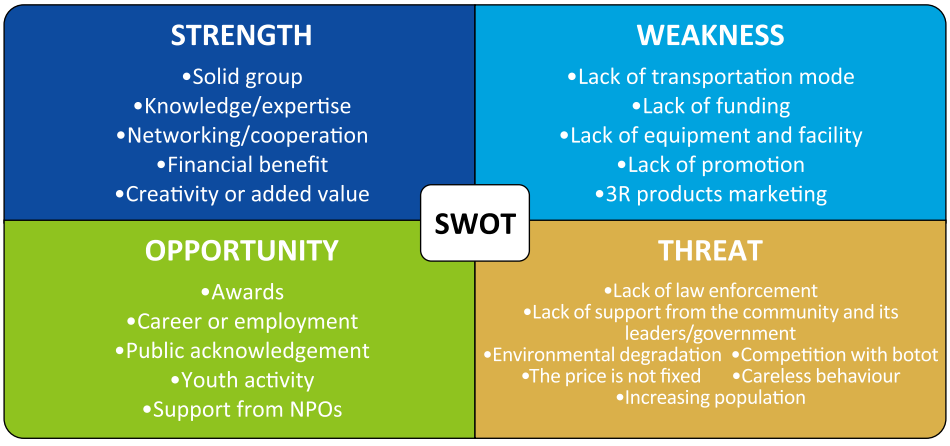


Figure 11. Summary of feedback to the SWOT analysis undertaken during the workshop on waste banks during the rapid assessment (26 Sep 2017 at Yayasan Pendidikan Graha Kirana, Medan City)

44. Bloomberg News (2016) This Asian Bank Lets You Borrow Cash and Pay in Trash. https://www.bloomberg.com/news/articles/2016-05-15/this-asian-bank-lets-you-borrow-cash-and-pay-in-trash
45. Melyanti, I. M. (2014) Pola Kemitraan Pemerintah, Civil Society, dan Swasta dalam Program Bank Sampah di Pasar Baru Kota Probolinggo. Kebijakan dan Manajemen Publik, Volume 2, Nomor 1, Januari 2014.

Recycling businesses

An industrial complex managed by the state-owned company PT. Kawasan Industri Medan (KIM) is located in Medan Deli and has a total area of more than 525 ha[46]. KIM is an enterprise that accommodates a wide range of industries including some recycling industries such as plastic, paper and steel. Details on the recycling industries in Medan City could not be clarified during the rapid assessment but some other recycling industries, mainly plastic industries, were spotted in other sub-districts in Medan City and neighbouring regencies such as Deli Serdang Regency.

Along with these recycling industries, there are many intermediate processing vendors and dealers in the recycling sector. The waste bank centre (Bank Sampah Induk Sicanang) is dealing directly with 11 recycling vendors. Three of these are formal registered companies while the remaining eight are non-registered informal vendors. The other waste bank units, especially those that are located far from the waste bank centre with an infrequent waste collection service, are also selling waste to these formal and informal recycling vendors. In Medan, an informal recycling vendor that deal directly with residents and/or scavengers to collect and sell recyclables (mostly family businesses) are called *botot*. There are many of these businesses in Medan, although the exact number is unknown. Usually, there are several recycling vendors, including *botot*, that function as part of the process between waste banks and recycling industries providing different functions, e.g., collection, transportation, separation, cleaning and intermediate processing (such as pelletising). In general, if there are more intermediators in the process, this means a lower street price and fewer waste bank sales.

Botot are often former scavengers, and they mainly buy waste from scavengers who collect recyclables informally from the streets, rivers, communities, TPS and TPAs. There is no accurate data on the population of scavengers and the amount of waste they recover in Medan City. In the TPA Terjun alone, the DKP officer stated that there are estimated 300-400 scavengers per day picking waste from the TPA. Assuming that there are 1,000 scavengers in Medan City and each of them recovers 5 kg of recyclables, the total amount of waste that could be removed from the waste stream and recycled by the scavengers could be estimated as 5 tons/day.

Challenges and Opportunities: China is a major importer of recyclable materials, but as of January 2018, the country has stopped importing plastics and this is causing problems for recycling businesses in many countries that rely on this market[47]. The location and/or proportion of end markets for recyclable materials from the waste banks in Medan (or Indonesia) is not well understood. However, this incident suggests that on the one hand Medan (or Indonesia) may have business opportunities as a potential importer of waste to substitute China's role, while on the other hand the waste market is fragile and could be discontinued at any time. In other words, there is a risk in promoting waste banks especially as profit-oriented activities, because 3R actions may cease if the sales price of waste drops and waste banks no longer want to receive the waste. If Medan City is aiming to become a "zero waste city", it needs to urgently strengthen its recycling industry. If various recycling industries are located within or nearby Medan City, this will give strength to recycling businesses in Medan and nearby cities due to reduced intermediate costs. Thus, if recycling industries deal more with the final production process rather than intermediate production processes, there will be less risk of being affected by foreign/domestic markets. Thus, a strategy that invites investment into the recycling industry could be considered as a development strategy for Medan City.

Composting

For the JICA Grassroots Project 2013-2015, a compost centre with a design capacity to produce 1,500 kg/month of compost was established in Belawan Sicanang at the same location as the waste bank centre (Bank Sampah Induk Sicanang). Currently, this is the only compost

46. PT. Kawasan Industri Medan: http://kim.co.id/
47. BBC News Indonesia (2018/01/02) Cina mulai terapkan larangan beberapa impor sampah, termasuk plastic: http://www.bbc.com/indonesia/majalah-42533509

centre available in Medan City. The compost centre regularly collected organic waste from the market, and produced compost and sold it to agricultural research institutions or gave it away free to the waste bank members. However, because the selling price of compost is low (IDR 5,000/kg or USD 0.4/kg) and operating costs (including material cost for making seed compost, purchasing of waste from the market, and transportation cost) are high, without any support from the city, the centre had to gradually reduce production while focusing more to waste bank activities. The total amount of organic waste as input to make compost was 60,769 kg in 2015, falling to 29,679 kg in 2016.

JICA Grassroots Project 2013-2015 also collaborated with DLH Medan City to distribute Takakura home compost baskets to communities. In 2014-2015, DLH distributed about 200 compost baskets to households in Sicanang in Medan Belawan and about 100 baskets to Salsabira in Medan Marelan. In the current quick assessment, a follow-up survey was conducted targeting the Salsabira communities to investigate the status of implementation of home composting after three or four years. The total number of respondents were 49 and the survey revealed that only two respondents (4.1%) were continuing composting at home since they received the composting basket, while others stopped using the tool mostly within three months. The low rate of continuation was considered to be due to the fact that the communities were initially expecting that the compost would be purchased by the government but this did not happen and participants lost motivation.

Challenges and Opportunities: The limited composting in Medan due to its low economic value and attractiveness is indeed a challenge, but this could be changed into an opportunity. One noteworthy thing about composting is that there is almost no conflict of interest compared to waste banks because of its low economic value. Thus, it is easier to introduce and more effective if the strategy could be shifted from selling the compost as fertiliser to self-sufficient use for agriculture and gardening purposes. Co-benefits of composting such as GHG reduction and greening of the city could also be expected. In addition, it also coincides well with the Ministry of Agriculture's policy to increase the use of organic fertiliser as a means to stop soil poverty due to excess chemical fertiliser use[48]. Medan City is currently planning to build another compost centre in 2018 in Cadika Pramuka Park which is a city-managed park.

3.7. Final Disposal

The current landfill site in Medan City is the TPA Terjun, located in Medan Marelan sub-district with a size of 13.7 ha and began operating in 1993. Meanwhile, one more landfill site – TPA Namo Bintang - was in operation until 2013. TPA Namo Bintang actually had additional space to accommodate waste but there was an order from the Ministry of Environment and Forestry in July 2013 to temporary close the site and shift operations to TPA Terjun[49]. TPA Namo Bintang is located in Medan Tuntungan sub-district, which is the southern-most sub-district, with part of the area stretching across the border of neighbouring Deli Serdang Regency. It has an area of 16 ha and began operating in 1987. Until its closure, TPA Namo Bintang was running in parallel with TPA Terjun, with TPA Namo Bintang mainly receiving waste from sub-districts in the south and TPA Terjun receiving waste from sub-districts in the north and centre. TPA Namo Bintang was initially designed with specifications to be a sanitary landfill site with a bottom liner to prevent contamination of leachate into the ground water as well as being equipped with a leachate treatment facility. However, in practice, it was operated as an open dumping site with no soil coverage. On the other hand, TPA Terjun was neither designed nor constructed as sanitary landfill site, so it is operated as an open dumping site. However, DKP began covering the waste periodically since 2017 so

48. Menteri Pertanian (2015) Rencana Strategis Kementerian Pertanian 2015-2019.
49. SumutPos (2013/07/16): TPA Namo Bintang Ditutup, Atas Perintah Menteri LH: http://sumutpos.co/2013/07/16/tpa-namo-bintang-ditutup-atas-perintah-menteri-lh/

the current status could be considered as a controlled landfill.

According to DKP, TPA Terjun can only last the next few years, and construction of an alternative landfill site has been a crucial issue for Medan City. As a temporary solution, Medan City is currently constructing an additional 4 ha of landfill site next to TPA Terjun. This site is designed as a sanitary landfill with a bottom liner, leachate treatment facility, gas ventilation pipes, and regular soil coverage. However, it is estimated that it can last for only 4-5 years and a more fundamental solution is needed. Meanwhile, acquiring a large area of land that can be used as a landfill site in Medan City is becoming very difficult not just due to availability of land and construction costs, but also more apparently due to protests from nearby residents. Alternatively, in the Medan City Sanitation Strategy 2017-2021, there is a rehabilitation project for TPA Terjun with an estimated budget of IDR 20 billion (USD 1.5 million). In addition, there is a plan for development of a new regional landfill site in Deli Serdang regency to accept waste from Medan City and Deli Serdang regency. This construction is due to take place from 2018 until 2020 with a total estimated budget of IDR 101 billion (USD 7.5 million). According to DKP, they are also considering expanding an additional 10 ha of land in TPA Terjun, in addition to the 4 ha site currently under construction. However, the proposed area is a conservation area and there are various difficulties in receiving construction permits. As for regional landfill site development, Medan City has already bought 10 ha of land in Tulan Kanas in Deli Serdang regency, and is currently in the process of exchanging an MOU with Deli Serdang regency. In addition, DKP is also considering the possibility of expanding an additional site at the already closed TPA Namo Bintang. Medan City has also shown an interest in using the land of TPA Namo Bintang. DKP is considering the option of using the land as a public park so that it can contribute to fulfilling the 30% green space requirement in Law No. 26 Year 2007 (UU No. 26/2007). The post-closure use of TPA Terjun is also something that Medan City is also exploring.

Challenges and Opportunities: TPA Terjun can be described as a huge pile of waste where many scavengers (300-400 people per day) gather recyclables, with trucks waiting in a long queue. Smoke emerges from several locations and the environmental conditions are extremely bad with foul odor, many flies, and blackish leachate flowing into the nearby river. According to DKP (manager of TPA Terjun), there has been no incident of large-scale spontaneous fire occurring in TPA Terjun in the past. However, it was also pointed out that scavengers sometimes burn waste in purpose so that it is easier for them to collect recyclables such as cans and metal materials (Figure 12). Other key challenges that were raised by DKP in the management of the TPA Terjun were: a) no pavement (the dump site becomes muddy during the rainy season and the accessibility is inhibited); b) limited heavy equipment (3 bulldozers, 3 power shovels, and 1 excavator are not enough); and c) limited space (site is almost full).

Figure 12. TPA Terjun covered with smoke from spontaneous fires (Source: YPGK, 2018)

4. SETTING OF GOALS AND TARGETS

In order to ensure that this Work Plan is consistent with existing relevant policies of Medan City on waste management, and also in line with the relevant national regulations, it is proposed that it outlines specific vision and mission statements. The Work Plan should also set targets considering both levels of policies as well as seeking to provide some realistic strategies and actions to achieve those targets.

4.1. Vision and Mission

The latest initiative of "Medan Zero Waste City 2020" jointly proclaimed by the Minister of Environment and Forestry, Governor of North Sumatra Province, and Mayor of Medan City in April 2018 is a very important first step whereby the top management at the national, province and city levels have joined together to commit in addressing the waste management issues of Medan City. Thus, the vision statement of this Work Plan could apply this slogan, and a mission statement could be the corresponding core strategy to achieve it.

Vision: Medan Zero Waste City

Mission: To Accelerate the Transition to Recycling Oriented and Livable City by Combining the Joint Efforts of All Stakeholders

4.2. Setting of Targets

The Medan City Sanitation Strategy 2017-2021 already sets five targets on waste management, so it is suggested to follow these targets as much as possible as well as being in line with the National Waste Management Policy and Strategy's (*Jakstranas*) targets in the Presidential Regulation (PP) No. 97/2017 (see Table 2). If we assume that the total waste generation amount will constantly increase following the same mean growth rate of population (0.94% per year) as shown in Table 6, the total waste generation in Medan City could reach 1,964 tons/day by 2021 and 2,040 tons/day by 2025. If we set 2016 as a baseline and assume that the amount of waste treated by 3R (composting and recycling) is 2 tons/day in total from the currently available data, the baseline for landfilling would be 1,577 tons/day and uncollected waste would be 295 tons/day. If we then apply the 10% reduction of waste that goes to landfill and 100% coverage of waste collection (= 0% uncollected waste) following the Sanitary Strategy 2017-2021, the amount of waste that needs to be reduced through 3R efforts will have to be dramatically increased to 545 tons/day (28% of total waste generation) by 2021. Meanwhile, the PP No. 97/2017 sets 2025 as the target year, so if we interpret that its requirement is to properly handle waste by 70% through intermediate treatment and final disposal, and then reducing 30% of waste at source through 3R efforts, then the waste that goes to landfill needs to be reduced to 1,428 tons/day while increasing the amount of 3R efforts to 612 tons/day by 2025 (Figure 13).

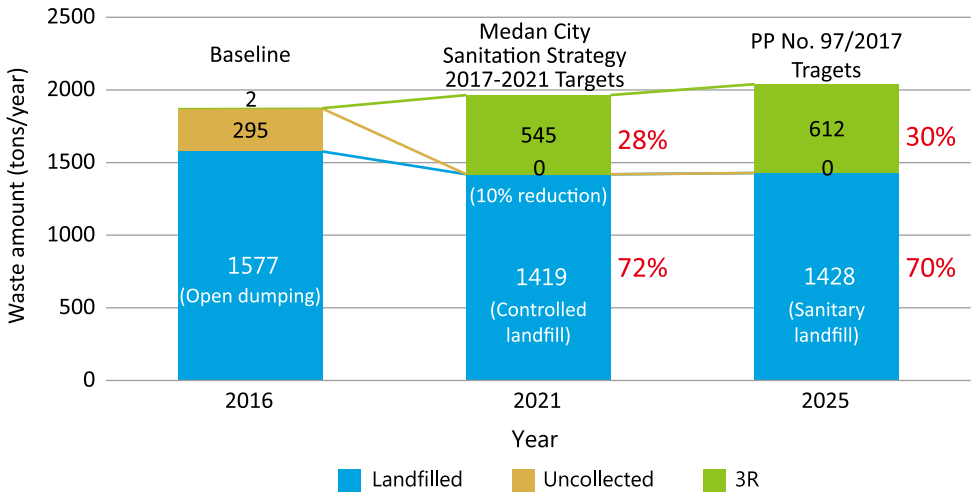


Figure 13. Allocation of required waste treatment mode to achieve the targets in the Medan City Sanitation Strategy 2017-2021 and the Presidential Regulation (PP) No. 97/2017 in comparison with the baseline year (2016)[50]

4.3. Steps to Achieving the 2025 Target

As shown in Figure 13, Medan City Sanitation Strategy 2017-2021 requires a reduction in waste by 545 tons/year by 2021 which is just three years from 2018. This is highly ambitious and not realistic. Therefore, a more realistic step toward 2025 targets which synchronises with the PP No. 97/2017 should be set as shown in Figure 14. At the initial stage, the social system and regulations are not yet ready and the capacity of city officials as well as public awareness are still limited, so it would be difficult to expect a sudden major achievement. In addition, it is important to show not only the public but also to government officials that "Medan City can do it" at the initial stage to generate motivation and buy-in. Thus, targets at the initial stages are relatively conservative. Meanwhile, in the later stages toward 2025 as the social system improves, the capacity of officers grows and public awareness increases, major achievements can be expected under the assumption that there will be a synergetic effect. It should be noted that the target of the Sanitation Strategy 2017-2021 to reduce waste that goes to landfill by 10%, which needs to be less than 1,419 tons/day, cannot be achieved even if the 30% waste reduction target in 2025 was achieved.

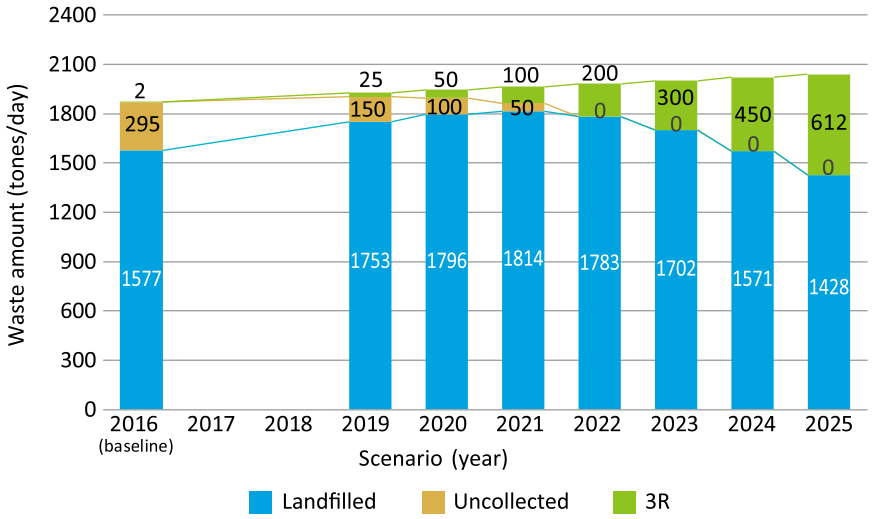


Figure 14. Proposed waste treatment scenario toward achieving the 30% waste reduction and 70% proper waste handling target of the Presidential Regulation No. 97/2017 by 2025 compared with the 2016 baseline

50. The total waste generation amount in 2021 and 2025 were estimated from the expected population growth and per capita waste generation amount.

4.4. New Targets and Corresponding Activities

Based on the waste collection and reduction scenario shown in Figure 14, the new target for this Work Plan is proposed in Table 12 with corresponding priority activities. The targets of 100% collection coverage and 5% budget allocation in the Sanitary Strategy 2017-2021 could stand as they are in the new target, while the current Work Plan would propose to add a target on "open burning" in addition to illegal dumping as it is one of the major SLCP emission sources. Regarding the 10% target to reduce waste that goes to landfill, it is suggested to synchronise with the 30% waste reduction target in the PP No. 97/2017 for consistency. The Sanitation Strategy already sets the target to initiate operation of sanitary landfill by 2022, thus the new target could shift to appropriate operation of the sanitary landfill.

Table 12. Comparison of the Medan City Sanitation Strategy 2017-2021's targets, the proposed new targets in 2022-2025 which is consistent with the Presidential Regulation No. 97/2017, and the proposed corresponding priority activities in the Work Plan

Medan City Sanitation Strategy 2017-2021 Target	Proposed new target 2019-2025	Priority activities in the Work Plan
100% of city area is covered for waste collection		**Goal A:** Strengthen Administrative Arrangement
City budget allocation to waste management will be increased to >5%		
Stop illegal dumping in drainage, rivers and open areas	**Stop illegal dumping and open burning**	
Waste that goes to landfill is reduced by 10%	**30% of waste to be reduced through 3R**	**Goal B:** Replicate Compost Centres
		Goal C: Improve Waste Bank System
		Goal D: Develop Community Waste Management System
		Goal E: Incentivise Commercial and Industry Sectors to Promote 3R
Initiate operation of controlled landfill by 2021 and sanitary landfill after 2022	**Appropriately operate sanitary landfill**	**Goal F:** Improve Final Disposal Site

The text highlighted in blue are suggested changes from the Sanitation Strategy 2017-2021.

5. PROPOSED ACTIVITIES

The six priority activities (strategic goals) identified in Table 12 together with the vision of this Work Plan is illustrated in Figure 15. Detailed activities to effectively achieve each goal are described in this section. It should be noted that this is not a comprehensive set of activities that ensures achieving the 30% waste reduction and 70% proper waste handling target by 2025. It is rather a set of key activities that provides foundation to accelerate the achievement of the targets.

Figure 15. Mission and strategic goals for the Work Plan

5.1. Strategic Goal A: Strengthen Administrative Arrangement

RATIONALE

A consistent and effective administrative arrangement and procedure are a fundamental part of supporting and improving waste management activities at all levels.

DIRECTION

Following the Mayor Regulation (*Perwali*) No.73/2017, the responsibility of waste collection, transportation and management was recently transferred from DKP to each sub-district, while DKP and DLH still share some other waste management responsibilities (Table 4). There may be some advantages of a sub-district taking the lead in waste management activities especially for those that require tailored support depending on the local conditions. However, a lack of central coordination and support mechanisms may invite gaps in the performance level among sub-districts and limit the synergetic effects at the city level. It is therefore suggested to carefully evaluate and reconsider what aspects need central coordination and what aspects could be led by the sub-districts.

ACTIVITIES

A.1. Strengthen Central Coordination of Waste Management

(Responsibility: BAPPEDA, DKP, DLH)

- A.1.1: If agreed, further transfer the waste management related responsibilities from DLH to DKP to concentrate all waste management administration to be overseen in a single department (DKP) to increase consistency and effectiveness of waste governance. However, this should be seen as a temporary solution toward achieving the current Work Plan targets. For a longer term solution, all waste management should be merged with environment responsibilities and governed under a single agency for consistency.
- A.1.2: Develop Standard Operating Procedure (SOP) for DKP and sub-districts on waste management considering each characteristics and strengths, and how they can best collaborate to enhance waste management.
- A.1.3: Appoint dedicated staff to monitor and manage all waste management data to track the progress of performance toward the set targets (see Section 6 "Key Performance Indicators") and to analyse data for improving waste management.
- A.1.4: Increase dedicated staff specialised in the 3Rs (e.g. waste banks, composting, waste separation, recycling, awareness raising and education) and continuously build their capacity to strengthen the 3R capabilities in DKP.

A.2. Increase Waste Collection Efficiency

(Responsibility: BAPPEDA, DKP)

- A.2.1: If agreed, retrieve the waste collection responsibility from sub-district to DKP to provide effective and stable waste collection services.
- A2.2: Review current waste collection system including identifying uncollected areas and consider ways to increase waste collection coverage and efficiency (e.g. privatisation of commercial and industrial waste collection, reallocation of trucks considering the waste loading ratio, improvement of collection route, covering shortfall of trucks and motorised tricycles by additional procurement, improvement of capacity of waste collection staff).

A.3. Strengthen Law Enforcement for Illegal Dumping and Open Burning

(Responsibility: BAPPEDA, DKP)

- A.3.1: Strengthen the law enforcement by issuing stricter and more effective local regulations for fining illegal dumping and open burning of waste including appropriate tracking of how the B3 waste are being collected, transported and disposed. The illegality of open burning should also be stipulated in the local regulations.
- A.3.2: Identify illegal (unauthorised) temporary dumping areas, ban further dumping and close such areas. The illegally dumped waste should be excavated and transported to TPA to show how serious the government is on this issue.
- A.3.3: Introduce a tracking system for commercial and industry waste to detect illegal dumping of waste by third parties who are collecting and transporting the waste. This could be done by registering and identifying all the waste trucks by ID and monitoring if they are properly dumping the waste at the formal final disposal sites.
- A.3.4: Establish an inspection team for illegal dumping and open burning of waste, and enforce strict inspection by conducting patrolling activities.
- A.3.5: Organise a city-wide campaign to stop illegal dumping and open burning.
- A.3.6: Develop an online notification system based on smart phone app or social media for reporting illegal dumping and open burning of waste directly from the citizens to intensify and accelerate effective detection.

A.4. Set Up an Advisory Group for City Waste Management Policy

(Responsibility: BAPPEDA, DKP)

- A.4.1: Set up an advisory group including relevant city officials, experts (e.g. academic institutions, consultants, etc.), NGOs, and practitioners to evaluate the progress and advise on the implementation of the Work Plan and other city waste management policies and strategies.
- A.4.2: The advisory group will also develop yearly strategies to win *Adipura* awards by identifying priority activities that can maximise the limited resources to satisfy both *Adipura* criteria and actual improvement of waste management for Medan City.
- A.4.3: Allocate city budget based on the strategic direction developed by the advisory group and upon approval by the city council.

5.2. Strategic Goal B: Replicate Compost Centres

RATIONALE

Organic waste makes up more than half of the waste generated in Medan City and is a major source for methane gas emissions if it is directly disposed of at the landfill site. If organic waste could be turned into compost (organic fertiliser) through aerobic fermentation and used for agriculture or gardening purposes, the waste carried to landfill and net GHG emissions could be reduced substantially, leading to co-benefits such as greening of the city.

DIRECTION

In order to boost waste reduction and production of compost, replication of compost centres on the medium-to-large scale and strengthening their capacity to increase productivity are considered to be most effective. For efficiency, it is suggested to start from specific sources where abundant organic waste is available and efforts for source separation (getting rid of other mixed waste) is limited. In this context, street/park garden waste and traditional market waste are considered to be the most appropriate targets to start with.

In Medan City, there is an existing compost centre in Belawan Sicanang and one TPST-3R (TPST-3R Pasar Tani Medan Berseri) which is producing compost using organic waste from traditional markets, so experience gained at these facilities could be used. However, both facilities have not gained much attention and have not been replicated. Furthermore, when much larger amounts of organic waste need to be processed, a stronger push needs to be taken by the city government. Firstly, it would be effective to learn from other Indonesian cities on advanced and successful cases of medium-large scale composting using municipal solid waste (e.g. Surabaya, Depok, Bali, etc.). Based on such lessons, a model project could be established in close collaboration with local academic institutions to secure scientific-based knowledge accumulation and long-term continuation of technical support. The model projects and subsequent replication of compost centres should take a step-by-step approach to avoid failure as well as to incorporate the use of compost for gardening in the process. Furthermore, because it is generally difficult to make a profit from composting without adequate tipping fees, DKP should intervene in the separated collection of organic waste and establishment and operation of compost centres including ensuring that the compost is used by the landscaping division.

ACTIVITIES

B.1. Develop Models for Compost Centres

(Responsibility: DKP, PD Pasar, Academic institution)

- B.1.1: Study and learn from advanced and successful cases of medium-large scale compost centres using municipal solid waste in other cities in Indonesia,

and identify an appropriate and feasible method for Medan City.

- B.1.2: In order to localise composting knowledge and experiences, identify a reliable academic institution to create and maintain a knowledge centre for composting in Medan City. This knowledge should be based on proven methodology with scientific evidence and should be tested locally.
- B.1.3: Identify several existing city-owned facilities (e.g. parks, traditional markets and TPS) that could be used for model projects of compost centres to test identified methods. The initial target would be to develop one compost centre with a capacity of 1 ton/day in each sub-district, in a total of 21 locations.
- B.1.4: Provide training to the operators and carry out compost production and management.
- B.1.5: Collaborate closely with DKP's landscaping division and PD Pasar in waste separation and collection of garden waste and market waste for composting. Ensure that the produced compost is used for street/park greening or disseminated to farmers for agriculture use as a substitute for purchasing chemical fertilisers. In order to cope with future increase of compost production, additional needs of compost shall be explored in consultation with other relevant agencies and/or companies that are working on fertiliser production, large scale plantations, forest and river catchment rehabilitation, and agricultural projects.
- B.1.6: The model compost centres shall conduct daily monitoring of temperature, moist contents, input and output amount, and periodically report to DKP. DKP shall then compile the data and estimate the operating cost and investment recovery of the compost centres. From this data, the effectiveness of replicating compost centres shall be evaluated in comparison with avoided costs for transportation and TPS/TPA management.

B.2. Replicate Compost Centres

(Responsibility: DKP, PD Pasar, Academic institution)

- B.2.1: Develop a replication plan of compost centres based on the calculation of investment recovery from the result of activity B.1 and strategically allocate compost centres throughout the city. The compost centres could also be replicated to private sectors including agricultural farms, plantations, commercial facilities, etc. where large amount of organic waste production could be expected.
- B.2.2: Replicate compost centres by prioritising effective use of existing facilities. Once the 1 ton/day models are successful, a scaled up model with more capacity (e.g. 2 tons/day, 5 tons/day, 10 tons/day) shall be developed.
- B.2.3: Allocate budget and appoint dedicated staff to promote and support compost centres in collaboration with the above mentioned knowledge centre. The services may include: organising training, networking and knowledge sharing among compost centres, monitoring and evaluation, providing technical and financial support.

5.3. Strategic Goal C: Improve Waste Bank System

RATIONALE

The waste bank system is an effective way to promote waste separation at source and recycling of resources which contributes to waste reduction, income generation, and reducing net GHG emissions by avoiding emissions from virgin product extraction and manufacturing.

DIRECTION

The current waste bank system in Medan City is based on the "one centre" system where most of the recyclables are transported over a long distance to the waste bank centre (Bank Sampah Induk Sicanang) at the northern most sub-district in Medan Belawan. This system requires high cost for fuels and vehicles for collection of recyclables. In order to promote waste banks, the incentives for the end-users

(i.e. mostly communities who provide waste) should be maximised in order to increase the collection of recyclables. And reducing the collection/transportation costs is considered to be most effective for increasing the end-user's price. In addition, improving the distribution system by allowing waste bank centres to directly deal with recycling industries and/or reducing intermediaries (middlemen) will also contribute in reducing the cost. The other strategy to increase the incentives for the end-users could be to stabilise the selling price by city government's intervention, either by purchasing all recyclables through registered waste banks and set stable prices for the materials, or by concluding an MOU with the recycling industries and vendors to control unfair practices and set fair and transparent pricing.

In terms of reducing transportation costs, several more waste bank centres could be established in strategic locations considering the current location of the waste bank units (Figure 10) and concentration of waste generation (Figure 4). For example, developing two more large waste bank centres following the existing waste collection service area in the RPIJM Kota Medan 2013-2017 will make collection more efficient (Option 1 in Figure 16). Alternatively, if each sub-district can develop and provide a waste bank service, this will be consistent with the new waste management policy whereby waste collection services are provided by the sub-districts, leading to a further increase in collection efficiency (Option 2 in Figure 16).

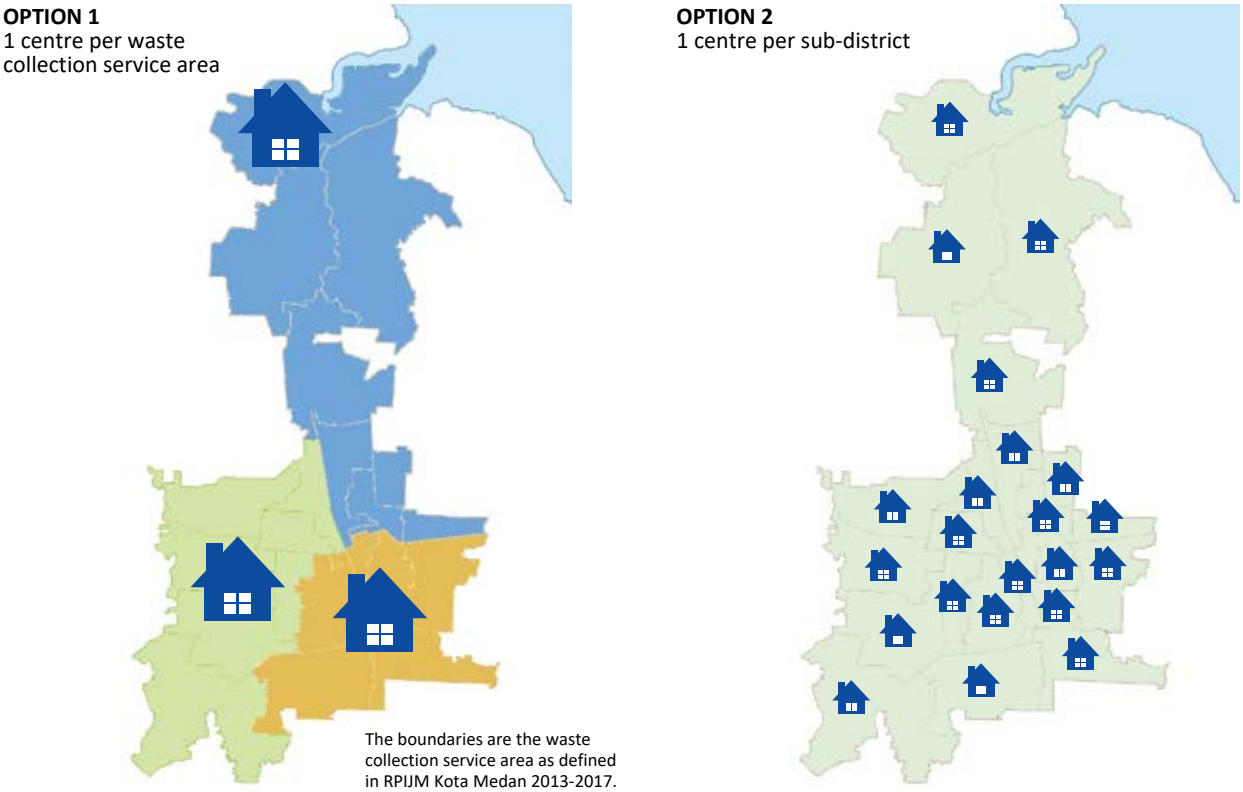


Figure 16. Possible options for waste bank system for enhancing the efficiency of waste collection and transportation. (The image of a house represents one waste bank centre.)

ACTIVITIES

C.1. Develop Effective Waste Bank System

(Responsibility: DKP)

- C.1.1: Consider and decide on the appropriate waste bank system for Medan City by involving relevant stakeholders and examining the pros and cons of each option including the two options shown in Figure 16.
- C.1.2: Develop Standard Operating Procedure (SOP) for waste bank centres and units based on the identified waste bank system. For example, the role of waste bank centres could be defined as not-for-profit

public services for supporting the waste bank units and maximising the benefits for the end-users. The SOP should also define the purpose of waste banks to avoid misunderstanding that it is a profit-oriented activity; it should rather emphasise that the waste bank is a tool to enhance recycling and cleansing of the communities as well as strengthening the community bond and empowerment. As a means to strengthen the waste banks' negotiating power toward recycling industries, the SOP could also consider establishing a formal network of waste bank centres and units in a form of cooperatives (*koperasi*) or federation.

- C.1.3: If agreed, Medan City or each sub-district will intervene in the waste banks' distribution system to allow waste bank centres to directly deal with recycling industries to reduce intermediaries, and work with recycling industries and vendors to stabilise the sales pricing of waste.

C.2. Conduct Model Project of New Waste Bank System

(Responsibility: DKP)

- C.2.1: Identify several representative areas to test the feasibility and effectiveness of the selected option of waste bank system described in C.1.1.
- C.2.2: Based on the results from the model project, develop a waste bank promotion plan for effective enhancement of waste banks in Medan City. The candidate locations of new waste banks could be considered using the data on waste generation (Figure 4) and waste bank distribution (Figure 10).
- C.2.3: Replicate waste bank centres and units based on the waste bank promotion plan.

C.3. Develop a Monitoring and Support System for Waste Banks

(Responsibility: DKP)

- C.3.1: In the SOP for the waste bank centres and units, encourage each waste bank unit to keep a record of the amount of waste sold to waste bank centres or to the recycling vendors, and monitor income generation. The waste bank centres shall collect this data and share it with DKP. DKP shall then use that data to provide support and policy development to improve the waste bank system.
- C.3.2: Allocate budget and dedicated staff who will be responsible for planning, coordination and technical support on all waste bank related activities in C.1-C.3. For effective notification of pricing or the location of units, etc. to the public, a smart phone app could be developed to disseminate information.

5.4. Strategic Goal D: Develop Community Waste Management System

RATIONALE

Nearly half of the waste in Medan City is considered to be generated from households. Coordinated efforts to promote decentralised waste management in the communities – to reduce waste using the 3Rs as much as possible at the source of the waste stream – play a key role in waste reduction at the city level.

DIRECTION

The approach of decentralised community waste management is expected to benefit the communities by combining activities with waste banks, home/community compost production, and cleaning and greening of the neighbourhood. This would also contribute to reducing the fuel and staff costs as well as lowering emissions by reducing the amount of waste that will be transported over long distances to landfill sites (Figure 17).

The experience of Surabaya City, which successfully decreased municipal solid waste by 30% (from about 1,500 ton/day to about 1,000 ton/day) over five years (2005-2009) suggested that technology alone will not solve the problem. The existence of a social support system was an indispensable factor for success in raising

awareness and motivating the community cleansing activities. The Surabaya city government identified environment cadres to support communities, and effectively utilised existing social networks (including a women's association called PKK) to promote community waste management, as well as providing various technical and financial support[51].

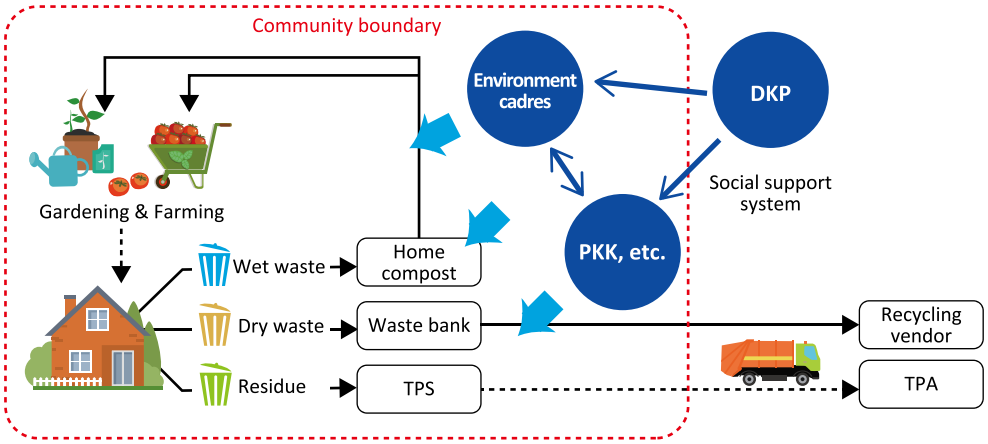


Figure 17. Concept of decentralised community waste management and social support system

Once the community waste bank is functional, recyclable dry waste could be brought to the waste bank. On the other hand, treating organic (wet) waste near the source (household composting) has been a challenge for many community waste management projects. Once the environment cadres are equipped with enough knowledge and experiences to teach and support the communities, methods such as Takakura home composting could be introduced. But without such a supporting environment, a simpler method such as biopori[52] would be safer to introduce to avoid failure.

ACTIVITIES

D.1. Appoint and Train Environment Cadres in Each Community

(Responsibility: DKP and Sub-districts)

- D.1.1: Collaborate with relevant NGOs and academic institutions to develop training courses for environment cadres who will take the lead in educating and supporting communities to appropriately practice 3R activities. If necessary, utilise existing facilities, such as the waste bank and compost centre in Belawan Sicanang, for training of environment cadres.
- D.1.2: Each sub-district to appoint and train environment cadres in each community and provide technical and financial support.

D.2. Develop Social Support System

(Responsibility: DKP and Sub-districts)

- D.2.1: Identify appropriate social support system for Medan City considering the differences in the social system depending on location (urban and rural) and income levels. The social support system may include appointment and training of environment cadres; collaboration with existing social networks; and a technical and financial supporting scheme by DKP and/or each sub-district.
- D.2.2: Allocate budget and appoint dedicated staff who will be responsible for supporting community waste management in DKP. These staff shall visit the communities frequently to understand the situation

51. Takakura K (2016) Research on Technological Transfer of Takakura Composting Method through International Technical Assistance. Doctorate Dissertation for Kitakyushu Institute of Technology. (In Japanese)
52. Biopori: A simple method to induce infiltration of rain water to the ground and decomposition of organic waste by digging a hole on the ground and putting organic waste. The method was invented by a professor in the Bogor Institute of Agriculture and widely introduced throughout Indonesia.

and closely collaborate with sub-districts and environment cadres.

D.3. Develop and Replicate Model Communities

(Responsibility: DKP and Sub-district)

- D.3.1: Identify and develop model communities in each sub-district to enhance decentralised community waste management. The model communities should introduce and test various methods and identify the most suitable one for each community, including: social support system; waste bank; household composting; community gardening; and community cleaning.
- D.3.2: Develop a community waste management promotion plan to effectively replicate the model communities throughout the city.
- D.3.3: Replicate best practices performed by the model communities to other communities based on the community waste management promotion plan. The environment cadres or the community leaders of the model communities could act as mentors to educate other communities.

D.4. Incorporate 3R in School Curricula and Activities

(Responsibility: DKP, Education Department)

- D.4.1: Identify and develop model schools in each sub-district that incorporate 3R concepts and activities into the school curricula. Activities may include: organising classes on the 3Rs; visiting waste banks, composting centres, and landfill sites for on-site learning; and actually practicing the 3Rs in schools (waste banks, composting, etc.).
- D.4.2: Develop 3R curricula for public schools based on the experiences and lessons learnt from the model schools. There are approximately 1,500 public schools in Medan City (900 elementary schools, 400 Junior high schools, and 200 High schools) and all of them are targets. The 3R curricula may be linked with the criteria of the *Adiwiyata*[22] programme to facilitate receipt of the award.
- D.4.3: Replicate best practices performed by the model schools in other public schools using the 3R curricula. DKP or Education Department should allocate budget and appoint dedicated staff who will be responsible for supporting 3R activities in all public schools.

D.5. Organise Competitions and Public Events

(Responsibility: DKP)

- D.5.1: Medan City to organise yearly competition on green & clean activities involving communities, public schools, commercial and industry sectors, etc. Performance of green & clean activities will be evaluated by simple and objective criteria, using a transparent process. An award will be presented to the winner in each category by the mayor.
- D.5.2: Medan City in collaboration with sub-districts, public schools, education sectors, commercial and industry sectors, religious leaders, etc. will organise other public events such as awareness campaigns on waste management or environment in general. It is suggested that the themes of the events will be chosen in line with relevant activities under this Work Plan and in a timely manner to increase effectiveness.

5.5. Strategic Goal E: Incentivise Commercial and Industry Sectors to Promote 3R

RATIONALE

The commercial and industry sectors are considered to be generating about 30% of the waste in Medan City so they should be responsible for the consequences of their economic and production activities. With many people working and visiting these sectors, the potential social impact could become huge when these sectors introduce the 3R concept.

The existing waste management fee system (retribution) for commercial entities and industries is basically determined based on the size and location of the buildings and not based on how much waste is actually generated, so there is no incentive to reduce and/or recycle waste. If the volume-based retribution (= "pay as you throw" concept) could be introduced similarly to the system for traditional market waste, there will be a clear incentive to reduce the waste, so the waste separation and recycling could be enhanced in these sectors based on market mechanisms. Furthermore, involving private collectors and recycling vendors for waste collection services will reduce the burden on the city and could increase both the efficiency of the waste collection as well as recycling rate in the commercial and industry sectors (Figure 18).

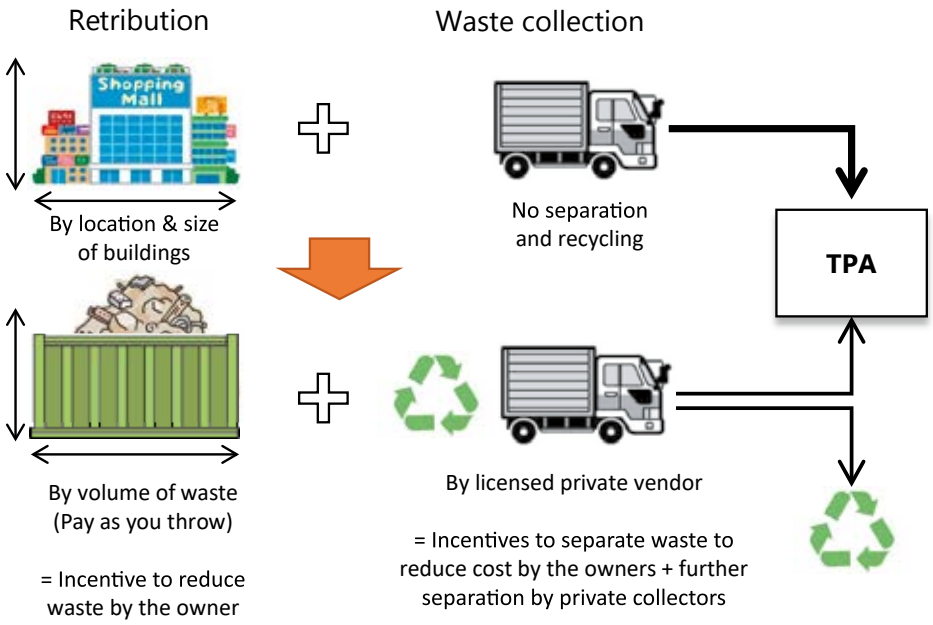


Figure 18. Concept of incentivising the waste reduction, separation, and recycling by changing the retribution system and privatisation of commercial and industrial waste collection

ACTIVITIES

E.1. Improve Waste Management Fee System for Commercial and Industry Sectors

(Responsibility: BAPPEDA and DKP)

- E.1.1: Improve transparency and accountability of waste management fee system by revising the existing *Perda Kota* Medan No. 10/2012 on retribution. Consider introducing the "pay as you throw" (volume-based waste disposal fee) system in the commercial and industrial waste retribution to incentivise waste reduction and recycling in these sectors. In designing the system and revising the regulation, review experiences and lessons learnt from other cities that have introduced the volume-based retribution for commercial and industry waste.
- E.1.2: Organise several briefing sessions and invite commercial and industry sectors to increase their understanding and recognition about the new retribution system. Emphasise that the new policy will benefit industries through cost reduction by reducing and recycling of waste, raising corporate value by enhancing green image and branding, and contributing to the society under corporate responsibility.

E.2. Enhance Involvement of Private Sector for Collection and Recycling

(Responsibility: BAPPEDA and DKP)

- E.2.1: Consider privatisation of waste collection and transportation services for commercial and industrial waste by revising the existing *Perda Kota* Medan No. 6/2015.
- E.2.2: In revising local regulations, ensure

strengthening of proper licensing of waste collection and recycling services by the private sector including existing third parties that are providing such services. In addition, stricter fines and penalties should be imposed when these private collectors violate the laws and regulations including disqualification of waste collection license. These measures are necessary to increase transparency and accountability as well as ensure the quality of commercial and industrial waste collection and recycling services.

E.3. Develop New Local Regulation on Source Separation by Corporate Sectors

(Responsibility: BAPPEDA and DKP)

- E.3.1: Consider developing a new local regulation on corporate responsibility to mandate source separation of waste to enable separated collection and recycling in the commercial and industry sectors. In designing the system and revising the regulation, review experiences and lessons learnt from other cities that have introduced mandatory source separation of waste by the commercial and industry sectors.
- E.3.2: Organise several briefing sessions and invite the commercial and industry sectors to increase their understanding and recognition about the new local regulation on mandatory source separation of waste.

E.4. Showcasing Good Practices in Commercial and Industry Sectors

(Responsibility: DKP)

- E.4.1: Launch a campaign to enhance the 3Rs in the commercial and industry sectors by showcasing some 3R initiatives and best practices by these sectors and emphasising the co-benefits.
- E.4.2: Organise a yearly award event to present awards to outstanding companies that have contributed to 3R practices. This could be combined together with the yearly competition on green & clean activities (Activity #D.5).

5.6. Strategic Goal F: Improve Final Disposal Site

RATIONALE

The current final disposal site (TPA Terjun) is an open dumping site and has been a major source of methane gas emissions as well as causing other environment problems. Its capacity is almost full and an ongoing plan to expand the area by another 4 ha (using a sanitary landfill system) is only expected to last for 4-5 years. Therefore, there is an immediate need to be prepared for next-step solutions for final disposal and treatment of waste.

DIRECTION

Upon issuance of the Presidential Regulation No. 35/2018 (which replaced the existing Presidential Regulation No. 18/2016 on the acceleration of development of waste to energy projects), several large cities in Indonesia are currently shifting to incineration of municipal solid waste as a means to treat waste hygienically and to prolong the lifetime of final disposal sites. However, considering the fact that Medan City has several options for landfill sites and that there are several barriers and risks in introducing the incinerators (e.g. low calorific value of waste for combustion, high initial investment and operation costs, technological uncertainties), it is suggested that Medan City prioritises developing and managing environmentally-sound landfill sites for the most basic infrastructure and services, while enhancing waste reduction and recycling efforts. Incineration could be considered as one of the future options for final disposal by objectively witnessing and learning from the experiences of other pioneering cities to avoid becoming a failure case.

In addition, effective use of existing and ongoing landfills (TPA Namo Bintang and TPA Terjun) including technologies to reduce methane gas emissions and/or effective use of waste as an energy resource, and

use of the land after ensuring proper closure, should also be considered in parallel (Figure 19). Installing gas ventilation pipes to effectively collect methane gas and then flaring the gas could be the simplest and most cost-effective technology in terms of investment and management. The collected gas could also be partly provided to nearby communities as an alternative energy fuel for cooking. For example, landfill sites in Kendari (TPA Sampah Puuwatu) have constructed a purpose-built "Energy Self Village" for scavengers and employees of landfill site, providing free gas[53]. The collected gas could also run a gas engine and generate electricity, as seen in TPA Benowo in Surabaya City (Capacity: 2MW) and TPA Jatibarang in Semarang City (Capacity: 0.8MW). However, this requires higher investment costs and needs careful cost-benefit calculation.

Meanwhile, some landfill sites in Indonesia including TPA Sampah Puuwatu in Kendari are using existing vehicle engines as a substitute for generating electricity for local consumption (use of electricity in the TPA facilities).

When mixed waste in disposed of at the landfill site, after a certain amount of time, the amount of methane gas generated will gradually decrease as the organic substances degrade, with the remaining waste being less-degradable materials, mainly plastics. This remaining waste has high calorific value and can be excavated to be utilised as an alternative fuel, called Refuse Derived Fuel (RDF), and there are many cases in developed countries using RDF in incineration and cement plants. One example in Indonesia is Cilacap City, Central Java Province, which introduced a RDF plant and is using RDF as an alternative fuel in the nearby cement factory. Theoretically, through RDF production, the excavated waste can be separated into burnable materials (for RDF production), other recyclables (metals and glass to be sold to recycling vendors), and others (to be reverted to landfill), so the post-excavation land can be used for other valuable purposes, such as for a new landfill site or public green space. However, a careful feasibility study including cost-effect analysis and collaboration with cement companies is needed.

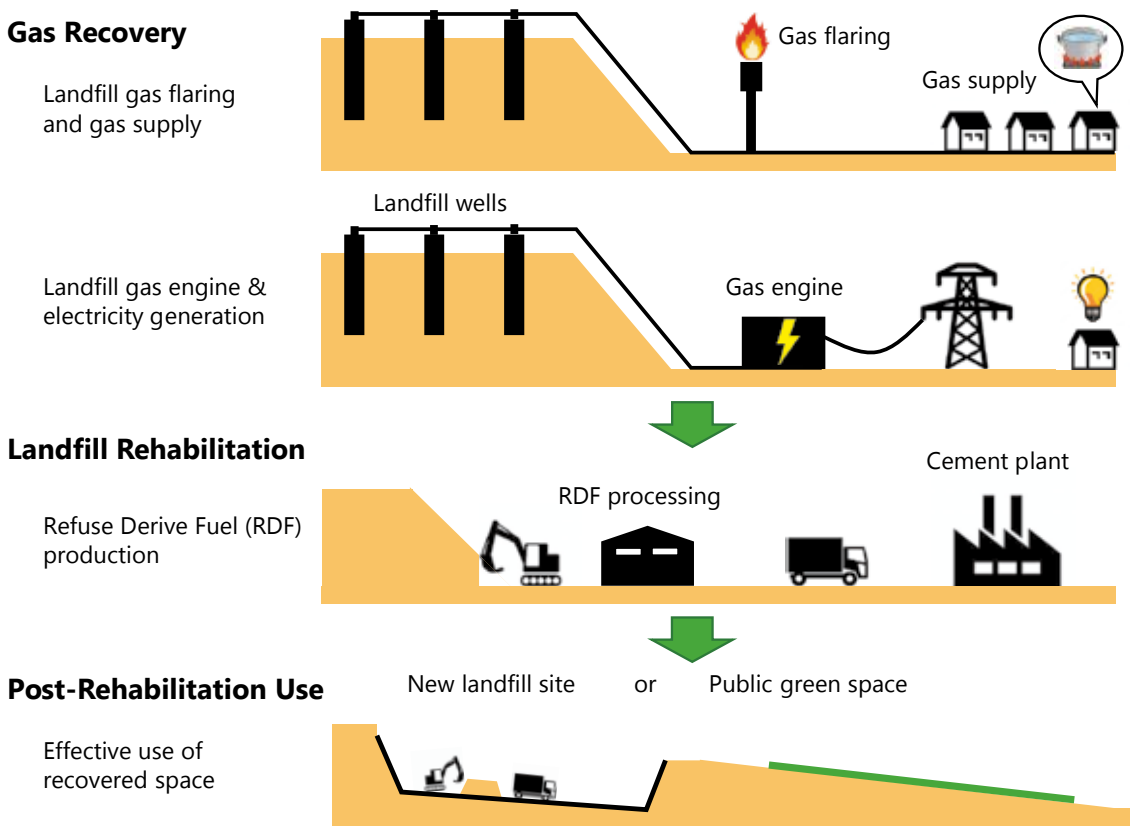


Figure 19. Concept of different options for effective use of existing final disposal sites

53. 2017 Energy Awards, Ministry of Energy and Mineral Resources: http://penghargaanenergi.litbang.esdm.go.id/index.php/penghargaan-energi/346-tpa-sampah-puuwatu-kota-kendari-memanen-energi-hasil-pengolahan-sampah

ACTIVITIES

F.1. Prepare for the New Landfill Site

(Responsibility: DKP)

- F.1.1: Conduct a comparative study to identify appropriate options for the new landfill site including location, applied system, timeline, and construction & management costs. If the landfill is to be located outside of Medan City, it is suggested that the DLH North Sumatra Province and the Ministry of Environment and Forestry will be involved in the process. The type of landfill site and other final disposal methods for comparative study may include:
  - (I) Sanitary landfill with no gas recovery
  - (II) Sanitary landfill with gas recovery (gas recovery options may include flaring, electricity generation, gas supply to nearby communities)
  - (III) Semi-aerobic sanitary landfill
  - (IV) Incineration
- F.1.2: Identify financing options for developing the new landfill site including city budget, national government subsidy (e.g. Ministry of Public Works and Housing), external donor funding, and Public-Private Partnership (PPP).
- F.1.3: Conduct feasibility study in conjunction with the identified financing sources and initiate necessary preparations, such as environment impact assessment (EIA), for the establishment and management of the new landfill site.

F.2. Upgrade Existing Landfill Sites

(Responsibility: DKP)

- F.2.1: Conduct a comparative study to identify appropriate options to upgrade and/or effectively use existing landfill sites (TPA Namo Bintang and TPA Terjun) considering cost-effectiveness:
  - (I) Landfill gas flaring
  - (II) Gas power generation (grid-connection scale or local consumption scale)
  - (III) Gas supply to nearby communities
  - (IV) Landfill rehabilitation (RDF production)
  - (V) Post-landfill rehabilitation use of land
- F.2.2: Identify financing options for introducing the technology to upgrade and/or effectively use existing landfill sites including city budget, national government subsidy (e.g. Ministry of Public Works and Housing), external donor funding, and Public-Private Partnership (PPP).
- F.2.3: Conduct feasibility study in conjunction with the identified financing sources and initiate necessary preparations, such as environment impact assessment (EIA), for the management of the existing landfill site.

6. KEY PERFORMANCE INDICATORS

In order to track the progress and evaluate the performance of the Work Plan toward the set targets in 2019-2025, it is proposed to use key performance indicators (KPI) based on future scenarios. The data shall be collected and managed by dedicated staff assigned for monitoring and evaluation in DKP (Action #A.1.3), then shared with the relevant departments and reported to the mayor once a year. If the performances are considerably lower than the set targets, possible causes of the limited performance should be examined and the targets adjusted as necessary.

The proposed KPI is shown in Table 13. It mainly focuses on the measurable indicators related to waste reduction in line with the targets shown in Figure 14. Other indicators that are difficult to measure numerically, such as administrative arrangements (Strategic Goal A) and final disposal sites (Strategic Goal F), were not included. The major means for waste reduction is expected to be by compost centres, and a lower proportion is expected from waste banks, households, public schools, and commercial entities and industries especially in the initial stages where the social system is not fully in place and public awareness is still low. Conversely, a higher proportion shall be expected from the commercial and industry sectors and from households in the later stages (Figure 20). This expected shift in allocation is synchronised with the figures in Table 13.

Table 13. List of key performance indicators to track the progress and evaluate the performance of the Work Plan toward set targets in 2019-2025

No	Key Performance Indicators	Targets (tons/day)							Calculation basis
		2019	2020	2021	2022	2023	2024	2025	
KPI1	Amount of waste dumped to TPA	1,753	1,796	1,814	1,783	1,702	1,571	1,428	Synchronised with targets in Figure 14
KPI2	Amount of uncollected waste	150	100	50	0	0	0	0	
KPI3	Amount of total waste processed by 3R [KPI3=KPI4+5+6+7+8]	25	50	100	200	300	450	612	
KPI4	Amount of waste processed by compost centres	21	42	84	150*	200*	250*	300*	2019: 21 sub-districts x 1 ton/day *assume to peak-out at 300 tons/day (about 15% of total waste generation)
KPI5	Amount of waste processed by waste banks	2.5	3.5	5	8	12	18	24	2019: 0.5 tons/day addition to 2018 production amount (2 tons/day)
KPI6	Number of households committed to 3R	0.5 (=500 house-holds)	1 (=1,000 house-holds)	5 (=5,000 house-holds)	25 (=25,000 house-holds)	50 (=50,000 house-holds)	75 (=75,000 house-holds)	100 (=100,000 house-holds)	2019: 1 kg/day x 500 house-holds (about 48 households x 21 sub-districts) = 0.5 ton/day
KPI7	Number of public schools committed to 3R	0.5 (=105 schools)	1 (=210 schools)	2 (=420 schools)	3 (=630 schools)	4 (=840 schools)	5 (=1,050 schools)	6 (=1,260 schools)	2019: 105 model schools x 5 kg/day = 0.5 ton/day
KPI8	Number of commercial and industrial entities committed to 3R	0.5 (=10 entities)	2.5 (=50 entities)	4 (=80 entities)	14 (=280 entities)	34 (=680 entities)	102 (=2,040 entities)	182 (=3,640 entities)	2019: 10 entities x 50 kg/day = 0.5 ton/day

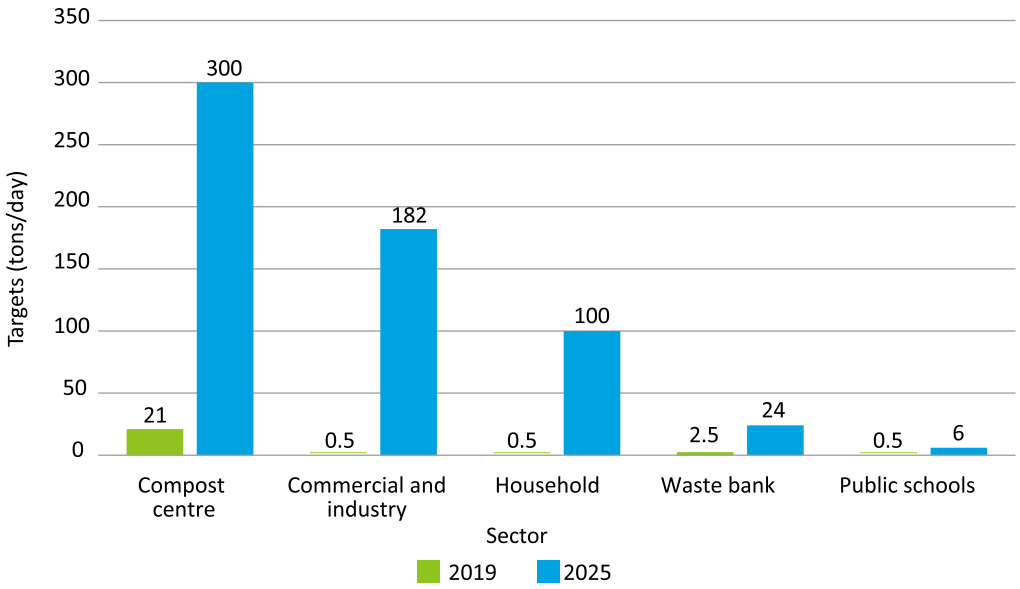


Figure 20. Transition of means (sectors) to reduce waste and reduction amount from targets in 2019 (green) to 2025 (blue)

7. POTENTIAL SLCP EMISSIONS

In order to estimate the potential SLCP emissions from the waste sector in Medan City, the Emission Quantification Tool (EQT) for Emission of GHGs/SLCPs from Solid Waste Sector[54] was used. For consistency with this Work Plan, the business-as-usual (BAU) scenario, which assumes that current waste management scheme will continue to be unchanged in the future, used the existing available 2016 baseline data from Medan City.

For comparison purposes, alternative scenarios were kept in line with the targets of the Key Performance Indicators shown in Table 13 – Scenario 1 was set at 10% reduction of waste (assuming target in 2022) and Scenario 2 was set at 30% reduction of waste (assuming target in 2025).

BAU Scenario

The estimated SLCP emissions and the total GHG emissions (CO_2 equivalent) from the BAU scenario are shown in Table 14. Notable net CO_2 reduction can be expected from recycling (waste banks) which contributes in avoiding the emissions from virgin product extraction and manufacturing. On the other hand, relatively a large amount of net emissions of methane (CH_4) can be expected from landfilling, open burning and scattered dumping due to anaerobic digestion of organic waste, as well as large amounts of net emissions of CO_2 from collection, transportation, open burning and scattered dumping due to combustion of fuels and/or waste.

Table 14. Summary of net GHG/SLCPs emissions from waste sector in Medan City as a business-as-usual (BAU) scenario using 2016 baseline data from Medan City

Area	Technology and conditions (calculation basis)	Unit	GHG/SLCP emissions			
			CH_4	BC	CO_2	N_2O
Collection and transportation	Transportation: Diesel consumption: 12,215 (8,500 + 3,715) L/day + Gasoline consumption: 2 L/day	kg/ton	0.001	0.009	20.879	0.001
Treatment for separated waste	Composting: 0.08 tons/day		3.999	-0.001	-4.259	0.286
	Anaerobic digestion: 0 tons/year		0	0	0	0
	Recycling: 2 tons/day		-0.007	-0.011	-874.722	-0.002
Treatment for mixed waste	Landfilling (open dumping): 1,577 tons/day		46.458	0	0	0
Uncollected waste	Open burning, scattered dumping: 295 tons/day		17.764	0.130	47.278	–
Total net GHG emissions (CO_2 equivalent) per tonne of generated waste		kg of CO_2-eq/tonne	1,199.826			

54. Menikpura N, Premakumara DGJ (2018) Emission Quantification Tool (EQT) for Emission of GHGs/SLCPs from Solid Waste Sector Version II – June 2018. Institute for Global Environmental Strategies.

Alternative Scenarios

Conditions for calculation basis in BAU and alternative Scenarios 1 and 2 are shown in Table 15. For ease of understanding, the conditions for transportation, waste composition, and treatment of uncollected waste were all kept the same. Meanwhile, the type of landfill was altered between open dumping for BAU scenario and sanitary landfill with gas recovery (landfill gas flaring) for Scenarios 1 and 2. The ratios between composting of food waste, composting of garden waste, and recycling were kept at 10 : 5 : 1 for Scenarios 1 and 2, in line with the ratio in the Key Performance Indicators. Note that this calculation is just an example to show the difference of emissions under different scenarios and there could be various different scenario settings.

Table 15. Calculation basis for estimating the potential GHG/SLCPs emissions from waste sector in Medan City for BAU and alternative scenarios

Key parameters			BAU (15.7% uncollected; 0.1% reduction)	Scenario 1 (0% uncollected; 10% reduction)	Scenario 2 (0% uncollected; 30% reduction)
Waste amount (tons/day)	Landfilling		1,577	1,783	1,428
	Uncollected		295	0	0
	3R	Composting (food waste)	0.08	125	383
		Composting (garden waste)	0	62	191
		Recycling	2	13	38
	Total generated waste		1,874	1,983	2,040
Fuel consumption for transportation (L/day)			Diesel: 12,215; gasoline: 2		
Type of landfill			Open dumping-deep (>5m waste) (start year: 1993, end year: 2020)	Sanitary landfill with gas recovery (landfill gas flaring) (start year: 1993, end year: 2020)	
Waste composition (for calculating emissions from landfill)			Food waste 48%; Garden waste 5%; Plastics 14%; Paper 17%; Textile 4%; Leather/rubber 2%; Glass 1%; Metal 1%; Others 8%		
Recyclables composition (for calculating emissions from recycling)			Paper and cardboard 47%; Plastic 47%; Aluminium 1.5%; Metal/Steel 1.5%; Glass 3%		
% uncollected waste openly burned / openly dumped			20% / 80%		

The summary results of the estimated GHG emissions per ton of generated waste between BAU and alternative scenarios are shown in Figure 21. Compared to BAU scenario, Scenario 1 emits about 29% fewer GHGs and Scenario 2 emits about 41% fewer GHGs.

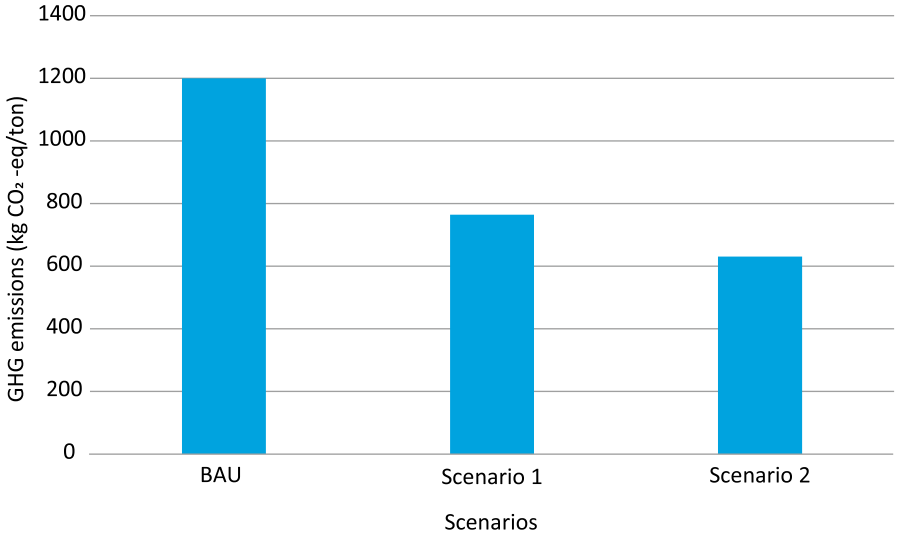


Figure 21. Estimated GHG emissions per ton of generated waste between BAU and alternative scenarios

CH_4 emissions between different landfill technologies

One of the major SLCP emissions from waste sector is the CH_4 from landfilling. The net amount of CH_4 emissions varies largely depending on the applied types of landfill technologies. Figure 22 shows the net CH_4 emissions between different types of landfill technologies using 2016 baseline dataset (in Table 14). The calculation for sanitary landfill sites with gas recovery option was set under the following conditions: efficiency of gas collection — 30%; treatment method — flaring; LFG (landfill gas) utilization efficiency — 80%; year of gas recovery — 1993-2020; and type of fossil fuel replaced by LPG — gasoline.

Net CH_4 emissions could decrease by about 50% by having shallower open dumping (< 5 m), and could decrease by about 38% using a managed semi-aerobic system. On the other hand, emissions could increase with sanitary landfill if no gas recovery options were installed because the sanitary landfill regularly covers waste with soil ensuring the waste is not exposed to oxygen. Keeping the depth of the landfill shallow is not realistic due to limitation of land, thus, the sanitary landfill with gas recovery or managed semi-aerobic system[55] are the preferable options in terms of reducing CH_4 emissions from the landfill.

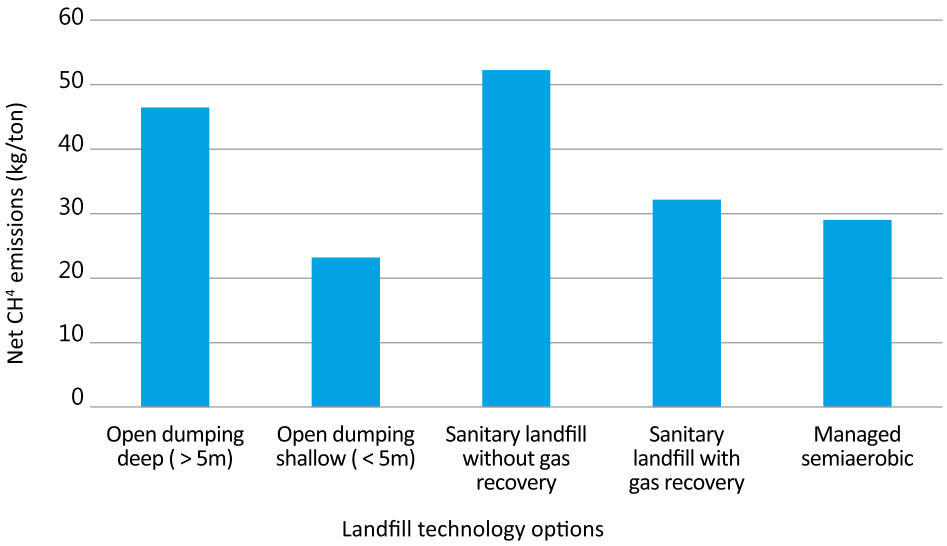


Figure 22. Net emissions of CH_4 per generated waste (kg/ton) between different landfill technology options

55. Semi-aerobic landfill system: A sanitary landfill system that is designed to promote collection of leachates and aeration at the same without using any type of mechanical equipment.

WAY FORWARD

The Presidential Regulation No. 97/2017 on National Policy and Strategy on Management of Household Waste and Waste Similar to Household Waste requests all the municipal governments in Indonesia to develop a Regional and Strategy (*Jakstrada*) on Waste Management Policy by 2018. This Work Plan thus provided a basis for the development of the *Jakstrada* for Medan City and a start for actual implementation.

As outlined in this Work Plan, both quality and quantity of waste management in Medan City lags behind other cities and there are many challenges ahead that Medan City needs to overcome. Achieving even a 10% waste reduction target could be quite challenging, and it would be even more difficult to achieve a 30% reduction by 2025. There is no easy way to boost the waste management ability and only steady advancement in stages can change Medan City into a clean and green city in the future. This Work Plan suggests 58 priority activities under six strategic goals to achieve such changes on a mid-to-long term basis.

Although DKP is the responsible agency for overall coordination and implementation of the Work Plan within the Medan City government, the set targets cannot be achieved with the efforts of DKP or Medan City government alone. In fact, it requires combined efforts and collaboration involving a wide range of stakeholders including communities, commercial entities and industries, NGOs and academia. In that sense, DKP should not be serving as a conventional waste collection service agency but should transform into a more dynamic agency with enhanced communication, coordination, and technical capabilities. This Work Plan or *Jakstrada* is expected to be used as a tool to involve a wide range of stakeholders to work together in improving the waste management and trigger such a transition.

The core responsibilities for implementation and budgeting of the Work Plan should indeed come from Medan City. Continued external support is considered to be necessary especially in the early stages of implementation, at least until some successful cases could be witnessed and Medan City as well as citizens become confident with what they are doing. Thus, external support to implement the Work Plan or *Jakstrada* both from technical and financial aspects is expected from the North Sumatra Province, the national government of Indonesia, and international organisations including CCAC.

In the long run, it is hoped that this Work Plan will help in transforming Medan City into a leading clean and green city representing not just the cities and regencies in North Sumatra Province, but as a key megacity in Indonesia.

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