

Identifying plastic waste leakage hotspots and flows in South-East Asia





Identifying plastic waste leakage hotspots and flows in South-East Asia

Issued June 2022

This publication may be reproduced in whole or in part and in any form for educational or non-profit services without special permission from the copyright holder, provided acknowledgment of the source is made. The United Nations Environment Programme would appreciate receiving a copy of any publication that uses this publication as a source.

No use of this publication may be made for resale or any other commercial purpose whatsoever without prior permission in writing from the United Nations Environment Programme. Applications for such permission, with a statement of the purpose and extent of the reproduction, should be addressed to the Director, Communication Division, United Nations Environment Programme, P.O. Box 30552, Nairobi 00100, Kenya.

Disclaimer:

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory or city or area or its authorities, or concerning the delimitation of its frontiers or boundaries. For general guidance on matters relating to the use of maps in publications, please go to <http://www.un.org/Depts/Cartographic/english/htmain.htm>

Mention of a commercial company or product in this document does not imply endorsement by the United Nations Environment Programme or the authors. The use of information from this document for publicity or advertising is not permitted. Trademark names and symbols are used in an editorial fashion with no intention on infringement of trademark or copyright laws. The views expressed in this publication are those of the authors and do not necessarily reflect the views of the United Nations Environment Programme. We regret any errors or omissions that may have been unwittingly made.

© Maps, photos and illustrations as specified

Acknowledgments

This document was developed in partnership with the United Nations Human Settlements Programme (UN-Habitat) with funding from the *SEA circular project – Reducing marine litter by addressing the management of the plastic value chain in South-East Asia* implemented by the United Nations Environment Programme (UNEP) Regional Office for Asia and the Pacific and the Coordinating Body on the Seas of East Asia (COBSEA), with support from the Government of Sweden. UNHabitat is the United Nations programme for human settlements and sustainable urban development.

This document provides assessments of city waste flows and plastic leakage by applying UNHabitat Waste Wise Cities Tool (WaCT) and Waste Flow Diagram (WFD) developed by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Eawag and University of Leeds UK for initial policy and infrastructure gap analysis. The studies were conducted in Cambodia (Kep and Sihanoukville), Malaysia (Seremban), Thailand (Chonburi) and Viet Nam (Tam Ky and Hoi An).

The report was prepared by UN-Habitat in collaboration with United Nations Environment Programme and the Secretariat of the Coordinating Body on the Seas of East Asia (COBSEA) and the UNEP Regional Office for Asia and the Pacific and in close consultation with national governments, local authorities and stakeholders in Cambodia, Malaysia, Thailand and Viet Nam in six cities.

Table of Contents

List of Abbreviations	vii
Executive Summary	ix
Key definitions	xi
1. Introduction	1
2. City waste assessment and potential plastic leakage for initial policy and infrastructure gap analysis	3
2.1 Overall approach, challenges and lessons learned	4
2.2. Kep City/Cambodia	6
WaCT and WFD Survey Results	7
Policy and Infrastructure Gaps Analysis	9
Stakeholder workshop	13
Recommendations	15
2.3. Sihanoukville/Cambodia	16
WaCT and WFD Survey Results	17
Policy and Infrastructure Gaps Analysis	20
Stakeholder workshop	24
Recommendations	25
2.4. Tam Ky City/ Viet Nam	27
WaCT and WFD Survey Results	27
Policy and Infrastructure Gaps Analysis	30
Stakeholder workshop	33
Recommendations	34
2.5. Hoi An/Viet Nam	35
WaCT and WFD Survey Results	36
Policy and Infrastructure Gaps Analysis	39
Recommendations	43
2.6. Chonburi / Thailand	44
WaCT and WFD Survey Results	45
Policy and Infrastructure Gaps Analysis	49
Governance	56
Recommendations	57
2.7. Seremban/Malaysia	59
WaCT and WFD Survey Results	59
Policy and Infrastructure Gaps Analysis	62
Recommendations	67
3. Conclusion	69

List of Figures

Figure 1:	Selected sites for WaCT and WFD implementation.....	4
Figure 2:	Household waste generation and composition analysis in Kep city, 2021	7
Figure 3:	Monthly number of tourists in Kep Province (comparison 2016-2021)	7
Figure 4:	WaCT flow chart results in Kep City, 2021	8
Figure 5:	WFD results in Kep city (plastic tonnes per year), 2021	9
Figure 6:	Breakdown of recovered materials in Kep City	11
Figure 7:	Site visit to the disposal site in Kep City	12
Figure 8:	Potential opportunities for improving the SWM system in Kep City.....	15
Figure 9:	Photo of participants at General Secretariat of National Committee on Coastal Area Management and Development (Left) and at Sihanoukville meeting hall (right), July 2020.....	17
Figure 10:	Monthly number of tourists in Sihanoukville (comparison 2016-2021).....	18
Figure 11:	Household waste generation and composition analysis in Sihanoukville, 2021	18
Figure 12:	WaCT flow chart results in Sihanoukville City, 2021	19
Figure 13:	WFD results in Sihanoukville City (tonnes per year), 2021	20
Figure 14:	Composition of plastic waste in the MSW in Sihanoukville	20
Figure 15:	Waste transfer station in Sihanoukville in Village1, Sangkat 1, Sihanoukville	21
Figure 16:	Breakdown of recovered materials by fraction in Sihanoukville City	21
Figure 17:	Site visit to the disposal site in Sihanoukville, 2021	23
Figure 18:	Potential opportunities for improving the SWM system in Sihanoukville City	25
Figure 19:	Screenshot of the Kick-off workshop in Tam Ky City	27
Figure 20:	Household waste generation and composition analysis in Tam Ky city, 2021	28
Figure 21:	WaCT flow chart results in Tam Ky City.....	28
Figure 22:	Plastic waste flow diagram (tonnes per year), 2021	29
Figure 23:	Composition of plastic waste in the MSW in Tam Ky.....	30
Figure 24:	The waste collection and transportation services is operated by the Provincial Quang Nam URENCO	31
Figure 25:	Recovery facilities in Tam Ky, 2021	32
Figure 26:	Disposal sites of Tam Ky city in Tam Xuan 2 provincial landfill.....	33
Figure 27:	Screenshot of the stakeholders' workshop in Tam Ky City	33
Figure 28:	Opportunities for improving the SWM system in Tam Ky.....	34
Figure 29:	Screenshot of the Kick-off workshop in Hoi An city	36
Figure 30:	Household waste generation and composition survey in Hoi An city, 2021	37
Figure 31:	WaCT flow chart results in Hoi An City	37
Figure 32:	Plastic flow diagram for Hoi An, 2021.....	38
Figure 33:	Plastic waste composition in Hoi An.....	38
Figure 34:	The waste collection and transportation services operated by Hoi An Public Works Company (HAPWC).....	39
Figure 35:	Breakdown of recovered materials in Hoi An.....	40
Figure 36:	Existing dumpsite under closure process in Cam Ha ward – currently not use by the city.....	41

Figure 37: Provincial landfill in Nui Thanh district, 90 km from the City – currently used by the city	42
Figure 38: Screenshot of the Kick-off workshop in Hoi An city	42
Figure 39: Opportunities for improving the SWM system in Hoi-An	43
Figure 40: Kick-off meeting and technical training, Chonburi Province	45
Figure 41: Household waste generation and composition analysis in Chonburi Province	46
Figure 42: Waste composition analysis at (a) Laem Chabang City Municipal Landfill (b) Saen Suk Town Municipal Landfill and (c) Bo Thong Municipal Dumpsite.....	46
Figure 43: WaCT flow chart results in Chonburi Province, Thailand.....	47
Figure 44: Disposal and recovery facilities and their connections in Chonburi Province.....	48
Figure 45: WFD results in Chonburi Province, Thailand (tonnes per year).....	48
Figure 46: Plastic waste composition in Chonburi	49
Figure 47: Waste received at each recovery facility (tonne/day)	51
Figure 48: Breakdown of recovered materials in Chonburi Province.....	52
Figure 49: Control level of disposal facilities	54
Figure 50: Stakeholder’s Workshop, Chonburi Province	55
Figure 51: Screenshot of the kick-off workshop in Saramban.....	59
Figure 52: Waste bags collection and sorting process	60
Figure 53: Household waste generation and composition analysis in Seremban	60
Figure 54: WaCT flow chart results in Seremban	61
Figure 55: WFD results in Seremban (tonnes per year)	61
Figure 56: Plastic waste composition in Seremban	62
Figure 57: Four-wheel bins with 660 liters/1100 liters capacity and waste compactor truck	63
Figure 58: Compactor truck for collection of mixed municipal waste.....	63
Figure 59: Regular Illegal dumping spots in residential areas	63
Figure 60: Residents place the mixed recyclables in plastic bags.....	64
Figure 61: Drop-Off Centre at Bukit Palong for recyclables collected from SAS programme	64
Figure 62: An example of a Recycling Centre operated by a private collector.....	64
Figure 63: Plastic wastes accepted by Fizlestari for processing into pellets.....	64
Figure 64: Paper wastes are baled at the site prior to selling to recycling factory.....	65
Figure 65: Breakdown of recovered materials in Seremban	65
Figure 66: Landfill entrance, weighbridge and active tipping areas	65
Figure 67: Screenshot of the participants to the stakeholder workshop in Seremban	67
Figure 68: Opportunities for improving the SWM system in Seremban.....	67

List of Tables

Table 1: Challenges and lessons learned during the WaCT application in the selected cities	4
Table 2: Definitions used to classify and summarize the gaps identified at city level	6
Table 3: Key WaCT and WFD Data in Kep	8
Table 4: Main role and responsibilities from national to local government	9
Table 5: Potential for waste recovery in Kep.....	12

Table 6:	Assessment of the level of control of the disposal site in Kep City	12
Table 7:	Summary, classification, and prioritization of gaps in Kep City.....	13
Table 8:	Key WaCT and WFD Data in Sihanoukville City	19
Table 9:	Potential for waste recovery in Sihanoukville City	22
Table 10:	Assessment of the level of control of the disposal site in Sihanoukville	22
Table 11:	Summary, classification and prioritization of gaps in Sihanoukville	23
Table 12:	Key WaCT and WFD Data in Tam Ky City	28
Table 13:	Potential for waste recovery in Tam Ky City	31
Table 14:	Assessment of the level of control of the disposal site in Tam Xuan 2	32
Table 15:	Summary, classification and prioritization of gaps in Tam Ky City	33
Table 16:	Key WaCT and WFD Data in Hoi An City	37
Table 17:	Potential for MSW recovery in Hoi An.....	40
Table 18:	Basic level of control area met by the disposal site in Nui Thanh.....	41
Table 19:	Summary, classification and prioritization of gaps in Hoi An City	42
Table 20:	Key WaCT and WFD Data in Chonburi Province, Thailand.....	46
Table 21:	Potential for waste recovery in Chonburi Province.....	52
Table 22:	Waste received by disposal facilities and the control level	53
Table 23:	Summary, classification and prioritisation of gaps in Chonburi Province	54
Table 24:	Key WaCT and WFD Data in Seremban	60
Table 25:	Potential for waste recovery in Seremban	65
Table 26:	Basic level of control area met by the disposal site in Seremban	66
Table 27:	Summary, classification and prioritization of gaps in Seremban	66

List of Abbreviations

ADB	Asian Development Bank
BCG	Bio-Circular-Green Economic Model
CA	Concession Agreement
COBSEA	Coordinating Body on the Seas of East Asia
COMPED	Cambodian Education and Waste Management Organization
COVID-19	Coronavirus disease
CPC	City People's Committee
CSARO	Community Sanitation and Recycling Organization
EEC	Eastern Economic Corridor
EPR	Extended Producer Responsibility
EPS	Expanded Polystyrene
FBSB	Fizlestari Plastic Sdn Bhd
GDP	Gross Domestic Product
GGGI	Global Green Growth Institute
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HAPWC	Public Works Company
HDPE	High Density Polyethylene
ICTs	Information and Communication Technologies
IWA	International Women Association
KSWM	Kampong Som Waste Management (company)
LDPE	Low Density Polyethylene
MEF	Ministry of Economy and Finance
MGB	Mobile Garbage Bin
MoE	Ministry of Environment
MoI	Ministry of Interior
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
NGOs	Non-Governmental Organizations
NSWMD	National Solid Waste Management Department
PCD	Pollution Control Department
PCR	Post-consumer recycled content
PDoE	Provincial Department of Environment
PDoT	Provincial Department of Tourism
PDPWT	Provincial Department of Public Works and Transport

PDR	(Lao) People Democratic Republic
PET	Polyethylene terephthalate
PP	Polypropylene
PPEs	Personal Protective Equipment
PVC	Polyvinyl chloride
RDF	Refuse-Derived Fuels
SAO	Subdistrict Administration Organization
SAS	Separation At Source
SDG indicator	Sustainable Development Goal indicator
SEA circular project	South-East Asia circular project
SWCORP	Solid Waste Corporation
SWM	Solid Waste Management
The 3Rs	Reduce, Reuse, Recycle
The 4Rs	Refuse, Reduce, Reuse, Recycle
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
URENCO Quang Nam	Quang Nam Urban Environment Joint Stock Company
VND	Vietnamese Dong (currency)
WaCT	Waste Wise Cities Tool
WFD	Waste Flow Diagram
WtE	Waste to Energy
WTP	Waste Treatment Plant

Executive Summary

Marine litter is found in all the world's oceans and seas, even in remote areas far from human contact and obvious sources of pollution, constituting an increasing risk to ecosystem health and biodiversity, while entailing substantial economic costs through its impacts on public health, tourism, shipping, fishing and aquaculture. It is known that about 80% of the marine litter originates from land-based human activities¹ and some estimates say that every year, at least 11 million tonnes of plastic find its way into the world's oceans².

Mismanagement of the municipal solid waste in cities is one of the largest sources of the global plastic pollution. Currently 2 billion people do not have access to waste collection services and 3 billion is without access to controlled disposal facilities³. The study conducted by UN-Habitat and COBSEA in 6 cities in Cambodia, Malaysia, Thailand, and Viet Nam under the SEA circular project in 2021 and 2022 revealed that the MSW generation rates vary from 0.64 kg per capita per day in Hoi-An (Viet Nam), 0.88 kg per capita per day in Seremban (Malaysia), 1.2 kg per capita per day in Chonburi (Thailand) and up to 1.75 kg per capita per day in touristic cities such as Sihanoukville (Cambodia). These figures are higher than the World Bank's *What a Waste* estimates of waste generation rates (except for Malaysia).

The survey observed relatively high plastic compositions in MSW stream, Sihanoukville (Cambodia) with 23%, followed by Tam Ky (Viet Nam) with 21% and 19% in Kep (Cambodia). The remaining cities, Hoi-An (Viet Nam), Seremban (Malaysia) and Chonburi (Thailand) reported shares of 17% 16% and 15% respectively. The plastic waste composition observed in this study is all much higher than the regional estimate of plastic composition in the *What a Waste 2.0* report, which is 12%. The plastic composition observed in low-income areas in Tam Ky (Viet Nam) and Chonburi (Thailand) was as high as 25% and 26% with prominent consumption of plastic films. This indicates the plastic consumption in the region is increasing and probably much higher than conventionally considered.

The cities in Malaysia, Thailand and Viet Nam reported high MSW collection rates (>94%) whilst the two cities in Cambodia, Kep and Sihanoukville, reported 58% and 90% respectively. This indicates the capacity in waste collection in Cambodia is slightly lower than other countries, especially in small towns. However, it can be said that the region is showing relatively high performance in waste collection coverage, leaving small amount of waste uncollected.

Although cities are managing to collect MSW and transport it to transfer stations, recovery facilities or disposal facilities, but reaching basic level of environmental control of those facilities is still difficult. The proportion of MSW managed in controlled facilities in Tam Ky (Viet Nam), Kep (Cambodia) and Sihanoukville (Cambodia) are all 0%. It is 37% in Chonburi (Thailand). This means that many cities still mainly relying on open dumpsites.

The waste recovery system requires large infrastructural investments, most often in centralized facilities to achieve economies of scales. This is reflected in Hoi-An and Chonburi which reported a high recovery rate of 35% and 26% respectively. The remaining cities have relatively low recovery rates ranging from 1% to 11% which could be increased with infrastructural investments in separation at source and separate waste collection systems, MRFs and organic waste treatment, combined with policy strengthening and behaviour change measures.

1 Ocean Conservancy, 2015. *Stemming the Tide*. Ocean Conservancy, Washington. <https://oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf>

2 The Pew Charitable Trusts & Systemiq (2020). *Breaking the Plastic Wave: A Comprehensive Assessment of Pathways Towards Stopping Ocean Plastic Pollution*. <https://www.pewtrusts.org/en/research-and-analysis/articles/2020/07/23/breaking-the-plastic-wave-top-findings>

3 United Nations Environment Programme (2015). *Global Waste Management Outlook*. <https://www.unep.org/resources/report/global-waste-management-outlook>

Overall, it can be said that the region is currently in transition to developing full-fledged integrated waste management systems, where efforts to collect waste are improving, reaching basic levels of environmental control of waste management facilities is still a challenge. In less developed waste management systems such as in Cambodia, the waste collection is still a challenge particularly in small towns where infrastructure investments cannot be easily made.

The fact that the region is in a transition phase is also reflected in the plastic leakage into water systems observed as results of WFD. The highest plastic leakage into the water systems was observed in Kep (6.8 kg/capita/year) by Chonburi (5.5 kg/capita/year).

In the stakeholders' workshops held in cities, participants expressed strong interest in introducing waste to energy plants in some cities. However, it should be noted that thorough feasibility studies are required to assess the technical, financial, economic and social and environmental viability of proposed investments before embarking on certain solutions for the MSW. Advanced waste solutions such as Waste to Energy come with very high operational expenditure which need to be sustained by local governments over time. The affordability and environmental impact of such investments must be identified before pursuing such pathways.

The study proved the usefulness of WaCT and WFD applications to understand the current status of MSW and plastic leakage points and identify policy interventions and infrastructure investment gaps. A robust data management system can provide each city with key waste management data which can support governments in making evidence-based decisions. Routine waste data monitoring management using WaCT and WFD and action planning based on reliable data is one of the essential actions to prevent and tackle marine litter and plastic pollution in the region.

Key definitions⁴

MSW	Municipal Solid Waste includes waste generated from: households, commerce and trade, small businesses, office buildings and institutions (schools, hospitals, government buildings). It also includes bulky waste (e.g. white goods, old furniture, mattresses) and waste from selected municipal services, e.g. waste from park and garden maintenance, waste from street cleaning services (street sweepings, the content of litter containers, market cleansing waste), if managed as waste. The definition excludes waste from municipal sewage network and treatment, municipal construction and demolition waste.
Generation	Total MSW Generated by the City is the total MSW generated by the population and their economic activities within the defined system boundary.
Collection	Total MSW Collected refers to the amount of MSW generated that is moved from the point of generation, such as specific addresses or designated collection points, to facilities where the waste is recovered or disposed, regardless of collection modality (e.g., by municipal governments, non-state actors or informal sector). The remaining share of MSW generated is considered “uncollected”.
Recovery	Recovery means any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the facility or in the wider economy
Recovery facilities	Recovery facilities include any facilities with recovery activities defined below including recycling, composting, incineration with energy recovery, materials recovery facilities (MRF), mechanical biological treatment (MBT) facilities, etc.
MRF	Material Recovery Facility (MRF; or materials reclamation facility, materials recycling facility, multi re-use facility) is a specialized recovery facility that receives, separates and prepares recyclable materials for marketing to further processors or end-user manufacturers.
MBT	Mechanical Biological Treatment (MBT) facilities are a type of recovery facility that combines an MRF with a form of biological treatment such as composting or anaerobic digestion.
WtE	Incineration with Energy Recovery is the controlled combustion of waste with energy recovery.
Recycling	Recycling is defined under the UNSD/UNEP Questionnaire and further for the purpose of these indicators as “Any reprocessing of waste material in a production process that diverts it from the waste stream, except reuse as fuel. Both reprocessing as the same type of product, and for different purposes should be included. Recycling within industrial plants i.e., at the place of generation should be excluded.” For the purpose of consistency with the Basel Convention reporting and correspondence with EUROSTAT reporting system, Recovery operations R2 to R12 listed in Basel Convention Annex IV, are to be considered as ‘Recycling’ under the UNSD reporting for hazardous waste.
Waste pickers	Waste pickers extract recyclable materials from the waste stream to support their livelihood, selling materials into the recovery system.

4 Source: Waste Wise Cities Tool

Intermediate traders	Intermediate traders receive materials from both formal and informal recyclable collection systems (including waste pickers), store and prepare these materials for onward trading to apex traders.
End of chain recyclers	End of chain recycler/recovery entity receives materials from apex traders or direct from both formal and informal MSW collection systems and processes them into materials and products that have value in the economy either through recycling, incineration with energy recovery, or other recovery process.
Disposal	Disposal means any operation whose main purpose is not the recovery of materials or energy even if the operation has as a secondary consequence the reclamation of substances or energy.
Disposal facilities	Disposal Facilities refer to sites which are regularly used by the public authorities and private collectors, regardless of their level of control and legality, for the disposal of waste. Such sites may or may not have an official recognition, a permit or a license. Disposal sites may be managed in either a controlled or uncontrolled manner. The definition excludes unrecognized places where waste is deposited occasionally in small amounts which public authorities may clean up from time to time.
Landfill	Landfill is the deposit of waste into or onto land. It includes specially engineered landfill sites and temporary storage of over one year on permanent sites. The definition covers both landfills at internal sites, i.e. where a generator of waste is carrying out its own waste disposal at the place of generation, and at external sites.
MSW managed in controlled facilities	MSW Managed in Controlled Facilities refers to MSW collected and transported to recovery and disposal facilities that are operated under basic, improved or full control according to the Ladder of waste management facilities' control level (Table 2). The Ladder can be used as a checklist for assessing the level of control of a particular recovery or disposal facility. The facility should be classified by going through the decision-making tree attached in Annex 7. Note that the emphasis is on operational control rather than engineering/design. A facility that is constructed to a high standard, but not operated in compliance with Level 3 (or above) standard is not regarded as a controlled facility.
Formal waste management	Formal waste management relates to waste management activities undertaken by units working within the context of the formal governmental or non-state actors regulating and operating waste management; that is, organizations or individuals registered as economic units with government authorities and assumed to generally abide by local laws and regulations related to wastes and their management.
Informal waste management	Informal waste management refers to individuals or enterprises who are involved in private sector recycling and waste management activities which are not sponsored, financed, recognised, supported, organized or acknowledged by the formal solid waste authorities, or which operate in violation of or in competition with formal authorities (Scheinberg et al., 2010). Informal units are assumed to abide by local waste-related laws and regulations when it is in their interests to do so.



1.

Introduction

Marine litter is found in all the world's oceans and seas, even in remote areas far from human contact and obvious sources of pollution, constituting an increasing risk to ecosystem health and biodiversity, while entailing substantial economic costs through its impacts on public health, tourism, shipping, fishing and aquaculture. It is known that about 80% of the marine litter originates from land-based human activities⁵ and some estimates say that every year, at least 11 million tonnes of plastic find its way into the world's oceans⁶. This is rooted in unsustainable production and consumption patterns, poor solid waste management and lack of infrastructure, lack of adequate legal and policy frameworks and poor enforcement, including on interregional cross-border trade of plastic waste, and a lack of financial resources both at national and local level governments.

In 2020, UN-Habitat finalized the *Waste Wise Cities Tool (WaCT) – Step by Step Guide to Assess City Municipal Solid Waste Management (MSWM) Performance through the Sustainable Development Goal (SDG) Indicator 11.6.1 Monitoring*. WaCT guides cities and local governments through the steps to assess the environmental performance of a MSWM system, food waste generation and resource recovery systems in cities. By doing so, it provides critical information for cities and

countries to establish better waste and resource management strategies. In parallel with the WaCT development, the German development cooperation agency GIZ, Eawag and University of Leeds developed the Waste Flow Diagram (WFD) – a tool to estimate plastic leakage from municipal solid waste (MSW) management systems, using WaCT data. By combining two tools, WaCT and WFD can illustrate the current waste flow and where the infrastructure gaps are as well as urgent actions that need to be taken to prevent plastic pollution caused by MSW mismanagement in cities.

The United Nations Environment Programme (UNEP) and the Coordinating Body on the Seas of East Asia (COBSEA) partnered with UN-Habitat under the SEA circular project to apply the WaCT and Waste Flow Diagram (WFD) in 6 cities in Cambodia, Viet Nam, Malaysia and Thailand. The recommendations in this report are based on field observations, interviews with local stakeholders as well as international best practices. The current report does not substitute for full feasibility studies and any recommended interventions and follow-up decision-making processes should be informed by a comprehensive technical and financial feasibility study.

5 Ocean Conservancy, 2015. *Stemming the Tide*. Ocean Conservancy, Washington. <https://oceanconservancy.org/wp-content/uploads/2017/04/full-report-stemming-the.pdf>

6 The Pew Charitable Trusts & Systemiq (2020). *Breaking the Plastic Wave: A Comprehensive Assessment of Pathways Towards Stopping Ocean Plastic Pollution*. <https://www.pewtrusts.org/en/research-and-analysis/articles/2020/07/23/breaking-the-plastic-wave-top-findings>

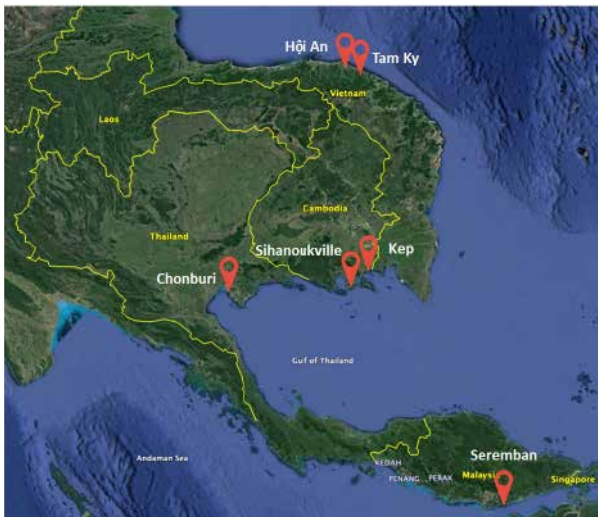


2.

City waste assessment and potential plastic leakage for initial policy and infrastructure gap analysis

UN-Habitat implemented the Waste Wise Cities Tool (WaCT) and Waste Flow Diagram (WFD) survey in the following countries and cities (Figure 1): Thailand – Chonburi, Malaysia – Seremban, Cambodia - Sihanoukville and Kep, Viet Nam - Hội An and Tam Ky City.

Figure 1: Selected sites for WaCT and WFD implementation



2.1 Overall approach, challenges and lessons learned

Upon selection of cities for the application of the WaCT and WFD, UN-Habitat started the coordination of the activities together with the country and regional offices. The communication and collaboration with the governmental stakeholders in each city were established early in the process. Kick off meetings and trainings have been organized and delivered as a first step before the start of the survey activities in the field. The kick-off meetings were followed by technical trainings with the city officials on the WaCT and WFD and with the volunteers engaged in supporting the implementation of the survey. During the implementation, several challenges were experienced related to the COVID-19 pandemic and stakeholders’ reluctance to cooperate with the survey team.

Table 1: Challenges and lessons learned during the WaCT application in the selected cities

Challenges	Lessons Learned
<p>COVID-19 pandemic</p> <ul style="list-style-type: none"> ▶ Reluctance from local authorities and households to participate in the survey due to the regulations on isolation and travel restrictions. The kick-off and technical training were not allowed to be organized in person. In some cases, UN-Habitat team relied on the support of local municipal staff to carry out survey activities and implement steps 1 to 6 of WaCT. ▶ Quantities reported by waste disposal facilities are significantly different compared to pre-COVID 19. ▶ Tourism activities, public activities as well as lifestyle and household consumption in the surveyed cities have changed and can affect the accuracy and representativeness of the survey data. 	<p>COVID-19 pandemic</p> <ul style="list-style-type: none"> ▶ Clear communication and provision of Personal Protective Equipment (PPE) and sanitizers are confirmed to be important; ▶ Use of Information and Communication Technologies (ICTs) in the training provision confirmed to be effective; ▶ Data on the Municipal Solid Waste (MSW) management system in the context of the Covid-19 pandemic provides a good opportunity to understand the system under special conditions.

Challenges	Lessons Learned
<p>Waste generation and composition</p> <ul style="list-style-type: none"> ▶ The waste generation is most likely impacted by the pandemic restrictions (e.g. restricted gatherings and curfews) and the pandemic impacts on households' income and expenditure; ▶ Most of the restaurants/food premises are closed and switched to deliveries, leading to increased volumes of food packaging waste; ▶ The non-household waste, mainly from the tourism industry is significantly reduced due to the lower touristic activities, school closure and lockdown; ▶ In Viet Nam, the implementation of the WaCT survey was done in the rainy season, therefore the data should be used with the weather condition. 	<p>Waste generation and composition</p> <ul style="list-style-type: none"> ▶ The data collected during COVID-19 should be used considering its limitations; ▶ Although commercial activities were reduced during the pandemic, the interview surveys of the non-household premises revealed that the share of the non-household waste is higher as compared to the 30% proxy given in the WaCT (56% in Kep and 63% in Sihanoukville).
<p>Collaboration with the waste recovery facilities</p> <ul style="list-style-type: none"> ▶ Lack of collaboration between the waste recovery facilities and the local government was observed. ▶ Informal sector was not always willing to share data. 	<p>Collaboration and engagement with the city officials</p> <ul style="list-style-type: none"> ▶ "Learning by doing" has proved to be an effective way of transferring knowledge especially for assessment of fact-based data on MSW by applying the WaCT.
<p>Waste quantities and composition at disposal sites</p> <ul style="list-style-type: none"> ▶ Visiting the disposal facilities and checking their control level was challenging, especially in the case of disposal facilities operated by the private sector. 	

The following sections of the report present the WaCT and WFD results in each of the selected cities. The presentation includes a status quo analysis of the SWM system, followed by an analysis of the results and a set of recommendations. An evaluation of the gaps related to policy, legal, infrastructural and equipment is presented in the form of colour indicators. The definitions for each colour code used are presented below.

COVID-19 pandemic, the city generated around 45-51 tonnes of waste per day with a peak generation rate of 55 tonnes per day. The waste collection and transport service has been contracted by a private service provider which covers around 50% of the city's waste. The landfill is located at 11.5 km from the city centre and receives around 25 tonnes of waste per day. Some of the key conclusions of the kick off meeting included:

Table 2: Definitions used to classify and summarize the gaps identified at city level

Type of gap	Colour used	Definition
Large gap	Red	No infrastructure or equipment is in place. There is no policy or legal initiative to support investments in infrastructure. Major gaps are identified and should be immediately addressed.
Medium gap	Orange	Some infrastructure or equipment is in place, but its use or condition is assessed to be poor or very poor. There are some policies or legal initiatives in place to support further investments, but these are not realistic or lacking proper enforcement mechanisms. Important gaps are identified which require immediate action.
Low gap	Yellow	The infrastructure or equipment is in place and having an important contribution to the overall SWM system. There are policies or legal initiatives to support further improvements in the system. Some gaps exist and should be addressed.

2.2. Kep City/Cambodia

A kick-off workshop was conducted in Kep, Cambodia in July 2021 in hybrid mode (online and offline). The municipality organized the group gathering at the meeting hall with Sangkat chiefs, community leaders as well as waste collection service providers, and then virtually connected to the online workshop. The other participants from the Provincial Department of Environment (PDoE), Provincial Department of Public Works and Transport (PDPWT), UNDP, and Global Green Growth Institute (GGGI) individually joined the online session. In total, 16 people participated in the workshop.

Kep Municipality recognizes its potential to become an eco-tour destination; however, the inadequate solid waste management is one of causes increased frequency of flooding and ecosystem deterioration, which consequently undermine its ambition to be eco-tour destination. Waste generation changes seasonally according to peak times of tourist influx. On average, before the

- ▶ Illegal dumping, including beach litter, has been identified as a key challenge;
- ▶ The stakeholders' workshop should include representatives from the provincial administration, PDoE, PDPWT, Provincial Department of Tourism (PDoT), formal and informal waste collection networks, junk shops, and other NGOs;
- ▶ Several junk shops, informal waste pickers and community groups have been identified as key actors in the recovery value chain;
- ▶ The landfill is located in the Damnak Changer Villlage, Sangkat Prey Thum and is currently uncontrolled;
- ▶ The waste in Kep is mainly generated by tourism related businesses.

WaCT and WFD Survey Results

Kep is one of the 26 secondary cities in Cambodia. The city has an approximate population of 21,000 inhabitants and is laid out on a coastal area of 79.52 Km². It is mainly recognized for its tourism potential while marine industry and salt processing are also known as key economic sectors. Kep's most popular tourist attractions are the beaches and colonial-era villas, the crab market and sea food restaurants, Koh Tonsay Island and the

National Park. The activities on ground started with a household waste generation and composition analysis (Figure 2), followed by analysis of the non-household waste, waste recovery, waste disposal data and plastic leakages into the environment.

The Covid-19 pandemic significantly reduced the number of visitors in the city, especially since the community outbreak registered in February 2021. The data from the Kep Provincial Department of Tourism in Figure 3 depicts the fluctuation of tourists between 2016 and 2021.

Figure 2: Household waste generation and composition analysis in Kep city, 2021



The result from the WaCT shows that 25 tonnes of waste is generated daily, of which 58% is collected and 0% managed in controlled facilities. The notable aspect of the survey is that 56% of the total municipal solid waste generated by non-household sources such as public spaces and restaurants, followed by markets and hotels. Around 58% of the waste is composed of organic waste whilst the plastic fraction represents the second highest, notably 19% at household level and 23% at disposal site, which is reflected to higher plastic leakage (almost 7 kg/person/year). The most common plastic products found in the MSW are single use bags followed by PET bottles. It is also worth mentioning that most of the special waste is represented by single-use medical masks.

Figure 3: Monthly number of tourists in Kep Province (comparison 2016-2021)

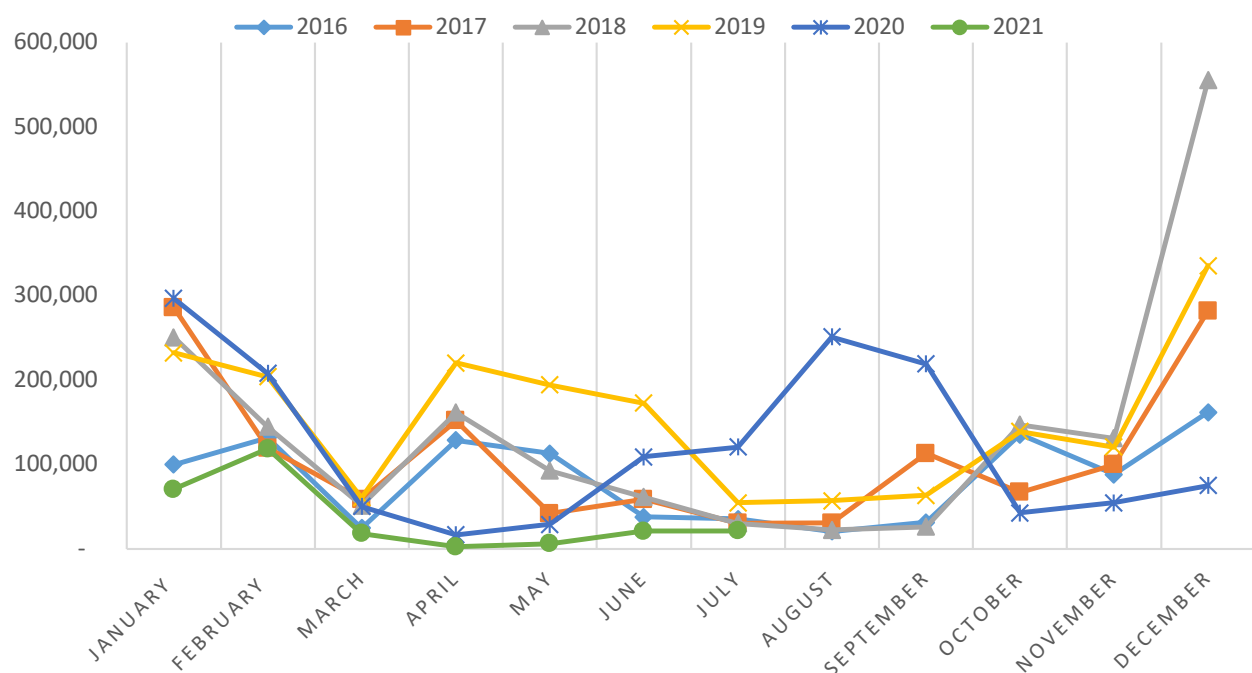


Table 3: Key WaCT and WFD Data in Kep

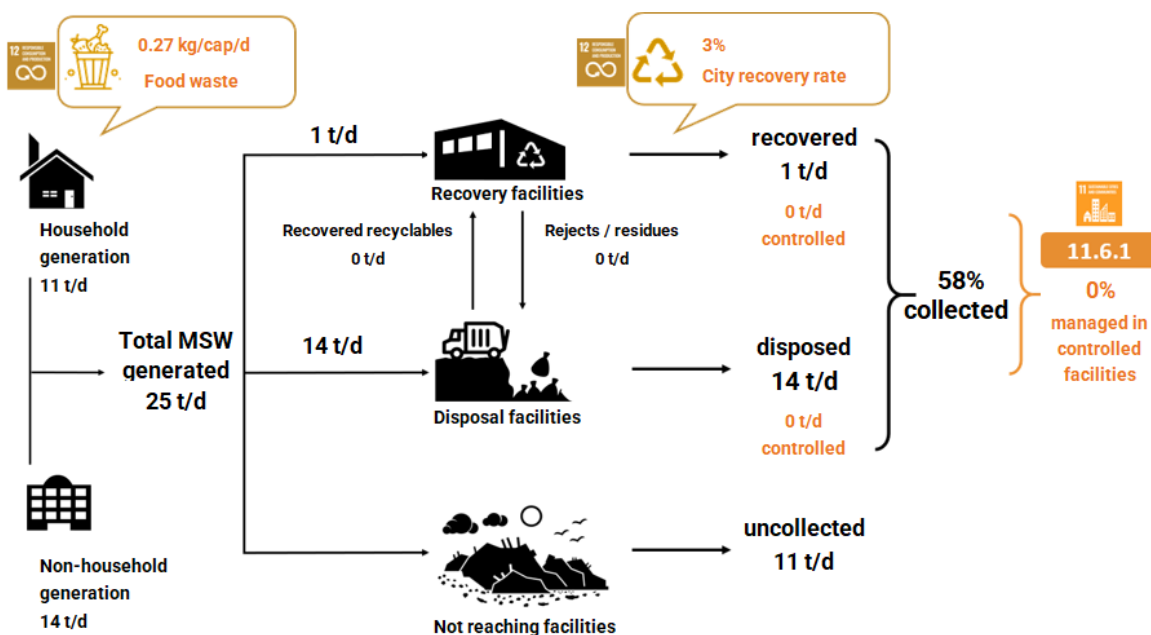
Income group	High income	Middle income	Low income
Waste generation rate (kg/capita/day)	0.60	0.54	0.43
Total population	1,180	16,708	3,316
Total MSW generated from household (t/day)	1	9	1
Total MSW generated from non-household sources (t/day)			14
Total MSW generated (t/day)			25
Plastic leakage to water systems (kg/person/year)			6.8

The SWM system is mostly linear consisting of waste collection, transportation and disposal. Only 3% of the recyclable waste is collected from either household or non-household sources or from the disposal site by waste pickers or small traders. The overall collection rate is 58% and mostly covering the touristic areas and commercial areas. No waste is currently disposed in controlled facilities, although the potential for improving the control level of the disposal facility is high with the construction of a new sanitary landfill being underway and operations of the new facilities planned to commence soon. Around 11 tonnes of waste per day is estimated to be uncollected.

Around 2,026 tonnes of plastic are produced per year in which only around 6% equivalent to 114 tonnes is recovered mainly by the informal sector. The reject rate proxy of 10% has been used for recovery facilities. PET is the most recovered material while a small amount of film plastics like bags and packaging is recycled by the International Women Association⁷ (IWA). Open burning is the main disposal method of uncollected waste while illegal dumping on land or water bodies is also commonly found.

With the high consumption of plastics, limited waste collection, and low recycling rate, the

Figure 4: WaCT flow chart results in Kep City, 2021



⁷ IWA website (<https://www.iwakep.com/>)

average plastic waste leakage in the water per capita per year is very high (6.8 kg/cap/year). The main reason leading to the high consumption of plastic is represented by low citizen awareness and behaviours which favour the use of single use plastic while there are no alternative materials to fulfil the same functions. The most significant leakage influencers are from disposal facilities. Cover material is not used, and compaction is being done intermittently. Fire is prevalent in the dry season, due to the lack of fire control. Waste picking activities are intense especially in the waste discharge area of the disposal site.

Policy and Infrastructure Gaps Analysis

Sub-degree 113 is recognized as the primary legislation of MSWM in Cambodia, adopted in 2015, which regulates waste separation, storage,

collection, transportation, recycling as well as landfill management. The main objectives are to consolidate the responsibilities of relevant key actors, to decentralize waste management to municipal/district administration, to determine the necessary measures to improve efficiency and safety, and to promote public education and citizens' participation in preparing and implementing measures. An overview of the institutional roles determined in this sub-degree are shown in Table 4.

The penalties for noncompliance activities range from USD 2 to 250 according to the severity of the non-compliance. These include improper waste separation and packaging, littering, burning, lack of bins from businesses, mixing solid waste with hazardous waste, etc. After the sub-degree 113 was enacted, other supporting regulations have

Figure 5: WFD results in Kep city (plastic tonnes per year), 2021

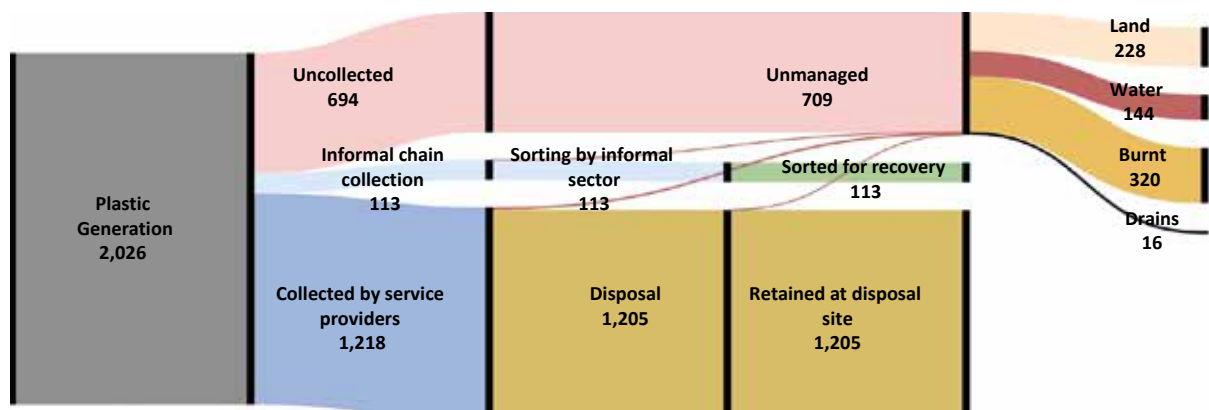


Table 4: Main role and responsibilities from national to local government

Institution	Role
Ministry of Interior	Coordinate and seek any support for sub-national administration and intervene monitoring and evaluating performance of the management.
Provincial Administration	Lead and push the operation implementing by municipal and district administration.
Municipality/ District	Prepare strategic planning and lead the solid waste management within the territorial jurisdiction.
Sangkat/Commune	Implement delegated solid waste management activities.
Ministry of Environment	Prepares policies, national strategic plans, legal instruments, and technical guidelines; Provides technical advice and capacity building to the municipality.
Provincial Department of Environment	Provides technical advice to municipality/district and promote citizens' education.

been continuously issued to facilitate enforcement and implementation, including:

- ▶ The inter-ministerial circular between the Ministry of Environment (MoE) and Ministry of Interior (Mol), 2015, clarifies the role of relevant ministries, the sub-national administration, and the Provincial Department of Environment (PDoE) to ensure the efficient implementation of sub-degree 113.
- ▶ Sub-decree 182 on the functions and structure of municipal administrations, aims to promote the efficiency of administration management, public service delivery, and local development at municipality level. Each municipal administration is required to have 13 offices and units, including an office of Public Works, Transportation, Hygiene, Environment, and Public Order, which is responsible for solid waste management in urban areas.
- ▶ Prakas⁸ 8682 on the management and use of revenues from waste related penalties issued by MoE, Mol, and Ministry of Economy and Finance (MEF), falls under the responsibility of the capital city, municipalities, or districts. A specific committee and/or working group should be established.
- ▶ Prakas 195, issued by MoE, Mol, MEF, determines the maximum fees to guide subnational administrations when setting up the service fees in their territory. The fee takes into account cleaning, collecting, and transporting MSW as well as landfill fees.
- ▶ Sub-decree 168, 2017, on the management of plastic bags, stipulates the restrictions on importing, producing, distributing, using, and recycling plastic bags in Cambodia. Its main aim is to reduce the use of single use plastic bags and promote the use of more environmentally friendly alternatives. Plastic bags of a certain thickness are banned from import and manufacturing while tax incentives will be put in place for the import or manufacturing of biodegradable bags.
- ▶ National policy on Solid Waste Management 2020-2030 requires the implementation of the 3Rs, strengthening the functional performance of subnational, development of supporting legal documents, technical, technology, and finance, encouragement of private participation, and public educational promotion.

Following the sub-degree 113 and sub-degree 182, the management of MSW falls under the responsibility of the public works, transport, sanitation, environment, and public orders office. Currently, there are only 2 dedicated staffs that have insufficient capacity to fulfil their duties. Most SWM activities are carried out by private contractors. There are no regular awareness-raising campaigns in Kep City, although some activities have been initiated at schools. The Royal Government of Cambodia through MEF has allocated a national budget for environmental cleanliness services to 26 municipalities, which amounts to approximately \$2 million in total per year. In Kep City, the total revenue allocated for public sanitation comes from the national budget amounting to approximately USD 50,000. There is no other budget allocated for SWM.

Waste collection and transfer

In Kep Municipality there is no waste transfer station, therefore the waste collected from the generation point is directly transferred to the disposal site. In general, collection and disposal are carried out by a private contractor that charges a tipping fee to households and businesses. Both waste collection and service fee collection are run door to door and found to be inefficient and insufficient.

Challenges include insufficient waste collection points, low fee collection rate exacerbated by the COVID-19 pandemic and a sparsely populated territory combined with a poor road infrastructure. Littering is a common practice in under-serviced areas, situated outside the main road and remote areas. Littering is also concentrated along major tourist spots, particularly at the beach. This is worsened during events such as the New Year's

⁸ Prakas is a Cambodian term meaning "official proclamation". It is a ministerial or inter-ministerial decision.

festival, at which times the city experiences a large influx of tourists. The SWM system is overwhelmed during these events. Marine litter is another major concern. It occurs both inland and from fishing activities according to the city administration officers. Although no detailed study has been carried out, this is evident from beach cleaning activities in Koh Ach. Marine littering in Kep is also a trans-boundary concern as waste from Vietnamese borders is washed up on Kep's coastline.

The collection services are carried out by the private operator using two trucks of 5 tonnes and 13 tonnes capacity. The operator employs a total of 32 staff, out of which more than 50% are women (mostly hired for low level jobs). The services are delivered based on formal contracts as well as other arrangements such as for market waste. Information on operator revenues is not publicly available. The monthly collection fees range from USD 2.5-3.5 for small households up to USD 30 for large businesses and hotels.

The contractual arrangements between the private operator and the municipality include:

- ▶ A 16-year fee-based service contract with Provincial Authority to operate the collection and disposal of waste and maintenance of landfill as well as access road to site;
- ▶ An annual budget allocation from MoE to operate waste collection from public spaces (streets, parks, parking spaces, schools);
- ▶ Additional fee-based service collection arrangements with market authorities (including the Crab Market).

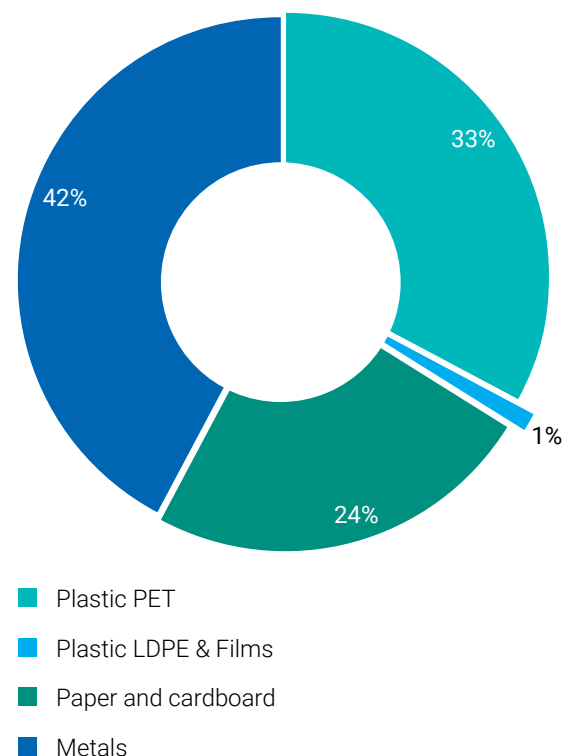
Waste recovery

The waste recovery rate in Kep is 3% and it is exclusively done by informal facilities. Two junk shops buy recyclable waste from multiple small traders or individual waste pickers who in turn pick or buy the waste from either households or non-household premises. Bigger size junk shops in nearby districts buy the recyclable waste and reportedly send it to Phnom Penh which is believed to be exported to either Thailand or Viet Nam.

In addition, there is a woman group known as IWA which has been active in the recovery of plastic bags and cement plastic packaging. The materials are firstly bought from individuals including waste collection and construction workers, and then cleaned, processed, and eventually transformed into usable products such as handbags, wallets, satchels, and shopping bags. This is a small-scale operation with only 4 women. During COVID-19 pandemic, the manager of the facility expressed that the production reduced significantly because their market relies on international tourists who come to the city. Therefore, they currently produce around 10 items per day.

The Figure 6 below shows the recovered materials in City. In term of quantity, metal takes the largest percentage equivalent to 42%. Other 33% and 24% are plastic PET and paper or cardboard respectively. 1% of LDPE or plastic film is recovered by IWA, but it is known that there is high fluctuation based on demand. The main challenges of recovery activity are the absence of source separation and related recovery infrastructure. In general, the informal sector contribution to improved MSW management is not officially recognized.

Figure 6: Breakdown of recovered materials in Kep City



The below table summarises the potential for waste recovery in Kep. This amount of waste consists of MSW recyclables currently uncollected or ending up in the disposal site.

Table 5: Potential for waste recovery in Kep

Waste category	Uncollected materials (t/d)	Materials in the disposal site (t/d)
Paper and cardboard	0.4	0.7
Plastic films	1.1	1.6
Plastic dense	1.0	1.7
Metals	0.2	0.6
Organic	6.3	8.6

Waste disposal

The waste is currently disposed at a landfill site located 11.5 Km from the city centre in Damnak Chang'aeur Village, Sangkat Prey Thum. The

Figure 7: Site visit to the disposal site in Kep City



disposal site is “no control” with no designated areas for daily waste placement and several other parameters not meeting the WaCT criteria for controlled facilities. Waste burning is a common practice especially in the dry season. Additionally, the site lacks any form of rainwater and leachate management systems. Waste is placed in

Table 6: Assessment of the level of control of the disposal site in Kep City

Assessment areas	Questions	Kep (Yes/No)
Security	Is there boundary and access control allowing single point of supervised access	No
Water control	Is there any perimeter drainage maintained around the site	No
Slope stabilization	Are the slopes stabilized, mitigating risk of landslide	Yes
Waste handling, compaction and cover	Are waste trucks directed to a specific operational area of disposal	Yes
	Is there heavy mechanical equipment reliably available	No
	Is waste layered and compacted within the specific operational area	Yes
	Is there some use of cover material	No
Fire control	Is there zero evidence of burning of waste on the surface of the landfill	No
Staffing	Are staff on site during operational hours	No
Records	Is there a functional weighbridge in use	No
EHS	Are there toilets and hand washing stations	No
	Are basic personal protective equipment in use	No
Other	Is there a site drawing showing the landfill boundary and filling area	No

excavated cells with no soil and groundwater protection. Additionally, the presence of informal waste pickers in the disposal area poses serious occupational health and safety risks both for the working staff and the waste pickers.

The city is currently constructing a new sanitary landfill with financial support from the Asian Development Bank (ADB). More details are provided in the box below.

The prioritization is made considering the complexity of the intervention, the capacity of the government to implement it and the urgency

of the problem considering public health and environmental related impacts.

Stakeholder workshop

A stakeholder workshop was organized in November 2021 to showcase the results of the survey to the local stakeholders. As a result of the workshop, several policy intervention and infrastructure investment gaps have been identified and solutions have been proposed to improve the status of MSW. Around 30 participants including representatives from the local authority, MoE, PDoE, PDPWT, PDoT, private waste collection

Brief description of the new sanitary landfill

A new sanitary landfill is currently under construction as part of an ADB funded project “Second Greater Mekong Subregion Tourism Infrastructure for Inclusive Growth Project”. The project includes several components related to transport, tourism and SWM with the overarching goal of improving transport-related and environmental infrastructure in Kep province. Under this project, the existing waste in the old dumping site will be rehabilitated and closed, while new sanitary landfill infrastructure will be constructed. The new landfill will consist of 4 waste cells, a passive leachate treatment system, a septage treatment cell, a hazardous waste cell, a Material Recovery Facility (MRF), administration and service buildings, and an access road of 3.5km. The waste cells have a combined estimated footprint of 68,000 m² and a capacity of approximately 600,000 to 700,000 m³. The estimated lifespan of the landfill site is minimum 20 years. This new landfill facility and operation will benefit the SWM in Kep city by improving the working conditions of waste pickers and increasing waste recovery through an MRF and reducing environmental pollution through a safe disposal and a leachate treatment system.



New landfill site under construction in Kep

Table 7: Summary, classification, and prioritization of gaps in Kep City

City/Country	Kep, Cambodia		Prioritization (1-high, 3-low)
	Policy / Legal	Infrastructure	
Separation at source			1
Waste collection coverage (incl. waste collection fees)			1
Waste transfer stations			3
Material recycling			2
Biological treatment (incl. waste to energy)			2
Waste disposal			1
Informal sector (incl. integration)			1
EPR (incl. similar policies)			3
SWM planning			1

Priority

High		1
Medium		2
Low		3

Gaps

Large	
Medium	
Low	

company, informal sector, and market managers joined the workshop. The key outcomes from the discussions are described below.

Waste collection

Several challenges were discussed in the stakeholders workshop as follows:

- ▶ The waste collection service is accessible only in the tourist and commercial areas along the main roads. To improve the waste collection, a detailed survey of the exact number of households which do not have access to the service is required.
- ▶ An affordability and willingness to pay survey is required to determine the level of the service fee and the mechanisms for revenue collection.
- ▶ The numbers of trucks are insufficient. Due to the collection capacity and the length of the collection route, the fleet is able to deliver 2 collection rounds per day or an equivalent of 36 tonnes. Waste collection service is overwhelmed during special events such as New Year's festival, and long holidays such as water festivals when the city experiences a large influx of tourists.

Participants of the workshop also discussed the possible interventions to improve the waste collection service as follows:

- ▶ Setting up additional collection points, promoting separation at source and developing and enforcing a regular collection schedule is essential
- ▶ Separation at source is not common in Cambodia due to the lack of policies, infrastructure, and a strong private sector for recycling. In Kep, only some types of recyclable wastes such as metals, paper or cardboard and PET plastics are separated and sold within the informal sector. In order to increase waste separation, there is a need to engage communities to secure their acceptance and a high participation. In parallel, appropriate infrastructure should be arranged accordingly for example:
- ▶ The collection vehicles and schedule should be differentiated by the type of waste

- ▶ Better enforcement is needed to complement infrastructural investments and other system interventions.
- ▶ Although the legislation on source separation is in place, clear guidelines and implementation measures are missing. The Polluter Pays Principle should be promoted, in which waste generators should pay for the true cost of waste management.

Waste recovery

The participants highlighted 3 main recommendations to increase the recovery rate in Kep city:

- ▶ Waste separation at source,
- ▶ Market development and investments in sorting facilities
- ▶ Integration of the informal sector.

Because most of the waste is organic waste (food and garden waste), one of the solutions with high impact is represented by organic treatment such as composting. Plastic waste is the second largest stream in the MSW as such plastic recovery should be considered. For instance, there should be support to IWA and other similar organizations to extend their activities. There are a number of organizations currently active and interested in pursuing opportunities in waste recovery such as: [Chip Mong Insee](#), [Community Sanitation and Recycling Organization \(CSARO\)](#) and [Cambodian Education and Waste Management Organization \(COMPED\)](#) and the informal sector. Possible policy interventions required to stimulate waste recovery are related to tax exemption for recycling businesses, discount on the water and electricity bills, and promotion of the use of recycled products.

Waste disposal

The control level of disposal facilities is supposed to be significantly improved with the operation of the new sanitary landfill. However, the future operation plan is unknown and the survey could not find any sustainable operational plan for the currently constructed new sanitary landfill as the responsibility to manage the landfill site lies with the national government and not with the municipality.

In order to enhance the collaboration with informal sector, the recommendation is to integrate them into the formal collection and recovery chain such as with the private collection company or in operation of the landfill site and of the Material Recovery Facility (MRF).

The ban of single use plastics is a complex task and it requires a large effort and mobilization from all actors in the SWM system and beyond. One prevention option is to promote the use of reusable or biodegradable materials for businesses such as restaurants and coffee shops. The municipality should also raise awareness about the negative impact of plastic on the environment.

Governance

The current challenges in governance are the lack of financial and technical capacity and limited participation by businesses and citizens in the SWM system. This can be achieved through community focus groups, radio jingles, communication materials in the touristic and market areas. There is no policy on EPR (Extended Producer Responsibility) system in Cambodia yet, and therefore it is impossible to utilize or accelerate this in Kep. The participants raised the importance of this policy to improve the MSW in

the city especially on glass which is not recovered by informal sector.

Recommendations

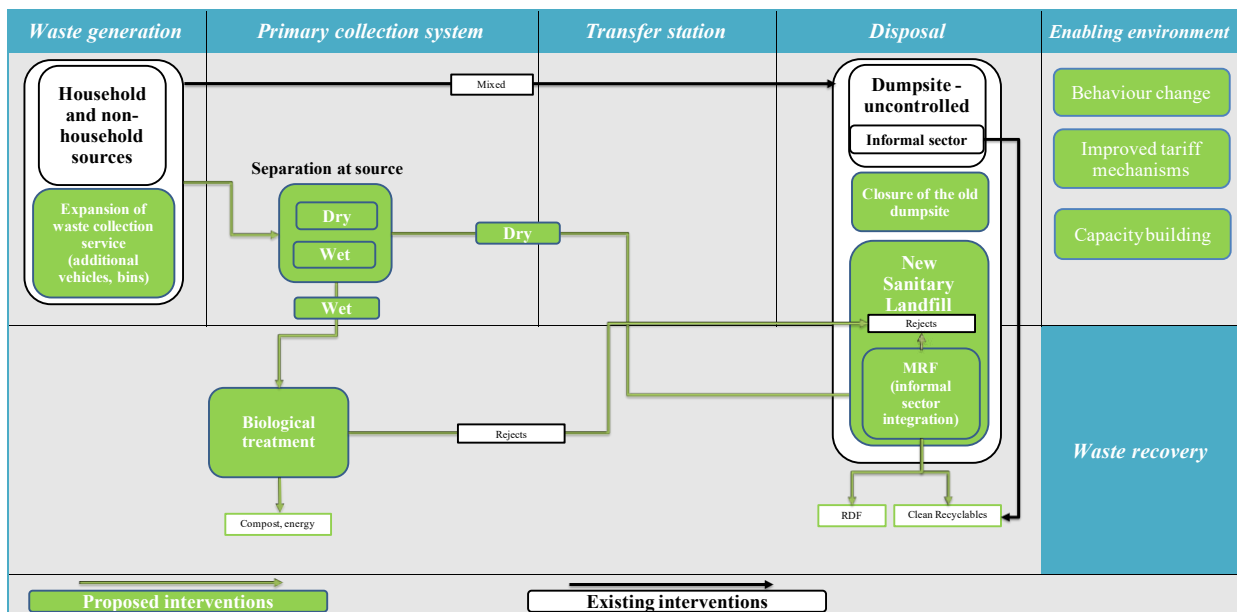
Based on the WaCT results and local stakeholders' workshop results, a set of recommendations have been identified and proposed for each key step in the municipal SWM system from waste generation and collection to waste recovery, waste disposal and governance, as shown in the figure below. Figure 8 depicts the existing municipal SMW system and the recommendations proposed to improve the current situation.

The recommendations are clustered in four sub-sections (collection, recovery, disposal and governance) and further detailed below.

Waste collection

A more detailed assessment of the areas currently not served is recommended. The analysis should cover the current practices, gaps and infrastructure required to address the gaps. Another important fact to look at is the affordability of households and the willingness to pay for waste collection services. The operator is currently using two trucks to collect and transport the waste and especially

Figure 8: Potential opportunities for improving the SWM system in Kep City



during the peak of the touristic season the service is overwhelmed due to the increase volumes of waste. Therefore, additional human and equipment resources are needed. Other recommendations to improve the quality of the waste collection system include:

- ▶ Targeted behaviour change campaign to advocate for waste collection services and separation at source;
- ▶ Implementation of a source separation for at least two fractions. This system should be aligned to support the future MRF at the new sanitary landfill;
- ▶ Enforcement of sub-degree 113 especially on waste collection fees, separation at source and regular collection;
- ▶ The contractual arrangements between the service provider and the municipality must include clear performance and service quality indicators.

Waste recovery

Since agriculture is a one of the key economic areas in Kep with around 70% of population working in this sector, a clean source separated organic waste could be treated under a biological treatment process such as composting. The organic waste is the largest waste stream in the MSW based on the result from WaCT. A feasibility study could be conducted to determine the quality of the organic waste, to assess the technological options viable for treating the organic waste and to determine the quality and market value of the compost.

The MRF facility at the sanitary landfill currently under construction would require a clear operational plan and business model. The MRF could be designed for clear dry waste or mixed (dirty) waste. The potential use of the output materials depends on the MRF technology and the quality of the feedstock (collection system), and could include clean recyclables to be sold to existing market chains or refused derived fuel (RDF) for co-processing in cement kilns.

Since the presence of the informal waste pickers is significant, a comprehensive social impact assessment is required to identify the

social impacts of the new sanitary landfill and MRF facilities to the informal activities and the livelihood of the waste pickers. The assessment must identify the exact number of waste pickers, the current practices and preferences, current revenues earned from recycling activities and a clear strategy to engage and integrate them into the formal system particularly the MRF, waste collection activities and landfill operation.

Waste disposal

The current dumpsite has been operated in an uncontrolled manner and will be closed after the new landfill is in use. A dialogue between the national and sub-national government is needed to establish a feasible plan for a safe closure of the new dumpsite as well as the sustainable operational planning for the new landfill site. The new sanitary landfill will trigger additional operating costs for the government, due to the more advanced technologies employed. As such, the government must come up with a clear funding mechanism for the operation of the landfill site in order to ensure high operational standards.

Governance

While the country has recently undertaken a decentralisation process, the City of Kep has great autonomy and responsibility in delivering urban services such as solid waste management following the sub-degree 113. The responsible office has only two staff and their waste management knowledge and oversight capacity remain a challenge. With the limited number of staff, it is crucial for the municipality to have a robust plan/strategy for MSW and an efficient mechanism to transfer roles and responsibilities to sub-national levels such as Sangkat and villages.

2.3. Sihanoukville/Cambodia

A kick-off workshop was organized in hybrid mode (online and offline) in July 2021 with 16 participants from the public and private sector. Current status of MSWM in Sihanoukville was discussed among the participants. The highlights are below:

- ▶ The city has experienced a sharp increase of waste generation due to the rapid urbanization induced by the Chinese residents and

tourists increase in the past years. The MSW generation was estimated between 800 to 1,200 tonnes per day. However, the generation has significantly decreased to around 300-350 tonnes per day since the beginning of 2021 due to the restrictions imposed because of the Covid-19 pandemic on various sectors.

- ▶ Waste collection was predominantly conducted by a private company Kampong Som Waste Management Co., Ltd. (KSWM). In addition to this, there are 3 private companies in charge of collecting construction waste. The waste generation has significantly.
- ▶ Around 30% of the households in Sihanoukville use the waste collection services.
- ▶ KSWM operates a transfer station in Sangkat 1 and then transports the waste to the landfill located in Prey Nob district, 36 Km out of the city, which is an uncontrolled dumpsite.
- ▶ A new engineered landfill has recently been constructed and is expected to be inaugurated in the next few months.

Figure 9: Photo of participants at General Secretariat of National Committee on Coastal Area Management and Development (Left) and at Sihanoukville meeting hall (right), July 2020



The main SWM challenges of the city as seen by the participants at the kick-off workshop included:

- ▶ SWM decentralization to municipality-district is still new and municipality-districts lack implementation procedures and capacities;

- ▶ The landfill is far (36 Km from the city) which leads to increased transportation costs;
- ▶ City infrastructure remains insufficient to operate the waste collection services throughout the whole city;
- ▶ MSW is mixed with other special fractions, such as construction and demolition waste;
- ▶ The source of the waste leakage into the sea environment cannot be exactly determined;
- ▶ The quantity of waste in the water sources cannot be estimated;
- ▶ There are limited information and awareness campaigns to promote proper waste collection and disposal, leading to the lack of participation from citizens in the proper storage, separation and disposal of waste.

The participants also concluded that the main improvements in the sector should focus on supporting the municipality to transfer the SWM responsibility to Sangkats, expand the waste collection and transport services to hard-to-reach areas, revising the waste collection fee to include cost recovery principles and the cost of operating the new landfill, improved management of construction and demolition waste and organizing awareness campaigns to promote citizen's participation in the SWM system.

The participants suggested that for the final stakeholders' workshop, participants from key institutions should be included such as: the Provincial Administration, General Secretariat of National Committee on Coastal Area Management and Development, PDoE, PDPWT, Provincial Department of Tourism (PDT), formal and informal waste collection, junk shops, NGOs, and development partners.

WaCT and WFD Survey Results

Laid out on an area of around 84.36 km² with around 83,000 inhabitants, Sihanoukville is the largest among the other coastal cities of Cambodia such as Kep, Kampot and Koh Kong. The city is situated in Preah Sihanouk province in the south-eastern part of the country, at about 230 km from Phnom Penh. A study conducted by

the MoE and Luma System⁹ in early 2021, found that there are 126,360 additional residents (both national and international) who are currently living and working in the city and are not reported/registered in the official population. This leads to increased quantities of waste generated on a daily basis. Furthermore, the city has grown rapidly along with infrastructural developments such as the Preah Sihanouk Sea Ports, the Special Economic Zone, tourism, International Airport and Coal Power Plants. In line with Cambodia's Industrial Development Policy 2015-2025, the Royal Cambodia Government set out the target to develop the province into a multi-purpose economic zone. In addition, the city has experienced very rapid and substantial investment, primarily from China. This led to profound changes in the land management in the city, with up to 100 new hotels and other tourist facilities opened in the last two years or under development. The quantity of waste generated in 2021 decreased drastically due to the decrease in the number of tourists (Figure 10).

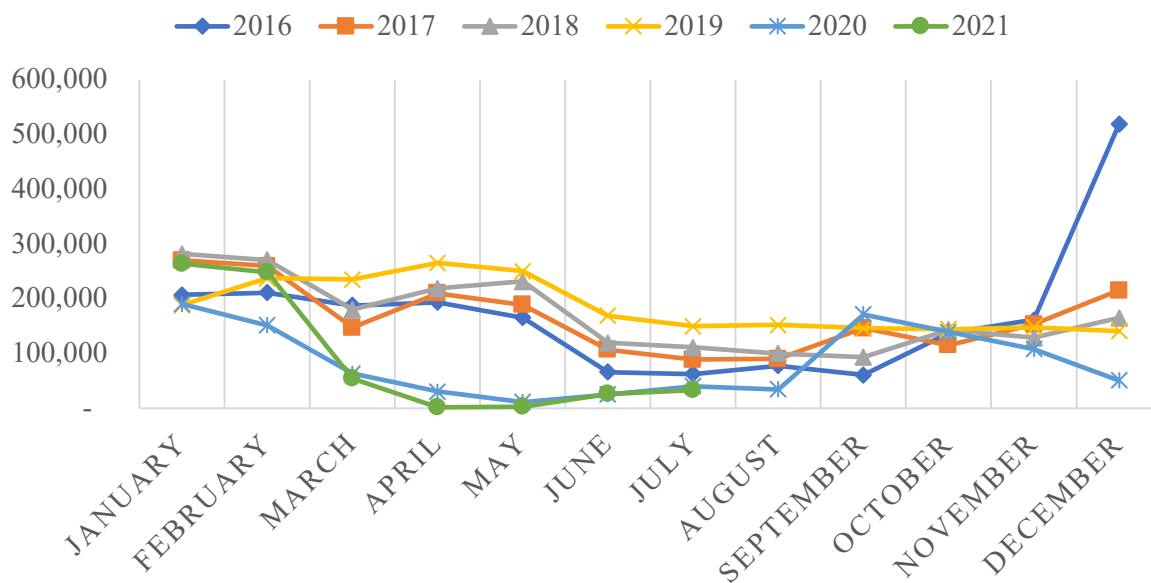
The result from WaCT shows that 366 tonnes of waste is generated daily, of which 63% from non-

household sources. The most dominant waste stream in the MSW consists of organic waste, 49% at household level and 44% at the disposal site. Notably, the second largest composition is plastic, with 19 % at household level and 23% at disposal site, out of which 60% is plastic bags.

Figure 11: Household waste generation and composition analysis in Sihanoukville, 2021



Figure 10: Monthly number of tourists in Sihanoukville (comparison 2016-2021)



⁹ Luma System website: <https://www.lumasystem.com/>, last accessed on February 4th 2021.

Table 8: Key WaCT and WFD Data in Sihanoukville City

Income group	High income	Middle income	Low income
Waste generation rate (kg/capita/day)	0.69	0.64	0.53
Total population	16,137	190,154	3,679
Total MSW generated from household(t/day)	11	121	2
Total MSW generated from non-household sources (t/day)			232
Total MSW generated (t/day)			366
City Plastic Leakage into water bodies (kg/person/year)			0.6

The SWM practices are traditional, consisting of mixed collection and disposal in an uncontrolled site. The collection rate is found to be significantly high and up to 90%. The service coverage is widely spread throughout the town, whilst the remote areas with narrow roads remain unserved. On the other hand, only 4% of the recyclable waste is collected from either household or non-household sources or extracted from the landfill by waste pickers or small traders. The junk shops or apex traders are the ones who buy from those individuals and then sell to bigger apex traders. Approximately 38 tonnes of waste is uncollected. It is commonly known that in some cases the waste generated from households is disposed in public dumpsters or open dumps.

Around 42,918 tonnes of plastic are produced every year out of which only around 3,446 tonnes are recovered through the informal sector. PET is the most recovered material, while the plastic film is less preferred by waste pickers at the landfill because it is light, low cost, and requires cleaning and drying before selling to apex trader. Illegal dumping is also commonly found on land, public spaces or water bodies. The most significant leakage influencers are from the collection system and the disposal facilities. Burning is prevalent in dry season, the waste pickers are active around the discharging zone of the site, and the compaction or management of waste is intermittent. The average plastic waste leakage in the water per capita per year is 0.6 kg.

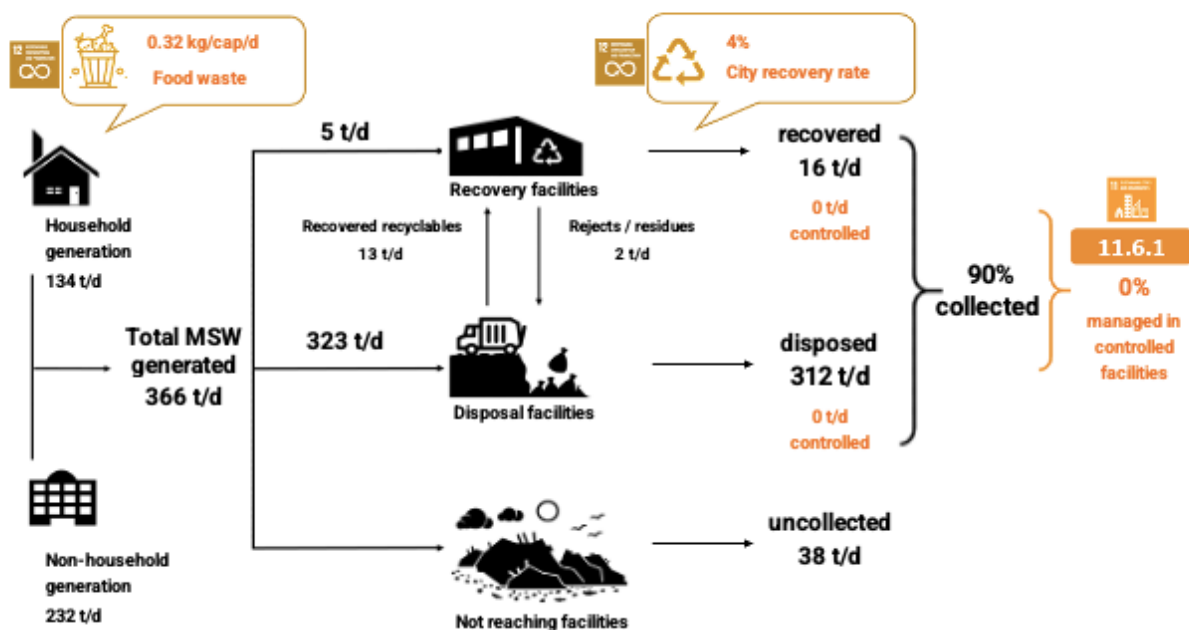
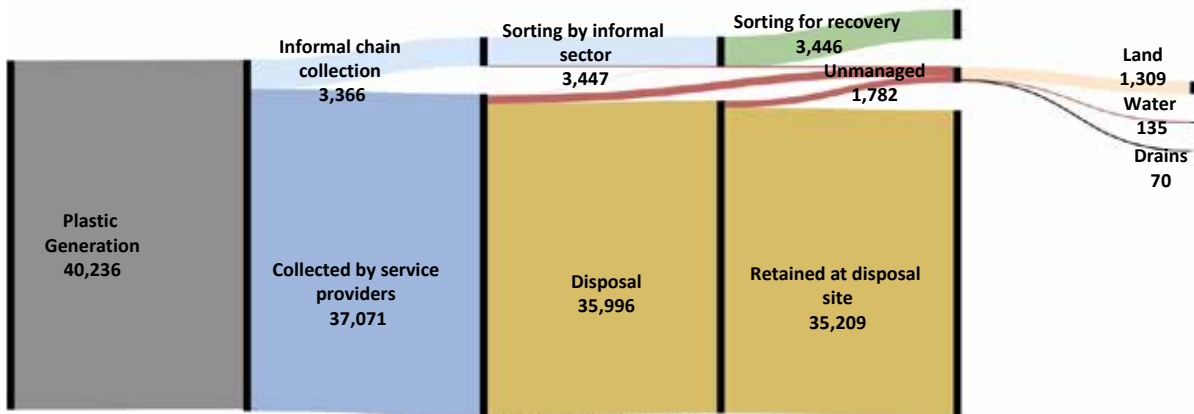
Figure 12: WaCT flow chart results in Sihanoukville City, 2021


Figure 13: WFD results in Sihanoukville City (tonnes per year), 2021

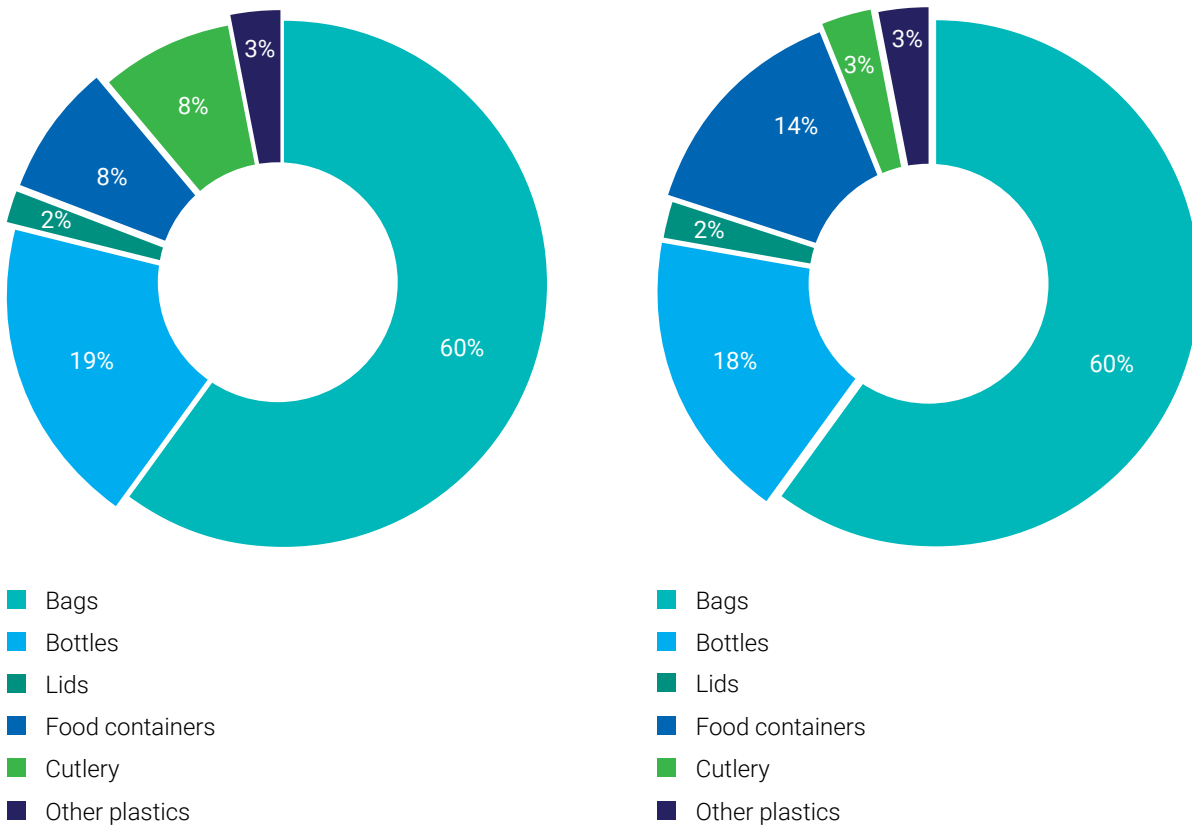


To better understand the composition of plastic waste in the MSW, a further disaggregation of the plastic films and dense was conducted during both the household and disposal site waste composition analysis. The results show that the most predominant plastic fraction consist of plastic bags (LDPE), followed by plastic bottles (mostly PET) and food containers.

Policy and Infrastructure Gaps Analysis

All the key regulations are already described above in the section covering Kep city. According to the sub-degree 113 and sub-degree 182, the management of MSW falls under the responsibility of the public works, transport, sanitation, environment and public orders and the full structure

Figure 14: Composition of plastic waste in the MSW in Sihanoukville



of the municipality. Currently, there are only three dedicated staffs that have limited specific SWM capacity and cannot cope with the work volume. The chief of the office has relevant experience in the environmental sector, but the other two staffs are less experienced. There are no awareness-raising programmes on SWM in Sihanoukville City, although some activities have been initiated, particularly at beaches. In Sihanoukville City, the total annual revenue allocated for public sanitation comes from the national budget amounting to cca. USD 67,000. This budget is used to contract a private company, Keat Sarin Peanich whose main responsibility is to clean the public roads, spaces, and beaches.

Waste collection and transfer

Sihanoukville Municipality signed a 10-year contract with KSWM to deliver waste collection and transport services, cleaning and sweeping along the public roads and other public places in the city. The company has a total of 255 employees, most of them working in operation (collection and transport). KSWM collect fees for their services from customers door to door. The fee varies based on type of customers and sometime through negotiations. Fees range from USD 1.5 to 13 per month for regular households, to up to USD 470 for large factories and up to USD 1,500 for large entertainment places such as night clubs or casinos. The typical frequency of collection is either daily or 3 times per week.

KSWM owns a transfer station with a capacity of 400-450 tonnes per day in Village 1, Sangkat 1,

Figure 15: Waste transfer station in Sihanoukville in Village1, Sangkat 1, Sihanoukville



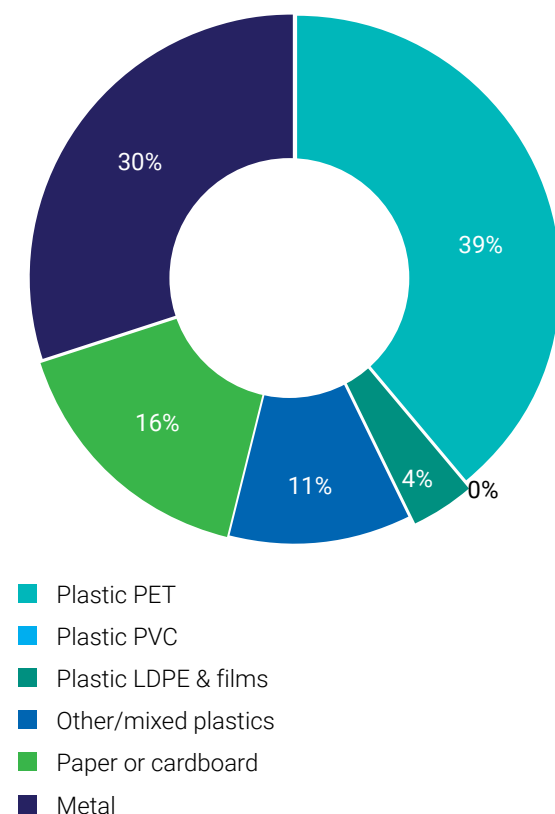
Sihanoukville city. The management of the transfer station is at limited control level. The common practice is to dump the waste on the ground and then reloaded into transportation vehicles before transportation to the disposal site.

Challenges around waste collection include illegal dumping practices, which are commonly found in open spaces. One of the causes for this is that people are not used or willing to pay for waste services. Additionally, the disposal site is located far from the city (36 Km) which leads to high transportation cost and reduced time for waste collection. Lastly, the narrow roads in some areas of the city remain inaccessible to the service, which can potentially lead to littering in the water bodies and open dumping.

Waste recovery

The recyclable waste is exclusively recovered by the informal sector. The figures below show that the type of materials recovered are primarily represented by plastic PET (39%), other/mixed plastic (11%), metal (30%), paper and cardboard (16%) and LDPE and plastic film (4%). The waste pickers reported that the plastic bags, paper,

Figure 16: Breakdown of recovered materials by fraction in Sihanoukville City



and cardboard are mainly collected in the dry season. There are no recovery activities going on for organic waste. The main challenges in waste recovery are the lack of separation at sources and policies to incentivise recycling activities.

The below table summarises the potential amount of recoverable waste in Sihanoukville City. This amount of waste consists of MSW recyclables currently uncollected or ending up in the disposal site.

Waste disposal

The waste is currently disposed in a landfill situated on an area of 50 hectares at 36 Km distance from the city, in Ou Tasek village, Ou Onhka Heng commune, Prey Nob District. It is an uncontrolled landfill with regular waste burning in the dry season. Around 200 waste pickers are active at the landfill and earn their income by sorting recyclable waste and selling it to apex traders. However, in

Table 9: Potential for waste recovery in Sihanoukville City

Waste category	Materials uncollected (t/d)	Materials in the disposal site (t/d)
Paper and cardboard	2.4	18
Plastic film	5.5	57.3
Plastic dense	3.1	41.3
Metals	0.7	7.3
Organics	20.5	158.7

Table 10: Assessment of the level of control of the disposal site in Sihanoukville

Assessment areas	Questions	Sihanoukville (Yes/No)
Security	Is there boundary and access control allowing single point of supervised access	No
Water control	Is there any perimeter drainage maintained around the site	No
Slope stabilization	Are the slopes stabilized, mitigating risk of landslide	No
Waste handling, compaction and cover	Are waste trucks directed to a specific operational area of disposal	Yes
	Is there heavy mechanical equipment reliably available	Yes
	Is waste layered and compacted within the specific operational area	Yes
	Is there some use of cover material	No
Fire control	Is there zero evidence of burning of waste on the surface of the landfill	No
Staffing	Are staff on site during operational hours	Yes
Records	Is there a functional weighbridge in use	No
EHS	Are there toilets and hand washing stations	No
	Are basic personal protective equipment in use	No
Other	Is there a site drawing showing the landfill boundary and filling area	No

Figure 17: Site visit to the disposal site in Sihanoukville, 2021



November 2021, the city moved the operations to the new sanitary landfill.

A new sanitary landfill has been completed and put in use in 2021 in the vicinity of the former landfill. More details are provided in the box below.

The major gaps identified in City which would require an immediate action are summarized in Table 11.

The prioritization is made taking into account the complexity of the intervention, the capacity of the government to implement it and the urgency of the problem taking into account public health and environmental impacts.

Brief description of the new sanitary landfill

In March 2020, the Royal Government of Cambodia officially allocated the budget of around USD 5 million through the Ministry of Economy and Finance to construct the new, well-designed and controlled disposal facility on an area of 17 hectares in the same area of the current landfill which occupies an area of 50 hectares. Its overall capacity is 884,088 m³ for 5-year use. The construction of the landfill is already finished and has been in use since 05 November 2021. The current operation is financed by the national government.



Table 11: Summary, classification and prioritization of gaps in Sihanoukville

City/Country	Sihanoukville, Cambodia		Prioritization	Priority
SWM stage	Policy / Legal	Infrastructure	(1-high, 3-low)	
Separation at source			1	
Waste collection coverage (incl. waste collection fees)			2	High 1
Waste transfer stations			1	Medium 2
Material recycling			2	Low 3
Biological treatment (incl. waste to energy)			2	
Waste disposal			1	Large
Informal sector (incl. integration)			1	Medium
EPR (incl. similar policies)			3	Low
SWM planning			1	

Stakeholder workshop

The stakeholder workshop in Sihanoukville was organized in November 2021 to present the results of the survey to the key stakeholders, to identify policy intervention and infrastructure investment gaps as well as a set of recommendations for future improvements. Around 30 representatives from the local authority, MoE, PDoE, PDPWT, PDoT, private waste collection company and informal sector joined the workshop. After the presentation session, the participants were divided into four groups, waste collection, recycling, disposal and governance, to discuss the findings and recommendations.

Waste collection

Hard to reach areas in Sihanoukville municipality remain uncovered by waste collection services. This creates a favourable environment for illegal dumping either on land or water bodies. Although sub-degree 113 stipulates a series of penalties for non-compliance activities, it lacks enforcement. In November 2021, a large campaign has been implemented to disseminate to the public the collection schedule on the main roads, and similar activities should be extended to the other roads throughout the city.

To improve waste collection in inaccessible areas, interventions could include:

- ▶ Purchase and use of small vehicles such as small trucks or motorised tricycles;
- ▶ Cooperation between the local authority and the waste collection company to evaluate the number of households without collection services and to set up collection points and implement collection schedules;
- ▶ City wide behavioural change campaigns on MSW management to promote services and to improve citizens' willingness to pay for waste collection services.

The participants acknowledged that the waste separation at source is the key measure to improve the municipal SWM, including waste recovery. To promote this, public educational campaigns along with law enforcement are must. On the other hand, proper infrastructure for collection and disposal should be put in place. The waste

should be categorized into three types including wet or organic waste, dry waste such as plastic, paper cardboard, glass, and other similar fractions and hazardous waste. Therefore, the 3 bins or other storage containers or coloured plastic bags should be given to citizens to encourage them to segregate their waste accordingly. The waste collection company also needs to collect the source separated waste with specific vehicles for each fraction to keep the waste fractions clean.

The operational expense for the new landfill is currently financed by the national government while the landfill tipping fee or the mechanism for landfill operation cost recovery remains unclear.

Waste recovery

The operation of the MRF at the new sanitary landfill has not started and the plans for the MRF remain uncertain. However, the demand for recyclable waste such as metal, PET, cardboard and paper is high. The major investment gaps identified in the area of waste recovery include lack of source separation, lack of infrastructure such as composting facilities and lack of policies to encourage the private sector participation. The key policy interventions to stimulate waste recovery could include EPR, landfill tax/tipping fee, enforcement of sub-degree 113 on waste separation at source. In case waste to energy solutions will be pursued, these must be accompanied by favourable legal, environmental and financial incentives to make these investments feasible. For example, there are no incentives for producing energy from waste.

Waste disposal

The new sanitary landfill was commissioned in November 2021 and is operated in a controlled manner. There are gas and leachate collection systems to prevent environmental pollution, weighting and recording systems, and compaction of the waste disposed. There are 14 staffs managed by the landfill management unit under the MoE. The head of the unit has high education and skills in waste management. The funding necessary to operate the new sanitary landfill is provided by the national government. There is no clear tipping fee mechanism in place yet. The old dumpsite closure plan remains unclear, though it is no longer used.

To create livelihood opportunities for waste pickers (200 people) at the new landfill site, an entrance card has been issued for each waste picker and they are allowed to continue their activities. In the future, when the MRF will start its operation, they should have the possibility to be recruited and work in the facility.

Governance

The current challenges in governance include the lack of skilled human resource which translates into a lack of capacity to manage the SWM system. The sub-degree 113 and sub-degree 182 shows the obligation to transfer the MSW management functions to municipal administration in which Public Works, Transportation, Hygiene, Environment, and Public Order Office is the main responsible team. However, the team has only 3 staffs with limited knowledge and skill in the sector and many roles and responsibilities to hold.

The educational campaign on proper waste disposal, the impacts of plastic consumption and waste management on public health and environment should be improved. These activities must be established as a norm and carried out in the long term. The target audience should include both residents and tourists.

Recommendations

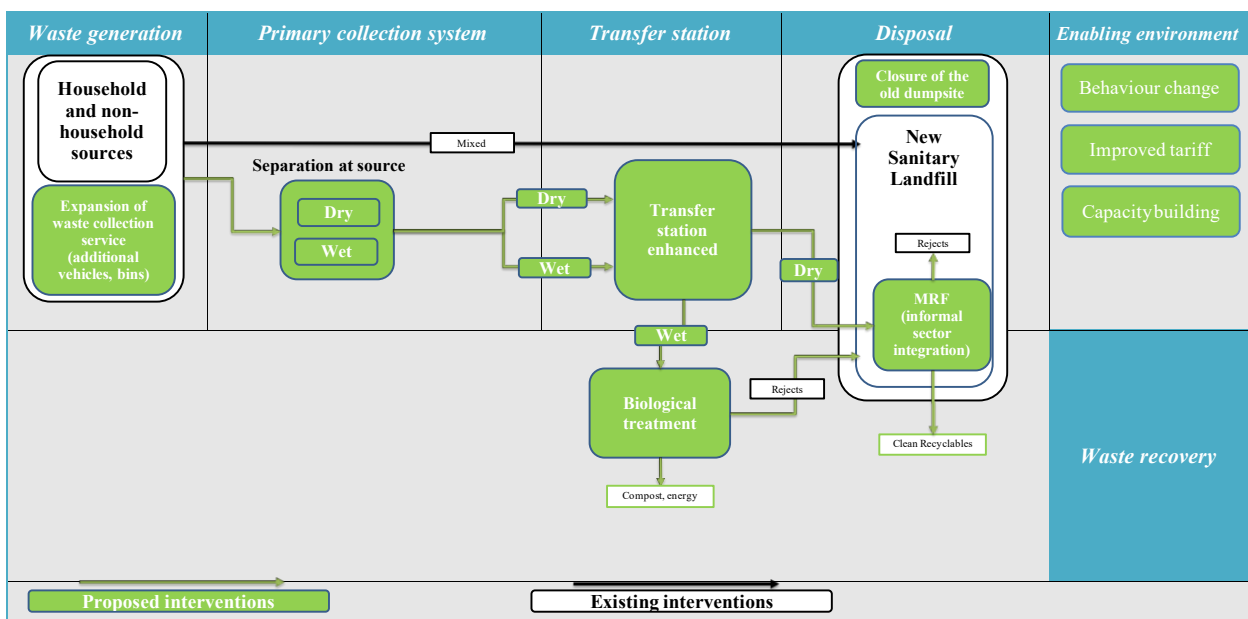
Based on the WaCT results and local stakeholders' workshop results, a set of recommendations have been identified and proposed for each key step in the municipal SWM system from waste generation and collection to waste recovery, waste disposal and governance, as shown in the figure below. Figure 18 depicts the existing municipal SMW system and the recommendations proposed to improve the current situation.

The recommendations are clustered in four sub-sections (collection, recovery, disposal and governance) and further detailed below.

Waste collection

New equipment and methods to access the narrow roads is needed. The areas without services consist of remote communities with narrow roads. The tricycles, carts, and small trucks should be considered for these areas. Plastic waste represents the second largest waste stream in the MSW composition. To address the concern of the impact of plastic waste into the environment, the ban on single use plastics in Sihanoukville should be promoted. It could be started with the businesses and the national and sub-national government should provide the alternative materials.

Figure 18: Potential opportunities for improving the SWM system in Sihanoukville City



With the operation of the new landfill in a controlled manner, the cost for SWM will be higher. It is expected that the waste management fees will increase to fund this increased operation cost. The implementation of such measures needs to be informed by studies to determine the level of affordability and the willingness of households to pay for waste services.

The behaviour change alone is not sufficient to promote the waste collection and transport service. These efforts should be accompanied by enforcement of the existing legal requirements. Following Prakas 8682, a committee is needed to be established to manage and use revenue from transactional penalties for non-compliance activities identified in sub-degree 113.

Separation at source is a prerequisite to reduce the amount of waste disposed at the landfill and improve the waste recovery rate. This should include at least two categories: wet and dry waste to enable further recycling activities particularly the operation of the new MRF.

The transfer station has been operated in an uncontrolled manner. The facilities do not have a drainage system and the waste was simply dumped on the ground and then loaded into transfer trucks by bulldozers. Compaction units and specialist containers and transportation vehicles could be used to improve the cost efficiency of transfer to the landfill site.

A dedicated team under the management of municipality is planned to be formed to support the waste management services. The municipality has the ambition to collect and manage the collection fee and then pay the private service providers based on the amount of waste disposed at the landfill. Nevertheless, the plan to achieve this goal remains uncertain. Thus, capacity building to the newly established team and municipality is a must. The training needs assessment should be carried out at the early stage to identify any competency gaps and to discuss ways to address them. The potential topics should be the assessment of the affordability to pay and cost accounting for various activities in SWM such as collection, sorting, transfer and disposal.

Waste recovery

The new MRF under construction at the sanitary landfill has not started its operation. If the separation at source is successful, it could be adapted to receive the dry waste. The MRF should be upgraded to produce quality materials which respond to the market requirements. This way, considerable revenues could be attracted and used to cover for the operational costs and to sustain its operations in the long term.

The manager of the landfill mentioned that the waste pickers could be hired once the MRF is operated. Similar interventions have proved to be unsuccessful in other countries as the integration of the informal sector must keep account of their preferences and done in a participatory way. To successfully integrate them into the formal system, a social impact assessment should be done to identify the impacts and associated mitigation measures and to establish a clear integration strategy, taking into account the views and opinions of all actors involved.

The landfill has space for other facilities and there is the concern that the new sanitary landfill could reach its maximum capacity sooner than planned due to the rapid urbanization and increasing waste volumes. It is therefore important to promote the recovery activities such as composting and recycling to divest waste from landfill and thus increase the lifespan of the site.

Waste disposal

The city started the operation of a new sanitary landfill in November 2021, as such there are no major gaps and improvement required with respect to waste disposal. A clear plan for the closure and rehabilitation of the old dumpsite is required. A dialogue between national government, sub nationals and development partners are the must to tackle this issue. For the new landfill site, a clear operational plan and business model must be in place to ensure that revenues can be attractive to cover for all operational costs required to keep the designed operational standards at high level.

2.4. Tam Ky City/ Viet Nam

The kick-off workshop on WaCT and WFD for Tam Ky City was conducted in August 2021 in hybrid mode. An in-person meeting was organized in Tam Ky with representatives of local authorities and social organizations of the City which connected virtually with the UN-Habitat Viet Nam and the Advisory team in Hanoi. Due to COVID-19 restrictions, the UN-Habitat consultant was not able to travel to Tam-Ky.

The main purpose of the workshop was to introduce the project, the WaCT and its applications to urban solid waste management, to discuss the next steps for project implementation and to initiate a first discussion on the current state of SWM in Tam Ky city. A total of 37 participants (33 from the City and 4 from UN-Habitat) joined into the workshop. The key institutions included:

- ▶ Representatives of Tam Ky City People's Committee (CPC) and related divisions (Natural Resources and Environment, Urban Management, Economics Division, etc.);
- ▶ Representatives of People's Committee of wards/communes participating in the survey;
- ▶ Representatives of Quang Nam Urban Environmental Company (URENCO);
- ▶ Representatives of city associations and unions from the solid waste management sector (Women Union, Youth Union, Farmer Association, etc.);

- ▶ Representatives of UNEP and UN-Habitat teams.

Mr. Le Quang Vu, a representative of URENCO, presented the current status of waste management in Tam Ky city. Tam Ky City has made significant efforts in waste management, but due to the limitation of infrastructure and technical capacities, the source separation of waste has not been appropriately implemented and the City is still lacking resources to ensure proper transportation and treatment of the MSW generated. Mr. Le Quang Vu proposed a number of solutions to improve the efficiency of waste management such as: supplementing resources in the sector, improving the capacity of environmental officials and staff, educating and raising awareness in the community, strengthening the monitoring and supervision of waste collection, transportation and treatment.

WaCT and WFD Survey Results

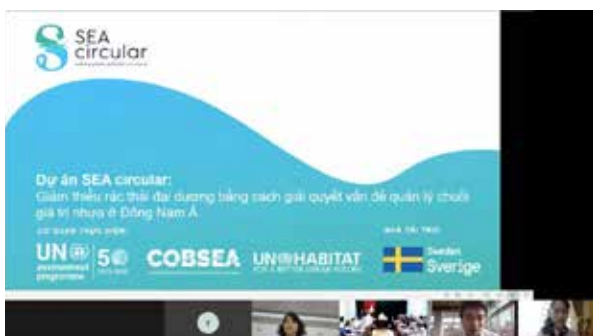
Tam Ky city is the capital city of Quang Nam province, a coastal province in the central key economic development region of Viet Nam. The city is bordered by Da Nang city and Thua Thien Hue province to the North; the East Sea to the East; Quang Ngai province to the South; Kon Tum province and the Lao People Democratic Republic (PDR) to the West.

Tam Ky city has an area of 93.97 km² and a population of about 123,564 people¹⁰. The city is classified as a grade II urban area and is considered the political, administrative, economic, cultural, educational, medical, scientific and technical centre of the Quang Nam province.

Tam Ky city comprises 13 administrative units (9 wards and 4 communes). URENCO is the operator in charge of waste collection, transportation and disposal for all 9 wards (An My, An Son, Hoa Huong, Phuoc Hoa, An Xuan, Hoa Thuan, Tan Thanh, An Phu, Truong Xuan) and communes (Tam Ngoc, Tam Thanh, Tam Phu, Tam Thang) in Tam Ky city.

The average household waste generation rate is 0.284 kg/capita/day, which is very low compared to other similar cities and countries. As Tam Ky is the administrative centre of Quang Nam

Figure 19: Screenshot of the Kick-off workshop in Tam Ky City



10 According to Tam Ky City Statistical Yearbook 2020.

Figure 20: Household waste generation and composition analysis in Tam Ky city, 2021



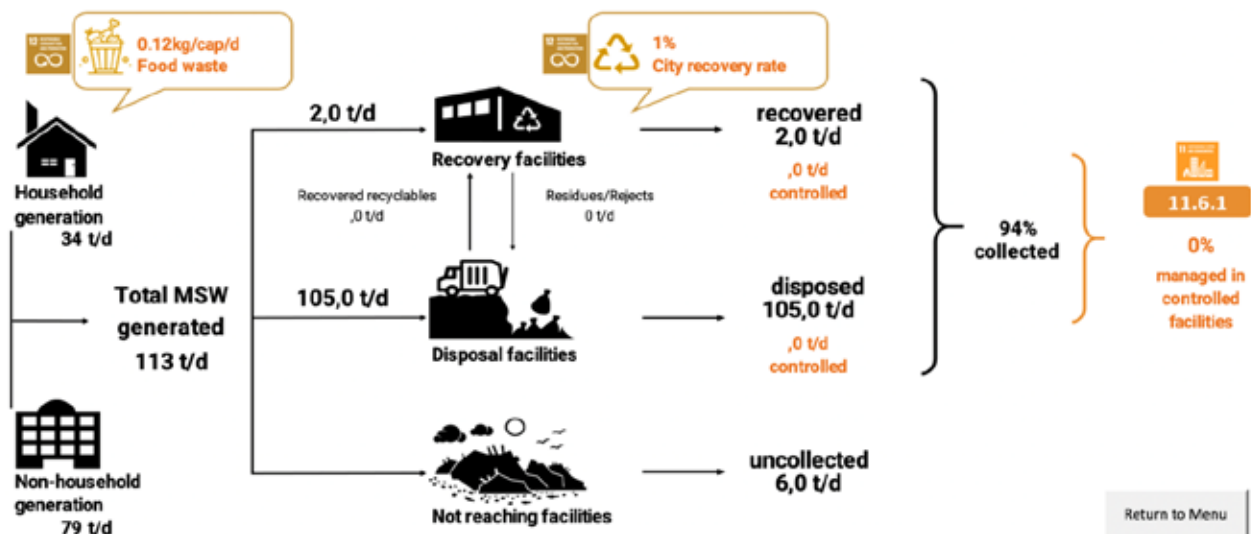
province where many administrative agencies of the province are located, the biggest part of MSW in Tam Ky City is generated from non-household sources. The MSW generate rate per capita is 0.94.

The total household waste generation of the city is estimated at 34.04 tonnes/day. The proxy of 30% to estimate non-household waste generation is recommended in the WaCT guidelines; however, the team applied a proxy of 70% for non-household waste. According to our observations, activities of administrative and commercial premises in Tam Ky were not as affected by the Covid-19 pandemic as the tourism activities in other cities at the time of the survey. The non-household waste generation is of 79 tonnes/day. The total MSW generation of Tam Ky city sums up to 113 tonnes/day.

Table 12: Key WaCT and WFD Data in Tam Ky City

Income group	High income	Middle income	Low income
Waste generation rate (kg/capita/day)	0.402	0.283	0.168
Total population	27,610	45,289	23,635
Total MSW generated from household(t/day)	12	15	7
Total MSW generated from non-household sources (t/day)	79		
Total MSW generated (t/day)	113		
City Plastic Leakage into water bodies (kg/person/year)	0.9		

Figure 21: WaCT flow chart results in Tam Ky City



Composition survey of household waste found lower plastic fractions found in the high-income areas (city centre wards) and higher fractions in low-income areas (far from the centre wards and rural communes). This is considered to be reflecting the plastic consumption pattern where there is no longer much changes observed between urban and rural or high and low income areas.

Currently, there are about 8 small-scale apex traders in Tam Ky city buying recyclable materials from waste pickers and small intermediate traders, which then store and prepare these materials for export to other cities such as Da Nang. The WaCT calculations shows that the recycling/recovery rate in Tam Ky is quite low, only about 1.68 tonnes/day, accounting for about 1% of the total MSW generation. The waste quantities and composition of MSW of Tam Ky was obtained at the provincial landfill site Tam Xuan 2 in Nui Thanh district, 9 km of distance from the city centre.

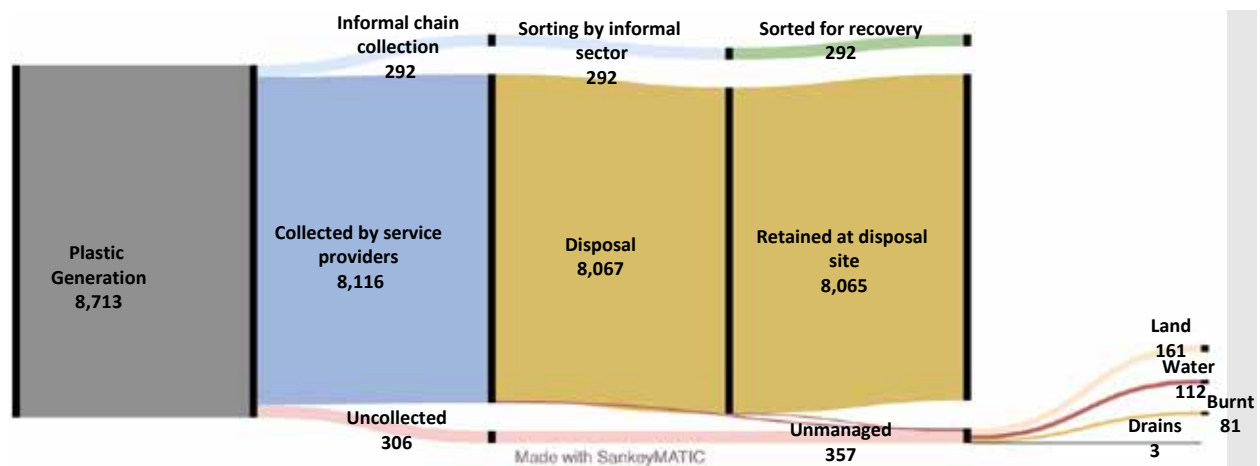
As reported by the URENCO Quang Nam, the amount of waste from Tam Ky City received by the landfill is about 185 tonnes/day in average in 2021, which translates into a waste generation

rate per capita of 1.5 kg/person/day. This waste generation rate is found very high, as compared to the national standards for grade II urban areas such as Tam Ky¹¹. Without a weighbridge used at the landfill site, the estimation of waste disposal was obtained through vehicle counting.

On the survey day (December 4th, 2021), there were 12 compaction trucks with a capacity of 12 m³ and 10 compaction trucks with a capacity of 8 m³ transporting waste from Tam Ky city to Tam Xuan 2 landfill. With a density of waste of 0.47 kg m³ taken from recorded data currently used by URENCO Quang Nam, the total amount of garbage received by the landfill in the day of the survey is 105 tonnes¹². The consultant uses the data of 105 tonnes/day to estimate the daily waste volumes received by Xuan 2 landfill from Tam Ky city.

Although the collection rate is relatively high, reaching about 94-95%, the assessment of the proportion of municipal solid waste managed in controlled facilities is 0%. The landfill control is assessed as „no control“. The proportion of waste managed in controlled facilities could increase to 93% in case a weighbridge is used in Tam Xuan 2 landfill.

Figure 22: Plastic waste flow diagram (tonnes per year), 2021



11 According to the waste generation standards specified in the National Technical Code on Construction Planning QCVN 01:2021/BXD, issued by the Circular No. 01/2021/TT-BXD dated May 19, 2021 of the Ministry of Construction, the waste generation rate does not exceed 1 kg/person/day in case of grade II urban areas such as Tam Ky city.

12 (12 trucks/day * 12 m³/truck + 10 trucks/day * 8 m³/truck) * 0.47 tonnes/m³ = 105 (tonnes)

The results of the WFD shows that the amount of plastic waste leaking into the environment accounts for about 4% of the generated plastic waste, with more than 30% leaking into water sources. The low plastic leakage found in WFD also shows that the efficiency of plastic collection (collection/generation) in Tam Ky is relatively good compared to other cities. The source of plastic leakages originates from uncollected waste and from the disposal facility. The leakage influencers include fencing of the disposal site and lack of daily coverage and compaction of the waste disposed. Another important leakage influencer is represented by rainfall events which are frequent throughout the year and thus contributing to plastic leakages into the water systems.

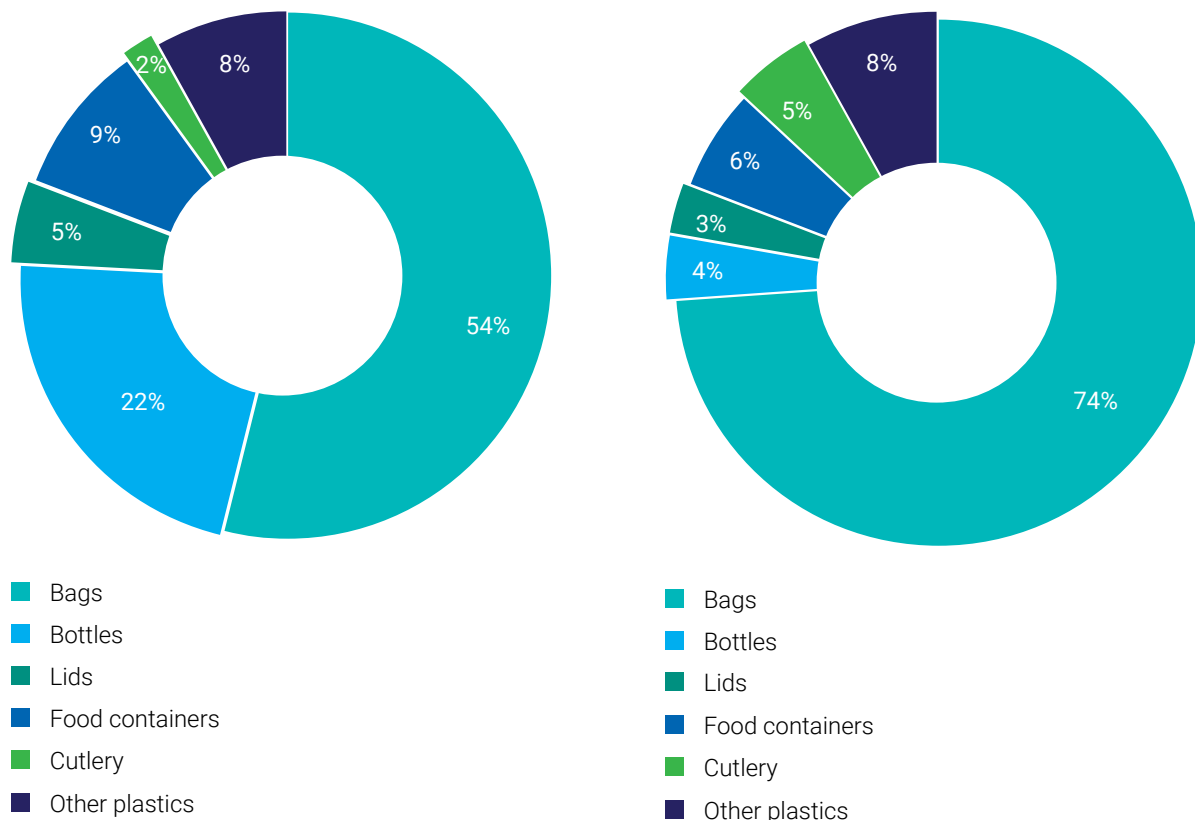
The MSW was further sorted to understand the type of plastic waste materials at the household and disposal site levels. The findings showed that the composition of the plastic waste is dominated by plastic bags (54% in the household waste and 74% in the disposal site). Interestingly, the plastic bottles represent 22% of the household plastic waste while the share in the waste at the disposal site is only 4%. This means that the plastic bottles are retrieved from the household waste prior to the disposal site.

Policy and Infrastructure Gaps Analysis

Decision-making at the city level is undertaken by the City People's Committee (CPC) in coordination with relevant actions decided by the Provincial People's Committee at the Provincial level and, as appropriate, People's Committees at the ward and commune level. The work of the CPC is advised by and administered/implemented through functional departments. Capital planning and investment in the waste sector is undertaken at the Provincial level in consultation with the city.

Over the years, the Quang Nam provincial government has issued many legal documents related to solid waste management in the province. One of the latest and most relevant is Decision No. 1662/QĐ-UBND dated June 19, 2020, approving the Plan on Solid Waste Management in Quang Nam Province until 2025, with a vision to 2030, clearly defining specific goals, such as, 100% of the total amount of municipal solid waste generated will be collected and treated in an environmentally sound manner by 2030, out of which 85% will be recycled, reused, recovered through energy or used to produce organic fertilizers. With a current 1% recovery rate, Tam Ky City is still far from the province's planned target. The Plan also states

Figure 23: Composition of plastic waste in the MSW in Tam Ky



that by 2022, each district/town/city must have at least one solid waste treatment facility in the locality. The provincial inter-regional landfill will be saturated in the next 2 years, meaning the Tam Xuan 2 will be closed in December 2023.

Waste collection and transfer

The collection, treatment and the transportation of waste to the disposal site are performed by the Quang Nam URENCO. In urban areas (central wards), there are four main types of waste collection: door-to-door collection on major roads, in some areas there is a collection point near residential areas (within 200 m) with a frequency of collection of once a day or once every 2 days using big compaction vehicles; 500 kg collection trucks collect and transport waste from large alleys; and tricycles to collect waste from small alleys with limited access.

Figure 24: The waste collection and transportation services is operated by the Provincial Quang Nam URENCO



In sub-urban wards and rural communes, waste collection staffs come to collection points to collect waste from residential areas with narrow roads (waste is collected by the commune's waste collection team and transported to specific transfer stations).

Waste recovery

The waste recovery rate in Tam Ky is 1% and it is exclusively done by the informal sector. Currently, in Tam Ky City, there are about 8 small-scale apex traders or intermediate traders, which buy recyclable materials from waste pickers and then store and prepare these materials for export to other cities such as Da Nang. The figure below shows the breakdown of recovered materials in Tam Ky. The largest fraction is plastic, with 47.60%, followed by metal with 29.2%, 21.4% paper/cardboard and 16.1% other waste. A large amount of the organic fraction of the MSW has not been recovered.

The table below presents opportunities for waste recovery in Tam Ky. The amount of plastic waste in the uncollected waste and the waste ending up in the landfill site is estimated at more than 100 t/d. Other recyclable materials include more than 20 t/d of paper and cardboard, 6 t/d of metals, 8 t/d of glass. As expected, the largest fraction of waste ending up in the landfill site is represented by the organic waste.

The opportunity to increase the recovery rate of Tam Ky city is high. With a high rate of organic waste, the ability to recover it through biological treatment (composting) could have a high impact on the overall system.

Table 13: Potential for waste recovery in Tam Ky City

Waste category	Uncollected waste (t/d)	Materials remaining in the landfill site (t/d)
Paper and cardboard	2.41	18.06
Plastic	8.61	98.62
Metals	0.66	5.77
Glass	0.73	7.30
Organics	20.56	158.71

Figure 25: Recovery facilities in Tam Ky, 2021



Waste disposal

The waste is transported directly to the provincial landfill Tam Xuan 2 in Nui Thanh district. This is a sanitary landfill which compacts and covers the waste with soil regularly. The landfill area has

a boundary but not fully protected with a fence. Access is guarded. The landfill has a suitable location and is designed to operate in accordance with sanitary landfill standards. Leachate is collected, treated and the soil, and groundwater protection is ensured by natural clay or HDPE liner. There is staff in charge of operation and management which benefit from comprehensive health and safety provisions. All operations are recorded and available at request. There is a plan in place for landfill closure.

Still, the fact that the province’s Tam Xuan 2 landfill operates without a weighbridge for daily control of waste quantity disposed of at the landfill, leads to an assessment of the control level of “limited control” and results in the rate of 0% of waste managed in controlled facilities.

The prioritization is made taking into account the complexity of the intervention, the capacity of the government to implement it and the urgency of the problem taking into account public health and environmental impacts.

Table 14: Assessment of the level of control of the disposal site in Tam Xuan 2

Assessment areas	Questions	Provincial Landfill in Tam Xuan 2 (Yes/No)
Security	Is there boundary and access control allowing single point of supervised access	No
Water control	Is there any perimeter drainage maintained around the site	Yes
Slope stabilization	Are the slopes stabilized, mitigating risk of landslide	Yes
Waste handling, compaction and cover	Are waste trucks directed to a specific operational area of disposal	Yes
	Is there heavy mechanical equipment reliably available	Yes
	Is waste layered and compacted within the specific operational area	Yes
	Is there some use of cover material	Yes
Fire control	Is there zero evidence of burning of waste on the surface of the landfill	Yes
Staffing	Are staff on site during operational hours	Yes
Records	Is there a functional weighbridge in use	No
EHS	Are there toilets and hand washing stations	Yes
	Are basic personal protective equipment in use	Yes
Other	Is there a site drawing showing the landfill boundary and filling area	Yes

Figure 26: Disposal sites of Tam Ky city in Tam Xuan 2 provincial landfill



Stakeholder workshop

The stakeholders Workshop in Tam Ky City was conducted in January 2022, in a virtual mode via Zoom, having as participants representatives of relevant local authorities and social organizations of the City (19 participants from CPC, URENCO, relevant departments within CPC and ward representatives, Women’s Union, Youth Union and Farmer Association) and virtually connected representatives of UN-Habitat, UNEP and other partners of UN. The purpose of the workshop was to present the results of WaCT and WFD survey in Tam Ky city and to discuss policy interventions and infrastructure investment to address the gaps in the system.

Table 15: Summary, classification and prioritization of gaps in Tam Ky City

City/Country	Tam Ky, Vietnam		Prioritization	Priority	
SWM stage	Policy / Legal	Infrastructure	(1-high, 3-low)		
Separation at source	Red	Red	1	High	
Waste collection coverage (incl. waste collection fees)	Yellow	Yellow	2	Medium	
Waste transfer stations	Yellow	Yellow	3	Low	
Material recycling	Red	Red	1	Gaps	
Biological treatment (incl. waste to energy)	Yellow	Yellow	2		Large
Waste disposal	Red	Red	1		Medium
Informal sector (incl. integration)	Yellow	Yellow	3	Low	
EPR (incl. similar policies)	Yellow	Yellow	3		
SWM planning	Red	Red	1		

Figure 27: Screenshot of the stakeholders’ workshop in Tam Ky City



Recognizing the importance of solving ocean plastic pollution, the Government of Viet Nam has paid special attention and made the first steps by passing fundamental pieces of policies and regulations on environmental protection including practical actions such as:

- ▶ Promulgating the National Action Plan on ocean plastic waste management to 2030;
- ▶ Decision 1407/QD-TTg approving the project that Viet Nam actively prepares and participates in the development of a Global Agreement on Ocean Plastic Pollution.

Viet Nam General Department of Sea and Islands highly welcomed the activities of localities to improve the waste management system against ocean plastic waste, including the pilot application of the WaCT tool implemented by UN-Habitat.

Presentation of the WaCT and WFD surveys results in Tam Ky city

The WaCT survey found that the waste collection rate is 94% in Tam Ky City. However, the percentage of waste managed in controlled facilities is 0% - even though the disposal site is a sanitary landfill and many criteria are being assessed as basic control. The control level of Tam Xuan 2 landfill is only assessed as limited control due to the lack of a weighbridge. At present, the city's infrastructure is very limited and does not provide possibilities for source separation of waste. It is expected that in

2022 the city will develop a project to separate solid waste at source, in which there will be a roadmap and specific plan to invest in infrastructure to ensure the implementation of waste separation at source (bins and collection trucks). To improve the treatment of waste, the city is currently working on the idea of linking neighbouring districts and investors to develop a waste to energy (WtE) investment project. In addition, the city needs to come up with solutions to reduce the use of plastic bags especially in low-income areas.

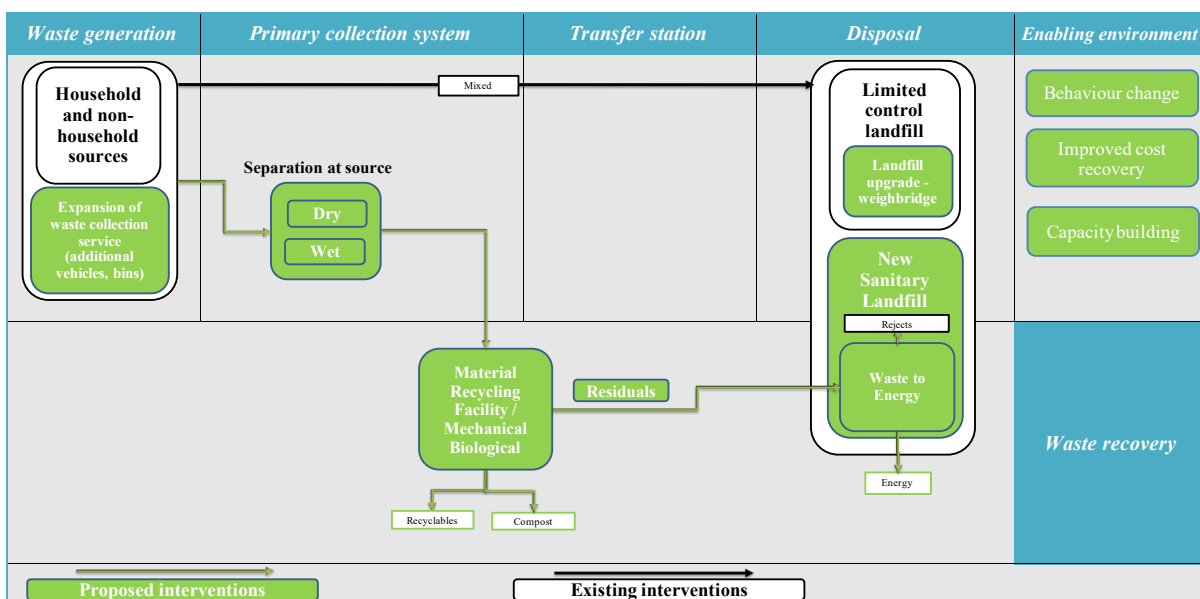
With the goal set out in the Decision 1662/QD-UBND dated June 19, 2020 of the province requesting the closure of Tam Xuan 2 Landfill in December 2023, the province currently has a plan to build a new landfill site (named Tam Nghia) near Tam Xuan 2. Moreover, the city will submit a request to the province to equip the landfill with a weighbridge because the landfill is used for many administrative units in the province and is managed by the Department of Natural Resources and Environment.

Recommendations

Based on the WaCT results, existing and planned initiatives by the local government and the current understanding of the situation at the local level, the recommendations for city could include:

- ▶ Expansion of waste collection coverage to reach 100%;

Figure 28: Opportunities for improving the SWM system in Tam Ky



- ▶ Separation at source;
- ▶ Material recycling facility or mechanical biological treatment to treat the waste separated at source;
- ▶ Introduce weighbridge in the landfill site to improve its control level to basic;
- ▶ Feasibility study to determine the feasibility of the WtE;
- ▶ Closure of the current landfill site and construction of a new sanitary landfill in 2023.

Waste collection

In order to improve the waste collection services, interventions should focus on enhancing the collection system to reach 100% and to introduce separation at source. This would create opportunities for the city to significantly improve the recovery rate as the source separated waste can feed specialized facilities which would in turn treat the waste fraction and recover the valuable materials.

Waste recovery

The city plans to construct a WtE facility. Such investment must be initiated after a thorough feasibility study which would identify the technical and financial parameters required for such an infrastructure. In particular, the capacity of the government to attract enough revenues to fund the operation of the WtE is recommended to be investigated and to inform the decision of pursuing such project. This would ensure the sustainability of the investment over time. To further improve the recovery rate, it is recommended that prior to the WtE facility, the waste is fed to a material recycling facility or a mechanical biological treatment facility. These facilities could be designed to further improve the city's recovery rate by recovering high valuable materials such as dry recyclables as well as to treat clean organic materials under a biological treatment process. The residuals would then be fed to the WtE. The calorific value of the waste required for the WtE facility should be validated as part of the feasibility study.

Waste disposal

The control level of the current landfill site could be improved through the installation and use of the weighbridge. This investment will significantly improve the share of waste managed in controlled facility. Since the current landfill will reach its capacity in ca. 2 years, plans must be in place for a new landfill facility. The closure of the existing landfill site must be conducted to minimize any public health and environmental impacts.

2.5. Hoi An/Viet Nam

The kick-off workshop for Hoi An City was conducted in July 9th 2021 in hybrid mode. An in-person meeting was organized in Hoi An with representatives of relevant local authorities and social organizations of the City which connected virtually with the representatives of UN-Habitat Viet Nam and the Advisory team in Hanoi.

The main purpose of the workshop was to introduce the project to the city, the Waste Wise Cities Tool and its applications to urban solid waste management, and to initiate a first discussion about the current state of solid waste management in the city. There were 17 participants (13 from the city and 4 from UN-Habitat) to the workshop, as follows:

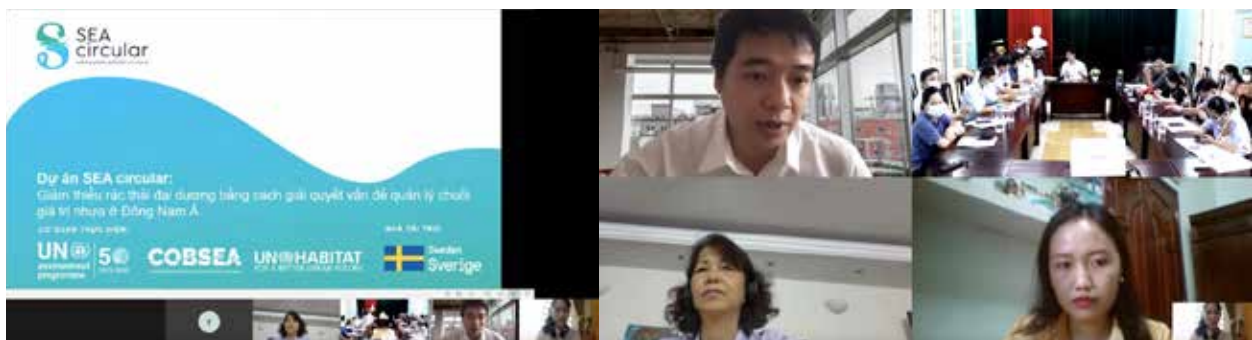
- ▶ Representative of Hoi An City People's Committee;
- ▶ Representatives of Wards and Communes People's Committees of Hoi An City;
- ▶ Representatives of city social organizations participating in solid waste management: Women's Union, Youth Union, Farmer Association;
- ▶ Representatives of UN-Habitat Viet Nam.

Hoi An City is a famous tourism city of Quang Nam province, located in the centre of Viet Nam. Experiencing a significant growth rate of tourist arrivals in Hoi An from 2016 to 2019, the waste generation in the city increased considerably from

26,037 tonnes/year to 37,188 tonnes/year in 2019 and decreased to 29,234 tonnes/year in 2020 due to the Covid-19 pandemic and significant decrease in the tourism sector. Hoi An Public Works JSC is the company responsible for solid waste management in Hoi An City. Waste collected in the city is either composted (the organic fraction) at the composting plant or disposed of at Cam Ha landfill of the city. The Quang Nam Province requested to the city to close the landfill in 2021 since it reached full capacity and to transfer the waste to another provincial landfill.

more than 70% of the City's GDP. The standard of life for the majority of people has improved thanks to this economic sector, the per capita income in 2019 reaching more than 53 million VND (equivalent to about 2,300 USD). However in 2020, due to the impact of the global Covid-19 pandemic, Hoi An's tourism was highly impacted with the reduced number of tourists which resulted in the decreased revenue of the tourism operators. The total number of visitors to Hoi An decreased by nearly 84% and revenue from tourism activities decreased by more than 86% compared to 2019.¹⁴

Figure 29: Screenshot of the Kick-off workshop in Hoi An city



The plan of the city expressed in the kick-off meeting is to continue implementing policies and measures in the direction of the 4Rs (Refuse-Reduce-Reuse-Recycle).

WaCT and WFD Survey Results

Hoi An city is located on the coast of the East Sea in the South Central Coast region of Viet Nam, located in the northeast of the Quang Nam Province, centre of Viet Nam. The city has an area of 63.549 km² with a total population in 2019 of around 98,625 people.¹³

Since being recognized by UNESCO as a World Cultural Heritage site in 1999, Hoi An City has become an attractive national and international tourist destination. Tourism is the primary industry in Hoi An. Over the past 20 years, the tourism industry has grown dramatically and accounts for

At the time of WaCT survey in September - October 2021, due to the Covid-19 pandemic, there were almost no tourism activities in Hoi An City. Hoi An City is comprised of 13 administrative units (9 wards and 4 communes) including an island commune that has its own waste management system. Thus, in this study, we focused only on the wards and communes on the mainland.

Based on statistics from the 2019 Hoi An city Statistical Yearbook and considering other relevant characteristics of the city, a list of 6 wards and 3 communes were proposed to participate in the household MSW generation and composition survey, corresponding to 3 income areas classified by high-income level (Minh An, Tan An, Cam Pho); medium-income level (Thanh Ha, Cam Chau, Cam Nam) and low-income level (Cam Thanh, Cam Ha, Cam Kim).

¹³ According to Hoi An City Statistical Yearbook 2019

¹⁴ Information from various reports and portals of Hoi An city: hoian.quangnam.gov.vn/webcenter/portal/hoian

Figure 30: Household waste generation and composition survey in Hoi An city, 2021



The total MSW generated in Hoi An is 62t/day, of which 99% is collected. The survey found that the relatively lower waste generation rate from household and higher waste generation from non-household sources which is as high as 62%. This

ratio could be a realistic number in the Viet Nam context, since another study 10 suggests that the share of non-household waste could be as high as 70%.

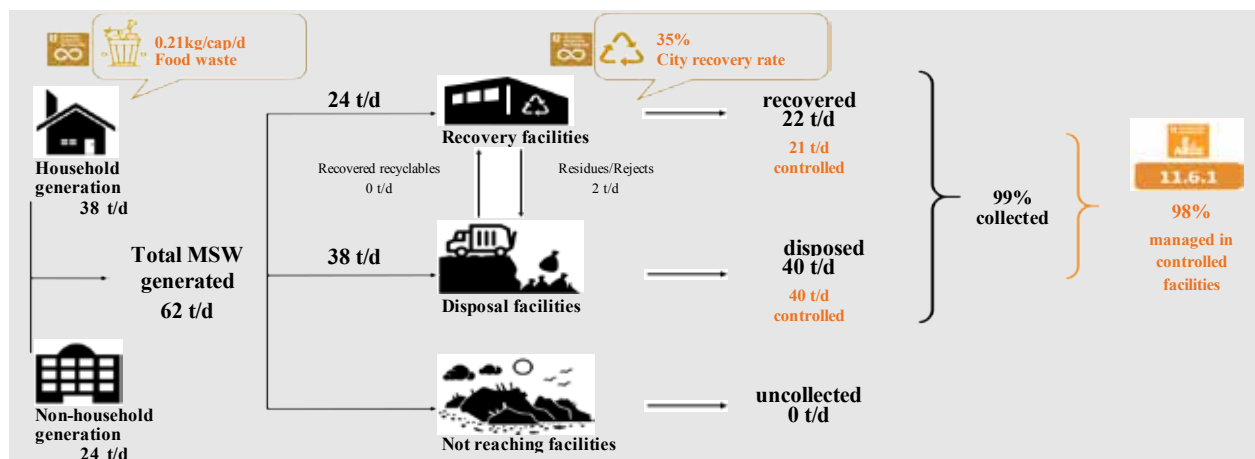
In Hoi An, the MSW collected is first transported to the waste treatment plant and only the rejects are afterwards transported to the disposal site. According to the data of Hoi An City, the estimated amount of MSW transported to the Hoi An Waste Treatment Plant during Covid-19 times was of about 62 tonnes/day and before Covid-19 in 2019 the volume of waste was estimated to 80 tonnes/day. Therefore, a proxy of about 38% of total MSW was applied for non-household waste generation in Hoi An City

The percentage of waste managed in controlled facilities of Hoi An City is very high as compared with other cities in Viet Nam, with all of residues from the controlled Waste Treatment Plant (WTP), a composting facility with semi-mechanised sorting process, being transported to the basic controlled provincial landfill in Nui Thanh district

Table 16: Key WaCT and WFD Data in Hoi An City

Income group	High income	Middle income	Low income
Waste generation rate (kg/capita/day)	0.493	0.379	0.321
Total population	27,610	45,289	23,635
Total MSW generated from household(t/day)	14	17	7
Total MSW generated from non-household sources (t/day)	24		
Total MSW generated (t/day)	62		
City Plastic Leakage into water bodies (kg/person/year)	0.1		

Figure 31: WaCT flow chart results in Hoi An City



for disposal, as reported by the City. In case the waste would have been disposed in the existing dumpsite in Cam Ha with limited control level, the percentage of waste managed in controlled facilities would only reach 33% or even lower - 0% - if limited control level appears in other recovery facilities such as the Hoi An WTP which is assessed as basic control level in the existing system.

The plastic leakage into water systems is extremely low. This is due to the high waste collection

coverage and the share of MSW managed in controlled facilities. However, the source of the very low plastic leakage is mainly from the uncollected waste and from the collection system.

The wastecompositionanalysiswascomplemented by a further analysis of the plastic waste. As the WaCT suggests a breakdown of plastic waste on two types, plastic dense and plastic films, a further disaggregation was conducted to understand the type of plastic applications in the MSW.

Figure 32: Plastic flow diagram for Hoi An, 2021

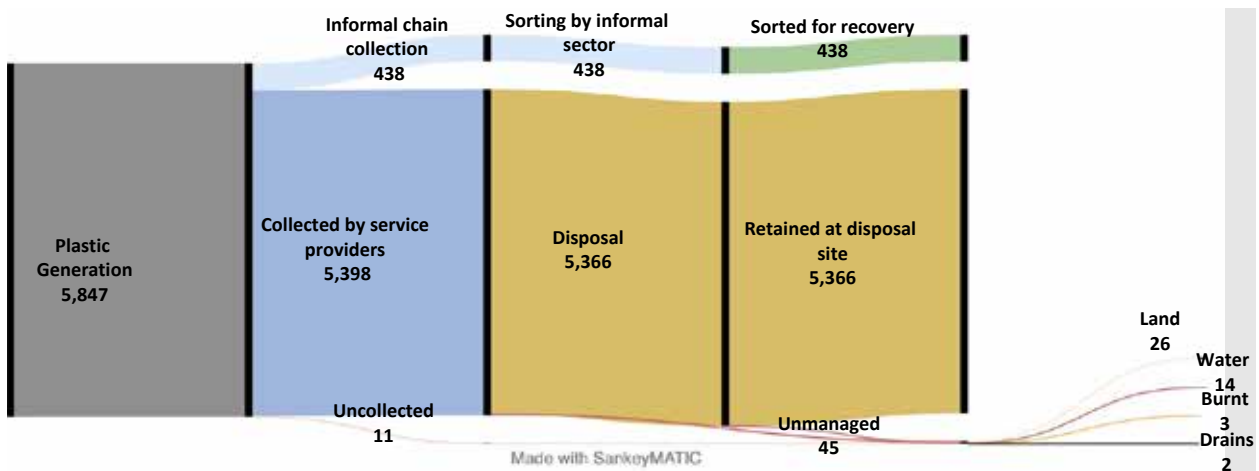
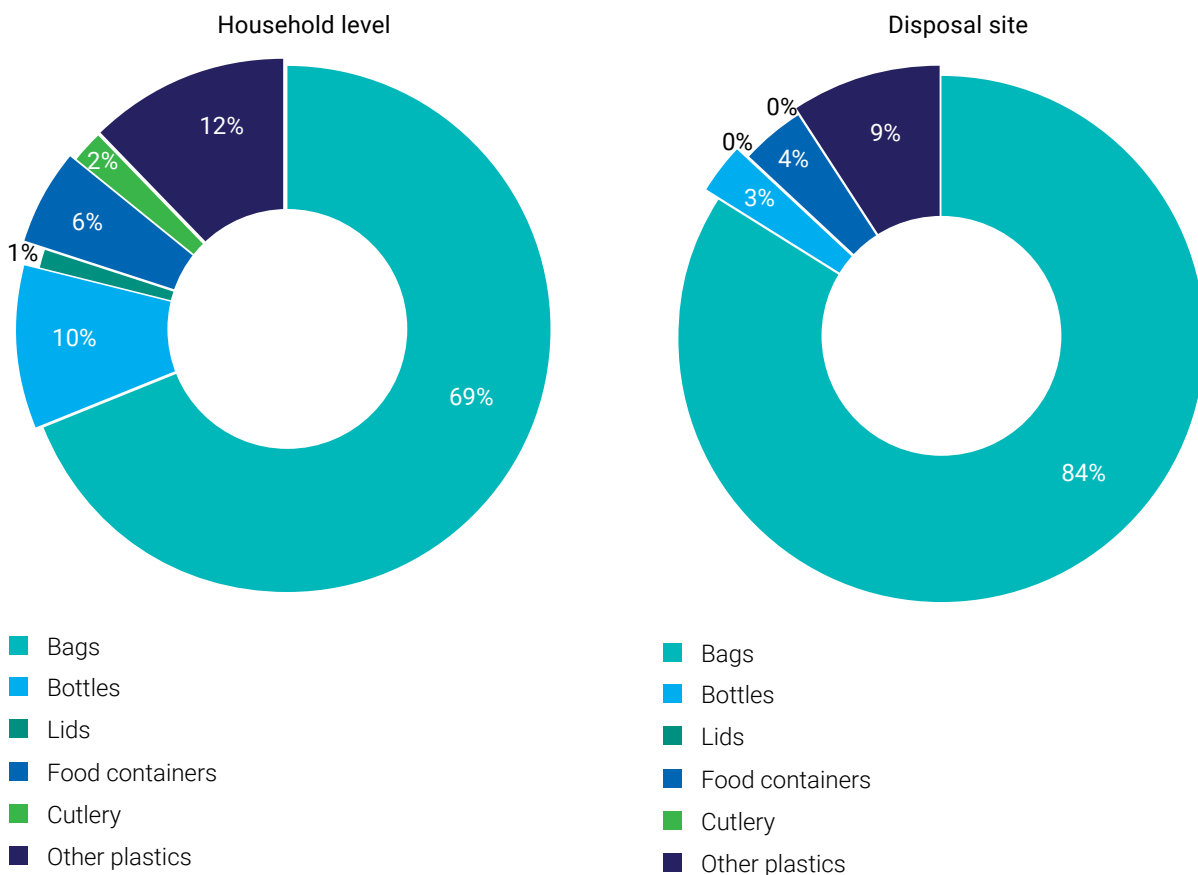


Figure 33: Plastic waste composition in Hoi An



The results show that the most predominant plastic application is plastic bags. The plastic bottles represent 10% of the household plastic waste whilst in the disposal site the share is only 3%. This confirms that plastic bottles are diverted from disposal site through recovery activities. The high share of plastic bags in the disposal site shows that these materials do not have a market value, especially when the materials are contaminated with other waste streams during the mixed waste collection process.

Policy and Infrastructure Gaps Analysis

Decision-making at the city level is undertaken by the City People's Committee in coordination with relevant actions decided by the Provincial People's Committee at the Provincial level and, as appropriate, People's Committees at the ward and commune level. The work of the City People's Committee is advised by- and administered/implemented through functional departments. Capital planning and investment in the waste sector is undertaken at the Provincial level in consultation with the city. The Solid Waste Management Plan for Quang Nam Province for the period 2011-2020 stipulates that 70% of household and similar wastes (including tourism wastes) should be reused or recycled. The People's Committee of Hoi An City has also issued an Action Plan in March 2020 on reducing the use of plastic and non-biodegradable plastic bags. The WaCT shows the city recovery accounts for 35% of total MSW generation, which is a rather high rate but still, below the targets set by the province and city.

The city aims to minimize the amount of landfilled waste, even targeting a zero-waste disposal with the pursuit of a private investment project to build a WtE plant. The investment project has been approved in 2020 by the Quang Nam Province People's Committee¹⁵.

Waste collection and transfer

The collection, treatment and transportation of MSW to the disposal site are performed by the Hoi An Public Works Company (HAPWC). The city has adopted a waste separation at source collection system that is aligned with its investments in

Figure 34: The waste collection and transportation services operated by Hoi An Public Works Company (HAPWC)



waste treatment. Waste generators are requested to voluntarily separate organic materials from other materials. The HAPWC collects easily degradable materials on Monday, Wednesday and Friday, and other materials on Tuesday, Thursday and Saturday.

HAPWC indicates that the share of waste separated at source out of the total MSW collected is approximately 60% and is slowly decreasing. Businesses (largely hotels and restaurants) also participate in the source separation system; HAPWC reported that the level of source separation by businesses is better than that of households. In order to ensure effective composting at the waste treatment plant and an increased recycling rate, the city has to maintain the existing collection system while carrying out information and awareness raising campaigns coupled by enforcement of the regulations. The residual wastes from the waste treatment plant are currently transported to Nui Thanh, 90 km from the city.

Waste recovery

Recovery of materials is done by both the formal and the informal sector. Currently, there are about 8 small-scale apex traders or intermediate traders in Hoi An City, which receive recyclable materials from waste pickers and then store and prepare

¹⁵ Decision No. 516/QD-UBND dated 27/02/2020

these materials for export to other cities such as Da Nang or Hung Yen. In addition, there are 2 other recovery facilities that can be considered end-of-chain recyclers in Hoi An: the ReForm Plastic / Evergreen Labs Co. Ltd. which receives PET, HDPE, PP, PVC, LDPE&film, EPS, other plastic, Tetra Pak from informal waste pickers and other small traders to produce recycled waste containers with a production capacity of about 1-2 tonnes/day; and the Hoi An Waste Treatment Plant (WTP) that formally receives organic waste from MSW collection services for composting and further sorting and collection of other recyclable materials (accounting for about 1-2% of the total MSW received daily, including plastic, metal, paper/cardboard) with the help of about 20 waste pickers working at the plant. The total amount of waste reduced via the treatment plant is about 22 tonnes/day (as reported by the Plant, the received waste of the Plant is about 62 tonnes/day and the waste out of the Plant to landfill is about 40 tonnes/day).

Municipal wastes are delivered to the WTP in Cam Haward. Wastepickers recover recyclable materials before waste is fed to a semi-mechanized waste separation system that is designed to separate the organic materials from the remaining recyclable materials and residual wastes. The sorting system has a capacity of 55 tonnes/day of input material. Following the separation of materials:

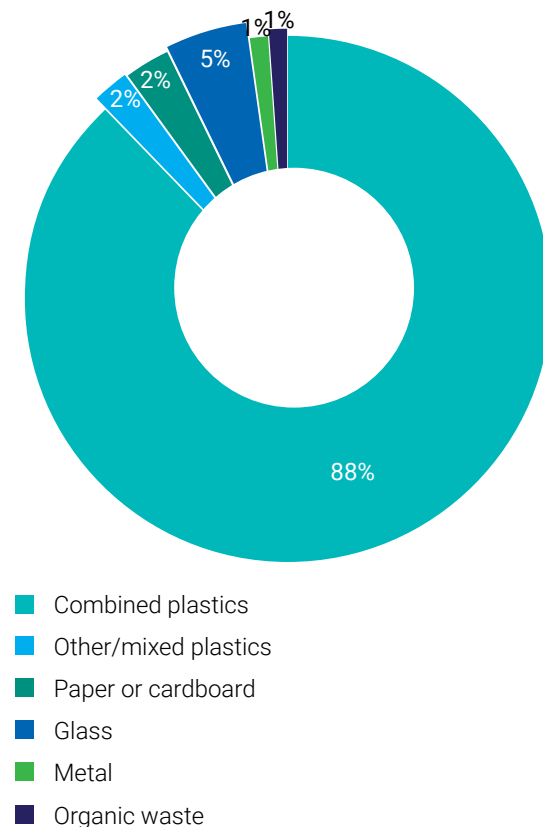
Organic materials are fed into a two-stage, 7-week composting system (primary and secondary aerobic fermentation). Primary fermentation is undertaken in 9 forced-air static pile bunkers with an area of 15 x 5 m each; secondary fermentation is undertaken in an open roofed area of 1,789 m². The compost is screened and made available for sale. The city reports that it is not able to sell the compost; however, all the compost is used for greening the city or given away for free, and there is a high demand from residents for the compost on this basis.

Other recyclable materials are informally collected and sold to apex traders by waste pickers.

Previously, residual materials were fed into an incinerator purchased in 2010, which is currently not in operation. Residual wastes are currently transported to Nui Thanh, 90 km from the city.

The figure below shows the recovered materials in Hoi An with the biggest fraction being organic waste (90%) via formal recovery at the WTP; the informal recovery of other materials accounts for a small portion (3.8% of total plastic; 3.5% of paper/cardboard; 0.94% of metal; 0.72% of glass).

Figure 35: Breakdown of recovered materials in Hoi An



Despite the high recovery rate, the waste sent to the disposal site contains considerable volumes of waste materials which could be recovered in the future. The estimated volumes of these materials are presented in the table below.

Table 17: Potential for MSW recovery in Hoi An

Waste category	Waste in the disposal site (t/d)
Paper and cardboard	1.65
Plastic	14.70
Metals	0.26
Glass	0.95
Organics	6.00

Waste disposal

Residual materials from the WTP were previously fed to an incinerator purchased in 2010, which is currently not operational. Waste disposal has previously been undertaken at a landfill in Cam Ha located in the middle of a cemetery, but this has been closed (except for emergency waste storage – e.g. for debris after a storm). There are

no environmental controls at the Cam Ha landfill, which contains an estimated 100,000 m³ of waste and has been prioritized for remediation. As reported by the City, all of the residual wastes from the waste treatment plant are currently transported to the provincial landfill in Nui Thanh district, 90 km from the city. The level of control of this landfill was defined as „basic control”.

Table 18: Basic level of control area met by the disposal site in Nui Thanh

Assessment areas	Questions	Provincial Landfill in Nui Thanh Dist. (Yes/No)
Security	Is there boundary and access control allowing single point of supervised access	Yes
Water control	Is there any perimeter drainage maintained around the site	Yes
Slope stabilization	Are the slopes stabilized, mitigating risk of landslide	Yes
Waste handling, compaction and cover	Are waste trucks directed to a specific operational area of disposal	Yes
	Is there heavy mechanical equipment reliably available	Yes
	Is waste layered and compacted within the specific operational area	Yes
	Is there some use of cover material	Yes
Fire control	Is there zero evidence of burning of waste on the surface of the landfill	Yes
Staffing	Are staff on site during operational hours	Yes
Records	Is there a functional weighbridge in use	Yes
EHS	Are there toilets and hand washing stations	Yes
	Are basic personal protective equipment in use	Yes
Other	Is there a site drawing showing the landfill boundary and filling area	Yes

Figure 36: Existing dumpsite under closure process in Cam Ha ward – currently not use by the city



Figure 37: Provincial landfill in Nui Thanh district, 90 km from the City – currently used by the city



Table 19: Summary, classification and prioritization of gaps in Hoi An City

City/Country SWM stage	Hoi An, Vietnam		Prioritization (1-high, 3-low)	Priority	
	Policy / Legal	Infrastructure			
Separation at source	Yellow	Yellow	1	High	1
Waste collection coverage (incl. waste collection fees)	Yellow	Yellow	3	Medium	2
Waste transfer stations	Yellow	Red	3	Low	3
Material recycling	Yellow	Yellow	2	Gaps	
Biological treatment (incl. waste to energy)	Yellow	Yellow	3	Large	Red
Waste disposal	Red	Red	1	Medium	Yellow
Informal sector (incl. integration)	Red	Yellow	2	Low	Yellow
EPR (incl. similar policies)	Red	Yellow	3		
SWM planning	Red	Yellow	1		

The prioritization of mitigation measures for Hoi An is presented below. This is made taking into account the complexity of the intervention, the capacity of the government to implement it and the urgency of the problem taking into account public health and environmental impacts.

Stakeholder workshop

The stakeholders workshop in Hoi An City was conducted in November 2021 in hybrid mode with an in-person meeting organized in Hoi An with representatives of relevant local authorities and social organizations of the City and with representatives of UN-Habitat, UNEP and other partners connecting virtually. The workshop was carried out to present the results of WaCT and WFD survey results in Hoi An City and to discuss policy intervention and infrastructure investment gaps for improving the SWM system. There were a total of 30 participants, 21 from the City and 9 from UN-Habitat and UNEP.

Figure 38: Screenshot of the Kick-off workshop in Hoi An city



Waste collection

The waste is collected every other day, with easily degradable materials being collected on Monday, Wednesday and Friday, and other materials on Tuesday, Thursday and Saturday. The existing collection system which uses trucks might be sufficient, however there is a need for supplementing the system with around 20,000 special bins for households to separate organic waste (to avoid odour due to 2-day storage of organic waste). Another intervention could be done to mitigate the long-distance transportation of waste to the provincial landfill (about 90 km). Building a transfer station and using large capacity vehicles could reduce the number of trips to the landfill site. The city clarified that this transportation of waste to provincial landfill is performed with specialized vehicles. In addition, this transportation of waste from Hoi An to the provincial landfill in Nui Thanh district is just a temporary solution and their long term solution will be Waste to Energy plant (see the following sections).

Waste recovery

The City plans to consider a private investment to build a WtE plant in Hoi An City, with a capacity of 120 tonnes per day.

Waste disposal

The City plans to close and remediate the existing Cam Ha dumpsite. In the future, the city will focus on reducing waste ending up in the landfill site through an investment in a WtE plant.

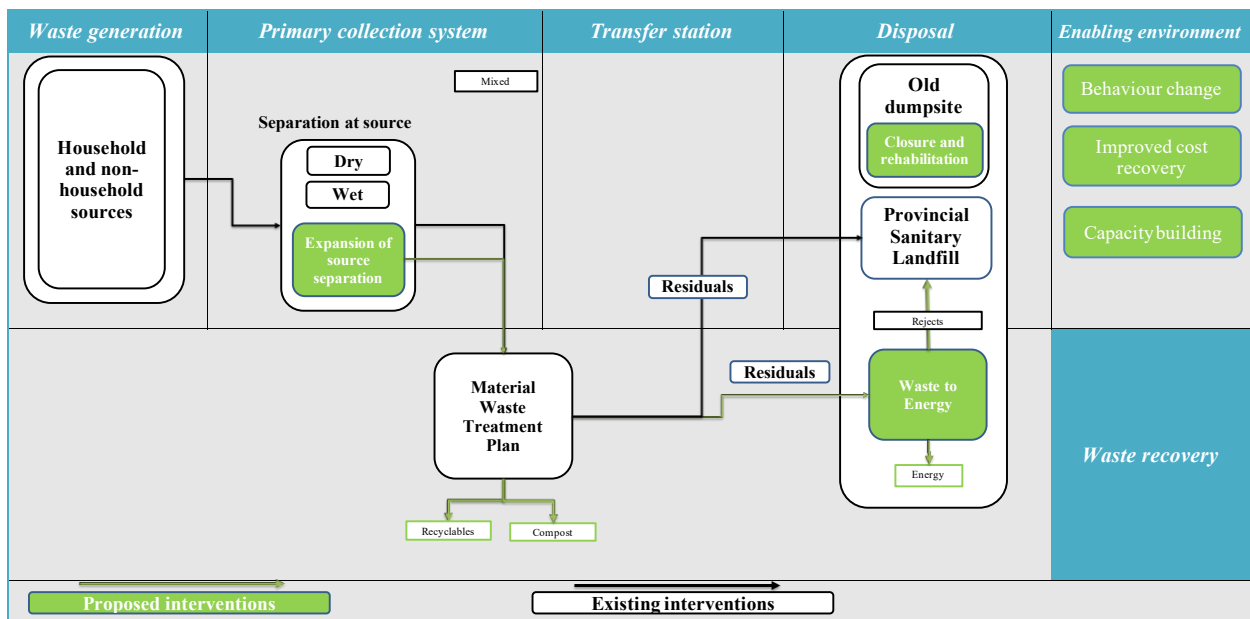
Recommendations

Based on the WaCT results and current understanding of the situation at the local level and the priorities disclosed by the city, the recommendations include:

- ▶ Expansion of source separation combined with behaviour change and law enforcement;
- ▶ Closure and rehabilitation of the old dumpsite;
- ▶ Feasibility study for the construction of a WtE plant.

The proposed measures are further detailed in the next sections.

Figure 39: Opportunities for improving the SWM system in Hoi-An



Waste collection

In order to improve the waste collection services, interventions should focus on enhancing the existing separation at source system. This would create opportunities for the city to significantly improve the recovery rate as the source separated waste can be recovered at the existing treatment plant before reaching the landfill site or the future WtE plant. The collection capacity of the operator must be appropriate in order to collect the separated waste and to avoid contamination of different waste fractions which would compromise the further waste treatment processes.

Waste recovery

The city plans to construct a WtE facility. Such investment must be initiated after a thorough feasibility study which would identify the technical and financial parameters required for such an infrastructure. In particular, the capacity of the government to attract enough revenues to fund the operation of the WtE is recommended to be investigated and to inform the decision of pursuing such project. This would ensure the sustainability of the investment over time. To further improve the recovery rate, it is recommended that before reaching the WtE facility, to feed the waste to the existing WTP to recover highly valuable materials such as dry recyclables as well as to treat clean organic materials under the composting process. In this sense, the existing capacity of the WTP should be assessed to identify solutions to increase its overall capacity and process efficiency. In this way, only the residuals would then be fed to the WtE whilst the recyclable waste could be recovered and diverted away from landfill. The calorific value of the residual waste required for the WtE facility should be validated as part of the feasibility study.

Waste disposal

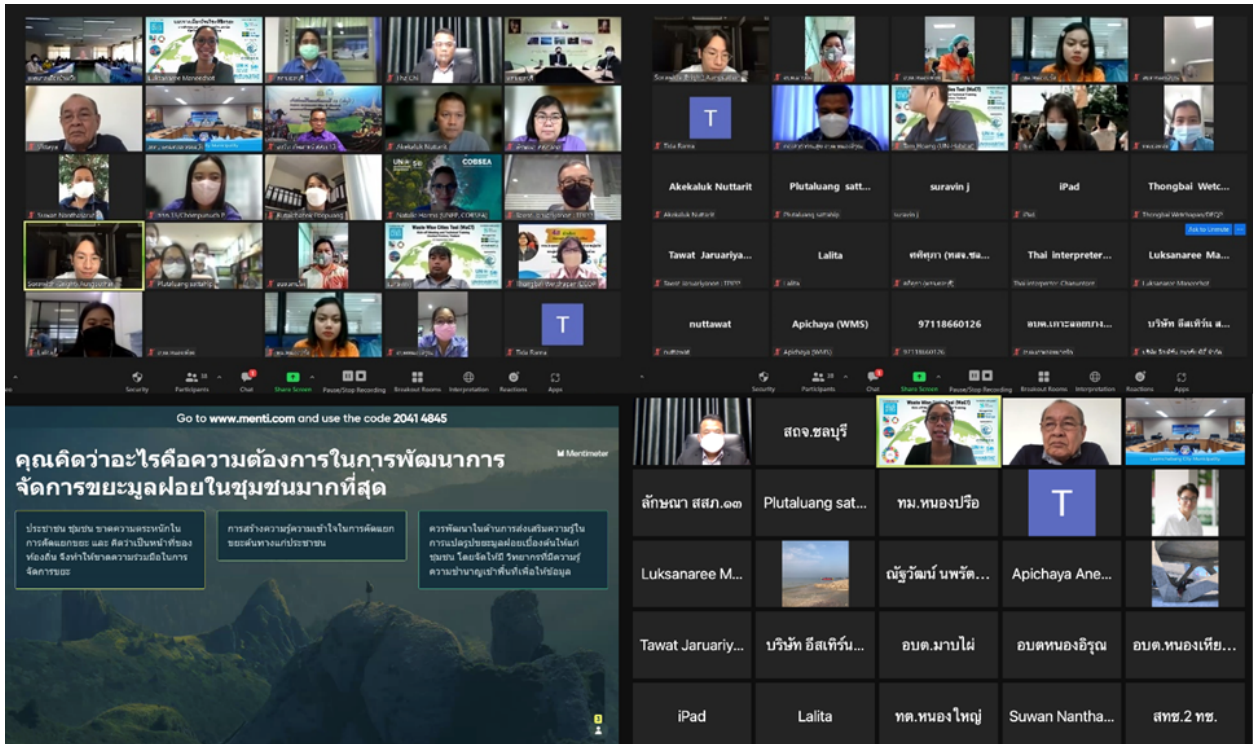
Even with a WtE plant, the city would still rely on a landfill site. If the city is planning to use the provincial landfill, due to the large distance, a transfer station could be considered to reduce transportation costs. If the provincial landfill is not an option, the government should investigate the possibility of constructing a new sanitary landfill in the proximity of the city. The closure of the old dumpsite must be conducted to minimize any public health and environmental impacts.

2.6. Chonburi / Thailand

The kick-off meeting and technical training for Chonburi Province have been held in September 2021. Due to the Covid-19 pandemic and the regulations for pandemic control, the meeting was carried out virtually through Zoom platform. Even if the meeting was online, 38 participants have registered from Chonburi Provincial Office, public and private sectors, and other stakeholders, as listed below:

- ▶ Two departments of the Thai Government: Department of Environmental Quality Promotion and Department of Marine and Coastal Resources;
- ▶ Three organizations related to environment control: Regional Environment Office 13 (Chonburi), Chonburi Provincial Office of Administrative Promotion and Chonburi Provincial Office of Natural Resources and Environment;
- ▶ 15 local administrative organizations: Pattaya City, Laem Chabang City Municipality, Nongprue Town Municipality, Sattahip Town Municipality, Saensuk Municipality, Banbung Municipality, Pong Municipality, Nongyai Municipality, Bothong Municipality, Nongree Subdistrict Administrative Organization, Plutaluang Subdistrict Administrative Organization, Nong Erun Subdistrict Administrative Organization, Nhongheang Subdistrict Administrative Organization, Mabpai Subdistrict Administrative Organization, and Kohloybanghak Subdistrict Administrative Organization;
- ▶ Three recovery facilities and two disposal facilities (TPI Polene Power Public Company Limited (PCL), Samchai Recycle Co., Ltd, Mabpai Community for Recycling, Smart Grand Corporation Co., Ltd, and Waste Management Siam Public Company Limited);
- ▶ Burapha University.

Figure 40: Kick-off meeting and technical training, Chonburi Province



WaCT and WFD Survey Results

Chonburi Province covers an area of 4,363 km², located in eastern Thailand and close to the Gulf of Thailand. In the urban areas there are 65,806 business establishments, 3,280 industry facilities, and 1,001 hotels¹⁶. Chonburi Province has a registered population of 1.6 million.¹⁷ The province comprises 11 districts and 98 local government organizations (Pattaya City, Laem Chabang City Municipality, Chao Phraya Surasak City Municipality, 10 town municipalities, 35 sub-district municipalities, and 50 sub-district administrative organizations (SAO)). The local government organizations take responsibilities for a range of services, including MSWM in their defined areas.

Survey data for disposal and recovery facilities were received from 23 disposal facilities and 7 recovery facilities and Chon Buri Provincial Office of Natural Resources and Environment. The control level of 22 facilities was checked via site visits

and physical interviews from 20 to 25 December 2021, while others were interviewed by phone calls. The waste composition analysis from three different income levels were conducted at Laem Chabang City Municipal Landfill represented for high income, Saen Suk Town Municipal Landfill for middle income and Bo Thong Municipal Dumpsite for low income.

From the survey data and secondary data inputs in WaCT, the waste generation rate is in the range of 0.41-0.64 kg/capita/day. Noticeably, the waste generation rate of middle-income households is the lowest, mainly due to the higher number of household members. The rationale behind this observation needs to be further investigated.

The registered population in Chonburi Province is lower than residents due to migrant workers. Chonburi Province estimated that 0.42 million people are not registered¹⁸. The total population in WaCT has been analysed and estimated by the combination of registered population¹⁹ and

16 Chonburi Provincial Office of Industry, 2020

17 Chonburi Provincial Statistical Office, 2021

18 National Statistical Office of Thailand (NSO). (2021). Report of Thailand Non-registered Population in 2020.

19 Data were updated in August 2021, provided by Office of Registration Administration, Department of Provincial Administration

Figure 41: Household waste generation and composition analysis in Chonburi Province



Figure 42: Waste composition analysis at (a) Laem Chabang City Municipal Landfill (b) Saen Suk Town Municipal Landfill and (c) Bo Thong Municipal Dumpsite



Table 20: Key WaCT and WFD Data in Chonburi Province, Thailand

Income group	High income	Middle income	Low income
Waste generation rate (kg/capita/day)	0.64	0.41	0.55
Total population	944,744	781,434	242,160
Total MSW generated from household(t/day)	608	322	322
Total MSW generated from non-household sources (t/day)			1,354
Total MSW generated (t/day)			2,418
City Plastic Leakage into water bodies (kg/person/year)			5.5

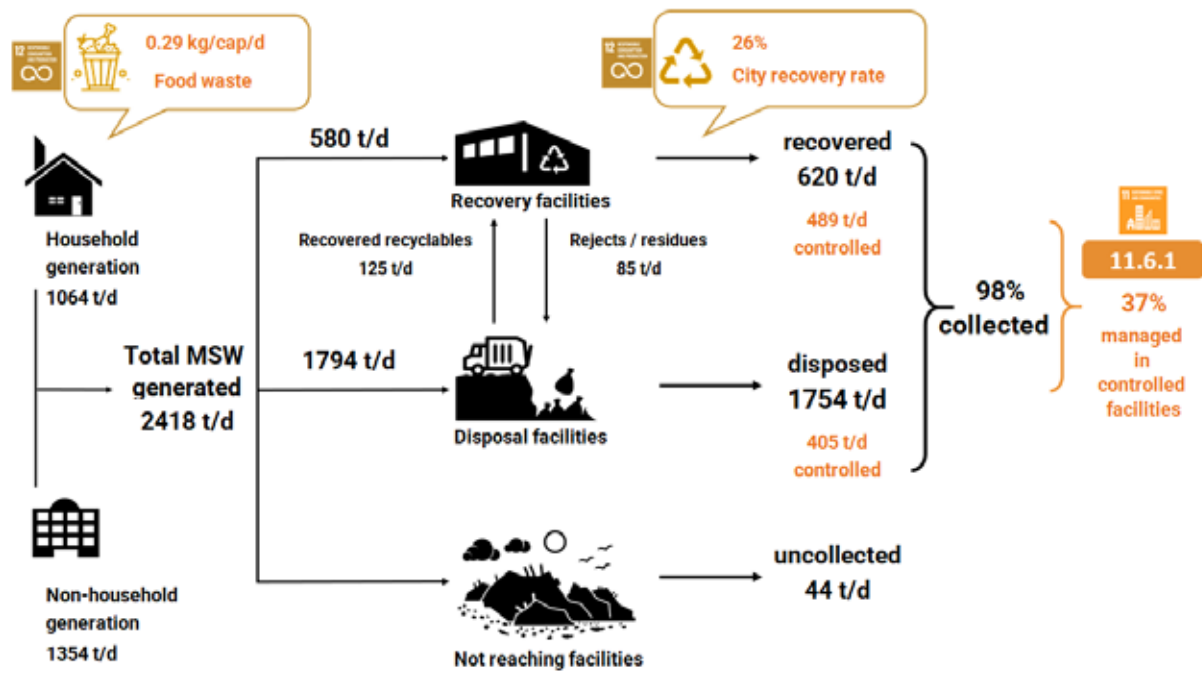
numbers of registered employees²⁰. Therefore, the population in WaCT is estimated to be 1,968,338, which is 0.39 million higher than the registered population.

In WaCT, the total MSW generated from non-household sources (1,354 tonne/day) is evaluated by a proxy using 56% of the total MSW generated. The percentage is calculated by subtracting from the total MSW collected in the survey areas, the total MSW generated from households, assuming a collection rate of 100%. Total MSW generated of 2,418 tonne/day could be evaluated from the survey, secondary data and additional analysis.

About 74% from the total waste generation (1,754 tonne/day) is disposed at the 20 disposal facilities out of which 15 facilities are operated by local governments and 5 facilities by the private sector.

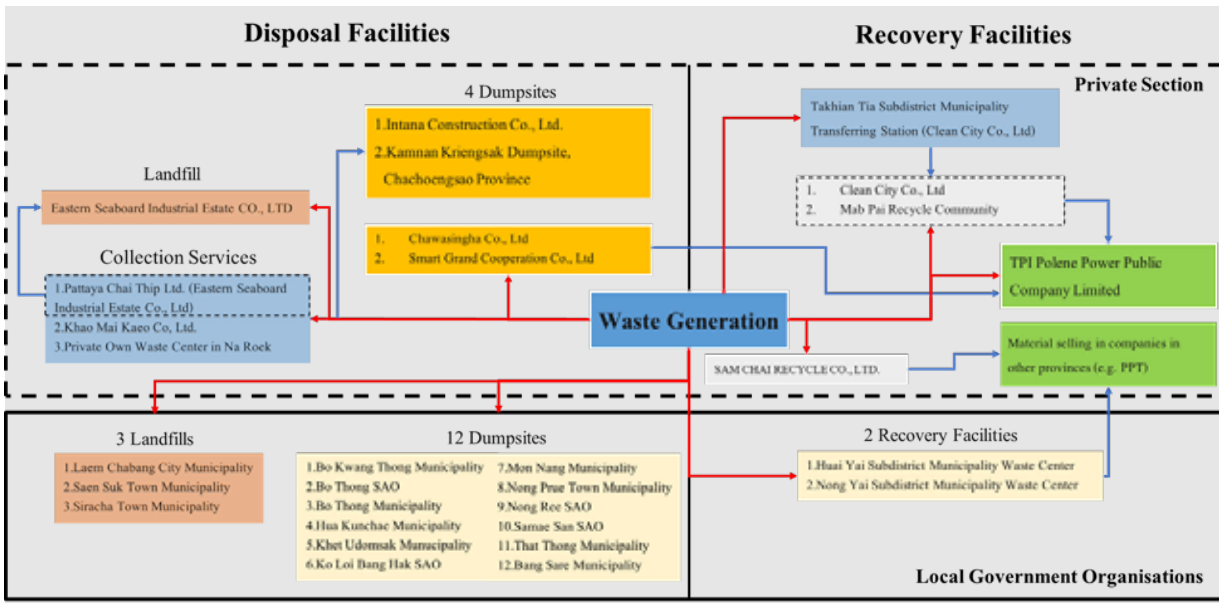
Approximately 620 tonne/day of waste is recovered at 7 recovery facilities, two of them belonging to local governments and five facilities to the private sector. Additionally, two private disposal facilities recover 125 tonne/day of collected waste into Refused-derived Fuel (RDF), namely TPI Polene Power PCL, in Saraburi Province. At the recovery facilities, large items and special wastes are usually rejected and disposed of as residues - about 85 tonne/day. Around 44 tonne/day is estimated to be uncollected waste, for two reasons: (1) Nong Prue Subdistrict Administrative Organization does not have waste collection service in their defined area and (2) bulky items (e.g., broken beds and furniture) are disposed in abandoned areas, collection sites and along the public roads. Overall, 98% of the waste generated is collected in the Chonburi Province, of which 37% is managed in controlled facilities.

Figure 43: WaCT flow chart results in Chonburi Province, Thailand



20 Data for 2018 by Chonburi Provincial Employment Office.

Figure 44: Disposal and recovery facilities and their connections in Chonburi Province



From the waste composition analysis and WaCT results, the WFD evaluates 254,595 tonne/year of total plastic amount generation, out of which 33% and 56% are recovered and disposed, respectively. The retained plastic at disposal sites amounts to about 134,287 tonne/year. In considering the waste to energy recovery, 68,255 tonne/year could be used to generate energy through the RDF process. Significantly, 10,765 tonne/year (26% of unmanaged waste) and 15,620 tonne/year (38% of

unmanaged waste) could leak into water sources and land, respectively.

The household and disposal site waste composition analyses were complemented by a further analysis of the plastic waste. As the WaCT suggests a breakdown of plastic waste on two types, plastic dense and plastic films, a further disaggregation was conducted to understand the type of plastic applications in the MSW.

Figure 45: WFD results in Chonburi Province, Thailand (tonnes per year)

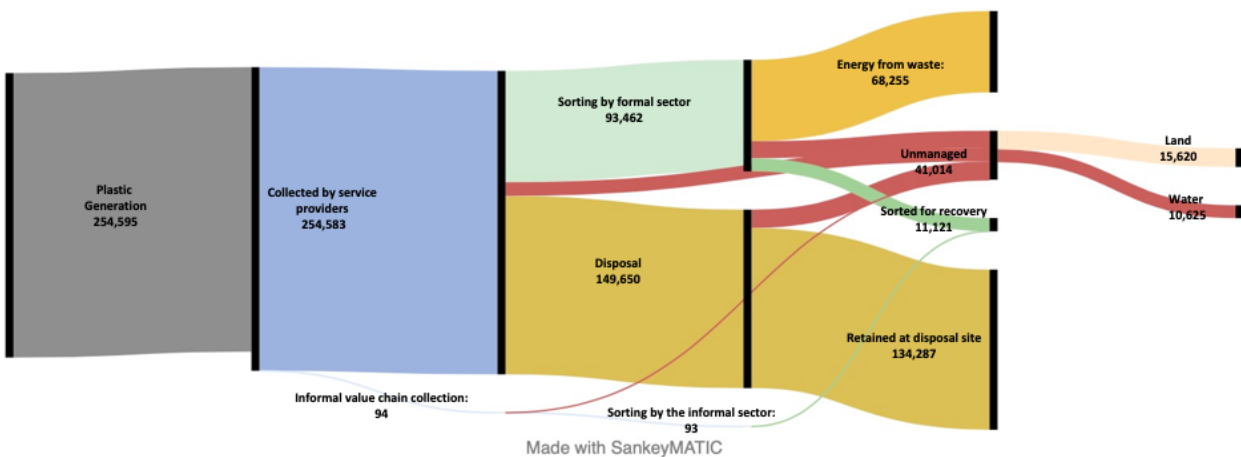
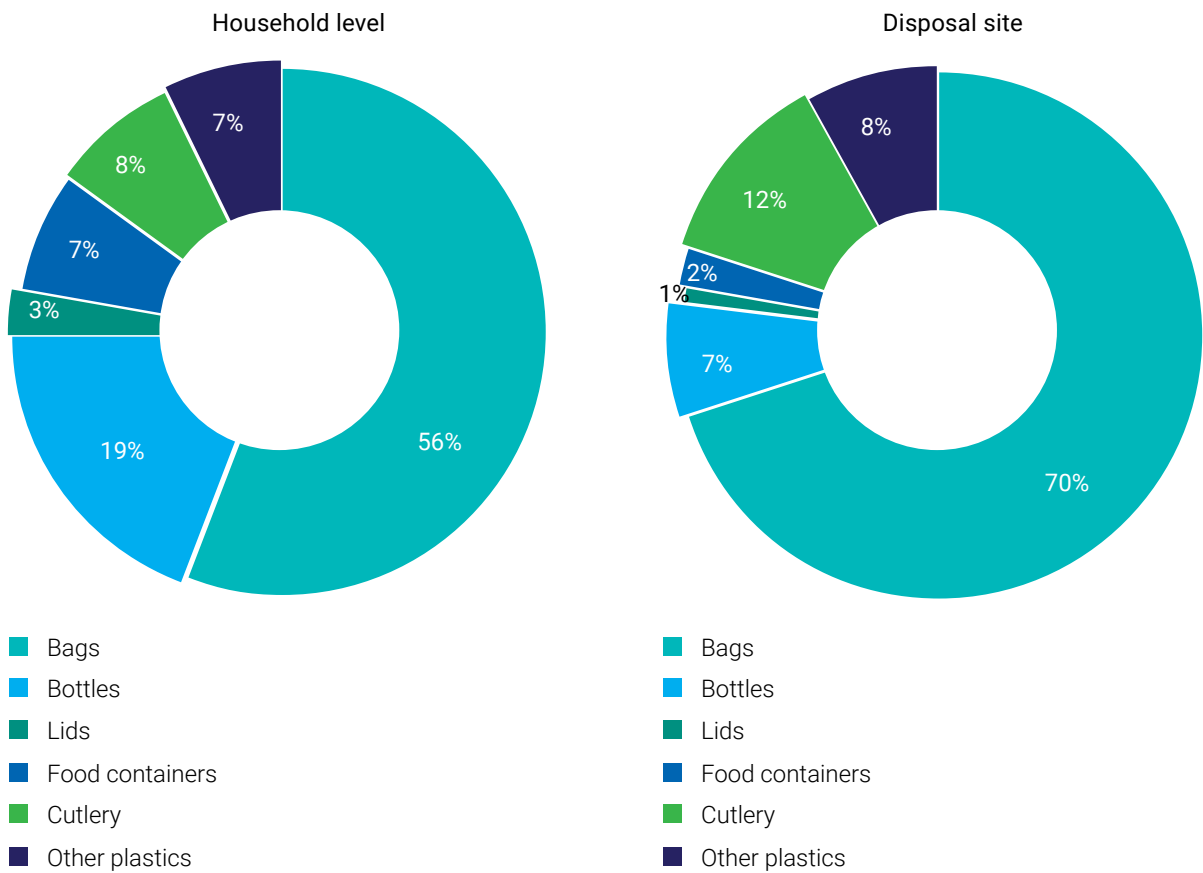


Figure 46: Plastic waste composition in Chonburi



The results show that the most predominant plastic application is represented by plastic bags at both household and disposal site levels. The second largest plastic stream is plastic bottles followed by cutlery at the household level and cutlery followed by other plastics at the disposal site level.

Policy and Infrastructure Gaps Analysis

Municipal SWM has to be handled by local government organizations as stipulated under the local policies²¹. It means that the local government organization has powers and responsibilities to organize public services for MSW and sewage and to manage the environment and pollution. In the context of municipal SWM, Pollution Control Department (PCD) has explained that MSW is solid waste generated from community activities, excluding hazardous, infectious and industrial wastes²². Due to the Act, local

government organizations in Chonburi Province (Pattaya City, municipalities and Subdistrict Administrative Organizations - SAO) have to provide waste collection services, waste disposal and treatment in their defined areas. In practice, without private sector engagement in MSWM, the local government organization does not have the authority to transport the MSW from their own areas to other provinces, meaning that they have to complete MSWM in their province boundary. With the option of private sector engagement, the MSW can be transferred from the original sources to disposal or recovery facilities outside of the provincial boundary.

The circular economy concept is applied to the SWM policies and plans in the Eastern Economic Corridor (EEC) areas (Chachoengsao, Chonburi and Rayong Provinces). The SWM plans consist of two phases: the years 2018-2021 for Phase 1

21 Under the Determining Plans and Decentralization to Local Government Organization Act B.E. 2542 (1999)

22 Pollution Control Department 1998. Guideline of Municipal Solid Waste Management

and the years 2022-2027 for Phase 2. Since “Zero Waste” is a purpose in Phase 1, the guideline provides the following steps²³ (GISDA, 2022):

- ▶ Improving the performance of waste management centres,
- ▶ Enhancing proper management of contaminated waste in the MSW,
- ▶ Increasing the number of waste management experts and officers and inviting specialists from academic institutes and the private sector to participate in the MSWM system,
- ▶ Investing in appropriate technologies for SWM and engaging with the private sector,
- ▶ Improving the environmental quality of marine and coastal resources,
- ▶ Providing management systems for hazardous and non-hazardous industrial wastes,
- ▶ Providing centres for collecting hazardous waste from the community and disposal facilities,
- ▶ Monitoring industrial facilities and factories to treat industrial waste according to the standards, and
- ▶ Implementing environmental pollution control and monitoring pollution sources based on the standards

Waste collection and transfer

In most Chonburi Province areas, bins with and without lids are provided at collection points whose locations are decided by waste generators. In some cases, if bins are not provided, the waste generators set up the collection points themselves, and waste collection workers commonly collect the waste from these undesignated points. In some municipalities, basic separation bins (recovery, general, organic and hazardous wastes) are also provided in non-household areas such as markets, schools, institutions, due to their

MSWM campaigns. The recoverable materials in the separation bins are generally collected by waste pickers and waste collection workers. Other separated wastes are disposed at disposal/recovery facilities. Act B.E. 2542 (1999) stipulates that local government organizations have to pay for the costs of waste collection services. With the budget limitations and number of workers in MSWM, waste collection services in Chonburi Province are carried out by three groups: (1) companies, (2) local government cooperating with a company, and (3) local government.

In high-income cities (e.g., Pattaya City), the collection services company is either under yearly or quarterly contracts with lump sum payments, and takes the responsibility to collect all MSW. In the case of Pattaya City, they also have clear responsibilities to collect the waste about 3-4 times/day in tourism zones and beaches and more frequently during special events. The companies are also responsible for transferring the waste to disposal or recovery facilities. Based on waste recovery policies and the Phase 1 of the SWM plan in place, MSW is collected at the transfer station in Pattaya area and transferred for RDF production at TPI Polence PCL in Saraburi Province. However, the collection services provided by companies have some disadvantages. For example, the collection routes, frequency, and defined zones are at the company’s own convenience without informing the local government. In some municipalities, selecting the disposal and recovery facilities can be freely decided by the companies. There are challenges with monitoring the control levels of facilities and waste flows in the case of transferring the waste to other provinces.

With regards to the second system of service provision - local government cooperating with a company (e.g., Laem Chabung City Municipality, Bang Sare Subdistrict Municipality, and Sam San SAO) - the local government mainly designs the collection zones, frequency and size of trucks based on the estimation of waste amount and worker experience. The collection services provided by the government are regularly operated. Companies help the local government by collecting MSW on narrow roads, around complex terrains

23 Ministry of Natural Resources and Environment (MNRE). (2019). Environmental Plan of Eastern Economic Corridor (EEC): the Year 2018–2021.

and in areas with high generation of waste where more frequent collection in a day or/and night-time is required.

The third system, where waste collection services are provided only by the local government, is the predominant system in Chonburi Province, especially in the middle- and small-size cities such as Saen Suk Sub-district Municipality and most SAO. The city size allows the local government organizations to be able to operate services regularly; for example, Saen Suk Sub-district Municipality provides daily collection within specific zones with suitable trucks based on the amount of waste generated. In rural areas, the residential areas and households are far away from each other; accordingly, the collection services are required to carry out pick up once every two/three days in the defined zones, considering locations and waste amount.

Waste recovery

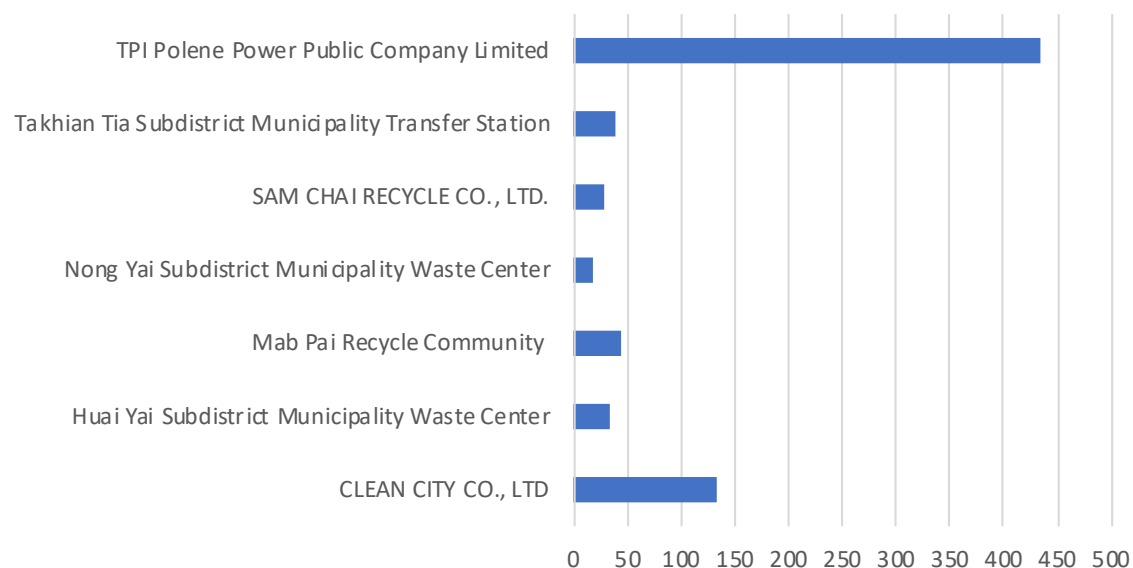
In Chonburi Province, the MSW collected through private and public waste collection services from 28 local governments, about 690 tonne/day of MSW, is primarily transferred to 6 recovery facilities. More specifically, Takhian Tia Subdistrict Municipality Transfer Station receives about 38 tonne/day of MSW from the Takhian Tia Subdistrict Municipality areas and transfers them to a recovery facility (Clean City Co., Ltd). The first step is to separate the large items, which are always residues or process rejects. At five facilities

(Clean City, Huai Yai, Mab Pai, Nong Yai and Sam Chai), the second step is to recycle plastic bottles, glasses, papers, metals, and others by workers. Then, organic wastes are separated from other materials by pre-shedders and trommel screens. The materials from three facilities (Clean City, Mab Pai, and Nong Yai) are then transferred to RDF process at TPI Polene Power PCL. Additionally, at Huai Yai Subdistrict Municipality Waste Centre, an air clarifier separates heavy and lightweight materials and then transfers them to end of chain recyclers in Rayong Province. The TPI Polene Power PCL proceeds with the RDF process.

The control levels of all facilities have been checked by using the WaCT guideline. It was found that only the end of chain recycler (TPI Polene Power PCL) manages waste in improved control level by considering effective process control by engineers and experts, pollution control compliance to environmental standards, health and safety regulations, weighing and recording of all incoming and outgoing trucks. On the other hand, other facilities are graded as limited control because of (1) no weighing and recording for outgoing materials is done, (2) no environmental pollution control in place, and (3) there is no protection for workers in terms of health and safety.

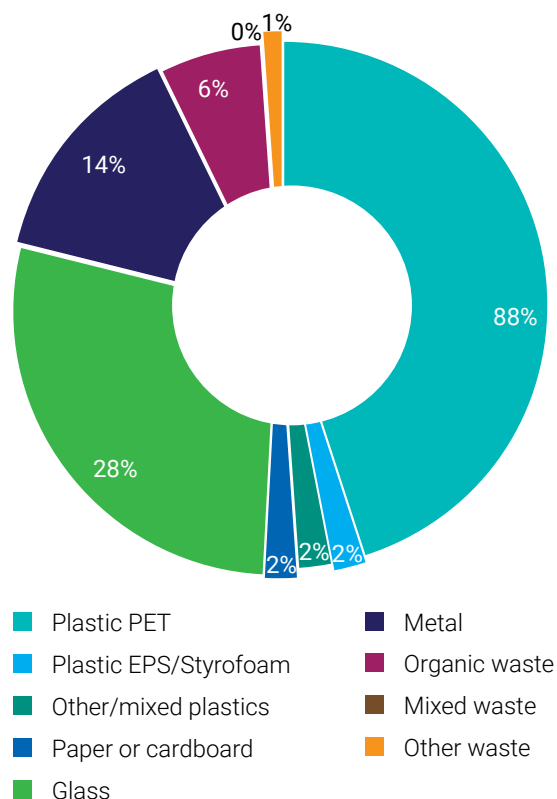
Because there is no recorded data of outgoing materials at the limited control level facilities, their recyclable materials were estimated by interviews. With recorded data and waste composition analysis from the TPI Polene Power PCL, the WaCT

Figure 47: Waste received at each recovery facility (tonne/day)



presents a breakdown of recovered materials in Figure 48. From all MSW received at facilities, mixed plastics represents about 45%, organic waste 28% and small percentages of metal, glass, and paper. Moreover, the WaCT estimates waste recovery potential of up to 1,276 tonne/day of organic waste and around 120-180 tonne/day for paper, plastic-film, plastic-dense and metal.

Figure 48: Breakdown of recovered materials in Chonburi Province



The table below presents the potential for further recovery of waste materials which are either uncollected or ending up in the landfill sites.

Table 21: Potential for waste recovery in Chonburi Province

Waste category	Potential by expanding waste collection services (t/d)
Paper and cardboard	157
Plastics	416
Metals	12
Organics	941

Approximately, 157 t/d of paper and cardboard and 416 t/d of plastic waste end up mostly in the landfill site. These relatively high amounts of materials in the landfill site represent an opportunity for the province to improve its recovery rate by investing in material recovery facilities for example, to divert the waste from landfill site.

Waste disposal

The waste collected from 65 municipalities and SAO areas is transferred to 23 disposal facilities in Chonburi and Chachoengsao Provinces. Laem Chabang City Municipality Landfill receives the highest MSW amount, approximately 800 tonne/day from Laem Chabang City Municipality (465 tonne/day), Chao Phraya Surasak City Municipality (282 tonne/day) and Ang Sila Town Municipality (51 tonne/day).

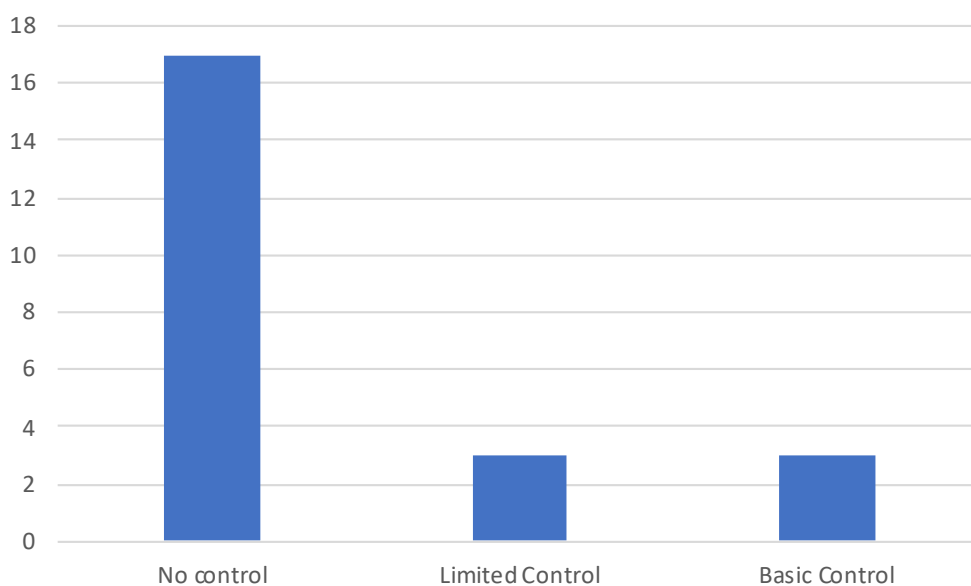
The second highest waste amount (321 tonne/day) is disposed at the Chawasingha Co., Ltd. dumpsite that collects MSW from 20 local government organizations in the northern Chonburi Province. The disposal site exceeds its designed capacity, but it is still receiving daily amounts of waste of over 300 tonne/day and having a height higher than 12 meters. Moreover, the disposal site is located in the middle of sugarcane fields. Considering the unstable slope, lack of worker’s health and safety protection, irregular weighing and recording, and no environmental control in terms of leachate, odours and contamination, the dumpsite is graded “no control”.

The Eastern Seaboard Industrial Estate Co., Ltd and Saen Suk Town Municipality Waste Centre are sanitary landfills in the “basic control” level and receive about 234 and 140 tonne/day of MSW, respectively. Over 100 tonne/day of MSW from Nong Prue areas, as residential areas for Pattaya City, are collected at Nong Prue Town Municipality Dumpsite. The dumpsite is managed in no control level, similar with 16 other dumpsites in Chonburi Province. Three disposal facilities (Laem Chabang City Municipality Landfill, Si Racha Town Municipality Landfill and Khet Udomsak Subdistrict Municipality Dumpsite) are operated in the limited control level and three disposal facilities (Eastern Seaboard Industrial Estate Co., Ltd, Saen Suk Town Municipality Landfill and Smart Grand Cooperation Co., Ltd (dumpsite) in the basic control level.

Table 22: Waste received by disposal facilities and the control level

Disposal Facility Name	Waste received (tonne/day)	Control Level
Private Own Waste Centre in Na Roek	19.5	No control
Bo Kwang Thong Subdistrict Municipality Dumpsite	4.4	No control
Bo Thong Subdistrict Administrative Organization Dumpsite	8.6	No control
Bo Thong Subdistrict Municipality Dumpsite	4.0	No control
Chawasingha CO. LTD	320.8	No control
Eastern Seaboard Industrial Estate CO., LTD	233.7	Basic Control
Pattaya Chai Thip LTD. (Eastern Seaboard Industrial Estate CO)	28.0	No data
Hua Kunchae Subdistrict Municipality Waste Centre	21.6	No control
Intana Construction CO., LTD.	8.5	No control
Kamnan Kriengsak Dumpsite (Chachoengsao Province)	5.2	No control
Khao Mai Kaeo Co, Ltd.	10.3	No control
Khet Udomsak Subdistrict Municipality Dumpsite	30.4	Limited Control
Ko Loi Bang Hak Subdistrict Administrative Organization Dumpsite	2.3	No control
Laem Chabang City Municipality Waste Centre	796.3	Limited Control
Mon Nang Subdistrict Municipality Dumpsite	15.4	No control
Nong Prue Town Municipality Dumpsite	104.9	No control
Nong Ree Subdistrict Administrative Organization Dumpsite	14.8	No control
Saen Suk Town Municipality Landfill	140.3	Basic Control
Samae San Subdistrict Administrative Organization Dumpsite	19.0	No control
Si Racha Town Municipality Landfill	35.7	Limited Control
Smart Grand Cooperation Co., Ltd	26.1	Basic Control
That Thong Subdistrict Municipality Waste Centre	2.9	No control
Bang Sare Subdistrict Municipality Dumpsite	26.0	No control

Figure 49: Control level of disposal facilities



Based on current MSWM in Chonburi Province, the identification of significant gaps is summarized in the following table. Since local governments always have short-term planning and strategies based on their yearly budgets so that MSWM systems are changed every year, long-term planning should be the first priority to carry out effective MSWM. Currently, the full capacity of disposal facilities is a key issue in Chonburi Province. Heavy mechanical and advanced technological equipment are requested for waste to energy processes, material recovery and waste disposal management at facilities.

Stakeholder workshop

The stakeholder’s workshop was held in January 2022. Due to the rapid increase of the Covid-19 cases at the beginning of 2022, the physical meeting changed to a virtual meeting via Zoom Platform. There were 71 registered participants in the workshop, belonging to 3 provincial offices, 2 regional offices, 25 local governments, 6 companies and 5 relevant organizations.

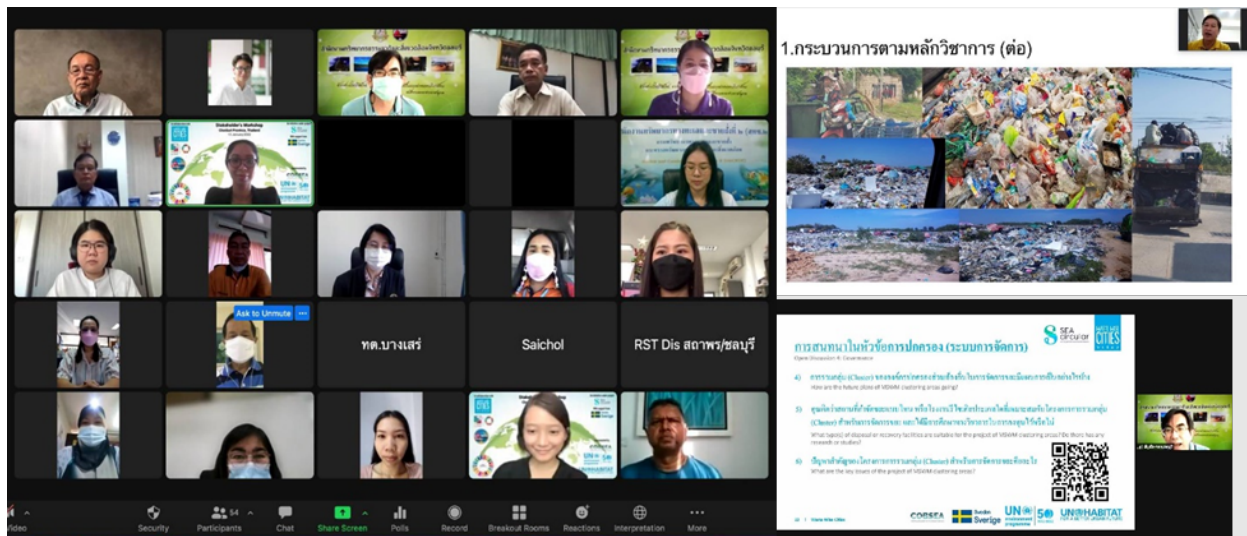
Table 23: Summary, classification and prioritisation of gaps in Chonburi Province

City/Country SWM stage	Chonburi, Thailand		Prioritization (1-high, 3-low)
	Policy / Legal	Infrastructure	
Separation at source			1
Waste collection coverage (incl. waste collection fees)			3
Waste transfer stations			2
Material recycling			1
Biological treatment (incl. waste to energy)			1
Waste disposal			1
Informal sector (incl. integration)			2
EPR (incl. similar policies)			2
SWM planning			1

Priority	
High	1
Medium	2
Low	3

Gaps	
Large	
Medium	
Low	

Figure 50: Stakeholder's Workshop, Chonburi Province



Waste Collection

Pattaya District has hired a private company to collect MSW in-land. Off-shore waste is managed by a separate entity and is not counted as part of in-land waste management flow. The contract includes collecting waste along public roads within and around the designated bin, including large items and covers large events in the city. Pattaya municipality deals with waste around the beach and also in private residential area (e.g., villages, condominiums, etc). During the high season, Pattaya municipality schedules more frequent rounds of trash collection to deal with the increase of waste along the beach. Each route takes the distance between each bin, the quantity of the bin, and opening hours of the business in the area into consideration for frequency of waste collection. After the waste collection process, the waste is transported to the collection station at Sukhumvit Phraya 3. The waste is unloaded onto the container and is transported to TPI Polene Power PCL.

Pattaya city will start this year to use separate waste bins around the beach areas. The recycle bin is separated into two sub-categories: glass and aluminium and collected waste will be weighed for further analysis. Waste in **Laem Chabang** is separated into two categories: MSW and industrial waste. MSW is managed by a private company except for 20 large size container bins that are managed by the municipality itself. Industrial waste is dealt with by private companies and charged to business owners directly. The MSW is

disposed at the Laem Chabang City Municipality Landfill. The waste collection area is divided into six zones. Some zones are hard to reach due to narrow alleys. A variety of sizes and types of trucks are used to transport waste in accordance with available access. The **Bo Kwang Thong Sub-district Municipality** owns 2 waste collection trucks but only operates one due to human resources limitations. The entire area is covered within 5 days, with 5 tonnes per day collected in average. Waste collection only operates on weekdays. The municipality has encouraged sorting at the source and separating organic waste in designated bins. This campaign has helped the problems of pollution at the dumpsite due to the absence of wet organic waste fraction. The municipality also has a project to encourage waste recycling which also generates income in the community. The municipality is looking for an area for the landfill at the moment as the current one will reach its capacity soon.

Waste Recovery

While recyclers think of waste as a valuable resource, local government organizations who manage upstream waste see it as an invaluable material. The local government organizations should have a sorting site in every community, as like the Bo Kwang Thong sub-district municipality case. Accordingly, it would be better to expand middle-scale recovery facilities in each community and allow the local community to be a part of waste management.

TPI Polene Power PCL processes 3 types of waste, including organic waste, landfill waste, and small or medium sizes recovered materials from traders. The company produces around 2,000 tonnes per day of organic waste, 5,000 tonnes per day of RDF-2 (course RDF), and 1,500 tonnes per day of RDF-3 (fluff RDF). The company usually faces the problem of mixed waste that has not been thoroughly sorted to meet the standard of each type. In general, the company does not deal with the government directly. The company is currently installing 6 more processing lines to meet the increasing targets of the upcoming SWM plan.

Waste Disposal

Since most disposal facilities are managed in no control level, this section shares the information from basic control Saen Suk Town Municipality and discusses the key issues the disposal facilities face.

The Saen Suk Town Municipality Landfill is located 20 km away from the Saen Suk Town Municipal Administration Zone. The solid waste is collected from Saensuk Municipal and Bang Phra SAO. The landfill is separated into four different zones with office administration, weighing building, water waste treatment facility, and five landfilling zones. The annual statistics of the municipality show that the volume of waste generated increased together with urbanisation. With regard to the environmental impact, there are three main issues to control: odours, a buffer zone with a fire prevention plan and leachate ponds. The current challenges are mostly related to the fact that the landfill has been used for a long period of time and reaching its maximum capacity. This leads to increased maintenance costs and manpower. Thus, landfill reclamation is the proposed solution to increase the void space and thus the lifespan of the landfill site.

The volume of solid waste disposal for Laem Chabang City Municipality is quite large and has been increasing constantly for about 100 to 200 tonne/day. The Laem Chabang is gradually growing in comparison to other municipalities. But if the Laem Chabang Port Development Project in Phases 3 and 4 will be operated, the waste generation might increase substantially. The management of the landfill is the responsibility of a private company. Since the Laem Chabang City Municipality has a lot of incoming waste but limited

machinery and workers, there is a plan to process RDF, managed by private company. Due to the royal property land, however, the private parties are not allowed to invest and need to seek approval from the treasury department in order to undertake private investment. It is a complex process, and the area is outside the municipality's jurisdiction, which means the need to seek approval from other municipalities to carry out any other activities.

Governance

The responsible agency for the cluster project (MSWM-Cluster) is the Ministry of Interior, while the Chonburi Provincial Office of Administrative Promotion acts as secretary and Chon Buri Provincial Office of Natural Resources and Environment provides recommendations and conducts research and data gathering from a technical standpoint. Since 2017 the Chonburi Province proposed to separate the local government organizations into five groups:

- ▶ Cluster 1: Sriracha District in authority of Sriracha City Municipality;
- ▶ Cluster 2: Bang Lamung District and Sattahip in authority of Pattaya City;
- ▶ Cluster 3: Mueang Chon Buri District managed by San Suek Town Municipality;
- ▶ Cluster 4: Ban Bueng District, Phan Thong District, Ko Chan District, Bo Thong District, Phanat
- ▶ Nikhom District, and Nong Yai District in authority of Ban Beung Municipality;
- ▶ Cluster 5: Ko Sichang District in authority of Ko Srichang Municipality.

However, they are facing the issue of area management because no one would like to provide areas for new disposal facility construction and there are complaints from their residents. Since 2021 Chonburi Province has suggested that a solution for improving SWM would be to turn disposal facilities into Waste-to-Energy plant. One solution would be to privatise the project, allowing the private sector to invest. Without financial support from government, one challenge for the private sector is how to ensure the long-term benefits of new recovery facility investment.

Nowadays, government regulations and directions are designed to support the Bio-Circular-Green Economic Model (BCG) and climate actions to achieve sustainable management. From this perspective, waste management has to be included in every sector/level, especially at the household level. The process and method of waste management should be adapted according to the context of each area within a community, using suitable technology and the strength of the local administrative organization in convincing the residents to separate the waste. Since the Ministry of Natural Resources and Environment would like to improve environmental quality, waste to energy is the best current option as the target is to get rid of waste, and this waste could be transformed into energy and other materials, e.g., road construction materials, bricks, etc. The private sector is aware as well that the government sector cannot invest. Thus, the waste amount should be guaranteed for their operation effectiveness.²⁴

Recommendations

Waste collection

Nowadays, few areas in Chonburi Province (Pattaya City, Saen Suk Town Municipality, Bang Sare Subdistrict Municipality, Klet Kaeo Subdistrict Municipality, Bo Kwang Thong Subdistrict Municipality, Nong Pla Lai Subdistrict Municipality, and Bang Phra sub-district) have developed awareness raising campaigns for waste separation and provided separation bins at schools, some markets, and institutions. To improve waste separation at source, local governments should provide bins not only to non-household premises but also to household premises. The importance of waste separation, waste composition information, and MSWM should also be shared with residents through simple materials (e.g., pamphlet with animation or cartoon style). Thus, everyone, including children, can easily understand the information.

Several local government organizations have not designed specific collection routes and frequency for the waste collection services, leaving this task to the collection crew. For example, the waste amount generated on Monday is always bigger than in other days. Without planning, the number of trips for waste collection could increase up to 2-3 times per day. This might increase the costs and result in ineffective management. In improving the performance of the waste collection system, firstly, the local government should make records of waste generated amount in each village or area. Then, crew size, vehicle types, collection frequency, and collection routes can be identified in each area based on waste generated data. Also, the designed collection routes should be followed six criteria: (1) beginning and ending near arterial streets, (2) starting the routes from the top of the grade and ending at the downhill, (3) collecting the waste as early in the day at traffic-congested areas, (4) collecting at the first part of the day for large quantities, (5) identifying regular collection frequency for small quantities such as once collection in two days, and (6) using specific vehicles at each route²⁵. A route optimization study could be conducted to improve the overall efficiency in the collection system and to reduce operation costs per tonne of waste collected.

Waste recovery

The recovery facilities in Chonburi Province are mostly managed in a limited control level. The gaps consist of lack of environmental control, protection of workers' health and safety, recording. Additionally, health and safety for protecting workers should be prior enhanced through: (1) supporting PPE, (2) providing yearly health check-up, (3) arranging appropriate places for hand washing and showering, (4) organizing zones for heavy machine equipment, and (5) informing all workers to recognise dangerous zones and safe zones in the facilities.

²⁴ Mr. Aweera Pakamat, General Director of Regional Environment Office 13, Ministry of Natural Resources and Environment

²⁵ Kreith and Tchobanoglous, 2002

The second improvement should be environmental control. At all recovery facilities in Chonburi Province, the collected waste is temporary put in the open areas before the recovery process. During the rainy season, a large amount of waste generates leachate, contaminating land, groundwater and canals. Building of roofs or/ and additional material cover on the land with engineered drainage systems are required to protect the infiltration and leakages. Moreover, schedules of regular cleanliness and maintenance for heavy machinery equipment should be set up.

Thirdly, the amount of waste received is usually recorded at the facilities due to data requirements from the local government. However, the weighing of outgoing materials is ignored. With consideration of control level in the WaCT guideline, the measurement of process inputs and outputs through weighing is significant not only to evaluate recovery rate and process performance, but also to analyse the costs and benefits. Therefore, this issue could be enhanced by weighing and recording both incoming and outgoing materials.

Waste disposal

As mentioned above in Figure 50, about 17 disposal facilities are managed in no control level. Some of the issues are similar to the recovery facilities, which have no provisions of PPEs, worker's health and safety, no weighing and records, and lack of environmental pollution control. From the field surveys, about 70% of disposal facilities do not have the recorded data of waste received due to the unavailability of weighbridges at their sites. Thus, they usually estimate the waste amount by vehicle capacity, number of trips and waste density. Exceptionally, there is a weighbridge at a dumpsite (Chawasingha Co., Ltd.), but regularly weighing and recording are not carried out. Without any recorded data, the lifespan of the disposal facilities cannot be determined and thus impacting the long-term planning and strategies, including closure plans. If no weighbridges can be provided, an interim solution would be an integrated database where the number of trips, payload and capacity of each truck is recorded and reported into an integrated system for monitoring purposes.

Environmental pollution control is another critical issue for the dumpsites in Chonburi Province. Firstly, waste is not layered and compacted promptly. Most of the facilities have monthly/quarterly/yearly schedules for waste covering and compacting depending on their budgets. The impact of odours is concerning and very often the residents complain; accordingly, the effective microorganisms (EM) solution is always used to decompose organic waste and to reduce the strong smell at the dumpsites. Moreover, contamination of groundwater and river flows from leachate could occur at many facilities considering their design, maintenance, and operation. From the interviews, overflow of leachate always occurs during heavy rain at limited control landfills. Protection of leachate leakage is challenging according to the current conditions of most facilities as most facilities do not have a leachate treatment system. In the absence of such treatment plans, a possible and practical solution is to pump leachate into tanks and transport it to other treatment plants.

In summary, critical problems have been mentioned for the improvement of SWM at disposal facilities. Therefore, the infrastructure such as weighbridge and heavy machine equipment (such as excavators) is required for all uncontrolled level facilities.

Governance

Some local government organizations have contracts with private sector/companies for waste collection and disposal services. However, a proper monitoring and supervision system is missing. The Department of Local Administration provides a database system (URL: waste.dla.go.th) for receiving MSWM information and waste collected amount from local government. However, local government staffs tasked with data reporting into the system are not trained and most often the data reported is not checked for errors. Therefore, trainings and data validation systems for each local government organization are recommended.

The MSWM-Cluster project, in which the local governments in Chonburi Province were grouped into five SWM clusters, has been conducted since

26 Chonburi Province, 2021

27 Bangkok Business News, 2022

February 2017 in order to improve the system²⁶. In January 2022, Cluster 2 of MSWM-Cluster project, combining 22 local government organizations in Sriracha, Bang Lamung, and Sattahip Districts, planned to construct an incineration plant with 29.7 megawatts of electric power generation. It is planned to start the operation in January 2027²⁷. Other Clusters are still under discussion because of the political challenges between some municipalities/SAO and agreements from residents. Other types of facilities (Landfill, dumpsite, incineration with energy, recovery facilities) are also under consideration.

According to the plan for Cluster 2, further research should be conducted in the next step on the locations of transfer stations and collection points, environmental impact assessment, cost and benefit analysis, and sustainable waste management planning. With regards to other clusters, preliminary study for various facility types is recommended to be conducted to identify the best solutions from a range of technologies. The results of waste generation and waste composition obtain through the WaCT could contribute to these further studies.

2.7. Seremban/Malaysia

The kick-off meeting was held online in October 2021, chaired by YB Teo Kok Seng, Member of Negeri Sembilan State Executive Council. It was attended by various stakeholders including Negeri Sembilan State Office, Seremban Municipal Council and Solid Waste Corporation (SWCORP) with 15 participants overall. The main scope of the kick-off meeting was to better understand the current

SWM system in Seremban, issues and challenges and to discuss next steps in the implementation of the WaCT and WFD surveys.

Main findings from this meeting are listed below:

- ▶ Seremban Municipality consists of 2 main cities: Seremban and Nilai, the latter being newly added in 2020;
- ▶ The whole of Negeri Sembilan State is under Solid Waste and Public Cleansing Management Act 672; therefore SWM related services in Seremban Municipality are monitored by SWCORP.
- ▶ SWCORP oversees the waste collection services provided by the appointed concessionaire called SWM Environment Sdn Bhd and also the landfill operation by the contractor Cypark Smart Technology Sdn Bhd.
- ▶ The recyclable waste collection is done once a week by SWM Environment in all residential areas under a Separation At Source (SAS) programme using open tipper trucks.
- ▶ Industries and private commercial buildings manage their own wastes by appointing private contractors which are licensed under SWCORP.

WaCT and WFD Survey Results

Seremban is the capital city of Negeri Sembilan which is administered by Seremban City Council. Seremban gained its city status on 20 January 2020. The total area of Seremban is 959 km² and has a total population of 630,000 inhabitants in

Figure 51: Screenshot of the kick-off workshop in Seremban



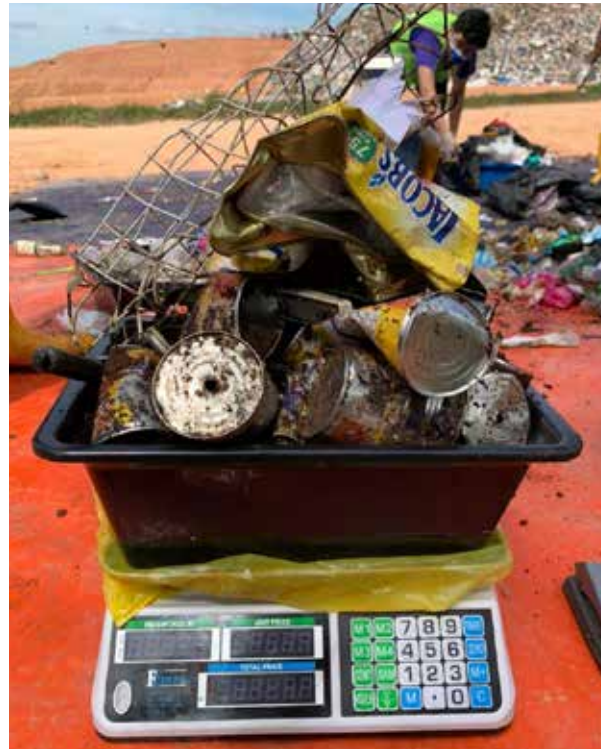
2020²⁸. The population density is 638 people per km². The total number of residential units under Seremban City Council is 224,937²⁹. Seremban is the business and commercial centre for most towns and villages in Negeri Sembilan. The manufacturing sector is the backbone of the economy, contributing to almost half of the Gross Domestic Product (GDP), followed by tourism, agriculture and construction.

The waste composition survey for households and disposal site were carried out in October 2021. For the household survey, plastic bags were distributed to the identified high, medium and low-income households which were differentiated by colour i.e. black for high income, blue for middle income and green for low income in order to ease the sorting at the disposal site.

Figure 52: Waste bags collection and sorting process



Figure 53: Household waste generation and composition analysis in Seremban



High income households have the highest waste generation rate per capita, 0.61 kg/capita/day, compared to middle- and low-income households which generate 0.53 and 0.59 kg/person/day, respectively. The average waste generation rate is 0.574 kg/capita/day. Total waste generated is 556 tonnes/day, out of which 70% comes from household sources.

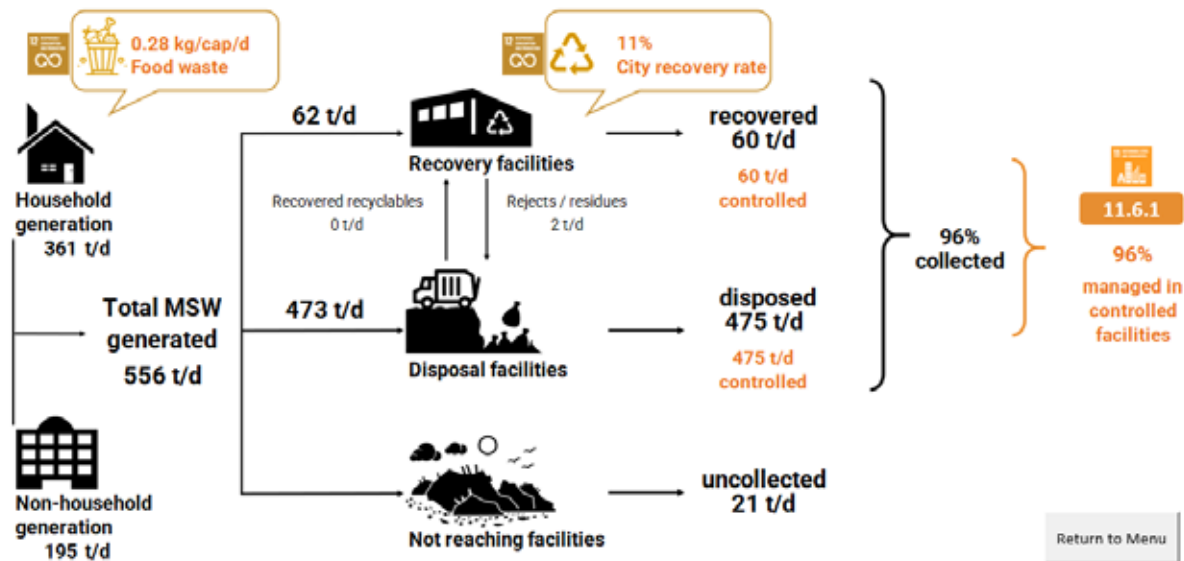
Table 24: Key WaCT and WFD Data in Seremban

Income group	High income	Middle income	Low income
Waste generation rate (kg/capita/day)	0.61	0.53	0.59
Total population	118,440	246,330	265,230
Total MSW generated from household(t/day)	73	132	157
Total MSW generated from non-household sources (t/day)			195
Total MSW generated (t/day)			556
City Plastic Leakage into water bodies (kg/person/year)			1.4

28 Department of Statistics Malaysia

29 SW CORP

Figure 54: WaCT flow chart results in Seremban



Total MSW generated is 556t/d, comprised from 361t/d from household sources and 195t/d from non-household sources. Out of this, 473 tonnes are being disposed of in a controlled landfill, 62 tonnes are being recovered and 21 are uncollected. The City’s waste recovery rate is 11%. The recovery rate is expected to be higher than reported in this study. This is due to the lack of willingness of the private sector to share data. The uncollected waste is mainly illegally dumped.

The source of plastic leakage in Seremban is the uncollected waste. Some leakages are also

reported from the formal sector sorting and from the collection system. There are no leakages registered from the disposal site. The unmanaged plastic ends up on land and water followed by air emissions through burning and drains.

The household and disposal site waste composition analyses were complemented by a further analysis of the plastic waste. As the WaCT suggests a breakdown of plastic waste on two types, plastic dense and plastic films, a further disaggregation was conducted to understand the type of plastic applications in the MSW.

Figure 55: WFD results in Seremban (tonnes per year)

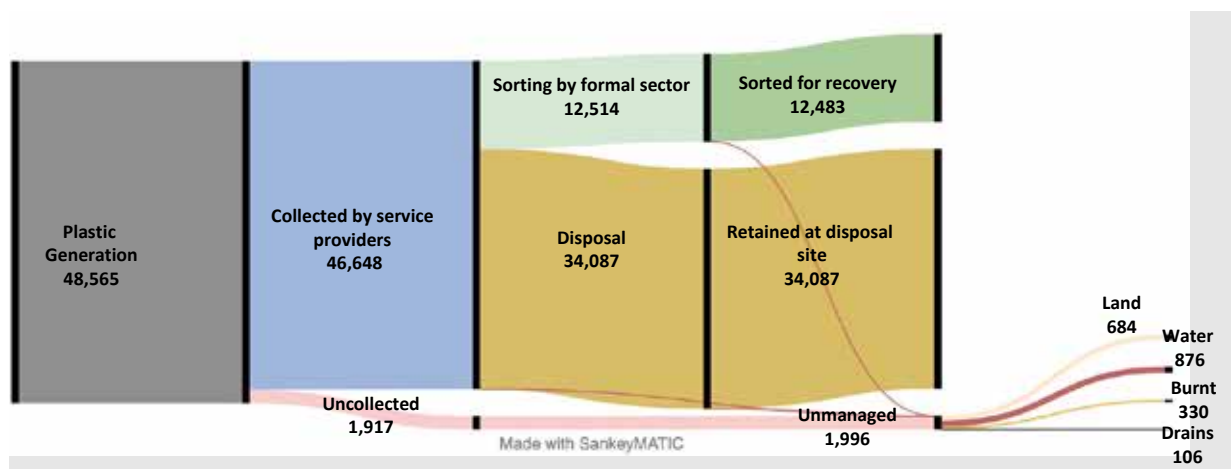
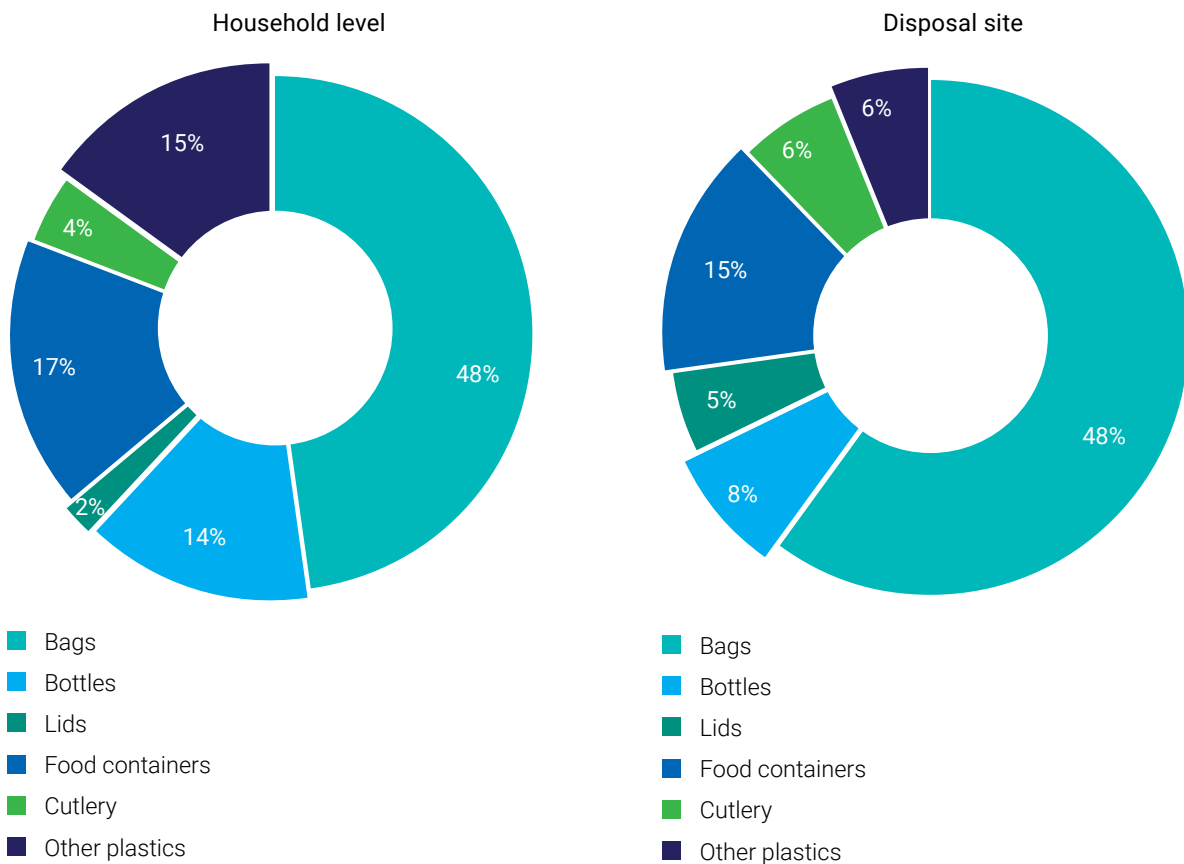


Figure 56: Plastic waste composition in Seremban



The results show that the most predominant plastic application is represented by plastic bags, followed by food containers.

Policy and Infrastructure Gaps Analysis

The Solid Waste and Public Cleansing Management Act 672 has been adopted in Seremban and the whole of Negeri Sembilan since year 2011. With this Act, SWM - including bins provision, waste collection, recycling, treatment and disposal - are under the jurisdiction of the National Solid Waste Management Department (NSWMD) under the Ministry of Housing and Local Government. Monitoring and supervision of the operation on the ground is carried out by SWCORP. The waste collection and bins provision at residential, commercial premises, government offices and schools are carried out by the appointed waste concessionaire which is SWM Environment Sdn Bhd. In industrial areas and privately owned commercial buildings, the waste is collected

by private contractors appointed directly by the building owners. They also purchase their own bins. The appointed private contractors must be registered with the i-Lesen system which is managed by NSWMD. The contractors can register online at <https://ilesen.swcorp.my>. Once approved, NSWMD will send the license to the contractor.

Waste collection and transfer

Waste collection from households, commercial premises and government institutions are collected by SWM Environment Sdn Bhd based on agreed schedule with SWCORP. The collection frequency and type of collection trucks are in accordance with the signed Concession Agreement (CA). For mixed MSW, a compactor truck is used whilst for garden, bulky waste and recyclables, the company uses open tipper. As part of the CA requirements, SWM Environment Sdn Bhd provided Mobile Garbage Bin (MGB) to each landed house and shophouse and central bins for high-rise residential buildings.

Figure 57: Four-wheel bins with 660 liters/1100 liters capacity and waste compactor truck



The waste is collected and transported by compactor trucks to the landfill at Ladang Tanah Merah in Port Dickson, which is about 40 minutes travelling time one way. The frequency of collection is in accordance with the CA signed by the concessionaire, SWM Environment Sdn Bhd. The payment is based on agreed rate as stated in the CA which is paid monthly in the following month by NSWMD after the invoice is being verified by SWCORP. The total payment is calculated based on the rate per premise multiplied by the total number of units served. Different rate is applied for landed and non-landed residential and commercial premises. The budget for waste collection comes from NSWMD (from the federal government) and mostly from Seremban Municipality. For residential and commercial units serviced by SWM Environment Sdn Bhd under the privatization scheme, the premise owner does not have to pay for the collection service since they have paid an assessment fee to Seremban Municipality. This assessment fee is paid annually to Seremban Municipality for all municipal services including waste collection and disposal. For private industries and commercial buildings, they have to pay directly to their appointed private waste contractors for waste collection and final disposal.

The existing challenges consists of a lack of public participation in source separation which results in very low quantity of recyclables recovered from the system, the existence of many hotspots of illegal dumping which require regular collection and incur higher costs, and the difficulty to obtain

Figure 58: Compactor truck for collection of mixed municipal waste



waste and recyclables data from industries or commercial entities.

Figure 59: Regular illegal dumping spots in residential areas



Waste recovery

Under the solid waste privatization, SAS is one of the main activities to be carried out and promoted to the public. SAS is compulsory under the Act 672 but currently not fully enforced. Residents separate the recyclables from other non-recyclables wastes, put the mixed recyclables in plastic bags and place it beside the mixed waste bin outside their house. The recyclables are collected for free once a week by SWM Environment Sdn Bhd based on the schedule agreed by SWCORP. For this collection, no incentive is given to the public. The

collected recyclables will be transported to SWM Environment Sdn Bhd's Drop Off Point at Bukit Palong near Port Dickson. Recyclables are sorted here into various types such as paper, plastics and metal before selling it to recyclers. Among the recyclables collected are plastic bottles, plastic containers and various types of paper including cardboards and books. Most of the items are low value because the high value recyclables are being sorted and sold to private recyclers.

Figure 60: Residents place the mixed recyclables in plastic bags



Figure 61: Drop-Off Centre at Bukit Palong for recyclables collected from SAS programme



There are also private recycling centres where public and private collectors can sell their recyclables. Below is an example of a private recycler who sorts the recyclables by type and stores it in large roll on roll off containers prior to selling them to recycling factories.

Figure 62: An example of a Recycling Centre operated by a private collector



Plastic waste recovery

Fizlestari Plastic Sdn Bhd. (FBSB) is one of the largest and most established recycled plastic pellet manufacturers in Nilai, Negeri Sembilan which specializes in manufacturing HDPE flakes, HDPE pellets and PP pellets from 100% post-consumer recycled (PCR) content. FBSB purchased the plastic wastes from waste collectors in bulk.

There are several recycling centres for paper. However, not many were willing and open to cooperate. Below is the photo of a recycling centre owned by N9 Fibre Sdn Bhd which is located in Jalan Industri Galla 12, Galla Industrial Park, Taman Mutiara Galla, Seremban. The company receives old newspaper, magazines, mix paper

Figure 63: Plastic wastes accepted by Fizlestari for processing into pellets



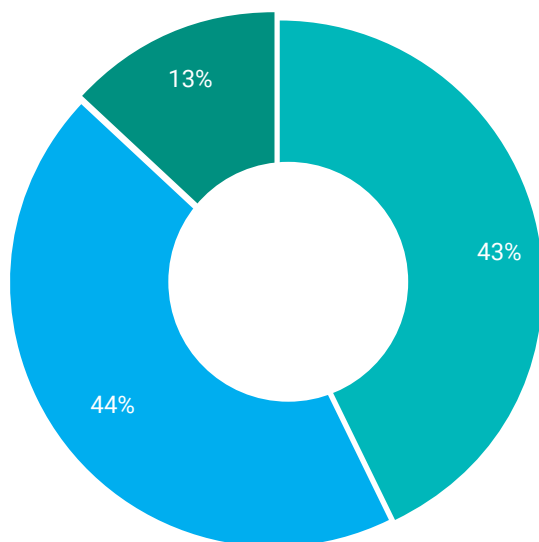
and cardboard products. N9 Fibre Sdn Bhd only accepts paper from collectors or bulk seller. The paper is then baled and sold to paper factories.

Figure 64: Paper wastes are baled at the site prior to selling to recycling factory



The figure below shows the recovered materials in Seremban. 44% is paper and cardboard, PET is 13%, and 43% is plastic LDPE and Films. There are no recovery activities going on for organic waste. Data for metal recovery could not be obtained.

Figure 65: Breakdown of recovered materials in Seremban



- Plastic PET
- Plastic LDPE & films
- Paper or cardboard

The below table summarises the potential amount of recoverable waste in Seremban. A high quantity of plastic film is observed. This is due to the little to no value of this type of plastic. Organic waste contributes the highest amount with 179t/d.

Table 25: Potential for waste recovery in Seremban

Waste category	Uncollected waste (t/d)	Waste in the disposal site (t/d)
Paper and cardboard	1.2	31.1
Plastic film	1.9	67.2
Plastic dense	1.4	26.2
Metals	0.3	6.3
Glass	0.4	4.3
Organics	12.1	265.4

Waste disposal

Solid waste collected from Seremban municipality areas are transported directly to Ladang Tanah Merah Sanitary Landfill for final disposal. The landfill is situated nearby Kualiti Alam Sdn Bhd which is the treatment facility (incineration, recycling, secured landfill) for industrial toxic and hazardous waste. It is located about 40 km from

Figure 66: Landfill entrance, weighbridge and active tipping areas



Table 26: Basic level of control area met by the disposal site in Seremban

Assessment areas	Questions	Seremban (Yes/No)
Security	Is there boundary and access control allowing single point of supervised access	Yes
Water control	Is there any perimeter drainage maintained around the site	Yes
Slope stabilization	Are the slopes stabilized, mitigating risk of landslide	Yes
Waste handling, compaction and cover	Are waste trucks directed to a specific operational area of disposal	Yes
	Is there heavy mechanical equipment reliably available	Yes
	Is waste layered and compacted within the specific operational area	Yes
	Is there some use of cover material	Yes
Fire control	Is there zero evidence of burning of waste on the surface of the landfill	Yes
Staffing	Are staff on site during operational hours	Yes
Records	Is there a functional weighbridge in use	Yes
EHS	Are there toilets and hand washing stations	Yes
	Are basic personal protective equipment in use	Yes
Other	Is there a site drawing showing the landfill boundary and filling area	Yes

Seremban city. This is the only approved sanitary landfill for Seremban waste disposal. It is a sanitary landfill with proper control equipped with security facilities, weighbridges, and heavy machinery for waste levelling, daily cover and leachate treatment plant.

The prioritization is made taking into account the complexity of the intervention, the capacity of the government to implement it and the urgency of the problem taking into account public health and environmental impacts.

Table 27: Summary, classification and prioritization of gaps in Seremban

City/Country	Seremban, Malaysia		Prioritization	Priority
SWM stage	Policy / Legal	Infrastructure	(1-high, 3-low)	
Separation at source			1	High 1 Medium 2 Low 3
Waste collection coverage (incl. waste collection fees)			1	
Waste transfer stations			3	
Material recycling			1	Gaps Large Medium Low
Biological treatment (incl. waste to energy)			1	
Waste disposal			3	
Informal sector (incl. integration)			1	
EPR (incl. similar policies)			2	
SWM planning			1	

Stakeholder workshop

The stakeholder workshop was held in December 2021 at Klana Resort Hotel, Seremban. The workshop was held in hybrid mode (online & offline). There were a total of 25 participants attending the workshop physically and 15 online participants, via Zoom.

Figure 67: Screenshot of the participants to the stakeholder workshop in Seremban



The key discussions that took place at the stakeholder workshop revolved around the topics of separation at source and its effectiveness, how to minimise single use plastic, how to propose and enforce illegal dumping mitigation measures, public

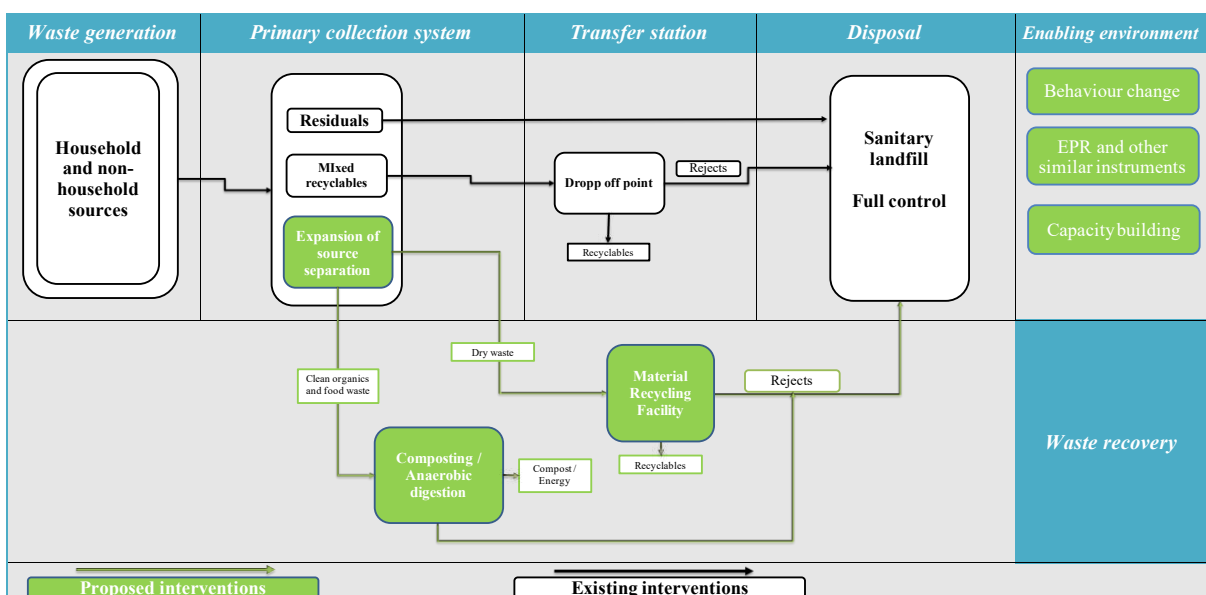
awareness and training, EPR implementation, effective technology to treat organic waste and available facilities for mechanical waste segregation. The solutions that were proposed to mitigate some of the SWM system problems and improve its functionality were the following: to fully enforce separation at source at all levels of society; focus on MRF development; focus on organic waste separation and treatment; carry out intensive and consistent public awareness campaigns; introduce an EPR system for single use plastic minimisation and increased recovery rate; and, finally, to put into place control measures for illegal dumping.

Recommendations

The major gaps identified in Seremban which would require an immediate action include the following:

- ▶ Public awareness and willingness to separate recyclables at source
- ▶ Proper Material Recovery Facilities for waste sorting
- ▶ Centralised waste database for all type of premises including industries, commercial, institutional and residential and also key players i.e waste collectors, recyclers and waste facilities operators

Figure 68: Opportunities for improving the SWM system in Seremban



- ▶ Illegal dumping root cause investigation and mitigation measures
- ▶ Industries waste management system

Waste collection

In order to improve the waste collection services, interventions should focus on enforcing the separation at source, both at household and non-household level, and to minimize the illegal dumping. An action plan could be established to monitor the illegal dumpsites, to identify the root cause and mitigation measures to reduce the number of hotspots. For non-household premises, one measure could consist of requesting entities to produce a proof of proper waste management for business license renewal. Primary collection enhancement of recyclables can be achieved through providing dedicated recycling trucks for each separated waste stream. Systematic collection of recyclables from commercial and industrial premises should also be established. For the household waste, a separate collection system must be established for high rise buildings (apartments) as there is no proper system in place to collect source separated waste. The participation from the public is low and it can be enhanced through behaviour change campaigns especially for high rise residential buildings. For organic and food waste, a separate collection system could be established at household level as well in restaurants, hotels and other non-household premises. Clean organic and food waste could be supplied to specialized facilities for treatment. Some initiatives took place in the past, but these were done on pilot levels and never scaled up.

Waste recovery

The recovery rates could be aligned to the national targets of 40% by year 2025 as mentioned in the 12th Malaysia Plan. As reported by SWCORP, in 2020, Malaysia recorded a recycling rate of 30.67%, exceeding the target of 30% set for that year. There is not EPR system in place and such system in place could contribute to the target. Waste recovery facilities need to be improved and coordinated with the existing operators. The waste operators need to have a platform such as a committee for better coordination and to discuss improvements and support required from the government and private agencies. A centralised database is also important in order to record all recovered materials and identify further improvements to capture the potential recyclables. A centralized clean MRF could be established to separate the mixed recyclables into specific material streams and then supplied into the value chains. Organic waste recovery is an area to be improved since organic waste consists of almost 50% of total waste composition. The priority shall be given to easily separated organic waste such as garden waste, food waste from restaurants, hotels, food courts and wet market. The clean organic waste could be supplied to composting or anaerobic digestion facilities to produce compost or energy.

Waste disposal

The existing waste disposal site already has sufficient control. Regular environmental monitoring reports are already in place as it is a requirement under the Department of Environment. The landfill was commissions in 2015 with an estimated lifespan of 20 years.



3.

Conclusion

The WaCT survey conducted in 2021 in the six cities included in this study revealed that the MSW generation rate varies from 0.64 kg per capita per day in Hoi-An (Viet Nam), 0.88 kg per capita per day in Seremban (Malaysia), 1.2 kg per capita per day in Chonburi (Thailand) and up to 1.75 kg per capita per day in touristic cities such as Sihanoukville (Cambodia). Those are higher than the estimate made by World Bank's What a Waste's waste generation rates of those countries, except Malaysia.

In terms of the plastic waste composition in the MSW, the highest share of plastic waste is reported in Sihanoukville (Cambodia) with 23%, followed by Tam Ky (Viet Nam) with 21% and 19% in Kep (Cambodia). The remaining cities, Hoi-An (Viet Nam), Seremban (Malaysia) and Chonburi (Thailand) reported shares of 17% 16% and 15% respectively. The plastic waste composition observed in this study is all much higher than the regional estimate of plastic composition in the What a Waste 2.0 report, which is 12%. The plastic composition observed in low-income areas in Tam Ky (Viet Nam) and Chonburi (Thailand) was as high as 25% and 26% with prominent consumption of plastic films. This indicates the plastic consumption in the region is increasing and probably much higher than conventionally considered.

The cities in Malaysia, Thailand and Viet Nam reported high MSW collection rates (>94%) whilst the two cities in Cambodia, Kep and Sihanoukville, reported 58% and 90% respectively. This indicates the capacity in waste collection in Cambodia is slightly lower than other countries, especially in small towns. However, it can be said that the region is showing relatively high performance in waste collection coverage, leaving small amount of waste uncollected.

Although cities are managing to collect MSW and transport it to transfer stations, recovery facilities or disposal facilities, but reaching basic level of environmental control of those facilities is still difficult. The proportion of MSW managed in controlled facilities in Tam Ky (Viet Nam), Kep (Cambodia) and Sihanoukville (Cambodia) are all 0%. It is 37% in Chonburi (Thailand). Hoi-An (Viet Nam)'s value on controlled management is 98%, but it should be noted that Hoi-An is using

provincial landfill site located far from the city, due to the closure of dumpsite being used before. Hoi-An city's plan is to stop using the provincial landfill site by introducing Waste to Energy plant, for which the municipality do not have a feasibility study. This means that many cities still mainly relying on open dumpsites.

The waste recovery system requires large infrastructural investments, most often in centralized facilities to achieve economies of scales. This is reflected in Hoi-An and Chonburi which reported a high recovery rate of 35% and 26% respectively. The remaining cities have relatively low recovery rates ranging from 1% to 11% which could be increased with infrastructural investments in separation at source and separate waste collection systems, MRFs and organic waste treatment, combined with policy strengthening and behaviour change measures.

Overall, it can be said that the region is currently in the transition to the full-fledged integrated waste management system, where efforts to collect waste is being fruitful while reaching basic level of environmental control of waste management facilities is still a challenge. In less developed country such as Cambodia, the waste collection is still a challenge particularly in small towns where waste management investments cannot be easily made.

The fact that the region is in the transition phase to the full-fledged integrated waste management system is also reflected in the plastic leakage into the water systems observed as results of WFD. High plastic leakage into the water systems were observed in Kep (6.8 kg/capita/year) followed by Chonburi (5.5 kg/capita/year). The results obtained in the remaining cities range from 0.1 to 1.4 kg/capita/year indicating that the relatively lower plastic leakage. The reason why Chonburi recorded high plastic leakage is due to the low level of control of landfill site as well as exposure to storm events.

In the stakeholders' workshops held in cities, strong appetite to introduce Waste to Energy plants were observed in some cities. However, it should be noted governments should conduct thorough feasibility studies to check the technical, financial, economic and social and environmental viability

of the proposed investments before embarking on certain solutions for the MSW. Advanced waste solutions such as Waste to Energy come with very high operational expenditure which need to be sustained by local government over long time. The affordability of such investments must be checked before pursuing such pathways. Smaller scale, modular solutions and with more positive environmental impacts such as material recovery facilities, organic and food waste treatment solutions combined with education and behaviour change measures and legal and financial incentives allow more flexibility for cities in improving their municipal solid waste management systems.

Through the study, it was proved that WaCT and WFD applications are found to be useful and practical to understand the current status of MSW and plastic leakage points and identify policy intervention and infrastructure investment gaps. A robust data management system can provide each city with key waste management data which can support governments in making evidence-based decisions. Routine waste data monitoring management using WaCT and WFD and action planning based on the reliable data is proven to be one of the essential actions in order to prevent and tackle marine litter and plastic pollution in the region.



SEA
circular
solving plastic pollution at source