Development of City Action Plans to Reduce GHGs and SLCPs from Municipal Solid Waste Management (MSWM) in Southeast Asia

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CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

IGES
Institute for Global Environmental Strategies

1. Introduction

Asia's rapid urbanization and economic growth over the past few decades have resulted in an increasing number of social and environmental challenges. Municipal Solid Waste Management (MSWM) stands out amongst these issues, as the waste itself is highly visible and prevalent, increasing environmental pollutions (land, air and water), climate change impacts and associated public health issues. Because of its cross-cutting nature, MSWM has an important and direct bearing on the achievement of the Sustainable Development Goals (SDGs) at local and national levels, including but not limited to SDG 6 (Water and Sanitation), SDG 11 (Cities), SDG 12 (Consumption and Production), SDG 13 (Climate) SDG 14 (Life Below Water), and SDG 15 (Life on Land)[1] .

Asian cities also represent the front line in addressing climate change by mitigating emissions from MSWM systems. Municipal landfills comprise the third largest source of global anthropogenic methane emissions[2]. The open burning of municipal waste, incomplete combustion of fossil fuels from waste collection and transportation vehicles as well as waste recycling and treatment equipment and facilities emit black carbon and other air toxins as well as greenhouse gases (GHGs).

The scientific data shows that methane (CH4) and black carbon (BC) 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[3]. Thus, international initiatives such as the Climate and Clean Air Coalition (CCAC) are increasingly emphasizing the importance of mitigating GHGs together with near-term measures targeting SLCPs to ensure average global temperatures remain below 1.5 to 2.0 degrees Celsius (°C)[4]. In this context, the Institute for Global Environmental Strategies (IGES) provides research and technical supports to cities in developing countries in Asia to reduce SLCP emissions from MSWM systems, on behalf of the Municipal Solid Waste Initiative (MSWI) of CCAC and its partners. These supports included the development of action plans or work plans to improve MSWM and reduce SLCPs, capacity building on applying the basic tools, such as the Emission Quantification Tool (EQT) developed by MSWI and IGES to measure SLCPs produced from MSWM, and facilitating city-to-city cooperation and peer learning.

[1] UNEP-IETC and ISWA (2015). *Global Waste Management Outlook.* Osaka; Ljiljana, R and Wilson, D. C (2017). Resolving Governance Issues to Achieve Priority Sustainable Development Goals Related to Solid Waste Management in Developing Countries. *Sustainability,* no. 404: 1-18. url:https://pdfs.semanticscholar.org/93e3/80824a47c0bdd40e24baa1029085f98d6737.pdf; Premakumara, D.G.J and Amanuma, N. (2018). Governing Integrated Solid Waste Management: The case of San Carlos, Philippines in *Governance for Integrated Solutions to Sustainable Development and Climate Change: From Linking Issues to Aligning Interests* (edited by Eric Zusman and Nobue Amanuma)

[2] Global Methane Initiative. (2011). *Landfill Methane: Reducing Emissions, Advancing Recovery and Use Opportunities,* https://www.globalmethane.org/documents/landfill_fs_eng.pdf,

[3] European Investment Bank. (2016). *Short-lived Climate Pollutants (SLCPs) An analysis of the EIB's policies, procedures, impact of activities and options for scaling up mitigation efforts.* https://www.eib.org/attachments/thematic/short_lived_climate_polluants_report_2016_en.pdf

[4] UNEP/WMO (2011), Integrated Assessment of Black Carbon and Tropospheric Ozone

1.1. Objectives

On behalf of CCAC-MSWI, IGES has been collaborating with selected cities in Southeast Asian countries including the Philippines, Indonesia, Myanmar, Cambodia, Thailand, Malaysia and Laos with the aim of mitigating SLCPs from MSWM systems. During the period 2017 to 2019, these activities were focused on strengthening the network among cities by facilitating two regional training workshops and provision of follow-up technical support for selected cities in compiling basic data and preparation of action plans to reduce SLCPs from MSWM sector using the emission quantification tool (EQT). Regional training workshops were also aimed to:

- Raise awareness of CCAC-MSWI and its contribution to reducing SLCPs from MSWM systems;
- Motivate local and national governments to improve their MSWM systems towards achieving the global commitments, such as NDCs and SDGs;
- Facilitate knowledge sharing and good practices on climate-smart waste management systems through peer-to-peer learning among cities on SLCP mitigation strategies in the MSWM sector;
- Provide training and capacity building on specific tools of MSWI such as EQT and its practical application for the development of city-level actions and work plans to reduce SLCP/GHG emissions from MSWM systems;
- Promote vertical coordination between local and national governments to set up an effective Measuring, Reporting and Verification (MRV) system to monitor and report the SLCP emission reduction that will be achieved from mitigation actions in the waste sector.

The rest of the report thus summarizes the key activities carried out during the period of 2017-2019, action plans developed by four cities – Nay Pyi Taw (Myanmar), Nonthaburi (Thailand), Jambi (Indonesia) and Kampong Chhnang (Cambodia) – and key considerations to reduce SLCP from MSWM systems.

1.2. Methodology

Selection of the cities –The regional activities started with identifying the cities that expressed interest in joining the network activities, and those that participated in the regional programme are shown in table 1.

Table 1: List of cities participating in the regional training programmes and their key roles

Country	City/ National Agency	1st Regional Workshop, 2-4 April 2018, Bacolod, Philippines	2nd Regional Workshop, 26-27 November 2018, Nonthaburi, Thailand	Remarks
Myanmar	Nay Pyi Taw	Presented city action plan (draft)		Developed city action plan to reduce SLCP from waste management systems (summarized in this report)
Thailand	Nonthaburi	Presented city action plan (draft)	Presented city action plan (final)	Developed city action plan to reduce SLCP from waste management systems (summarized in this report)

	Phichit		Shared current practices of MSWM	Observer
	Phitsanulok		Shared best practices and experiences	Mentor city
	Kohkha		Shared current practices of MSWM	Observer
	Map Ta Phut		Shard best practices and experiences	Mentor city
	Bangduea		Shared current practices of MSWM	Observer
	Pakkret		Shared current practices of MSWM	Observer
Indonesia	Medan	Presented city work plan (draft)		Developed a detailed work plan (published separately)
	Jambi	Presented city action plan (draft)		Developed city action plan to reduce SLCP from waste management systems (summarized in this report)
	Metro		Shared current practices of MSWM	Observer
Cambodia	Kampong Chhnang	Presented city action plan (draft)		Developed city action plan to reduce SLCP from waste management systems (summarized in this report)
Lao PDR	Ministry of Public Works and Transport		Shared current practices of MSWM	Observer
Malaysia	Penang		Shared best practices and experiences	Mentor city
Philippines	Cebu	Shared best practices and experiences		Mentor city
	San Carlos	Shared current practices of MSWM		Observer
	Solano	Shared current practices of MSWM		Observer
	Maragusan	Shared current practices of MSWM		Observer

	Province of South Cotabato	Presented city action plan (draft)	Presented city action plan (final)	4 cities in province of South Cotabato developed city action plans to reduce SLCP from waste management systems (summarized in Philippines' city action plan)

First regional training workshop – The first regional training workshop was co-organized with the Philippine Department of Environment and Natural Resources (DENR) and National Solid Waste Management Commission (NSWMC), and held over 2-4 April 2018 in Bacolod City, Philippines (fig. 1). The workshop raised awareness of the importance of addressing SLCP emissions associated with MSWM and provided training on how to institutionalise use of the EQT for planning and implementation of climate-friendly waste management actions at the city level. The discussions also focused on understanding key drivers, negative impacts and potential actions needed to mitigate SLCP emissions from the MSWM system[5].

Compilation of data and use of EQT – After the first regional workshop, technical assistance was provided to selected cities (table 2) to develop their city action plans to reduce SLCP emissions from MSWM systems. Training was also provided on how to collect the necessary data and apply EQT to measure emissions from the MSWM system for the baseline state and post-improvement state (proposed actions). Where possible, interested cities were paired with mentor cities for compiling the relevant data and preparing the city action plan using the tool.


Figure 1: 1st Regional training workshop in Bacolod, Philippines, 2-4 April 2018

Table 2: List of cities selected to develop action/work plans and mentor cities providing support

Country	Cities Selected to Develop Action/ Work Plans	Supporting Mentor Cities	Remarks
Myanmar	Nay Pyi Taw	Phitsanulok	Summary of action plan provided in this report
Thailand	Nonthaburi	Phitsanulok and Map Ta Phut	Summary of action plan provided in this report
Indonesia	Medan	Surabaya and Kitakyushu	Published as separate report
	Jambi	Surabaya	Summary of action plan provided in this report
Cambodia	Kampong Chhnang	Battambang	Summary of action plan provided in this report
Philippines	4 cities in province of South Cotabato (Polomolk, Lake Sebu,	Cebu	Published as separate report

[5] For more information, refer to: https://pub.iges.or.jp/pub/regional-workshop-measuring-and-mitigating

	Santo Nino and Tiboli) (developed action plans separately)		

Second regional training workshop – The second regional workshop was held over 26-27 November 2018 in Nonthaburi, Thailand (fig. 2) to discuss the best practices associated with climate-smart MSWM systems in participating cities and countries across the region. The participants also discussed how national governments could support local governments to improve their waste management systems, and how local waste management policies and interventions could be used for preparing evidence-based national waste management policies and regulations. As such, a key focus of the event was to address MRV and how it could be aligned with Nationally Determined Contributions (NDCs).

Figure 2: 2nd Regional training workshop in Nonthaburi, 26-27 November 2018

2. Current Municipal Solid Waste Management (MSWM) System in Selected Cities

In this section, we summarize the current MSWM systems in Nay Pyi Taw (Myanmar), Nonthaburi (Thailand), Jambi (Indonesia) and Kampong Chhnang (Cambodia), which have been involved in developing action plans to reduce SLCP from the municipal waste sector. In general, these cities all have some similarities regarding MSWM systems, such as inefficient operations and low standards. Annex 1 gives more information about the MSWM systems in each city, the key findings of which are summarized below.

Municipal waste generation – As shown in table 3, per capita waste generation ranges from 0.32 to 1.77 kg/capita/day. Volumes of waste generated generally correlate with income levels in the country. Among the four cities, the highest per capita waste generation was recorded in Nontahburi, Thailand (1.78). However, this figure is still low compared to the per capita waste generation (2.20 kg/day) in some developed countries[6].

Table 3: Per capita waste generation in the four case study cities

Description	Nay Pyi Taw	Nonthaburi	Jambi	Kampong Chhnang
Country	Myanmar	Thailand	Indonesia	Cambodia
GDP per capita (USD), 2017[7]	1,256	6,595	3,846	1,384
Per capita waste generation (kg/day)	0.52	1.77	0.53	0.32

Waste composition – Figure 3 shows the waste composition of the cities. The largest single waste category recorded in all case study cities is organic waste (food and garden waste), making up about 40-80%. Dry waste, including recyclables (plastic, paper, metal and glass) represents about 10-25% of the remaining waste.

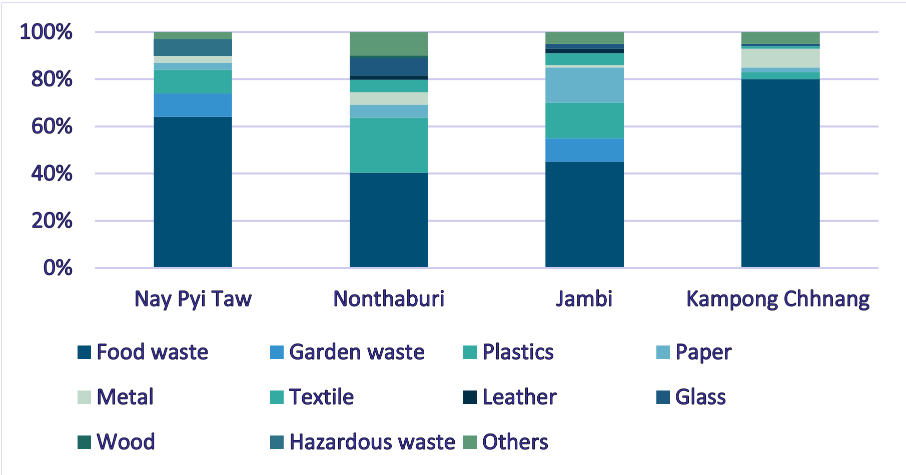

Figure 3: Waste composition in case study cities

[6] World Bank (2018). What a Waste 2.0. http://documents.worldbank.org/curated/en/697271544470229584/What-a-Waste-2-0-A-Global-Snapshot-of-Solid-Waste-Management-to-2050
World Bank (2018). What a Waste 2.0, World Bank, Washington DC
[7] World Bank national accounts data, https://data.worldbank.org/indicator/ny.gdp.pcap.cd

Collection/transport – The waste collection rates vary among the cities from 24-100%, the lowest being Kampong Chhnang (24%). The most prevalent waste collection methods are house-to-house collection and communal collection. Figure 4 shows the door-to-door waste collection system in Nay Pyi Taw. Cities have different scales and types of collection vehicles, including collection trucks, small vehicles and handcarts to collect waste from either the kerbside or communal collection points. It was also observed that the waste collection rate is substantially higher in urban and city centers compared to the peri-urban and more rural areas within the cities.

Typically, all cities faced a number of challenges in providing effective waste collection services, such as

Figure 4: Bell-ringing, door-to-door waste collection in Nay Pyi Taw

a lack of waste collection vehicles, equipment and staff, poor planning and management skills, lack of budget due to inefficient collection fee system, as well as high operational costs. These issues often resulted to low waste collection coverage, irregular collection services, open dumping, and burning of waste in cities.

Due to the absence of a formal (official) waste collection service, the informal sector performs an important role in providing a waste collection service to the residents, particularly in Nay Pyi Taw, Jambi and Kampong Chhnang (fig. 5). Informal waste collectors, usually individuals or groups, provide a waste collection service directly to households based on agreed fees. In addition, the informal sector is also involved in plucking valuable waste (recyclable waste) from the street and final dumping sites. After picking and sorting, informal recyclers sell these recyclable materials to supplement their livelihoods.

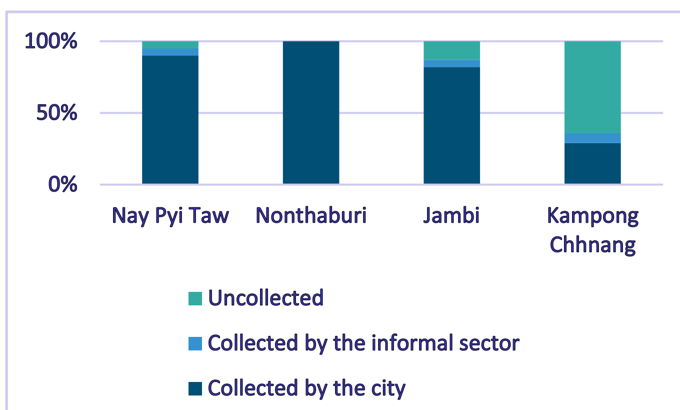

Figure 5: Waste collection coverage in case study cities

Disposal – As shown in fig. 6, open dumping is the most common and prevalent waste disposal method in the cities (except Nonthaburi city, which has a sanitary landfill site) for final disposal. Over 90% of waste is dumped in open disposal sites without proper environmental measures such as leachate treatment, gas treatment or other necessary infrastructures to control the negative impacts on the environment and public health. Discussions with city officials also revealed that over 50% of uncollected waste is burned at source (household level) due to the absence or low efficiency of waste collection services. Thus, introducing effective waste collection and environmentally friendly disposal methods would be key when designing sustainable MSWM systems for the cities.

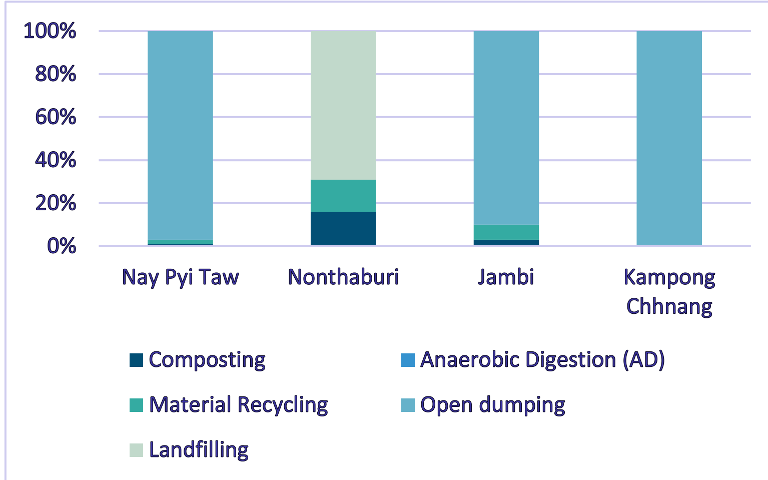

Figure 6: Waste treatment and disposal methods in case study cities

Although the cities have taken some initiatives to introduce material recovery and recycling (including composting for organic waste), their contribution to the entire MSWM system is still limited. Informal recyclers are often active in collecting recyclable materials from households, streets and dump sites. After picking and sorting, informal recyclers sell them to small enterprises or intermediaries who then sell them on to waste recycling or waste processing companies. The informal recyclers often receive very little compensation from such buyers for the recyclable materials sold.

The municipal workers involved in waste collection and transport activities also simultaneously separate recyclables, and sell them on to informal sector dealers or buyers. In addition, cooperatives formed within the informal sector undertake some work, such as waste collection under a formal contract with municipal authorities while also being involved in informal recycling. These activities have realized important economic savings for municipal governments as a way of reducing the total waste amounts to be collected by the formal sector, as well as lowering labour, transport and infrastructure expenditures for municipalities. In addition to these economic benefits, informal sector activities contribute significantly to reducing GHG emissions through resource and energy recovery due to recycling. Thus, engaging the informal waste sector representatives in developing city action plans is necessary for sustainable waste management.

3. GHGs and SLCPs from Current MSWM Systems - Business as Usual (BAU)

Table 4 summarizes the GHG and SLCP emissions from MSWM systems in the case study cities based on current practices (business as usual). GHG and SLCP emissions were estimated using the EQT developed by IGES with CCAC-MSWI, in line with IPCC[8] and other internationally recognized guidelines and emission factors[9].

Table 4: Summary of GHG and SLCP emissions from current waste management systems (BAU) in case study cities

Description	Nay Pyi Taw		Nonthaburi		Jambi		Kampong Chhnang	
	GHG	BC	GHG	BC	GHG	BC	GHG	BC
Collection (kg of CO_2-eq/ tonne)	1,412	439	3,622	1,127	2,369	737	195	16
Composting (kg of CO_2-eq/ tonne)	2	1	840	3	145	1	0	0
Recycling (kg of CO_2-eq/ tonne)	(29)	(2)	(2,640)	(40)	(738)	(7)	0	0
Final disposal (kg of CO_2-eq/ tonne)	22,156	53	87,438	105	92,234	96	102	1
Burning at final disposal site (kg of CO_2-eq/ tonne)	660	1,134	0	0	0	0	16	45
Uncollated (scattered and open burning) (kg of CO_2-eq/ tonne)	67	40	0	0	1,062	492	462	743
Total climate impact from GHGs (tonnes of CO_2-eq)	34,710 (82%)		86,356 (98%)		125,800 (98%)		1,679 (52%)	
Total climate impact from BC	7,366 (18%)		968 (2%)		793 (2%)		1,542 (48%)	

[8] IPCC (2006): IPCC Guidelines for National Greenhouse Inventories, IGES, Japan. http://refhub.elsevier.com/S0956-053X(18)30577-4/h0065

[9] Premakumara, D.G.J, Menikpura, S.N.M, Singh, R. K, Hengesbaugh, M, Magalang, A. A, Ildefonso, E. T, Valdez, M. D. C. M, & Silva, L. C (2018): Reduction of greenhouse gases (GHGs) and short-lived climate pollutants (SLCPs) from municipal solid waste management (MSWM) in the Philippines: Rapid review and assessment, Waste Management 80 (2018), 397-405. https://doi.org/10.1016/j.wasman.2018.09.036

(tonnes of CO_2-eq)				
Total climate impact from both GHG and BC (tonnes of CO_2-eq)	42,076	87,324	126,593	3,221

- Different types and quantities of emissions, such as GHG (Methane (CH_4) Carbon Dioxide (CO_2) and Nitrous Oxide (N_2O)) and Black Carbon (BC) are generated from the MSWM systems in the cities. Thus, cities require the correct data and sufficient capacities to estimate these emissions and their quantities in order to understand current emissions generated from the MSWM system and design alterative options to mitigate them. EQT, one of the user-friendly tools developed by IGES and CCAC-MSWI[10], helped the cities in this case to estimate the GHGs/SLCPs from MSWM systems.
- According to the data in table 4, the highest GHGs emissions have resulted from waste disposal. Waste degradation from deep dumpsites emits a significant amount of CH_4, which has resulted in the highest GHGs emissions from open dumping.
- Open burning of waste at the dumpsite or household level has resulted in higher generation of BC emissions. Open burning of waste at landfill sites occurs due to the lack of environmentally friendly disposal options. Waste is burned deliberately at disposal sites to reduce the quantity in open dumps/landfills. In addition, domestic waste burning takes place in back yards, small dumpsites on roadsides and remote dumpsites due to the lack of waste collection services. Open burning of MSW occurs for 30–50% of uncollected waste in the case study cities.
- In addition, fossil fuel combustion for waste collection, transportation, and operational activities would emit significant amounts of CO_2, N_2O and BC. Open waste burning and fossil fuel combustion from vehicles (most of which are aging) and equipment also contribute to a large percentage of global PM2.5 emissions.
- Composting is one of the technologies often used to reduce organic waste from landfill sites in the case study cities. It is a technologically simple option that simultaneously generates economic value for organic waste while also contributing to GHG mitigation, mainly through avoided methane emissions from inappropriate disposal of untreated organic matter and substitution of chemical fertilizers. Moreover, compost may also act as a carbon stock – in other words, offer a high carbon storage capacity, due to the slow carbon mineralisation process. However, if not properly handled, composting also emits GHG (in an anaerobic condition). In addition, the use of mechanical equipment in the process of producing composting generates CO_2, N_2O and BC.
- The highest GHGs saving potential is shown as deriving from recycling activities. A net negative value has resulted because of resource recovery and avoidance of conventional material production processes. Thus, discussions among the cities identified that sustainable MSWM systems should be developed based on the concept of *More with Less* – the sustainable development agenda that gained traction with the Brundtland Report, *Our Common Future* (WCED, 1987) and the *Waste Management Hierarchy based on 3Rs* (reduce, reuse and recycling).

[10] For more information about the EQT and its user manual, see https://pub.iges.or.jp/pub/emission-quantification-tool-eqt-estimation

4. Identifying Climate Friendly Technologies for MSWM

Based on the waste hierarchy, the case study cities proposed a new MSWM system shown in fig. 7 to reduce SLCPs and achieve other co-benefits, including economic and social benefits.

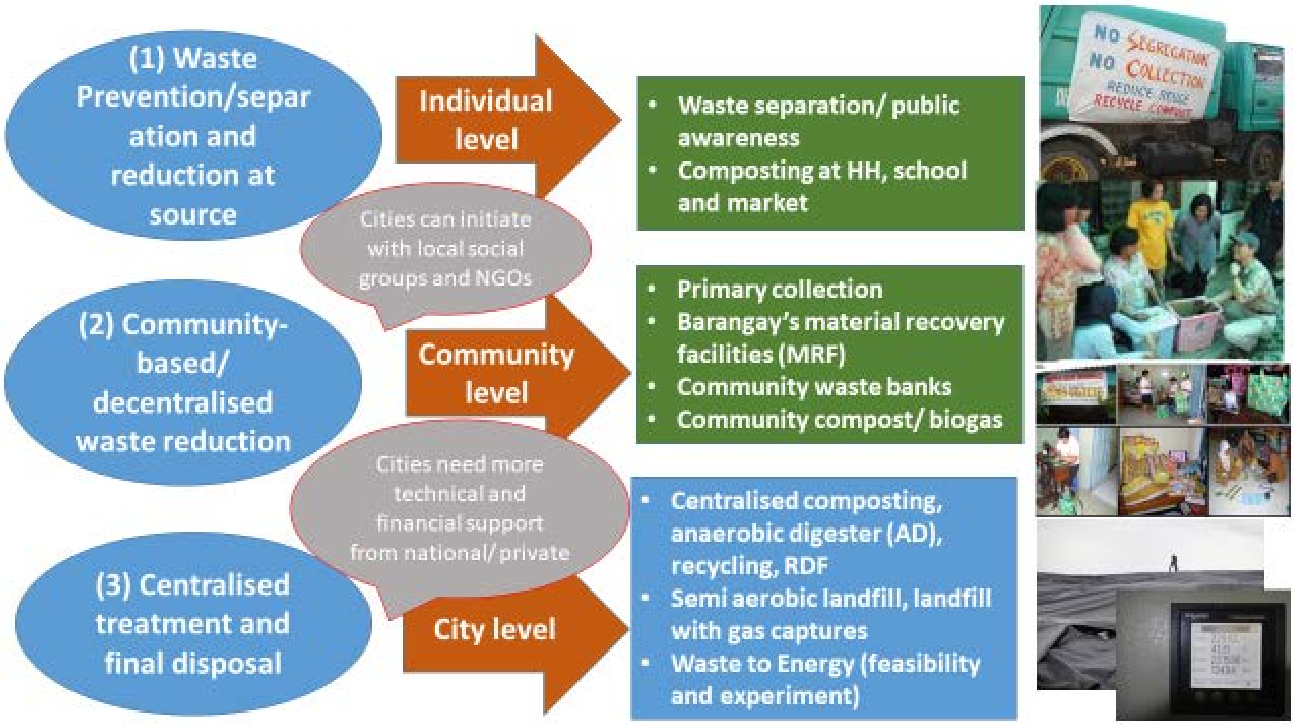

Figure 7: Sustainable, climate friendly MSWM system proposed for case study cities

Waste prevention – Waste prevention (reduce and reuse) is identified as a priority within the proposed MSWM system. When a material is source reduced (i.e., less of the material is made), this results in reducing the demand for raw materials and reduced GHG emissions (i.e., it avoids baseline emissions attributable to current production; forest carbon sequestration benefits in the case of paper products; and zero waste management GHG emissions). In addition to climate benefits, waste prevention helps to protect the environment (water, land and air), reduce public health impacts and save resources by closing the loop and returning both materials (recycling) and nutrients (composting) to beneficial use.

However, waste prevention often receives minimal priority during implementation due to a number of challenges, such as changing public attitudes and consumer patterns, contemporary culture dependent on convenience, lack of political will, lack of resources, lack of mandatory targets on waste disposal and recycling, and inadequate government initiatives, legislation and education. Successful waste prevention programmes thus need to follow three broad strategies – informational, promotional and regulatory. Informational strategies are aimed at changing behaviours and informing decisions, adopting public awareness campaigns, providing information on waste prevention techniques, training programmes for competent authorities, eco-labeling, and waste prevention information on products. Promotional strategies are focused on incentivising behavioural change and providing financial and logistical support for beneficial initiatives, such as support for voluntary agreements, promotion of ecodesign, development and promotion of environmental management systems, support for reuse and repair infrastructure, clean consumption incentives, and promotion of research and development for developing less wasteful products and technologies. Regulatory strategies include enforcing limits on waste generation, expanding environmental obligations and imposing environmental criteria on public contracts, such as Extended Producer Responsibility (EPR) policies, Green Public Procurement policies, and waste taxes and quotas.

Separated waste collection and transportation – Waste separation is a precondition for achieving high quality recycling systems and high recycling targets. Cities that have introduced mandatory separate collection of certain municipal waste fractions have high municipal waste recycling levels. When separate collection of organic waste is introduced at source, the overall rate of sorting dry recyclables (and other fractions) rises. However, securing the support of households, commercial establishments, markets, institutions, and industries for source separation remains a challenge for all case study cities. There also appears to be a need for a policy mandate to encourage the collection of separated waste, which may entail creating guidelines on extended producer and/or consumer responsibility. Further, it is crucial to both extend the technical infrastructure as well as inform and motivate the users of the separated waste collection systems.

Waste collection and transportation to disposal sites or recycling/ treatment facilities are basic activities of a waste management system, and they all use energy and fuels, primarily of fossil origin, which leads to GHGs and BC emissions. Some cities may use more than one type of fossil fuel for transportation (e.g. diesel, gasoline and/or natural gas). Emission factors also vary according to the type/age of vehicles, such as modern vehicles, old vehicles, and both modern and old vehicles. In this regard, the informal or community-based organizations play a key role in the primary waste collection system. These groups often perform house-to-house waste collection using handcarts or non-fuel (tricycles or bicycles). After collecting and sorting, informal recyclers sell the recyclable materials to specified centers, such as Waste Banks or Dry waste Recycling Centers. However, the informal sector is often marginalised in formal waste management plans. They also face many challenges, such as work in extremely hazardous environments, unhealthy conditions and low incomes. The case study cities therefore considered the importance of integrating the informal sector by creating more stable organizational structures, such as cooperatives, small enterprises or social businesses and establishing adapted infrastructure, such as sorting platforms at transfer stations or landfill sites to increase the participation of the informal sector in city MSWM systems.

Organic waste reduction and recycling – Most cities utilize composting and/or anaerobic digesters (AD) for managing organic waste, which is reported to represent over half of the city's total generated waste (see fig. 8).

Figure 8: Organic waste composting activities in Jambi City

Composting is a controlled aerobic biodegradation process for treating organic waste. The main output of this process is compost, which is used as organic fertilizer. Composting helps avoid GHG emissions generated from uncontrolled disposal of organic waste. The typical inputs for composting are food waste, agricultural waste, and the organic fraction of industrial and municipal wastes. Compost can be used instead of chemical fertilizers and has a number of benefits: it reduces soil erosion, improves soil structure, facilitates water and air transport in the soil and pH stabilization, among others.

Anaerobic digestion (AD) or Biogas consists of a microbiological biodegradation process that occurs normally in the absence of oxygen. Controlled AD can be performed with the appropriate technology, where organic waste is used as the input and the methane is collected for use. Depending on the quality of the input waste, waste composition and the state of technology, the biogas generated from the process can have a high methane content, e.g., organic waste from source separation at households and markets may produce gas of around 60% methane[11]. Biogas has a number of uses. Typically, small-scale biogas plants in developing countries convert it to heat and use this energy for cooking, heating, drying of grains, etc. However, plants with more complex technology can generate electricity and heat through cogeneration. Small-scale biogas plants are more frequent in developing countries, due to their easy-to implement technology and low construction and operation costs.

[11] Aparcana Robles, S. R., & Hinostroza, M. L. (2015). Guidebook for the Development of Nationally Appropriate Mitigation Actions on Sustainable Municipal Waste Management. UNEP DTU Partnership. https://orbit.dtu.dk/files/116707991/Guidebook_for_the_Development.pdf

Material recovery and recycling - Recycling can be identified as one of the most promising waste practices after waste prevention towards achieving SLCP reduction. Separately collected recyclable materials can be inserted into production chains in different ways, such as to partially or entirely replace raw materials within the same product (closed loop recycling) or replace raw materials of a new or different product (open loop recycling). Recycling can also provide wider benefits, such as the circular economy approach, where industries may exchange materials and energy to improve resource consumption, save costs and reduce emissions. Recycling contributes to SLCP reduction by avoiding key emissions linked to the use of raw materials.

Landfilling - Open dumping is the most common waste disposal practice and the largest contributor to GHG emissions from the waste sector in the case study cities. Despite the fact that landfill technologies have improved over the last few decades, these developments have not yet reached all parts of the world due to lack of technological and financial capacity at the city level. Even though some cities have sanitary landfilling (top cover, leachate treatment system), they operate without a gas recovery system. At present, all cities are interest in developing sanitary landfills with gas-to-energy projects, aiming to achieve co-benefits including GHG/SLCP reduction. Anaerobic degradation of mixed waste in open dumps and landfills eventually generates landfill gas (LFG) which contains approximately 60% methane (CH4) and 40% carbon dioxide (CO_2). However, the amount of methane generated at the disposal sites depends on many factors such as type of landfill/dump site, quantity and composition of waste, moisture content, and climatic situation[12].

[12] Aparcana Robles, S. R., & Hinostroza, M. L. (2015). Guidebook for the Development of Nationally Appropriate Mitigation Actions on Sustainable Municipal Waste Management. UNEP DTU Partnership. https://orbit.dtu.dk/files/116707991/Guidebook_for_the_Development.pdf

5. Reduction of GHG and SLCP Emissions from City Action Plans

The case study cities identified a number of strategic goals and actions to reduce GHG and SLCP emissions from MSWM systems, as shown in fig. 9. In general, avoiding CH_4 generation can be achieved by diverting organic waste away from landfills through segregated collection, processing and treatment of organic waste using composting and AD. CH_4 can be also reduced by the capture, recovery, and/or utilization of methane gas generated at sanitary landfill sites. On the other hand, BC generation can be mitigated by stopping waste burning in back yards, at the community level and at landfill sites. Increasing the efficiency and coverage of waste collection is a measure that can discourage community waste burning and improve the delivery of basic services to the public, but this is bound to increase GHG and BC emissions due to increased emissions caused by collection activities. Thus, the primary waste collection system should be aimed at incorporating community-based/informal sector involvement, waste diversion at the household level through waste banks and optimization of waste collection routes, and the use of cleaner vehicles and engines for secondary waste collection and transportation.

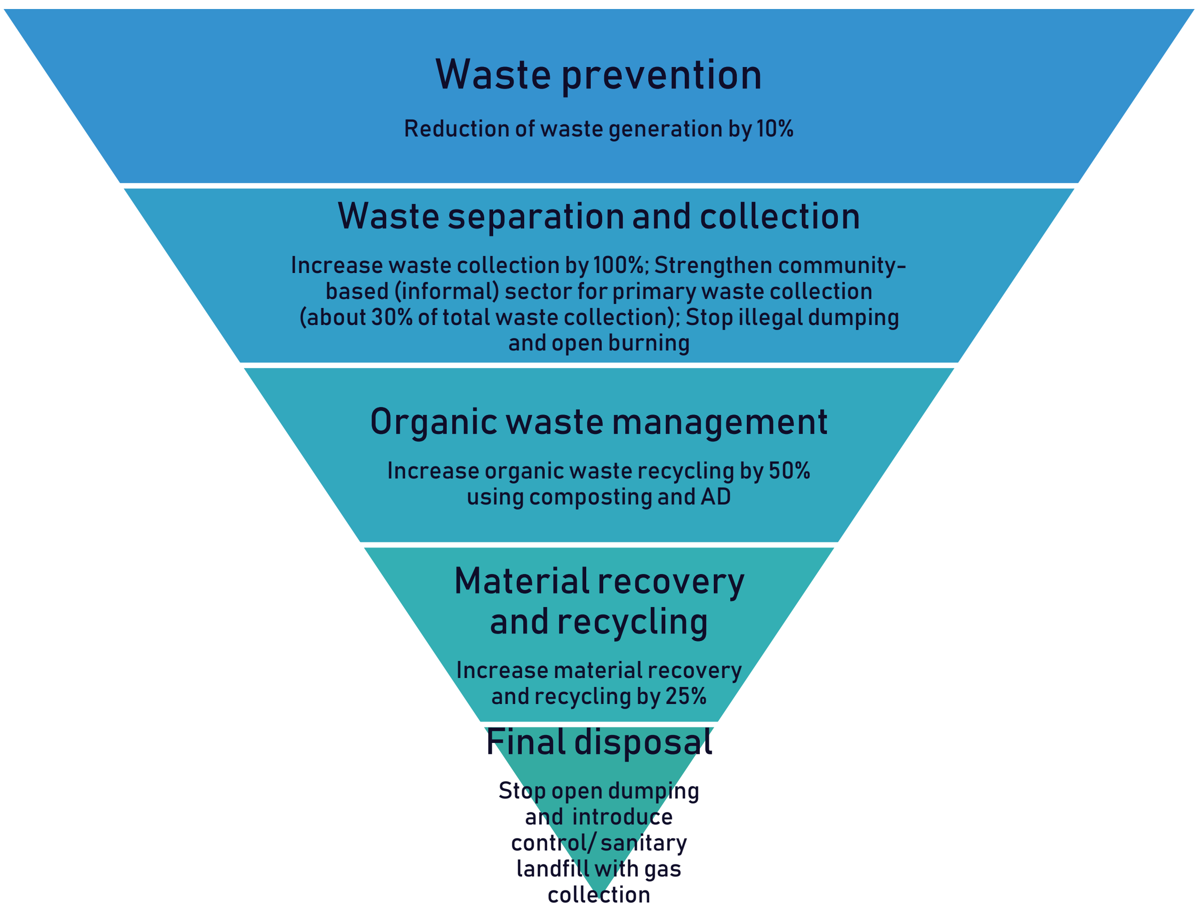

Figure 9: Strategic goals and actions to reduce GHG and SLCP from MSWM systems

Figure 10 shows the potential of the total climate impact mitigation including both GHG and SLCP emissions from MSWM systems comparatively between the BAU and the Proposed Scenario. The proposed scenario is based on an improved waste collection service, scaling up interventions targeting open burning, and promoting maximum resource recovery (composting, AD and recycling) including by encouraging waste separation and improving the conditions of open dumping and control over disposal practices. GHGs and SLCP reduction measures can be incorporated through strategic planning and selection of appropriate climate-friendly technologies while making efforts to terminate/enhance the status of conventional disposal practices. As such, a well-designed, integrated waste management system represents an important means of implementation for achieving climate-change mitigation targets in the cities.

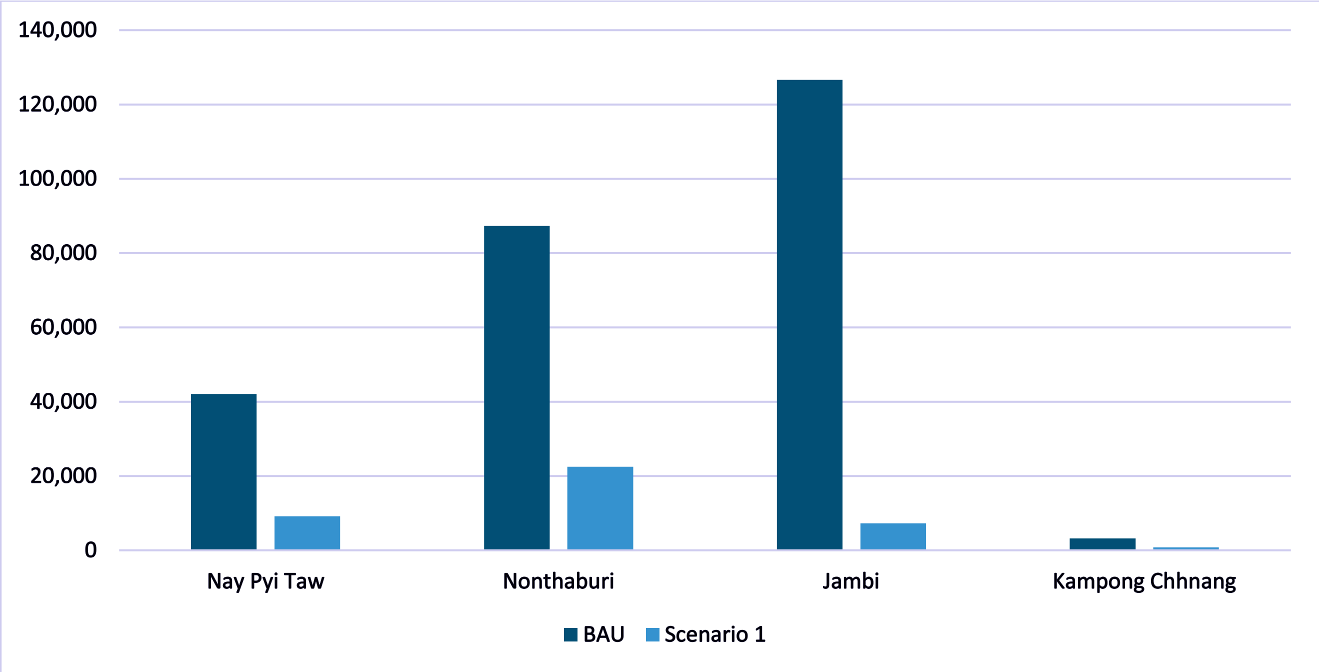

Figure 10: Comparative analysis of climate impacts in BAU situation and proposed scenario (tonnes of CO_2-eq)

6. Considerations

The following matters are identified as key considerations to create enabling mechanisms for the successful application of MSWM systems to reduce GHG and SLCP emissions:

Main barriers to be addressed - There are several barriers hampering the development of sustainable MSWM systems in developing countries. The city action plans need to incorporate analysis of these barriers in order to develop appropriate strategies and measures to overcome them. Some barriers influence waste systems at the operational level (collection, recycling, etc.) and others at the managerial level. How barriers are classified may vary in consonance with the local context but can be primarily grouped into social, technical, economical, institutional, political/legal and environmental barriers.

- ***Institutional barriers:*** Problems related to local authorities and their lack of organizational capacity and managerial skills (leadership), departmental or parallel structures and confusion regarding their delineation and distribution.
- ***Policy and legal barriers:*** Absence of adequate policies and lack of clear legislation, preventing correct interpretation and implementation by local authorities and other stakeholders. Furthermore, there is a lack of verification and enforcement mechanisms, confusion of roles and responsibilities of the relevant national agencies, and lack of coordination.
- ***Economic and finance barriers:*** Inefficient cost structures, unwillingness or inability to pay for services, budget constraints, and untapped revenue streams in the informal sector.
- ***Social and behavioural barriers:*** Lack of concern for the environment, unwillingness to pay for services, lack of awareness or participation in waste separation activities, social tensions among economic classes between the formal and informal sector.
- ***Technical barriers:*** Deficient waste equipment and infrastructure (waste transfer stations, aging waste vehicles), poor roads, etc. Related to capacity: lack of personnel with technical expertise in solid waste management planning and operation, lack of technical understanding regarding technologies suitable for local operational conditions – such as waste characteristics, waste amounts, types – unreliable data, and lack of information-sharing between stakeholders regarding technical issues.

Building strong partnerships with key stakeholders - Many types of stakeholders are involved in MSWM, depending on the context – city or local, and their differing roles and interactions are key to developing and implementing sustainable MSWM systems. Some of the most common stakeholder groups involved in MSWM systems are:

- ***Households, commercial establishments:*** they are essentially waste generators and, at the same time, service users.
- ***Local government/municipalities:*** they are responsible for the provision of solid waste services. As regards cooperation with private waste companies, local governments are responsible for the regulation, quality control and verification of services provided by them. Local governments are also responsible for implementing legislation, regulations to ensure sustainable waste services and enforcement thereof.
- ***National government:*** they often establish the institutional and legal frameworks for MSWM, ensuring that local governments have the necessary authority, powers and capacities for effective solid waste management.

- ***Private waste service providers***: this group includes a wide range of enterprise types, varying from micro-enterprises to large business establishments. Their main motivation is to generate profits from their investment in waste services, and they may cooperate with local governments through different forms of partnership.
- ***Informal private waste service providers:*** known also as "waste pickers", this group encompasses unregulated activities carried out by individuals, groups or small informal enterprises. Their main motivation is obtaining economic revenue from selling recyclable materials or from collection services in inaccessible or unserviced areas.
- ***Non-governmental organizations (NGOs):*** they primarily facilitate linkage between formal and informal stakeholders aiming to tackle social issues. For example, they can act as a provider channel for donor financing, support integration programmes for informal recyclers, women empowerment, awareness-raising activities, etc.
- ***External Support Agencies:*** frequently, external cooperation agencies are engaged in supporting sustainable waste management practices in low-income countries, aimed at tackling potential barriers and constraints to implementing sustainable waste management systems. This could encompass knowledge and technology transfer, financial aid, etc.

Institutionalize the Measuring, Reporting and Verification (MRV), including GHG and SLCP baselining, emission reduction calculations, and performance monitoring, for the city and national databases - One of the main considerations of the city action plans is setting up a proper measurement, reporting and verification (MRV) system. The key objective of MRV is to increase the transparency of mitigation efforts of the cities. It can also help national governments when developing and reporting their NDCs (Nationally Determined Contributions) and NAMA (Nationally Appropriate Mitigation Actions). The MRV framework needs to include a well-defined methodology and process for measuring and estimating GHG and sustainable development impacts, a system for reporting and process for verification of the claimed impacts. International partners are also required to build MRV systems that are sufficiently transparent.

Annex - 1

Nay Pyi Taw, Myanmar

Dr. Myat Taw Htat, Deputy Director, Nay Pyi Taw City Development Committee (NPTDC)

Background

Nay Pyi Taw, capital city of the Republic of the Union of Myanmar, is located between Yangon (approx. 393 km) and Mandalay (approx. 303 km). It comprises eight townships[13]: Zabyuthiri, Zeyarthiri, Oattarathiri, Dekhinathiri, Pobbathiri, Pyinmana, Lewe and Tatkone, covering a total area of 7,054 sq. km[14]. In 2018, the total estimated population of Nay Pyi Taw was about one million[15].

Waste Management Overview

At the national level, the Ministry of Natural Resources and Environmental Conservation (MONREC), Myanmar developed the country's first National Waste Management Strategy and Master Plan in 2018 as a holistic policy framework for improving MSWM in the country. In addition, waste management is partially regulated under other environmental regulations and laws, including Myanmar's National Environmental Policy (1994), Agenda 21 (1997), as well as the National Sustainable Development Strategy (2009), National Environmental Conservation Law (2012), Environmental Conservation Rules (2014), and Environmental Impact Assessment and Environmental Quality (Emission) Guidelines (2015)[16]. According to the above national policies and regulations, MSWM remains the sole responsibility of townships and city development committees (CDCs) at the local level. Given that, Nay Pyi Taw City Development Committee (NPTDC) enacts waste management functions under the Nay Pyi Taw Development Law of 2009[17].

Waste Generation, Collection and Transport

In Myanmar, municipal solid waste is defined as non-gaseous, non-liquid waste derived from residential and commercial sectors within a given administrative area. At present, the total waste generated amounts to an estimated 197 tonnes per day, with a per-capita rate of 0.52 kg/person per day. The existing waste collection system covers about 90% of the city area based on the bell-ringing method. Bell-ringing refers to a collection vehicle with one or two workers moving along a predetermined route at a set time and date, ringing a bell, informing residents to bring their waste to the vehicle for collection. Workers thereafter load the waste into the vehicle. Once maximum capacity is reached, waste is transported to the dumpsites. Residents are advised not to leave waste on the street for collection, which is aimed at stopping illegal disposal and beautification of the city. Waste generated from private enterprises (hotels, supermarkets, cinemas, restaurants, etc.) and other waste sources such as hospitals is collected based

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[13] The smallest administrative unit in Myanmar

[14] NPTDC (2018): Solid waste management in Nay Pyi Taw, a presentation made at the first Regional Training Workshop: Measuring and Mitigating Short Lived Climate Pollutants from the Municipal Solid Waste Sector, 2-4 April 2018 in Bacolod, Philippines

[15] https://www.dop.gov.mm/en/state-region/naypyitaw

[16] http://www.uncrd.or.jp/content/documents/6285Country-G-2-Myanmar.pdf

[17] http://www.burmalibrary.org/docs08/NLM2009-12-30.pdf

on an on-call system. According to the NPTDC, approximately two tonnes/day (1%) of collected waste goes to junkshops and another small portion of organic waste, around one tonne/day (0.5%) is used for making compost. The remaining collected waste is transported to final disposal sites. The uncollected waste (10%) in the city is potentially burned (5%) or discarded into open lands (5%) by local residents.

Waste Treatment and 3R Activities

Nay Pyi Taw currently does not conduct proper waste separation at source nor carry out any official efforts to promote 3R (reduce, reuse, recycle) activities. However, collection workers and informal waste pickers are engaged in sorting and collecting marketable materials such as plastic, paper, iron, copper, tin, and glass at the time of collecting and transporting waste. These materials are then sold to recycling buyers or junkshops to supplement incomes. As organic materials, including food waste and garden waste make up the largest percentage of the city's waste composition (74%), Nay Pyi Taw also intends to introduce composting. On a trial basis, a small composting facility is operated by the staff of NPTDC, using one tonne of organic waste collected from a local market. Here, a simple windrow method is employed and the final product is used for city parks as a substitute for chemical fertilizer.

Institutional and Financial Management

Nay Pyi Taw's Pollution Control and Cleansing Department (PCCD) is tasked with carrying out all waste management related functions for the city. PCCD is comprised of three divisions: Cleansing Division, Pollution Control Division and Office Administration and Motor Transport Division. The Cleansing Division is responsible for implementing sanitation plans, including waste collection and transportation to final disposal sites; the Pollution Control Division is responsible for operating disposal sites; and the Office Administration and Motor Transport Division manages city vehicles, especially those used for waste collection. According to PCCD, the city has around 74 waste collection vehicles and 340 workers for waste management functions.

Final Disposal

The city has two final disposal sites for disposing of collected waste. Disposal site 1 is located in Pobbathiri Township, serving six townships (Zabyuthiri, Dekhinathiri, Pobbathiri, Ottarathiri, Zayarthiri and Pyinmana Township). It receives about 127 tonnes of waste per day. The landfill site in Pobbathiri Township is maintained as a controlled landfill, with a requirement of minimum soil coverage after each laying of waste. The remaining landfill site (disposal site 2), which receives about 50 tonnes of waste daily, operates as an open disposal site.

Main Challenges

NPTDC in consultation with key stakeholders in the city, both public and private, identified the following challenges in order to improve the MSWM system in the city:

- Insufficient human capital (lack of experienced staff with suitable capacity) and budgetary allocation for waste management.
- Insufficient infrastructure (vehicles for waste collection, recycling facilities and final disposal sites, including sanitary landfills).
- Lack of public awareness and cooperation on waste separation and 3R activities.
- Lack of strategic vision, policy and necessary regulations to enable proper waste management and 3R activities.

Key Proposed Actions

The following actions were proposed for enhancing waste management in Nay Pyi Taw City.

- Introduce waste segregation at source and expansion of waste collection service for all. This includes issuing waste separation regulations, awareness raising programmes targeting students and the public, distribution of different colour bags for waste sorting and storing, and systematic planning on waste collection.
- Increase waste recycling and 3R activities, including upscaling of the city's existing composting programme and supporting informal waste workers and business groups to start new recycling initiatives in the city.
- Upgrade landfill operation. This aims to improve current landfill sites into sanitary disposal sites and evaluate possibilities for introducing more advanced technologies, including incineration.
- Establish a systematic data and information management system on waste.
- Setting up an effective coordination mechanism for engaging all involved stakeholders both within the city and at the regional and national levels.

Benchmark data on waste management in Nay Pyi Taw

Description	Units
1. Physical component	
1.1. Total population	1 million in 2018
1.2. Total waste generation	197 tonnes /day (0.52 kg/capita/day)
1.3. Waste collection	
Amount of waste collected by formal sector (cities/municipality/province or contracted private company)	177 tonnes/day (90% of generated waste)
Amount of waste collected by informal sector (without any contract with the city)	Unknown
Uncollected waste (assumed either openly burned/scattered dumped)	• Open burning (5%) • Scattered dumping (5%)
Types of waste collection vehicles used for waste collection and transportation	Compactor and trucks
Capacity of trucks	Compactor (2 tonnes/trip) Trucks (4 tonnes/trip)
Type of fuel use for collection and transportation	Diesel
Amount of fuel (L/day)	8 L/ tonne
Approximate distance from collection points to the landfills	26 km
1.4. Waste composition	
Approximate composition of collected waste	• Food waste - 64% • Garden waste - 10% • Plastics - 10% • Paper / Textile - 3% • Metal (aluminium and steel) - 3% • Hazardous waste - 7% • Others - 3%
1.5. Intermediate treatment and recycling	

Amount of organic waste used for composting	1 tonne/day (0.5% of collected waste)
Amount of organic waste used for anaerobic digestion	N/A
Amount of waste use for recycling	2 tonnes/day (1% of collected waste)
Composition of recyclables	• Paper and cardboard - 9% • Plastic - 60% • Aluminium (Metal/Steel) - 31%
1.6. Final disposal	
Specification of the landfill/open dumps	Approximate height, availability of landfill cover, management practices, etc.
Landfill 1	• Amount of waste disposed: 127 tonnes/day • Type of landfill: controlled landfill • Specifications: 3.34 ha, 6 metre depth, 0.5 metre thick soil covered for 2 metre depth of each waste layer • Year of starting operation: 2010 • Year of closing operation: 2025 • If fossil fuel used: Type/amount (L/day) (diesel/ 2L/ tonne)
Landfill 2	• Amount of waste disposed: 50 tonnes/day • Type of landfill: open disposal • Specifications: 3.34 ha, 6 metre depth, • Year of starting operation: 2010 • Year of closing operation: 2025 • If fossil fuel used: Type/amount (L/day) (diesel/ 2L/ tonne)
2. Governance component	
2.1. Degree of user inclusivity (citizen support and participation in waste separation and 3R activities) (low/ medium/ high)	• Low
2.2. Degree of provider inclusivity (private and informal sector participation in waste collection, composting and recycling) (low/ medium/ high)	• Low
2.3. Financial sustainability (population pays for waste collection, budget available for waste management) (low/ medium/ high)	• Low
2.4. Institutional sustainability (institutional capacity, policy and regulations) (low/ medium/ high)	• Low

Nonthaburi, Thailand

Ms. Jiraporn Pumwiset, Assistant Director, Nonthaburi Municipality

Background

Nonthaburi City is one of the fastest growing municipalities in Nonthaburi Province due to its proximity to Bangkok with easy access through various public transport options including the Bangkok Mass Transit Authority bus system, the Chao Phraya Express Boat, as well as the newly opened Metro Rapid Transit (MRT) Purple Line. Nonthaburi city covers an area of 38.9 sq. km and includes five sub districts (SuanYai, Talad Kwan, Bang Kean, Bang Krasaw, and Ta Sai). Based on 2015 census data, the city had a population of 256,457, making it one of the most dense (6,593 residents/ sq. km) municipalities in the province.

Waste Management Overview

In Thailand, municipal solid waste is defined as solid waste generated by municipal activities including from residential areas, retailers, service providers, marketplaces and institutions. Waste management is enacted by different national policies, laws and regulations, including Thailand's Enhancement and Conservation of National Environmental Quality Act (1992), Public Health Act (1992), Maintenance of Public Sanitary and Order Act (1992, 2017), National Waste Management Masterplan and Action Plan for Thailand Zero Waste (2016). According to the country's Municipal Act (1953) and Public Health Act (1992), Nonthaburi municipality is responsible for carrying out waste management functions including street sweeping, litter control, as well as disposal of hazardous waste and wastewater treatment.

Waste Generation, Collection and Transport

The city generates approx. 454 tonnes of municipal waste per day, or 1.7 kg per capita in 2015. In addition, two tonnes of hospital or medical waste and 11 tonnes of hazardous waste such as batteries, fluorescent lamps, spray cans, etc. are generated daily in the city. The city's waste composition is made up of food and green waste (40%), plastics (23.19%), paper (5.51%), textiles (5.17%), leather/rubber (1.76%), glass (7.41%), metal (5.34%), wood (0.95%) as well as other types (10.02%).

Nonthaburi municipality collects waste from households, schools, hotels, restaurants and other institutions using compactor trucks as well as boats. Approximately 74 tonnes/day of organic waste is collected from vegetable and fruit markets and residential areas (green/ garden waste) and then sent to a composting plant operated by the municipality. In addition, either the municipality or informal sector collects about 70 tonnes/day of recyclable waste. The remaining waste (310 tonnes/day) is transported to a sanitary landfill located in Nontahburi Province, approximately 35 km away from the city centre. In Nonthaburi, households pay fees for waste collection, although the total income from these fees does not cover the entire cost of MSWM in the city.

Waste Treatment and 3R Activities

According to the city staffs, the first official action to tackle the waste management issue was taken in early 2010, with the establishment of a Municipal Development Committee under the newly elected Mayor. The Committee consists of senior staff, representatives from the private sector, academics and community leaders. The Committee is responsible for developing and monitoring waste management strategies and action plans for the municipality. The first waste management strategy identified the importance of increasing waste reduction and recycling, such as setting a pilot solid waste reduction programme at source, particularly for households, schools, markets and offices, including through the promotion of recycling, and the composting of organic waste for fertilizer. As part of the strategic actions, separate bins were provided to collect organic waste separately from markets, selected restaurants, schools and community centres. The collected organic waste is thereafter transported to a composting plant and converted into compost that is sold to local farmers and gardeners in the city.

Although Nonthaburi's current waste management system is still dependant on these strategic principles, the city has identified several challenges that need to be addressed for successful implementation. For instance, waste segregation is still not fully practised in certain communities. The composting plant also faces some operational challenges during the rainy season (monsoon period) and requires technical solutions to handle leachate and odour issues. However, actual benefits from these activities far outweigh these initial difficulties. Waste collection has become less expensive for the municipality, since the total volume of waste has been reduced. Nonthaburi is also generating additional revenue from selling the compost and recyclable materials. There is also evidence of social benefits, such as cooperation among various stakeholders participating in recycling and waste reduction initiatives, which helps build a sense of solidarity within local communities. In total, all these efforts have benefited environmental protection, such as less polluted rivers, reduced waste in public areas and on the streets, as well as an overall cleaner and more liveable city for the residents.

Institutional and Financial Management

The Bureau of Public Health and Environment of Nonthaburi municipality is responsible for conducting all waste management related functions. According to city officials, more than 130 workers and about 39 vehicles are used for waste management. The city's total annual budget allocation for waste management is about 70 million Baht (USD 2.5M), split into 50 million for operations and 20 million for equipment.

Final Disposal

As stated above, Nonthaburi currently does not have its own final disposal site. Instead, the city transports its waste (310 tonnes of daily waste) to the sanitary landfill site managed by the Nonthaburi Provincial Administrative Organization (Nonthaburi PAO), which is the central disposal site of Nonthaburi Province. Located in Sai Noi District, Nonthaburi Province, about 35 km away from Nonthaburi Municipality, the site occupies a total area of 38.6 ha and has been operated since 1986. The landfill site also includes a leachate treatment system where leachate is collected, stored and treated in a stabilization pond adjacent to the site.

Main Challenges

Although Nonthaburi Municipality has made some efforts to improve its waste management system to date, the city has identified the following challenges to be addressed in order to strengthen the city's MSWM system:

- Low public awareness and lack of compliance with the waste separation and 3R activities, including recycling and composting programmes.
- Insufficient infrastructure, including lack of waste collection vehicles, recycling facilities and land constraints.
- Lack of human and technical capacity, especially for data management.

- Insufficient tipping fees, as waste collection fees do not cover the total cost of waste management.

Key Proposed Actions

The following actions are proposed for improving MSWM system in Nonthaburi municipality:

- Introduce enabling policies and incentives for reducing the city's per capita waste generation rate.
- Strengthen waste segregation and collection systems, including by setting different/specific days for waste collection.
- Conduct awareness raising programmes on waste management targeting students and the general public.
- Increase waste recovery rates by promoting recycling and 3R activities, including expanding the city's existing composting programme and fostering public, private and community partnerships to pilot new recycling programmes.
- Establish a waste transfer station as a pre-treatment facility before transporting wastes to final disposal sites.

Benchmark data on waste management in Nonthaburi municipality

Description	Units
1. Physical component	
1.1. Total population	256,457 in 2015
1.2. Total waste generation	454 tonnes /day (1.77 kg/capita/day)
1.3. Waste collection	
Amount of waste collected by formal sector (cities/municipality/province or contracted private company)	100%
Amount of waste collected by informal sector (without any contract with the city)	N/A
Amount of generated waste openly burned/scattered dumped	N/A
Types of waste collection vehicles used for waste collection and transportation	Compactor and trucks
Capacity of trucks	Compactor (7 tonnes/trip) Trucks (7 tonnes/trip)
Type of fuel use for collection and transportation	Diesel
Amount of fuel	8 L/tonne
Approximate distance from collection points to the landfills	35 km
1.4. Waste composition	
Approximate composition of collected waste	• Food and green waste - 40%, • Plastics - 23.19%, • Paper - 5.51%, • Textile - 5.17%, • Leather/rubber - 1.76%, • Glass - 7.41%, • Metal - 5.34%, • Wood - 0.95% • Others - 10.02%
1.5. Intermediate treatment and recycling	

Amount of organic waste used for composting	74 tonnes/day
Amount of organic waste used for anaerobic digestion	N/A
Amount of waste use for recycling	70 tonnes/day
Composition of recyclables	• Paper and cardboard – 31.16% • Plastic – 52.74% • Aluminium – 0.3% • Metal/Steel – 6.2% • Glass – 9.6%
1.6. Final disposal	
Specification of the landfill/open dumps	Approximate height, availability of landfill cover, management practices, etc.
Landfill 1 (Nonthaburi PAO sanitary landfill, a central landfill facility of Nonthaburi province)	• Amount of waste disposed: 310 tonnes/day • Type of landfill: sanitary landfill without gas recovery • Specifications: 3.34 ha, 6 metre depth, 0.5 metre thick soil covered for 2 metre depth of each waste layer • Year of starting operation: 1986 • Year of closing operation: • If fossil fuel used: Type/amount (L/day)
2. Governance component	
2.1. Degree of user inclusivity (citizen support and participation in waste separation and 3R activities) (low/ medium/ high)	• Low
2.2. Degree of provider inclusivity (private and informal sector participation in waste collection, composting and recycling) (low/ medium/ high)	• Low
2.3. Financial sustainability (population pays for waste collection, budget available for waste management) (low/ medium/ high)	• Medium
2.4. Institutional sustainability (institutional capacity, policy and regulations) (low/ medium/ high)	• Medium

Jambi, Indonesia

Dr. Mariani Yanti, Assistant Director, Jambi City Government

Background

Jambi City, the capital of Jambi Province, is one of the most thriving cities in Indonesia both economically and demographically. It is located on the island of Sumatra, lying about 26 km away from the ruins of Murao Jambi, an ancient city of the Srivijaya kingdom. The city occupies an area of 205.38 sq. km, with a population of approx. 681,616 in 2014. Divided into 11 sub districts and consisting of 1,537 community villages, Jambi is multi-ethnic, with an economy dominated by trading, industry, logistics, and communications, as well as construction, energy, water, finance, agriculture and mining industries.

Waste Management Overview

At the national level, Waste Management Act No.18 (2008) and Regulation No. 81 (2012), enacted by the Government of Indonesia, governs waste management. These national-level waste management regulations are implemented by Jambi city at the local level through several municipal regulations. One of the key local ordinances regulating the implementation of waste management in Jambi City is Local Regulation Number 8/2013, which consists of general provisions for managing waste in the city and prioritizing waste minimization and appropriate handling. It also defines the scope and outlines for waste management in the city, including for financing and other provisions. Local Regulation Number 8/2013 also sets out the roles (tasks, responsibilities, rights, obligations, etc.) for waste management actors, including local government, community and businesses.

Waste Generation, Collection and Transportation

According to an estimation, the total waste generation of Jambi City was about 362 tonnes/day, with an average waste generation per capita of 0.53 kg/day. The current MSWM system in the city includes waste collection, transportation and disposal. After the reduction of waste used for composting (10 tonnes/day), biogas (2 tonnes/day) and recycling (21 tonnes/day), the amount of waste collected and transported to the final disposal site is about 263 tonnes/day. The remaining waste, approximately 99 tonnes per day (18%) cannot be sufficiently tracked due to lack of information. However, it is assumed that uncollected waste is either burnt by households (8%) or discharged to the environment (10%). In the waste collection system, temporary collection points (TPS) operate to store waste prior to being transported to the landfill site. Jambi has four TPS within the city.

Waste Treatment and 3R Activities

Jambi City encourages communities to involve its 3R activities through a waste bank programme by issuing Mayoral Instructions 1123/BLH/2014 (which outline guidance for waste banks in every sub district) and Mayoral Instructions 660/736/BLH/2014 (which define instructions for waste banks in schools). As a result, 61 waste banks are currently operating in the city. These waste banks have so far successfully diverted about 21 tonnes of recyclable materials from the landfill every day. In addition to waste banks, several small-scale windrow composting plants also operate in the city, which treat an estimated 10 tonnes of organic waste per day. Jambi city is also now constructing a biogas facility at the landfill site, which is projected to treat two tonnes of organic waste per day under its commitment to become a green city through the development of sustainable and green infrastructure.

Institutional and Financial Management

In Jambi City, two local agencies are involved in overseeing the city's waste management portfolio; the Environmental Agency or *Badan Lingkungan Hidup* (BLH) and the City Cleansing Agency (Sanitation, Landscaping, and Cemetery Agency) or *Dinas Kebersihan, Pertamanan dan Pemakaman* (DKPP). Of these, DKPP remains the lead agency responsible for the waste collection, transportation, treatment and disposal. According to city officials, 41 waste collection vehicles with a capacity of 4 or 6 m^3 are available for waste collection activities. In addition, Jambi dispatches approximately 380 handcarts and 28 motorcycle carts for collecting waste at source. As with other cities in Indonesia, Jambi city receives a budget from the *Anggaran Pendapatan Belanja Daerah* (APBD), the Regional Government Budget, for waste management activities such as for the delivery of workshops for development of waste management policies; procurement for tools and equipment for waste handling; introducing waste management technologies; promotion of community programmes; improvement and maintenance of relevant tools and equipment; as well as operational upgrades and maintenance of the city's final disposal site.

Final Disposal Jambi

The city disposes of its waste in a semi-controlled landfill site, the Talang Gulo landfill, located approximately 15 km from the city center, in the Kenali Asam Bawah sub-district. The site covers a total land area of 31.6 ha with depths of 12 to 20 m and is divided into four zones; two active and two passive. It is also estimated that about 110 scavengers operate daily in the landfill site collecting recyclable materials. The city has also planned to construct a sanitary landfill in collaboration with KfW, National Public Works of Indonesia and Jambi's local government.

Main Challenges

Although Jambi has made some efforts to improve its waste management practices including by promoting 3Rs through its waste banks and composting programmes, the city has identified that the following challenges must be addressed in order to strengthen waste management:

- Lack of community awareness, such as poor compliance with waste separation and 3R activities, posing obstacles to the success of waste bank and composting programmes.
- Insufficient human and technical capacity, especially for data management.
- Financial limitations, including insufficient waste collection fees for covering the cost of waste management, and political sensitivity surrounding raising the tipping fees.

Key Proposed Actions

The following actions are proposed for improving the MSWM system in Jambi City:

- Introduce enabling policies and provide incentives to reduce the waste generation rate.
- Enhance waste segregation and systematic collection services, including by setting different/specific days for waste collection.
- Promote awareness raising initiatives targeting students and the general public.
- Increase waste recovery rates through additional recycling and 3R activities, including by replicating existing composting programmes and encouraging public, private and community partnerships on new recycling programmes.
- Expand the waste bank programme throughout the city.
- Construct a new sanitary landfill site.

Benchmark data on waste management in Jambi city

Description	Units
1. Physical component	
1.1. Total population	681,616 in 2014
1.2. Total waste generation	362 tonnes /day (0.53 kg/capita/day)
1.3. Waste collection	
Amount of waste collected by formal sector (cities/municipality/province or contracted private company)	296 tonnes/day (82%)
Amount of waste collected by informal sector (without any contract with the city)	5% estimated
Amount of generated waste openly burned/scattered dumped	• Open burning – 8% • Scattered dumping – 10%
Types of waste collection vehicles used for waste collection and transportation	Compactor and trucks
Capacity of trucks	Dump trucks (6 tonnes/trip)
Type of fuel use for collection and transportation	Diesel
Amount of fuel	8L/ tonne
Approximate distance from collection points to the landfills	15 km
1.4. Waste composition	
Approximate composition of collected waste	• Food waste - 45%, • Garden waste – 10%, • Plastics - 15%, • Paper - 15%, • Textile - 5%, • Leather/rubber - 2%, • Glass - 2%, • Metal - 1%, • Others - 5%
1.5. Intermediate treatment and recycling	
Amount of organic waste used for composting	10 tonnes/day
Amount of organic waste used for anaerobic digestion	2 tonnes/day (still in the construction)
Amount of waste use for recycling	21 tonnes/day
Composition of recyclables	• Paper and cardboard – 47% • Plastic – 47% • Aluminium – 1.5% • Metal/Steel – 1.5% • Glass – 3%
1.6. Final disposal	
Specification of the landfill/open dumps	Approximate height, availability of landfill cover, management practices, etc.
Landfill 1	• Amount of waste disposed: 263 tonnes/day • Type of landfill: semi-controlled • Specifications: 3.34 ha, 6 metre depth, 0.5 metre thick soil covered for 2 metre depth of each waste layer

	• Year of starting operation: 1998 • Year of closing operation: • If fossil fuel used: Type/amount (L/day)
2. Governance component	
2.1. Degree of user inclusivity (citizen support and participation in waste separation and 3R activities) (low/ medium/ high)	• Low
2.2. Degree of provider inclusivity (private and informal sector participation in waste collection, composting and recycling) (low/ medium/ high)	• Low
2.3. Financial sustainability (population pays for waste collection, budget available for waste management) (low/ medium/ high)	• Low
2.4. Institutional sustainability (institutional capacity, policy and regulations) (low/ medium/ high)	• Medium

Kampong Chhnang, Cambodia

Mr. Phorpminea Hing, Deputy Governor, Kampong Chhnang City

Background

Kampong Chhnang is the capital of Kampong Chhnang Province in central Cambodia. It is a popular port city located on the west bank of the Tonle Sap River, and is linked with Phnom Penh by a national highway route and railway. The economy of the area is dominated by rice production, with much of the local population living in floating fishing villages during the high-water monsoon season. The total land area of Kampong Chhnang municipality is about 46.65 sq. km, with an estimated population of approx. 42,734 in 2016.

Waste Management Overview

Several national-level policies have been directly or indirectly enacted for solid waste management in the country, including Cambodia's Law on Environmental Protection and Natural Resources Management, 1996; Sub-decree on Environmental Impact Assessment Process, Royal Government, Council of Ministers, No. 72 ANRK.BK, 1999; Sub-decree on Water Pollution Control, 1999; and Sub-decree on Solid Waste Management; and Royal Government Council of Ministers; No 36 ANRK.BK, 1999. The 1999 Sub-decree on Solid Waste Management addresses both municipal and hazardous wastes and governs all activities related to waste management. The Sub-decree also outlines the rules and responsibilities of municipalities and requires cities to enact waste management plans under the guidance of the Ministry of Environment to ensure sustainable practices. In addition, Cambodia's National 3R Strategy sets national targets to achieve by 2020, such as waste separation and recycling, which is targeted at 50% for household wastes, 70% for business wastes and 80% for industrial wastes. In addition, the strategy promotes organic waste composting (50%) and sanitary landfills (30%). However, these national 3R targets have yet to be fully enforced at the local level.

Waste Generation, Collection and Transportation

According to the city data, only 400 households (24%) receive the official waste collection service and the majority dispose of their waste haphazardly in neighbourhoods, including on public roads, into drainage systems, vacant land plots, nearby waterways and house yards. The municipality estimates that total waste generation is approximately 14 tonnes/day with a per capita waste generation rate of about 0.32 kg/capita/day. Kampong Channg has three open trucks to collect waste, which are in generally poor condition and operate unreliably. Two waste collectors and one driver operate each truck. In the areas where waste collection service is available, residents place their waste into plastic bags (most common), as well as jars and wood boxes in front of their houses for collection.

Waste Treatment and 3R Activities

There is no official programme to promote waste separation at source or 3R activities. While organic waste comprises approximately 80% of total waste, there is no proper method to conduct organic waste recycling. On the other hand, the informal sector manages the recycling functions. For example, informal buyers visit individual households or commercial establishments to purchase recyclables at source while scavengers collect valuable recycling materials from the streets and landfill sites and sell them to junk shops and other traders. Currently there are two major junk shops operating in the city.

Institutional and Financial Management

Currently, the private contractor provides a waste collection service under an agreement made with the Ministry of Finance and Economy through the Provincial Department of Finance and Economy. For the waste collection service, users had to pay waste collection fees monthly to the city based on set rates, e.g., households - 5,000–6,000 Riel (approx. USD 1.00-1.50), businesses - 20,000–50,000 Riel (approx. USD 5.00-12.00), and Hotels - 100,000–150,000 Riel (approximately USD 24.00-26.00).

Final Disposal

One dumpsite is available for Kampong Chhnang municipality to dispose of the collected waste, which is approx. three tonnes/day. The dumpsite is located near Phnom Touch Mountain in Pong Gnro village, approx. 11 km away from the Kampong Chhnang municipal center. The dumpsite has three hectares of land for waste disposal and is generally considered a suitable location due to many advantages such as distance from the city centre, accessibility, as well as engineering advantages such as clay soil and flood resistance due to its position and layout.

Main Challenges

Kampong Chhnang municipality has identified the following challenges in order to improve waste management:

- Lack of community awareness and participation in waste separation at source and 3R activities.
- Low rate of service fee payment.
- Absence of effective waste management policy, strategy and plan for the city for sustainable waste management and 3R activity guidance.
- Insufficient human and technical capacity in terms of municipality staff and private service provider.
- Limited law enforcement and regulatory mechanisms for waste management.
- Financial limitations for improving infrastructure, including waste collection, treatment, recycling and final disposal.

Key Proposed Actions

The following actions were identified for strengthening waste management in Kampong Chhnang municipality:

- Prepare a waste management plan and strategy for the introduction of new rules and regulations on waste separation at source and systematic waste collection.
- Introduce public awareness and education campaigns especially targeting community members and schoolchildren on waste separation, storage, waste reduction and related 3R activities.
- Increase the city's waste recovery rate through recycling and 3R activities, including scaling up ongoing recycling activities and introducing a composting programme for recycling organic waste
- Promote a more enabling environment for private sector participation in waste management.
- Establish a sanitary landfill site.

Benchmark data on waste management in Kampong Chhnang City

Description	Units
1. Physical component	
1.1. Total population	42,734 in 2016

1.2. Total waste generation	14 tonnes /day (0.32 kg/capita/day)
1.3. Waste collection	
Amount of waste collected by formal sector (cities/municipality/province or contracted private company)	24% (collected by private contractor)
Amount of waste collected by informal sector (without any contract with the city)	5% estimated
Amount of generated waste openly burned/scatter dumped	• Open burning – 80% • Scattered dumping – 20%
Types of waste collection vehicles used for waste collection and transportation	Dump trucks
Capacity of trucks	Dump trucks (4 tonnes/trip)
Type of fuel use for collection and transportation	Diesel
Amount of fuel	N/A
Approximate distance from collection points to the landfills	12 km
1.4. Waste composition	
Approximate composition of collected waste	• Food waste - 80%, • Plastics - 3%, • Paper - 2%, • Textile - 1%, • Glass – 1% • Metal - 8%, • Others - 5%
1.5. Intermediate treatment and recycling	
Amount of organic waste used for composting	N/A
Amount of organic waste used for anaerobic digestion	N/A
Amount of waste use for recycling	N/A
Composition of recyclables	• Paper and cardboard – 47% • Plastic – 47% • Aluminium – 1.5% • Metal/Steel – 1.5% • Glass – 3%
1.6. Final disposal	
Specification of the landfill/open dumps	Approximate height, availability of landfill cover, management practices, etc.
Landfill 1	• Amount of waste treated: 3 tonnes/day • Type of landfill: open disposal • Specifications: 3.34 ha, 6 metre depth,

	• Year of starting operation: • Year of closing operation: • If fossil fuel used: Type/amount (L/day)
2. Governance component	
2.1. Degree of user inclusivity (citizen support and participation in waste separation and 3R activities) (low/ medium/ high)	• Low
2.2. Degree of provider inclusivity (private and informal sector participation in waste collection, composting and recycling) (low/ medium/ high)	• Low
2.3. Financial sustainability (population pays for waste collection, budget available for waste management) (low/ medium/ high)	• Low
2.4. Institutional sustainability (institutional capacity, policy and regulations) (low/ medium/ high)	• Low