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Project – IUC: Sustainable and innovative cities and region

Sub-project – Baseline study for solid waste management in Gangtok

Deliverable – Final report

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1 Executive summary

This chapter is the executive summary of the baseline study and briefly discusses the assignment background; existing status of solid waste management, including plastic waste management, in Gangtok; learnings from international and national best practices; conclusion; and the way forward.

Assignment background

Preparation of study and problem statement: The baseline study for the solid waste management (SWM) project has been commissioned as part of the IUC-India program. The study is the key deliverable of the Urban Cooperation Local Action Plan for the city of Gangtok. The report has been prepared by Sundarajan Subramony (JNKE, IUC), based on secondary research, stakeholder consultations, case studies, etc. The objective of the assignment is to provide baseline information for SWM and plastic waste management (PWM) in Gangtok, by analyzing the current status of SWM, PWM and waste treatment and disposal facilities in Gangtok and identifying best practices in the PWM domain being followed by various international and national cities. This study may later form the basis for a detailed feasibility study.

Methodology employed: The baseline study was conceived during the discussion of various stakeholders involved in this strategic collaboration. The study aims to provide a detailed analysis on the existing SWM and PWM scenario in the city of Gangtok while also clearly laying out the way forward for streamlining and upgrading the SWM value chain, including PWM in the city. The study is based on: a) secondary research through reports shared by the IUC-India team, web search and case studies on PWM and plastic waste recycling and treatment facilities in Austria, Denmark, Slovenia and India; and b) stakeholder consultations with officials of the Gangtok Municipal Corporation (GMC) and the IUC-India.

Existing status of SWM in Gangtok

About Gangtok: Gangtok is the capital city of the state of Sikkim in North East India and is situated at a height of 5,410 feet above sea level. The city is spread over an area of 19 sq. km and had a population of 100,286 as per the 2011 census. The population of Gangtok was 169,739 as of 2018[1]. Apart from the resident population, the city has a large influx of tourists and results in a floating population of 30,000-40,000 people per day during the tourist season (September to mid-December and March to May). The city has 17 wards. The GMC is the main administrative body for Gangtok, under which various departments function for operation and maintenance of urban services.

Solid waste collection and transportation: Gangtok generates 50 tonnes of waste per day. As of 2019, 55% of the waste generated in Gangtok, was segregated, including both segregation at source and that at the landfill site. Collection of waste in Gangtok is primarily managed by GMC. Currently 88% of the waste generated (44 tonnes) in the city is being collected on a door-to-door basis. Every morning, the waste collection trucks of GMC, equipped with a driver and a khalasi (waste collector), ply through the assigned waste collection routes and ring a bell upon reaching the assigned area, to announce their arrival. On hearing the bell, residents come out of their houses and hand over the waste to the khalasi who load it onto the trucks. Additionally, backpackers employed by local co-operative societies and non-governmental organizations (NGOs) manually collect the waste from the inaccessible and high altitude areas, and bring it to a point where the waste collection trucks can pick it up. The waste collection trucks then carry the waste to the landfill site and compost plant located at Martam, 20 km away from Gangtok.

Solid waste disposal and treatment: Of the 44 tonne per day (TPD) of solid waste collected in Gangtok, only 5 TPD is processed in a 50 TPD capacity compost plant at Martam (not currently operating to its full capacity).

[1] *https://indiapopulation2019.com/*

The remaining 39 TPD waste is disposed at the landfill site. The landfill site was originally constructed only for Gangtok but now receives waste from various gram panchayats and other cities in the state. This, combined with other issues such as the site receiving unsegregated waste, has drastically reduced the lifespan of the landfill. Additionally, of the 4.2 hectare of the land at Martam, the area of the landfill site is just 1 hectare, due to constraints posed by hilly terrain and the Ranikhola river flowing nearby. The landfill site is not being operated scientifically with odors emanating and problems of water accumulation and stagnation.

Plastic waste management: Segregation of plastic waste is the main challenge in Gangtok wherein a certain portion of plastic waste is segregated by safai karamcharis (cleaning staff) at source and a certain portion is segregated by waste pickers at the landfill site. The remaining unsegregated plastic waste is dumped at the landfill site. The plastic waste that is segregated at the landfill site is sent to a recycling plant in West Bengal and is also handed over to the National Highway Infrastructure and Development Company Ltd (NHIDCL) for road construction. Gangtok does not have a recycling plant or energy recovery facility of its own. Another major challenge that Gangtok faces is imposing the plastic ban effectively in the city. Though the state of Sikkim has banned the use of single-use plastics, however multi-use plastics are still in circulation. In spite of the ban, items delivered by e-commerce websites come wrapped in plastic packaging, whereas television sets and other electronic items come wrapped in Styrofoam packaging, both of which are a menace for Gangtok. Also, it is quite challenging to impose the single-use plastic ban on tourists who cause littering by plastic waste.

Effect of climate change on SWM activities and vice versa: Gangtok faces various climatic changes such as increase in temperature, heavy rainfall, glacial melting, drying up of springs etc. and is highly prone to landslides, earthquakes and forest fires. All of these climatic changes, pose several challenges to solid and plastic waste collection, transportation, treatment, disposal at landfill and other SWM activities in Gangtok. Additionally, many a times uncollected waste is openly burnt in Gangtok, which leads to the release of harmful gases, and/or uncollected waste is disposed in jhoras (springs) which leads to water pollution. Uncollected plastic and other waste types are sometimes disposed in storm water drains, which leads to their clogging. The disposal of waste at the Martam landfill site results in a characteristic odor emanating from the landfill site, which is a big nuisance for the local residents.

Learnings from international and national best practices

Gangtok faces challenges with imposing plastic ban effectively and faces challenges with plastic waste segregation, collection, recovery/recycling, etc. This report therefore covers multiple case studies related to efficient PWM value chains, PWM best practices, solutions, technologies and plastic waste treatment processes followed both nationally and internationally. Key learnings from each case study, which can be adapted and implemented in Gangtok, have been detailed in the study.

Vienna, Austria: Altstoff Recycling Austria AG (ARA) is Austria's leading collection and recovery system for packaging. Vienna in Austria, uses the ARA system for managing the packaging waste resulting from day-to-day operations of the packaging production business and the retail industry. Manufacturers, packagers, importers, retailers are obliged to take back used packaging waste from consumers as per extended producer responsibility. However, under the ARA scheme, these stakeholders transfer to ARA their obligation to take back the used packaging waste. ARA therefore collects packaging waste from businesses and households and sends it for recycling/recovery through its network of waste recycling and waste disposal companies.

Ljubljana, Slovenia: A public company called Voka Snaga provides SWM services in Ljubljana. Ljubljana known as the 'zero waste' city, has an efficient system of waste segregation at source into six different waste streams which are stored in differently colored bins. Between 2004 and 2018, Ljubljana saw a 10-fold increase in waste segregation and, as of 2019, the city recycled 68% of its waste. The amount of waste sent for disposal reduced by 95% while keeping costs the lowest in Europe. The city has packaging free-vending machines and zero plastic waste stores for selling products to customers who bring their own reusable packaging.

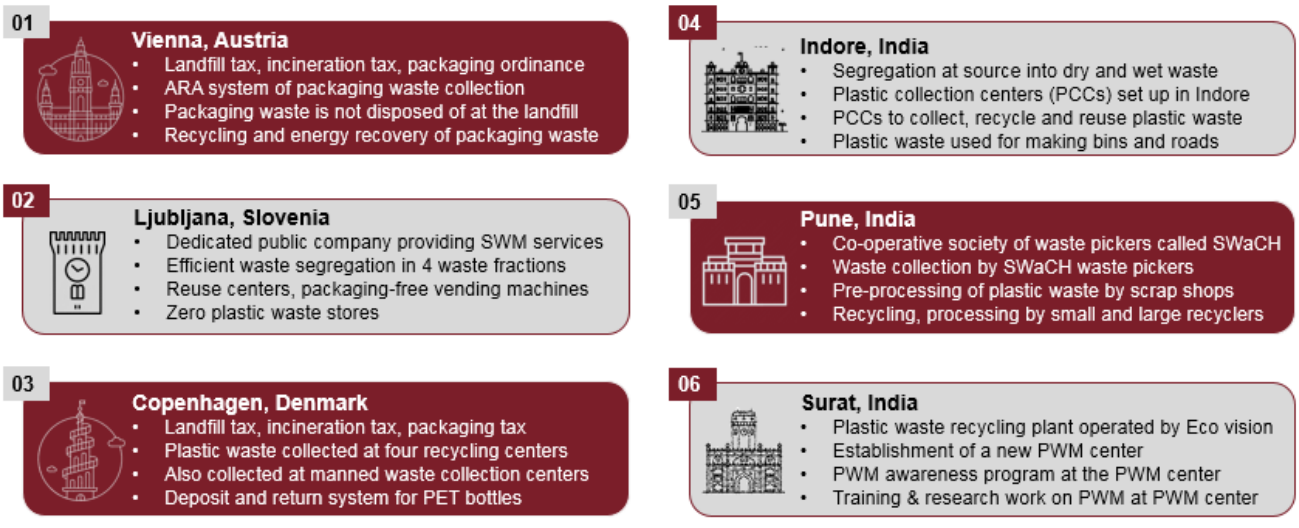
Copenhagen, Denmark: SWM regulations in Denmark impose a tax on waste that is landfilled and waste that is incinerated. The residual plastic waste generated from households in Copenhagen is collected directly from households while flexible, rigid plastic and bulky plastic waste is collected at Copenhagen's four recycling centers and waste collection centers wherein plastic waste is segregated, compressed, processed and sent for further use. Copenhagen also has a deposit and return system wherein polyethylene terephthalate (PET) bottles are returned to the point of sale, in exchange for a refund that is deposited by the consumer while purchasing the bottles.

Indore, India: Indore in India has implemented an efficient plan of managing plastic waste by segregating waste at source into wet and dry waste. Every household is strictly and diligently required to segregate waste. Plastic collection centers (PCCs) are set up in collaboration with local NGOs, to recycle and reuse the plastic waste generated in the city. The plastic waste at the PCCs is shredded, purified and bundled in blocks which are sent to cement plants or used for road construction. Discarded plastic in Indore is utilized for making bins which are distributed to the underprivileged sections of society either for free or at subsidized rates.

Pune, India: A co-operative and autonomous society of self-employed waste pickers called Solid Waste Collection and Handling (SWaCH) provides waste collection, sorting, recovery and other waste management services in Pune. The waste pickers collect waste not only from households and other waste generators but also from landfills, dump-sites, slums etc. which traditional waste collection systems cannot do. These waste pickers then sell the plastic waste to scrap shops where it is pre-processed and is then sent to small and large recyclers for recycling and processing. These waste pickers receive user charges from waste generators and also from scrap shops to whom they sell the plastic waste. They prevent tons of waste from ending up at the landfill, in Pune.

Surat, India: Surat in India has a plastic waste recycling plant which was built and is run on public-private partnership (PPP) mode, since 2017, by a private company called M/S Ecovision. Surat Municipal Corporation (SMC) has provided a two acre land on token rent and Eco-vision has invested ~INR 800 lakh (EUR 0.9 million) for phase I of the project. The plant currently recycles 35 TPD of plastic waste and is scheduled for a capacity expansion of up to 100 TPD under the phase-II of the project. A new plastic waste management center is set to be built in Surat by the central government, through INR 600 lakh (EUR 0.7 million) grant. The PWM center will recycle and process the plastic waste and will also provide training and awareness programs on efficient PWM and recycling.

Figure 1: Snapshot of international and national case studies



Key challenges for SWM in Gangtok

Waste segregation: Gangtok faces a challenge in terms of waste segregation at source. The waste segregation rate was 45% in 2018 and 55% in 2019. While some portion of recyclable waste is segregated at source by safai karamcharis, a certain portion is segregated by waste pickers at the landfill site while the remaining unsegregated waste is dumped at the landfill.

Waste collection: SWM including waste collection is a challenge in the hills due to rugged terrain, landform variations, scarcity of flat land, heavy rainfall, landslides etc.The waste collection trucks in Gangtok do not have separate compartments for segregated waste as a result of which the waste, even if segregated at source, gets mixed up in the trucks on its way to the landfill site. Tourist friendly plastic waste collection points do not exist in the city due to which the tourists throw plastic waste into jhoras, rivers, valleys and streets. They therefore cause littering and pollution by plastic waste in the city. Many a times uncollected waste in Gangtok is openly burnt thus contributing to air pollution.

Waste disposal: Initially the Martam landfill site was meant to cater to waste generated from Gangtok alone. But now, it receives waste from various gram panchayats and other cities in Sikkim which has drastically reduced its lifespan. Unsegregated waste reaches the landfill site such that 80% area under the landfill site is already covered. Additionally, the landfill site is not operating scientifically with odors emanating from the site, and water stagnating and accumulating, thus leading to diseases such as dengue and malaria.

Waste treatment/processing: The compost plant at Martam is not operating at its full capacity. Additionally, there is no recycling plant or energy recovery facility (incinerator) for treating plastic waste in Gangtok or nearby areas. The plastic waste is not properly segregated and there is no systematic procedure for handling and treating plastic waste in the city.

Plastic ban: The state wide ban on single-use plastics is not very effective in Gangtok, as items delivered by e-commerce websites come wrapped in plastic packaging whereas television sets and other electronic items come wrapped in Styrofoam packaging. Additionally it is challenging to impose the plastic ban and levy fines on tourists as they may not be very sensitive to PWM.

Possible solutions for SWM in Gangtok

Waste segregation: Waste segregation bins to be provided to the waste generators and GMC to ensure strict enactment of fines such that fines are levied on those not providing waste in a segregated manner. Additionally, GMC could tie some incentives/rewards for those who provide segregated waste regularly.

Waste collection: Waste collection trucks in Gangtok need to have different compartments for different waste fractions so that the waste does not get mixed up on its way to the landfill site. GMC could set-up recycling machines, at major tourist spots to encourage people to recycle and reuse their plastic waste. Additionally, GMC could set-up packaging-free vending machines, zero plastic waste stores and/or deposit and return system for PET bottles wherein people could return their bottles at point of sale, in exchange for a refund that is deposited by them, while purchasing the material. Also GMC could make it mandatory for manufacturers, producers etc., to take back packaging waste from consumers as per extended producer responsibility. To prevent people from openly dumping uncollected waste into jhoras, rivers, valleys etc., GMC could increase the waste collection rate in Gangtok as well as station workers at important locations, so as to levy fines there and then on those openly dumping their waste.

Waste disposal: GMC to allow only segregated waste to be disposed at the Martam landfill site. GMC could also look at finding an alternate site for the landfill which has flat topography and has adequate capacity to accept waste generated from Gangtok for years to come. Additionally, the Martam landfill site needs to be

upgraded so that it functions scientifically using odor control measures and adequate controls and processing systems to prevent water stagnation at the site.

Waste treatment: GMC to ensure that the Martam compost plant starts operating at its full capacity. Additionally, GMC to ensure that compost produced by the plant is certified by a laboratory, so that GMC could start earning revenue through its sale. To combat challenges posed by plastic waste, GMC to ensure that only non-recyclable and non-combustible plastic waste is disposed of at the landfill. GMC could set up a recycling plant and/or energy recovery facility in Gangtok, either through a Public-Private Partnership (PPP) or the Engineering Procurement and Construction (EPC) mode, for treating the recyclable and combustible fractions of plastic waste respectively.

Measures to impose plastic ban: GMC to ensure strict enactment of fines on both tourists as well as residents to ensure that they do not use banned plastic products in the city. Awareness programs need to be conducted for residents to develop good PWM practices and to sensitize them to mitigate harmful effects of plastic waste on the environment.

Figure 2: Key challenges and possible solutions

Key challenges	Possible solutions
Waste segregation	
• Low waste segregation rate	• Fines and incentives for waste generators to ensure segregation
• Low plastic waste segregation rate	• Awareness programs to promote waste segregation
Waste collection	
• No compartment for segregated waste in collection trucks	• Separate compartments for segregated waste in waste collection trucks
• Ineffective collection of plastic waste	• Recycling machine at tourist spots and deposit and return system for PET bottles
• Ineffective collection of packaging waste	• Packaging free vending machines, zero – plastic waste stores
• Open burning of waste, pollution of jhoras, valleys & streets	• Increase waste collection, ensure strict fines levied on those burning/ dumping waste
Waste disposal	
• Unscientific management of the landfill site	• Ensure current landfill site operates in a scientific manner
• Low capacity of the present landfill site	• Allow segregated waste at landfill, look for alternate landfill site with higher capacity
Waste treatment	
• Incomplete utilization of Martam compost plant	• Only segregated waste to be allowed as input at the compost plant
• No recycling/energy recovery facility at Gangtok	• Plastic waste treatment facility could be built at Gangtok
Plastic ban	
• Challenges in imposing single-use plastic ban	• Strict enactment of fines for both tourists and residents
	• Awareness programs to be conducted for residents to develop good PWM practices

Next steps/ way forward

Having established the need for an efficient SWM in Gangtok and the need to adapt and implement best practices from India and abroad, GMC should undertake a detailed feasibility study in this regard which should cover in detail the following:

- Technical feasibility: The technical feasibility report should cover all technical aspects, including upgrading and streamlining the SWM value chain, including PWM in Gangtok. It should also comprise of identification and assessment of best practices and processes used for waste collection, transportation, disposal, and processing/treatment, along with an estimation of feasibility and costs related with each new process or best practice thus added to the value chain. For the SWM value chain, the input and output specifications, performance standards, social and environmental assessment would also need to be conducted.

- Financial feasibility: The feasibility study should undertake a detailed financial assessment of streamlining the SWM value chain, including PWM, thus covering a detailed estimation of capital expenditure, operational expenditure and revenue, sensitivity analysis, and value for money analysis.

- Project structure: The study should cover the feasibility of appointing the private sector for integrated SWM in Gangtok covering processes of waste segregation, collection, transportation, processing and disposal at the landfill. This would include roles and responsibilities of various stakeholders, particularly that of the private developer and the implementing agencies, mode of contracting such as PPP or EPC, mode of payment and contract duration.
- Bid-process management: The feasibility study should provide details regarding the next steps in project preparation and execution, i.e., bid-process management and would explain in detail the number of stages that will be employed for the procurement process, bidding parameters, appointment of transaction advisors, formation of data rooms and customization of bidding documents.

2 List of acronyms & abbreviations

Abbreviation	Full form
ADB	Asian Development Bank
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
APC	Air pollution control
ARA	Altstoff Recycling Austria AG
ATREE	Ashoka Trust for Research in Ecology and Environment
BOO	Build, own, operate
BPCL	Bharat Petroleum Corporation Ltd
C&D	Construction & demolition
CBO	Community-based organization
CBWTF	Common biomedical waste treatment facilities
CDP	City development plan
CIPET	Central Institute of Plastics Engineering and Technology
CO_2e	Carbon dioxide emission
CSP	City sanitation plan
EU	European Union
GCoM	Global Covenant of Mayors
GHG	Greenhouse gases
GMC	Gangtok Municipal Corporation
GSCDL	Gangtok Smart City Development Ltd
HH	Household
IEC	Information, education and communication
IMC	Indore Municipal Corporation
IUC	International Urban Cooperation
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
MLP	Multi-layered plastic
MoEF&CC	Ministry of Environment, Forests & Climate Change (MoEF & CC)
MOHUA	Ministry of Housing and Urban Affairs
MoUD	Ministry of Urban Development
MSW	Municipal solid waste
MW	Megawatt
NERCCDIP	North East Region Capital Cities Development & Investment Program
NGO	Non-Governmental Organization
NHIDCL	National Highway Infrastructure and Development Company Ltd
PET	Polyethylene terephthalate

Abbreviation	Full form
PMC	Pune Municipal Corporation
PPP	Public-private partnership
PWM	Plastic waste management
PVC	Polyvinyl chloride
RDF	Refuse derived fuel
RMDD	Rural Management & Development Department
SIPMIU	State Investment Program Management and Implementation Unit
SIRD	State Institute of Rural Development
SMC	Surat Municipal Corporation
SPM	Suspended particulate matter
SWM	Solid waste management
TPD	Tonne per day
UDHD	Urban Development and Housing Department
ULB	Urban local body
WtE	Waste to energy

3 List of tables and figures

4 Introduction

This chapter contains the background of the assignment, city profile of Gangtok and the objectives of this baseline study. It also briefly explains the methodology followed in preparation of this study and the limitations of this exercise.

4.1 Assignment background

Baseline study: The baseline study for the SWM project has been commissioned as part of the IUC-India program. The study represents the key deliverable of the Urban Cooperation Local Action Plan for the city of Gangtok and has been prepared based on secondary research, stakeholder consultations, case studies etc. The objective of the assignment is to provide baseline information for SWM in Gangtok, by analyzing the current status of SWM and waste treatment facilities in Gangtok, focusing more on PWM in the city. The study also identifies best practices in the PWM domain, which are currently being followed by various national and international cities. This study may later be used as an input for a detailed feasibility study.

Program objectives: The IUC program's overall objective is to contribute to improved international urban policy diplomacy and increased decentralized cooperation on sustainable urban development and climate change. The program has two components: a) City/sub-national cooperation on sustainable urban development to strengthen the European Union (EU)-India cooperation among selected city/sub-national governments and between the national level and the EU, on sustainable urban development while contributing to India's Smart Cities Mission, the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and other national and international sustainable urbanization processes; and b) cooperation on sustainable energy and climate adaptation and mitigation, and access to clean and affordable energy, through building upon the Global Covenant of Mayors (GCoM) initiative in line with existing India-EU commitments.

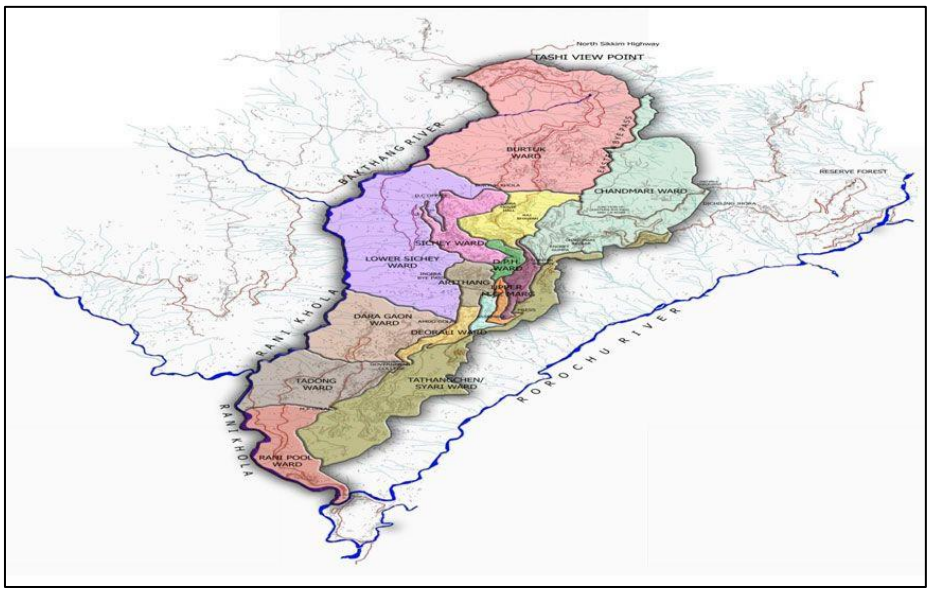
4.2 Gangtok – City profile

Gangtok: Gangtok nestled in the eastern Himalayan range is the capital and the largest city of the north eastern state of Sikkim in India. Gangtok is located at an elevation of 1,650 m (5,410 ft.) above the mean sea level and had a population of 100,286 as per 2011 census. The population of Gangtok was 169,739 as of 2018[2]. The population consists of people from difference ethnicities such as Lepachas, Nepali, and Bhutia etc. The city enjoys a mild temperate climate year round and is a major tourist center in Sikkim. Major tourist attractions in and around Gangtok are the Mahatma Gandhi (MG) road, Tsomgo lake, Nathula pass, Himalayan zoological park, Ranka monastery, Tashi view point etc. In the 20th century, during the British rule, Gangtok became a stopover on the trade route between Lhasa in Tibet and Kolkata in India. After India achieved independence in 1947, Sikkim chose to remain as an independent monarchy, with Gangtok as its capital. However, in 1975, Sikkim was integrated with India and became the 22nd state of the country. Gangtok today is a center of Tibetan Buddhist learning and culture and has several religious educational institutions and monasteries.

Gangtok Municipal Corporation (GMC): The first elections for the GMC were held in April 2010 and the councilors took their oath of allegiance to their offices in May 2010. The municipality has 17 wards and covers an area of 19.016 sq. km stretching from Tashi viewpoint up to Ranipool as shown in the map below. The GMC has received various awards, such as the best hill station in India (Aaj Tak), best top 10 cleanest cities in India (2015), best top 8 cleanest cities in India (2016) and Safaigiri awards from the Prime Minister (2015).

[2] *https://indiapopulation2019.com/*

Figure 3: Gangtok city region map



Source: Gangtok Municipal Corporation

4.3 Objectives of the study

Establish a baseline of the current practices to handle solid and plastic waste: The study has been prepared by doing extensive secondary research and multiple stakeholder consultations. The study analyses the solid waste and plastic waste generated in Gangtok, and captures the current solid waste and plastic waste management practices with respect to collection, transportation, handling, disposal and treatment of waste being followed in Gangtok. Policies and legal framework that influence SWM in Gangtok, commercial and financial aspects of SWM in Gangtok and future plans of GMC with respect to SWM are further analyzed. The study encapsulates the roles of various government organizations/agencies and other stakeholders in the entire SWM value chain. The study also explains the impact of SWM on climate change and vice versa.

Present national and international experience (with a focus on the EU) on similar processes: This report covers multiple case studies from Vienna (Austria), Ljubljana (Slovenia), Copenhagen (Denmark) and India (Indore, Pune and Surat) so as to identify efficient PWM value chains, PWM best practices and plastic waste treatment procedures followed both nationally and internationally. Key challenges as well as learnings from each city, in the PWM domain, which can be tailored, adapted and implemented in Gangtok have been detailed in the study.

Set the basis for a more detailed feasibility study: The findings of this report could form the basis for a detailed feasibility study. The study should focus on estimating the feasibility of new processes or technologies to be added to the SWM value chain, and estimating the capital expenditure, operational expenditure and revenues associated with new processes or technologies thus added to the value chain. The study should also focus on the feasibility of appointing the private sector for integrated SWM, and should thus focus on roles and responsibilities of various stakeholders, particularly that of the private sector and the implementing agency.

4.4 Methodology employed

The study is based on: a) secondary research through documents and reports shared by IUC-India and GMC team, web search and case studies on PWM; and b) stakeholder consultations with officials of the IUC-India team and officials of GMC.

Secondary research: Extensive secondary research was carried out during the preparation of this baseline study which included summarizing, collating and synthesizing the existing research pertaining to the city of Gangtok through reports shared by IUC-India and GMC, and web search. Case studies from Austria, Denmark, Slovenia and India provided additional information:

- Documents shared by IUC-India and GMC*:* GMC shared the document on data related to SWM and PWM in Gangtok which was imperative in the preparation of this baseline study. The IUC-India team also provided several reports on plastic waste management solutions as implemented in the EU. The document related to Gangtok provides a comprehensive overview of the current situation in Gangtok related to the SWM and PWM value chain whereas the documents related to plastic waste solutions in the EU highlight some of the best practices in the PWM domain being followed in European countries.
- Documents procured through web search: Various reports and articles related to urban infrastructure in Gangtok and current condition related to SWM and PWM were referred to while preparing this study. Some of these reports included the City Development Plan, City Sanitation Plan, Smart city plan - Gangtok, initial environmental examination report by Urban Development and Housing Department (UDHD), Sikkim state action plan, Sikkim state byelaws, and some reports related to SWM and PWM as obtained from the GMC website. Articles related to SWM, PWM as well as the effect of climate change on SWM activities in Gangtok were also reviewed. These reports and articles helped in identifying the problems related to SWM and PWM in the city and also helped in understanding the suggestions provided by various stakeholders and strategies developed to implement those suggestions.
- Case studies: As part of an extensive secondary research, six case studies were analyzed, i.e., Vienna (Austria), Ljubljana (Slovenia), Copenhagen (Denmark) and Indore, Pune and Surat (India). The cases focused on efficient PWM systems, as well as best practices and plastic waste treatment facilities. Key challenges as well as learnings from each city, in the PWM domain, which can be tailored, adapted and implemented in Gangtok have been detailed along with the case studies.

Stakeholder consultations: Stakeholder consultations were organized through video conferencing and conference calls. Discussions were held with various stakeholders such as Municipal Commissioner of the GMC Mr. Hem Kumar Chettri and officials of IUC India such as Dr. Panagiotis Karamanos (Team Leader, IUC), Ashish Verma and Neelabh Singh. Discussions were held to analyze the objectives of the study, role of GMC, background of SWM in Gangtok with a focus on PWM, as well as to understand the key points to be captured in the baseline study. Inputs and insights provided by these experts/officials were of great importance in the preparation of this study and these have been further included in relevant chapters of this study.

4.5 Limitations of the exercise

The study aims to provide a comprehensive analysis of the current solid waste management scenario in Gangtok including practices with respect to PWM in Gangtok, the future outlook for SWM services and to highlight the best practices related to SWM, followed across India and abroad. However, the study is limited in the sense that it is only a baseline study to assess the as-is situation of the SWM lifecycle in Gangtok, in addition to the assessment of existing facilities and practices for waste treatment. Additionally, this study relies heavily on secondary sources of information and data collection through stakeholder consultations. In the wake of Covid-19 and the subsequent restrictions laid out by the Government of India, on-ground verification of data and site visits were not feasible.

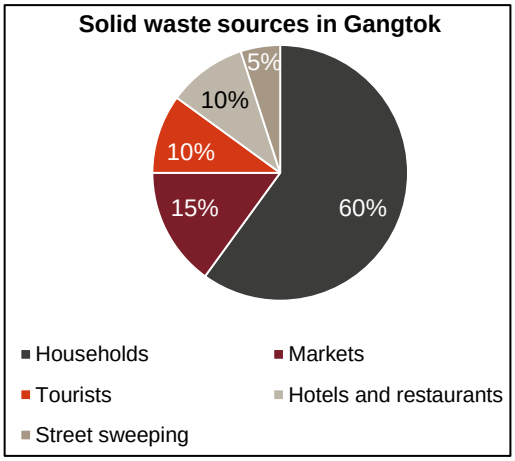
5 Existing solid waste management

This chapter captures the existing arrangement of SWM including PWM in Gangtok, covering the entire SWM value chain including waste generation, segregation, collection, transportation, disposal and waste treatment processes and technologies. The coverage of SWM activities within the city, prevailing waste types and sources of waste have been further explained. It also covers the roles and responsibilities of key stakeholders of the SWM system, policy and legal framework applicable to Gangtok SWM, and future plans of GMC, related to SWM. Environmental concerns related to SWM activities are also illustrated.

5.1 Solid waste generated in Gangtok

Amount of solid waste generated in Gangtok: As of 2018, the total municipal solid waste (MSW) generated from 17 wards in the GMC area is ~50 TPD. Out of this, 44 TPD of waste is collected for processing and disposal at the landfill site, resulting in a waste collection rate of about 88%. Of the 44 TPD of MSW collected, only 5 TPD is processed while ~39 TPD is disposed of at the landfill site.

Sources of waste in Gangtok: As per the initial environmental examination report[3] dated 2012, the main solid waste generation sources in Gangtok are households (60%), markets (15%), tourists (10%), hotels and restaurants (10%), and street sweeping (5%).



Types of waste in Gangtok: As per the initial environmental examination report dated 2012, compostable organic waste (food waste – 63.5%) forms a major part of the total waste generated, followed by inert materials (ash, fine earth, bricks, leaves, wood etc.) at 19.1% and recyclables (paper, plastic, metals etc.) at 17.4%.

Table 1: Waste composition in Gangtok as per initial environmental examination report, UDHD, 2012

Type of waste	Composition (in %)
Organics	**63.49**
Food waste	63.49
Recyclables	**17.4**
Paper	6.42
Plastics and rubber	3.99
Textile	3.72
Glass	1.96
Metals	1.31
Inert material	**19.11**
Ash and fine earth	13.22
Leaves and wood	4.11
Stone, brick, etc	1.78

[3] *This report was prepared by the State Investment Program Management and Implementation Unit (SIPMIU), Urban Development Housing Department (UDHD), Government of Sikkim, for the Gangtok SWM sub-project under the North East Region Capital Cities Development & Investment Program (NERCCDIP) scheme, funded by the Asian Development Bank (ADB)*

Source: Initial environmental examination report (UDHD, NERCCDIP), 2012

As per the initial environmental examination report, chemical analysis of the waste revealed a low carbon to nitrogen ration of 22:1, whereas the moisture content of the waste stood at an average value of ~45%. The gross calorific value was 1043 (Kcal/Kg).

5.2 Solid waste segregation, collection and transportation

SWM coverage: The UDHD, Government of Sikkim is the primary agency responsible for development and management of Gangtok town and looks after the aspects of physical planning, growth management and provision of core civic services. GMC is primarily responsible for collection, transportation, disposal and processing of solid waste. Gangtok is divided into 17 wards, of which 14 are covered by the door-to-door collection system. As of 2018, ~87% households were covered for solid waste collection, which increased to 90% in 2019.

Solid waste segregation: The waste is broadly divided in to two fractions – 1. Wet Waste and 2. Dry Waste. Wet waste is mainly biodegradable, while dry waste includes plastic, paper, metal, wood, etc. GMC has placed bins in the market area and most of the wards under GMC have segregation bins for both dry and wet waste. Arithang ward under GMC practices complete segregation at source. The safai karamcharis (Gangtok beautifiers) segregate recyclable waste such as bottles, plastic, cardboard, metals etc., at source. Some of the recyclable waste is also segregated by the waste pickers at the landfill site. 45% of the waste generated was segregated in 2018 and 55% was segregated in 2019. Some of the challenges that GMC faces, as far as segregation is concerned are non-cooperation from the public, lack of awareness, lack of enforcement, etc. Additionally, the waste collection trucks do not have separate compartments for segregated waste and therefore the waste gets mixed up on its way to the landfill site.

Solid waste collection: Collection of waste in Gangtok, is primarily managed by GMC on a door-to-door basis. Every morning between 4:30 – 5:00 am, truck drivers employed by GMC, ply on collection routes assigned to them. They are accompanied by khalasis (waste collectors) to help in loading and unloading the waste. Once the truck reaches the assigned area, the khalasis ring a bell to announce the arrival of the waste collection truck. On hearing the bell, residents come out of their houses and hand it over to the khalasis, who load it onto the trucks. Also from the inaccessible areas, backpackers, who are employed by local co-operative societies and NGO's, manually collect the waste and bring it to a point where the waste collection trucks can pick it up. Of the 50 TPD of waste generated in Gangtok ~44 TPD is collected for processing and disposal at the landfill site, resulting in a current waste collection rate of about 88%. The remaining waste is directly disposed of by the locals on roads or in jhoras or is converted into manure.

Solid waste transportation: Gangtok does not have any waste transfer stations. The trucks that collect waste from the designated areas, as described above, also transfer the waste directly to the landfill site at Martam.

Figure 4: Waste collection and transportation truck in Gangtok

Source: Gangtok Municipal Corporation

E-waste collection: In 2014, GMC in association with the Department of Information Technology set up an e-waste collection center at its premises for the collection of e-waste generated from all government departments, private organizations and households such as electronic devices, telecommunication devices, computer accessories, etc. The government has mandated all government offices to hand over e-waste to GMC. In consultation with the State Pollution Control Board, GMC has identified a West Bengal-based contractor - M/s JPS Pigments Ltd - whose workers come to GMC once or twice a year, collect e-waste and carry it to its recycling facility for recycling as per applicable procedures.

Plastic waste collection: Sikkim banned the use of single use plastics such as disposable plastic bags since 1998 and banned the use of other single use plastic products such as disposable products made from Styrofoam, thermocol products and packaged drinking water since 2016. However, multi-use plastics are still in circulation. Also, items delivered by e-commerce websites (Amazon, Flipkart) come wrapped in plastic packaging whereas television sets and other electronic items come wrapped in Styrofoam packaging. Additionally, Gangtok being a tourist city, faces littering of plastic waste and it is quite challenging to impose the single-use plastic ban on tourists visiting the city. Segregation of plastic waste is a challenge in Gangtok, wherein only a certain portion of plastic waste and other recyclables are segregated by safai karamcharis at source. The remaining unsegregated waste is collected by waste collectors and transported to the landfill site. Some portion of plastic waste is again segregated, from the waste received at the landfill, by waste pickers at the site while the leftover unsegregated plastic waste is dumped at the landfill.

Equipment/vehicles and staff employed: GMC has a fleet of 30 trucks of different sizes for collecting the waste and transporting it to the landfill site for processing and disposal. The corporation has 215 SWM workers including safai karamcharis, khalasis and drivers for sweeping, cleaning of roads and streets, collecting and transporting waste to the landfill site for processing and disposal. While few workers are permanent, most of them have been employed on a muster roll/contractual basis. These non-permanent workers are, however, provided with various facilities such as insurance, provident fund, etc.

5.3 Solid waste disposal and treatment

Solid waste dump yard: Before 2017, the solid waste generated and collected from Gangtok used to be disposed of at the 4.2 hectare, Martam dumping ground located 20 km away from Gangtok. Along with the municipal solid waste, hospital and chemical waste also used to be disposed of at the Martam dumping ground without any pre-treatment. The unregulated dumping of waste at the dumping ground used to pose severe health problems for the residents of the villages near the Martam ground.

Sanitary landfill: A sanitary landfill of area ~1 hectare was constructed at the 4.2 hectare Martam site, under the guidance of the UDHD and the GMC and was funded by the Asian Development Bank under the North NERCCDIP scheme, implemented by the Ministry of Housing and Urban Affairs (MoHUA), Government of India. The landfill was inaugurated in November 2017 and was handed over to the GMC for operations. The sanitary landfill was constructed only for the disposal of rejected waste from the compost plant (located at Martam itself) as well as the inert/non-biodegradable waste which cannot be processed or recycled. The landfill site was meant to cater to the waste generated by Gangtok alone and was designed for a period of 15 years.

Challenges faced at landfill site: Though 4.2 hectare land was available at the Martam site for the construction of the sanitary landfill, however a landfill of only ~1 hectare capacity could be built at the site due to constraints such as hilly terrain, scarcity of flat land as well as the Ranikhola river flowing adjacent to the site. Currently, waste from various gram panchayats and other cities in Sikkim is also disposed of at the landfill site, which has drastically reduced the life of the landfill site such that it can continue operations only for another 5-6 years. Additionally, the waste reaching the landfill is unsegregated and as of 2019, 80% of the area under the landfill is already covered. The Martam landfill site has not been operating scientifically wherein local residents and passersby complain of unpleasant odor emanating from the site. Also, water stagnation and

accumulation at the site leads to breeding of vectors which thus results in the prevalence of diseases such as dengue, cholera and typhoid.

Figure 5: Landfill site at Martam

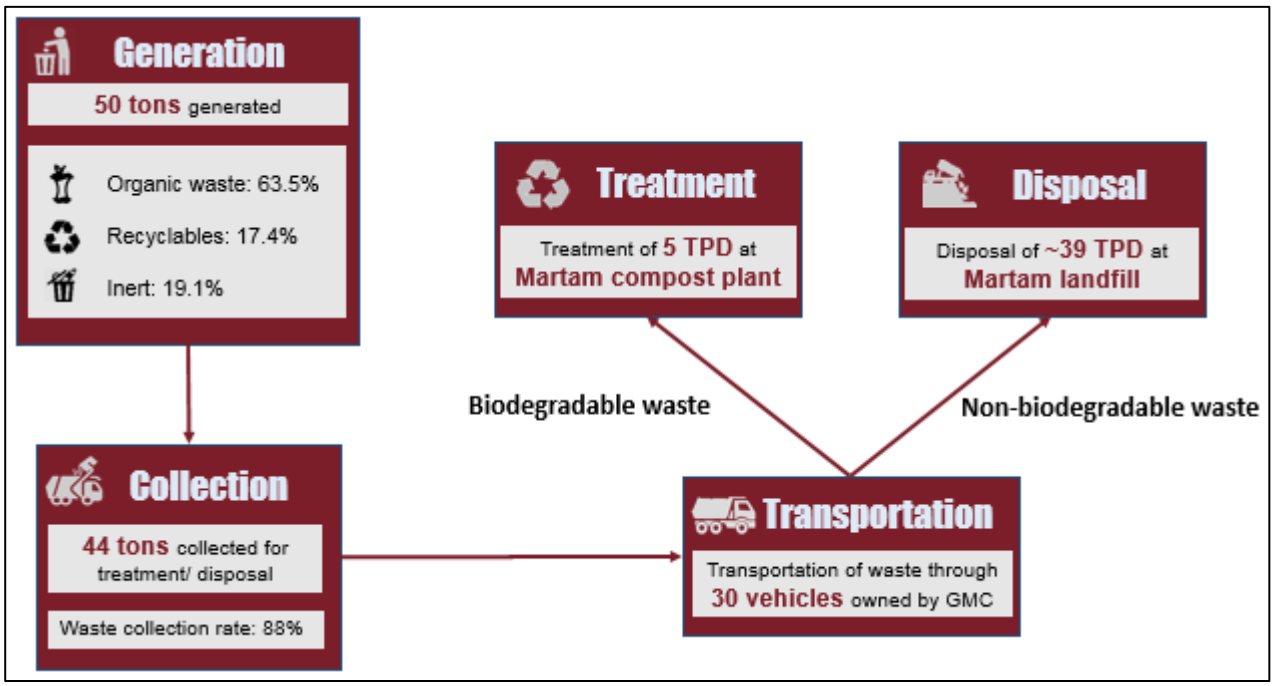
Source: Google maps, thesikkimchronicle.com

Solid waste treatment: There is also a compost plant at the Martam landfill site, which is designed to handle 50 TPD of waste and convert it into compost. The compost plant is designed to treat only segregated organic waste, with unsegregated waste resulting in the machine getting locked and hence incurring high maintenance cost. As the waste reaching the Martam facility from Gangtok is not properly segregated, the compost plant is not operating to its full capacity and currently processes only ~5 TPD of segregated organic waste. Before 2017, the plant used to be non-functional and therefore even the segregated organic waste received at the Martam facility used to be dumped instead of being treated at the compost plant. However, the plant was refurbished and revived under the guidance of UDHD and GMC. The plant was inaugurated and commissioned by UDHD along with the sanitary landfill site in November 2017, and was handed over to the GMC for operations. The compost generated at the plant is currently being used by Sajong Farmers Society on a trial basis. Once the quality of compost is certified by a registered laboratory, GMC plans to sell the compost and earn revenue.

Decentralized waste treatment: GMC has installed a compost plant with a capacity of processing 1 tonne of waste at the Khangchendzonga vegetable market in Gangtok in order to convert vegetable waste to compost. Additionally, 510 households in Arithang ward in Gangtok are treating their wet waste at source via composting.

Plastic waste treatment: As discussed above while a certain proportion of plastic waste is segregated by safai karamcharis at sources, a certain proportion is segregated by waste pickers at the landfill site. The plastic waste thus segregated and collected at the landfill site is then sent to a recycling plant in Siliguri, West Bengal (114 km from Gangtok), while some of it is handed over to the NHIDCL for constructing roads. Till date, NHIDCL has collected around 500 kg of plastic waste from the landfill site. The remaining un-segregated plastic waste is dumped at the landfill site. Gangtok does not have a recycling plant or an energy recovery facility of its own.

Figure 6: SWM value-chain in Gangtok



Source: GMC data

5.4 Commercial/financial aspects

Revenue and expenses of GMC: The overall revenues and expenses incurred by GMC in fiscal 2018 have been stipulated below.

- Revenue: GMC earned a revenue of ~INR 1,641 lakh (EUR 1.9 million) in fiscal 2018. Of this amount ~49% was revenue earned through various grants, contributions and subsidies and 32% was revenue earned through fees and user charges. ~8% comprised of other income, ~8% by tax revenue, ~6% by rental income from municipal properties and ~3% by income from investments. Apart from these, there were some minor sources of revenue such as sale and hire charges (~1% of total revenue) and interest earned (~1% of total revenue).

- Expenses: GMC spent ~INR 957 lakh (EUR 1.1 million) in fiscal 2018. Of this amount ~48% was for establishment expenditures (salaries, wages, bonus, benefits, allowances etc.), ~39% for operations and maintenance charges and ~7% for administrative expenses. ~5% was towards depreciation charges, ~1% for program expenses and 0.01% for interest and finance expenses. On account of GMC generating more income than incurring expenses, it has generated a profit of ~INR 683 lakh (EUR 0.8 million) in fiscal 2018.

Revenue and expenses from SWM activities: The revenue earned and expenses incurred on SWM activities have been stipulated below.

- Revenue from SWM activities: GMC has fixed waste collection fee rates for households, businesses and other waste generators for availing the SWM services as tabulated in Annexure A. While households pay waste collection fee of INR 50 per month, business/commercial establishments pay waste collection fee ranging from INR 50 to INR 5,000 per month. Waste collection fees from households is collected by, and go to the co-operative societies and the NGOs. As a revenue sharing mechanism, the co-operative societies and NGOs were earlier paying between INR 1,000 to INR 8,000 per month to the GMC, compensating GMC for the operations and maintenance cost of the waste collection trucks provided by GMC. However, due to the Covid-19 pandemic, they are currently not sharing any revenue with the GMC. The GMC is however planning to revert back to the previous revenue sharing mechanism post Covid-19.

While waste collection fee from households is collected by co-operative societies/NGOs, the waste collection fee from business/commercial establishments is collected by GMC, automatically during the trade license renewal. GMC earned a revenue of ~INR 235 lakh (EUR 0.3 million) in fiscal 2018, through collection of waste collection fees from business/commercial establishments as shown in Table 2.

- Expenses on SWM activities: In fiscal 2018, GMC spent ~INR 35 lakh (EUR 0.04 million) on repair and maintenance of SWM vehicles, ~INR 45 lakh (EUR 0.05 million) on operations and maintenance for garbage clearance, INR 6 lakh (EUR 0.007 million) on the purchase of pesticides for the compost plant etc. Apart from these expenses, GMC also incurred expenses such as depreciation of SWM equipment, depreciation of compost plant etc. On account of GMC generating more income than incurring expenditure on SWM activities, it has generated a profit of ~INR 143 lakh (EUR 0.16 million) in fiscal 2018.

Table 2: Revenue and expenditure related to SWM activities

Particulars (INR lakh)	FY17	FY18
User charges related revenue		
User charges from waste collection	82.10	235.40
Repair & maintenance expenses		
Repair & maintenance – SWM vehicles	14.37	35.40
Operations and maintenance expenses		
Garbage and clearance expenses	15.08	44.56
Cleaning by private agencies - outsourced	8.22	
Pesticides at compost plant - Martam	3.31	5.92
Depreciation		
SWM equipment	0.88	3.05
Compost plant		3.02
Total revenue from SWM activities	**82.10**	**235.40**
Total expenditure from SWM activities	**41.86**	**91.95**
Profit/Loss from SWM activities	**40.24**	**143.45**

Source: GMC financial statements

5.5 Policy and legal framework

Policies and by-laws applicable to SWM and waste treatment facilities in Gangtok as prescribed by the UDHD, Government of Sikkim have been described below. These are the Sikkim state policy and strategy on solid waste management (action plant) and by-laws of solid waste (management and handling) cleanliness and sanitation for the urban sector of Sikkim. These policies and by-laws provide clear directions for each step of the SWM value chain including waste segregation, collection, transportation, processing/treatment and disposal.

- **Sikkim state policy on SWM - 2019:** The state management policy was formulated with a vision to transform Sikkim into a zero waste state (with almost zero or very little waste at the landfill site) with a focus on MSW, e-waste, construction and demolition waste, plastic waste and household hazardous waste. The policy lists the best practices followed in different parts of Sikkim as far as SWM is concerned. It also provides for integration of waste pickers and scrap dealers in the formal waste management process at the state level. People engaged in MSW management will be termed as skilled labor or technicians and their services will be deemed as environmental services. As per the policy, waste reduction and following

Green Protocol to eliminate single-use plastics and decrease the use of small format plastics will be the primary focus of SWM. Alternate products and services would replace ecologically unviable and unsustainable plastic products. The policy promotes segregation at source, resource recovery, decentralized waste management and prohibits burning of waste. The policy promotes decentralized waste management

- **By-laws of solid waste (management and handling) cleanliness and sanitation for the urban sector of Sikkim - 2019:** These by-laws were implemented by the UDHD for regulating all matters, processes and things related to the collection, storage, transportation, and disposal and processing of MSW and other related sanitation matters. The by-laws prohibit littering, other waste related nuisance and ensure a clean household/premises. The by-laws provide clear directions for segregation, storage, delivery and collection of MSW, stating clearly the categories, into which the waste generators need to segregate and store their waste. The by-laws provide specifications for the treatment of different types of waste such as biodegradable, household hazardous, biomedical, construction and demolition, garden and horticulture, non-biodegradable (dry) and other waste categories, while strictly prohibiting open burning of waste. It also lists the obligatory duties of the municipal corporation providing specifications for the time schedule, frequency and root of collection, as well as providing for surprise checks. The by-laws also provide specifications for dry waste sorting centers and material recovery facilities, and list the amount of fine applicable for the breach of each by-law.

Various national policies and by-laws related to SWM are described below. These are the solid waste management rules - 2016, construction and demolition waste management rules – 2016, e-waste management rules – 2016, plastic waste management rules – 2016, bio-medical waste management rules – 2016 and hazardous waste management rules – 2016.

- **Solid Waste Management Rules, 2016**: The Ministry of Environment, Forests & Climate Change (MoEF & CC) revised the Municipal Solid Waste (Management and Handling) Rules 2000 as Solid Waste Management Rules, 2016. With the introduction of the solid waste management rules, 2016 a wider range of stakeholders have been held accountable for the efficient management of the SWM system. The new set of protocols define the responsibilities of each member in the value chain and also introduce awareness initiatives, incentives and penalties around the SWM process. They also introduce the criteria for setting up a waste treatment facility, criteria for a waste to energy process, specifications of sanitary landfills, and monitoring for their implementation. The policy explains the roles and responsibilities of stakeholders, and explain the power of ULBs to enforce user charges for SWM services. The policy also allows for incentives such as capital subsidy, co-marketing of fertilizer etc. for waste to energy plants. Additionally, the policy mandates, that non-recyclable waste having calorific value of 1,500 kcal/kg or more shall not be disposed of on landfills and shall only be utilized for generating energy either or through RDF or by giving away as feed stock for preparing RDF.
- **Construction and Demolition Waste Management Rules, 2016**: The MoEF & CC notified the Construction and Demolition Waste Management Rules in 2016. The rules are an initiative to effectively tackle the issues of pollution and waste management. The construction and demolition waste generated nationally is about 530 million tonne annually. The construction and demolition waste management rules, 2016 defines construction and demolition waste. The rules apply to every waste resulting from construction, re-modelling, repair and demolition of any civil structure of individual, organization or authority who generates construction and demolition waste such as building materials, debris and rubble. Additionally, the rules mandate that the local authority shall get the collected waste transported to appropriate sites for processing and disposal either through own resources or by appointing private operators.
- **E-Waste (Management) Rules, 2016**: The MoEF & CC notified the e-waste management rules, 2016 in supersession of the e-waste (management and handling) rules, 2011. The policy applies to every consumer, producer, manufacturer, collection centers, dealers, refurbishes, dismantlers and recyclers

involved in manufacture, sale, transfer, purchase, storage, collection, and processing of e-waste or electronic & electrical equipment which is listed in Schedule I. It also include parts, components and spares which make the product operational. The protocols superseded the e-waste management rules of 2011. In EWM rules of 2016, e-waste has been defined as whole or in parts of an electrical and electronic equipment discarded as waste by consumer as well as the rejected material from refurbishment, manufacturing and repair. As per these rules, it is the responsibility of the manufacturer, producer or dismantler to collect the e-waste generated during manufacture/production/dismantling and channelize it for recycling/disposal.

- **Plastic Waste Management Rules, 2016**: The MoEF & CC notified the plastic waste management rules, 2016 which will now supersede the Plastic Waste Management Rules, 2011. The policy defines plastic, compostable plastics, carry bags, virgin plastics, multilayered packaging and all types of plastic waste. It also lists the categories of plastics, lists the roles and responsibilities of prescribed authorities for plastic waste management, the roles and responsibilities of plastic waste generators and producers. The set of protocols explain the modalities of plastic waste management, environmental issues and challenges related with plastic waste and to promote the use of plastic waste in various tasks such as road construction, energy recovery etc.
- **Bio-Medical Waste Management Rules, 2016**: The MoEF & CC notified the bio-medical waste management rules, 2016 to replace the earlier rules, 1998. These protocols define the types of waste which are categorized as bio-medical waste such as human & anatomical waste, treatment equipment such as needles, syringes and other material used in healthcare and in the process of treatment and research. They also explain the waste categories for bio-medical waste and define the ambit of bio-medical waste generators such as blood banks, treatment or immunization processes in hospitals, nursing homes etc. Scientific disposal of such waste for effective disposal by hospitals and other waste generators. The roles and responsibilities of waste generators and producers as well as standards for incinerators and other bio-medical waste handlers are also explained.
- **Hazardous and other Waste Management Rules, 2016:** India's environment ministry MoEF & CC has issued its revised hazardous and other wastes (management and transboundary movement) rules 2016. The policy explains the type of waste, which by reason of its characteristics would be classified as hazardous waste and helps to distinguish between hazardous and other wastes. Hazardous waste classification, identification and storage & labelling requirements of hazardous waste are explained. Management of such waste, problems associated and importance of proper hazardous waste management is also illustrated. Roles, responsibilities and duties of waste generator and various stakeholders as well as environmentally sound management, management hierarchy, co-processing, disposal and recycling of hazardous waste is explained.

5.6 Waste management policies for Covid-19

Policy coverage: The Central Pollution Control Board, MoEF & CC has introduced guidelines for handling, treatment and waste generated during treatment/diagnosis and quarantine of Covid-19 patients. The guidelines are applicable for all stakeholders including isolation wards, quarantine centers, sample collection centers, laboratories, ULBs and common biomedical waste treatment and disposal facilities. These policies are applicable in addition to the Biomedical Waste Management Rules, 2016 (BMW rules).

Guidelines for Covid-19 isolation wards, sample collection center and labs: Separate color-coded bins/bags/containers should be employed in accordance with the BMW rules. The waste collected from isolation wards needs to be disposed of in double-layered bags (using two bags) to ensure strengths and no leaks. Waste collected should be clearly marked as 'Covid-19 waste', thus enabling priority treatment and disposal. The containers, bins and trolleys used for storage of Covid-19 waste should be daily disinfected with 1% sodium hypochlorite solution. Isolation wards should depute dedicated sanitation workers separately for bio-medical waste and general solid waste.

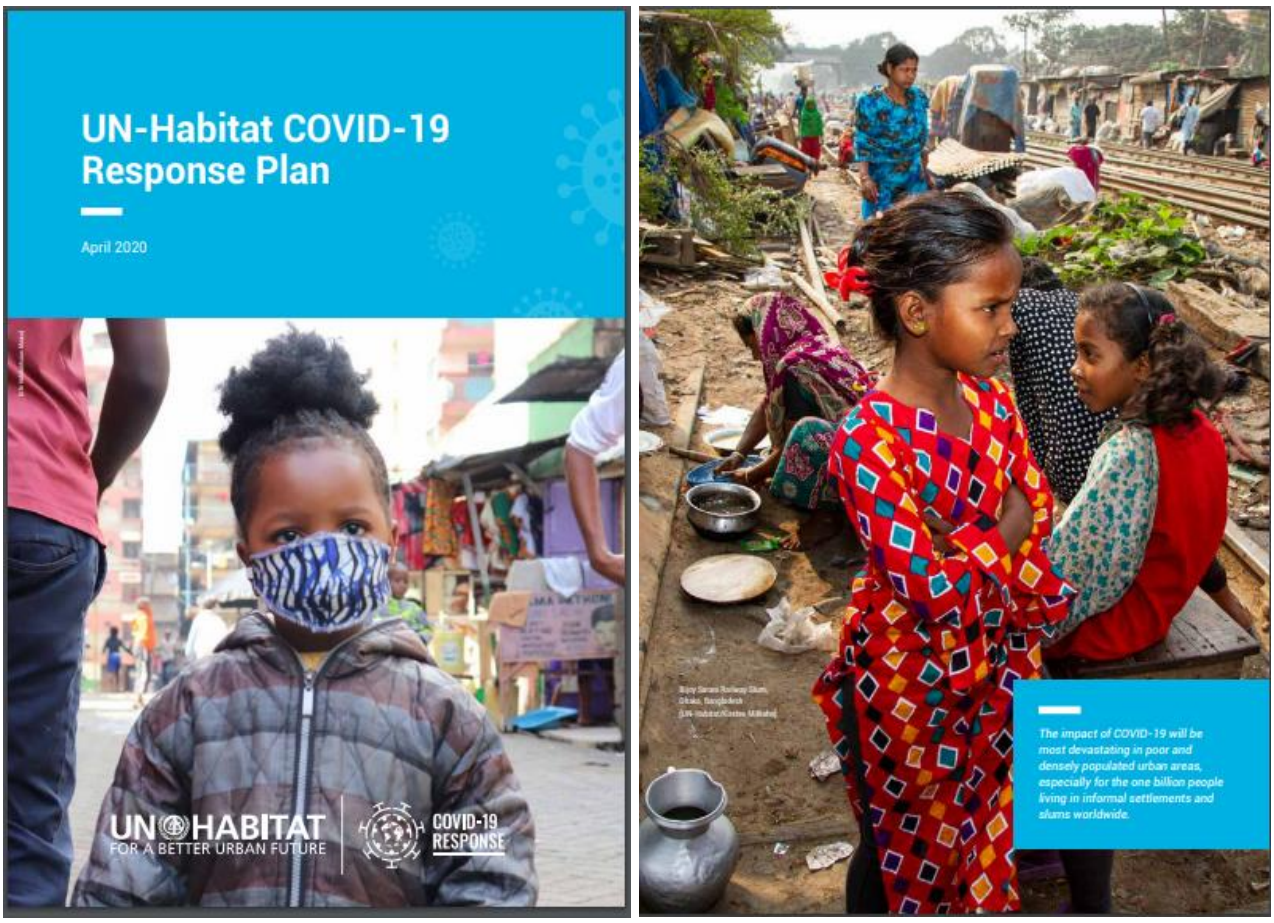
Responsibilities of persons operating quarantine facilities: Waste generated at quarantine facilities is expected to have less quantity of biomedical waste. The facility managers at these places are expected to ensure separate collection of biomedical waste in yellow bags, ensure collection of biomedical waste through common biomedical waste treatment facilities (CBWTF), door step collection or at designated deposition centers. In case of difficulty in accessing such facilities, people can contact their respective ULB.

Duties of CBWTF: The CBWTF are responsible for regularly reporting the receipt of waste from isolation wards, quarantine facilities and testing centers. The operator has to ensure regular sanitization of workers involved in collection and handling of biomedical waste. Personal protection equipment (PPEs) will be provided to sanitation and workers and dedicated, regularly sanitized, vehicles will be employed for waste collection. The operator must ensure that Covid-19 waste is disposed of immediately on receipt at the facility.

Duties of ULBs: Urban local bodies shall be responsible for ensuring safe collection and disposal of biomedical waste. The authorities will arrange necessary security, engage authorized waste collectors and CBWTFs for door-to-door waste collection. They shall be responsible for creating awareness, providing yellow waste bags, create provisions for PPEs and ensure smooth facilitation of the entire waste management collection and disposal cycle.

UN habitat Covid-19 SWM guidelines: Although there are guidelines for treatment of biomedical waste, these guidelines lack guidance on adapting the existing waste management practices for a pandemic. Keeping this in mind, United Nations Human Settlement Program has developed a 10-point strategy for SWM in the context of Covid-19. These guidelines are presented below:

Figure 7: UN habitat Covid-19 SWM guidelines



Source: https://unhabitat.org

- Map sources of waste generation to identify changes in generation amounts and flows: Places such as hospitals, home care units, testing labs, and quarantine camps should be identified as they will generate hazardous waste. Additionally, places such as schools, commercial units, etc., which will see decreased waste generation shall also be identified. Mapping of such sources will enable efficient resource allocation.
- Separate infectious waste in households: All potentially infectious waste should be put in clearly identifiable colored bags, ensuring double coverage if possible. If identification of or separation of infectious waste is not possible then all waste from the household should be sealed and handled as residual waste. Waste bags should be distributed to households (especially low income and in informal settlements).
- Maintain and expand waste collection services: Human as well as financial resources should be allocated efficiently as per the mapping exercise undertaken by the authorities. Increased and regular waste collection services should be provided to the identified biomedical waste sources, informal settlement and high population density areas. The authorities should promote reduced contact between people, especially during door-to-door collection of waste.
- Ensure safe waste treatment and disposal: On-site temporary storage and thermal treatment of infectious waste from identified sources in the city must be ensured. If thermal facilities are not available, adequate and safe sanitary landfill measures should be ensured.
- Protect waste workers, formal and informal: All workers, either formal or informal, must be properly trained to follow basic hygiene measures. Safe work practices including PPE should be made available for these workers. The authorities should also consider support for livelihood loss of informal waste workers.
- Regularly communicate with citizens and stakeholders: The new collection schedule and other changes must be effectively communicated through radio, newspapers, social media and other channels. Citizens should ensure proper disposal of waste in line with guidelines.
- Engage with stakeholders: The authorities must engage with waste stream stakeholders both formal and informal, to identify roles and responsibilities. Coordination and collaboration with informal workers, NGOs and waste management operations should be undertaken to strengthen and expand service and coverage.
- Accelerate procurement procedures: The procurement of safety equipment, additional storage bins and collection trucks should be expedited. A review of central and state funds should be undertaken to check the possibility of fund diversion from the existing programs to the pandemic-related activities.
- Apply national and international guidelines for healthcare and medical waste: The guidelines laid down by the respective governments will be followed. In case of an absence of government guidelines, the WHO guidelines should be followed.
- Design scenarios and contingency plans: The lesson learned from other countries should be considered and implemented in each phase of planning. The authorities should also conduct risk assessments associated with the failure of continued service; for instance, staff and equipment shortage, closure of recycling, waste treatment and disposal units.

5.7 Key stakeholders

This section introduces the key stakeholders in relation to solid waste management in Gangtok such as the Government of Sikkim, the Urban Development and Housing Department, Gangtok Municipal Corporation, Sikkim State Pollution Control Board, Local co-operative groups/CBOs/NGOs and waste pickers.

Figure 8: Key stakeholders of SWM in Gangtok

Source: SIKKIM state government, GMC and CRIS analysis

State government: The Government of Sikkim is the primary authority, which, through its line departments, such as UDHD, water resources department, health and family welfare department, etc., formulates strategies, policies and regulations, and ensures streamlining of urban development in the state. It also provides funding support for major projects related to various aspects of urban development, such as public health and safety, town planning and development, water supply, SWM, sanitation, etc. Hence, all other stakeholders need to follow the stipulated guidelines of the state government pertaining to SWM activities in Gangtok.

Urban Development and Housing Department: UDHD is the primary agency responsible for Gangtok's development and management, and oversees aspects of physical planning, growth management, and provision of core civic services. It formulates policies, such as the Sikkim state policy and strategy on solid waste management (action plan) and bye-laws of solid waste (management and handling) cleanliness and sanitation for urban sector of Sikkim.

State Pollution Control Board: The State Pollution Control Board (SPCB) (under the Forest Environment and Wildlife Management Department, Government of Sikkim) is a regulatory authority that has been established for implementing various pollution control laws and regulations in the state of Sikkim. SPCB has an ambient air and water quality monitoring programme to assess and analyze the status of pollution in the environment. These monitoring programmes are funded by the Central Pollution Control Board, Ministry of Environment and Forests, Government of India

Gangtok Municipal Corporation: GMC, which covers ~19 sq. km area, stretching from Tashi View Point up to Ranipool, had a population of 100,286, as per the census of 2011, and has 17 wards. It is primarily responsible for collection, transportation, disposal and processing of solid waste. It engages SWM workers (permanent and those on muster roll basis), and provides vehicles and equipment for solid waste collection and transportation. The operations of the landfill site and the compost plant at Martam are managed by the GMC.

Local cooperative groups/CBOs/NGOs: Backpackers employed by local cooperative groups, CBOs and NGOs manually collect the waste from high altitude areas or areas which are inaccessible for the waste collection trucks of GMC. They manually collect the waste from such areas and bring it to a point where the waste collection trucks can pick it up and transport it to the landfill site

Waste pickers: Waste pickers in Sikkim collect commercial, household and industrial waste, and extract waste of potential value from streets, waste bins, dump sites, trucks, waterways, etc. They depend on such waste for income, despite the health risks. The waste pickers help keep the city clean, and also help reduce household waste. The GMC has provided identity cards to a few waste pickers in Gangtok, and has urged the public to cooperate with the waste pickers when they reach their home for waste collection.

5.8 Future plans

Waste to energy (WtE) plant on PPP mode: To explore waste processing technologies, such as WtE, the Gangtok Smart City Development Ltd (GSCDL) is looking to engage a private party for the design, build, finance, operate, maintain and transfer (DBFOMT) of a waste processing plant with a component of energy generation. The project will be carried out under the Smart Urban City Development and Management Unit on Public-Private Partnership (PPP) basis and will ensure sanitary and aesthetic living conditions for residents of Gangtok and communities living near the landfill site at Martam.

- Obligations of the private party: Under the project, the private party will be required to design, build, finance, operate, maintain and transfer the WtE plant, with the generation of energy as a product, on PPP basis. 90% of the project cost will be borne by the private party/investor. The private party will not be allowed to raise funds in the name of the Government of Sikkim or use the Government's land as a collateral for the loan.
- Obligations of the GSCDL: GSCDL will provide the land situated at Martam, East Sikkim free from all encumbrances to the private party for a fixed concession period of 33 years for the development of the WtE plant. GSCDL will also provide viability gap funding of INR 1,800 lakh (EUR 2.1 million), or 10% of the project cost, whichever is lower. It will also provide unsegregated municipal solid waste, generated in Gangtok for processing at the plant and will facilitate in obtaining all applicable and necessary permits from the concerned line departments[4].

Extended producer responsibility initiatives: Though Styrofoam is banned in the state, television sets and other items come in Styrofoam packaging. GMC is in discussions with the State Pollution Control Board for devising a solution to manage such packaging material-related issues. The initiative involves coordination with manufacturers under the extended producer responsibility to ensure pick up of such packaging material from the end consumer and dispose/treat it responsibly in accordance with applicable standards.

[4] *As per expression of interest document for the waste to energy plant issued in September 2018 by GSCDL.*

6 Climate change and SWM

This chapter captures the impact of climate change, such as effect of increase in temperature, glacial melting, landslides, and drying up of springs on SWM activities in Gangtok. An estimate of greenhouse gas (GHG) emissions released through composting as well as from disposal of waste at the landfill has also been analyzed.

6.1 Impact of climate change on SWM activities

Effect of increase in temperature: A paper on climate change in Sikkim, by the Sikkim Forest Department revealed that the mean minimum temperature in Sikkim increased by 1.95 degree Celsius between 1981 and 2010. Also, as per the Sikkim state action plan on climate change, the average annual temperature in Sikkim is likely to rise by 1.8-2.1 degree Celsius in 2030, when compared with 1970[5]. Additionally, the temperature in the monsoon season is likely to rise by 1.6-6.4 degree Celsius in 2030 when compared with 1970. The increase in temperature may alter the waste decomposition and leachate production rates, thus leading to the spread of infectious diseases, and posing challenges for solid waste collection and disposal.

Effect of glacial melting: A study by scientists at the Wadia Institute of Himalayan Geology in 2020 has revealed that due to increase in temperature and global warming, glaciers in Sikkim are melting at a rate faster than that in other Himalayan regions. As per the study, large glaciers are thinning, while smaller ones are retreating owing to climate change. Due to glacial melting, high altitude glacial lakes have increased in area. The increase in volume of water in the glacial lakes increase the risk of glacial risk outburst floods. This may lead to flooding in Gangtok, which could result in accumulation of huge volumes of waste, making it challenging for waste collectors to collect it. Flooding at the landfill may lead to inundation, waste solution migration to neighboring areas, physical erosion, and increased leachate production etc. Flooding also has harmful effects on waste treatment procedures such as biological decomposition of waste, wherein the waste pile may remain saturated even after floodwaters have receded, leading to an increase in moisture content and a decrease in calorific value of waste.

Effect of landslides: Gangtok and Sikkim are highly prone to landslides particularly during the monsoon season between May to September. In 2015 a landslide had occurred at Rambhi near Siliguri which had severely disrupted the traffic movement between Sikkim and North Bengal. Additionally a landslide had hit the Sikkim-Bengal border in 2016 leading to loss of lives.[6] Landslides not only affect the water supply infrastructure, SWM infrastructure/ facilities, other infrastructure in the city but also cause financial and human losses. Climate changes such as rise in temperature and heavy rainfall, coupled with clogged drains could lead to more landslides in Gangtok[7]. Landslides pose several challenges to SWM activities. Due to landslides, large volume of rocks, soil and debris tumble down the slopes, thus leading to waste accumulation in cities/towns or landfill sites.[8] Landslides also lead to soil erosion and loosening of the soil and rocks, which could get accumulated in drains and water bodies. This type of waste needs to be properly managed. Soil and rocks may even damage infrastructure at the landfill site, such as weighbridges, leachate collection system, etc. Additionally, landslides may block the transport routes of vehicles carrying waste to the landfill site. Landslides may prove fatal for SWM workers as well, thus indirectly affecting the SWM operations in the city.

5 As per the State Action Plan on Climate Change for Sikkim, 2011
6 Rapid Climate Vulnerability Assessment of Gangtok, Sikkim
7 City Resilience Strategy – Gangtok (The Rockfeller foundation and ICLEI)
8http://www.carpathianconvention.org/tl_files/carpathiancon/Downloads/04%20Publications%20-%20Press%20-%20Gallery/Documents%20and%20Publications/WasteMountains_screen.pdf

Figure 9: Landslide occurrences in Gangtok

Source: Rapid Climate Vulnerability Assessment of Gangtok, Sikkim

Effect of rainfall: Sikkim is characterized by heavy rainfall, wherein rainfall increases from the pre-monsoon month of May and continues till September. July records the highest monthly average rainfall[9]. Gangtok has an average annual rainfall of around 135 inches which is much higher than the national average of ~49 inches. Heavy rainfall may lead to flash floods and landslides which along with clogged drains pose several challenges to SWM in the city. Both floods and landslides may lead to accumulation of large volumes of waste, making it challenging for waste collectors to collect the waste, and may affect the SWM infrastructure and facilities in the city. Floods and landslides also lead to soil erosion which could get accumulated in drains and water bodies. Floods and landslides may even damage the infrastructure at the landfill site and may block transport routes of vehicles carrying waste to the landfill site.

Effect of earthquakes: The state of Sikkim is prone to earthquakes as it is placed in Zone IV/V of seismic vulnerability indicating high risk zone. An earthquake of magnitude 6.9 had hit Sikkim in 2011, with its epicenter being located at Chungthang, Sikkim. The earthquake had killed 70 people and had destroyed several villages[10]. Earthquakes in general create large volumes of debris and solid waste. Depending upon the nature of the infrastructure and the severity of the earthquake, waste volumes can be equivalent to many times of the annual waste generated by a city. The large waste volumes overwhelm the existing SWM facilities and personnel and also affect the response and the recovery process of an earthquake affected area.[11] Earthquakes also cause significant damages to a landfill wherein stretching or tearing of the landfill liner (cover) or the geomembrane takes place due to seismic activity. Additionally earthquakes may cause damage to the methane collection systems at the landfill site.

Effect of forest fires: Gangtok and Sikkim are characterized by a large forest cover and are also susceptible to forest fires.[12] A major forest fire had broken out in 2017 at Tinjurey Ridge in the Fambanghlo Wildlife Sanctuary, located close to Gangtok[13]. Forest fires are caused by both natural and man-made causes. Many forest fires start by natural causes such as lightning which sets the trees on fire. Additionally climate changes such as high temperature and dryness offer favorable circumstances for a fire to start. Forest fires not only cause floods, soil erosion, loss of natural vegetation, loss of flora and fauna but also cause financial and human losses. These effects in turn pose challenges to solid waste collection, transportation, treatment and disposal at the landfill site.

9 Rapid Climate Vulnerability Assessment of Gangtok, Sikkim
10 Rapid Climate Vulnerability Assessment of Gangtok, Sikkim
11 Waste Management following earthquake disaster by Charlotte Brown
12 Rapid Climate Vulnerability Assessment of Gangtok, Sikkim
13 https://www.hindustantimes.com/india-news/major-fire-breaks-out-in-sikkim-s-fambanglho-wildlife-sanctuary

Effect of drying up of springs: Several water resources, including springs, are drying up in Sikkim, owing to the impact of climate change (erratic rainfall) on springs and their catchment areas.[14] Due to the drying up of springs and other water resources, Sikkim faces prolonged periods of water shortage. Lack of water may have effects on the SWM value chain as well. SWM workers deployed for collecting and transporting waste, and those working at the landfill site may face acute drinking water shortage due to drying up of water resources, which could result in, the workers not working at all or not properly undergoing their regular duties of waste collection/transportation/disposal etc.

6.2 Impact of SWM activities on the environment

The SWM activities in Gangtok could lead to several environmental concerns such as air pollution, water pollution, noise pollution, pollution by solid and liquid waste, pollution by plastic waste and high odor levels. These environmental concerns are highlighted below.

Pollution by solid and liquid waste: Unscientific management of collection centers, landfill site and transportation trucks could result in solid waste pollution along the routes and in neighborhoods, wherein scavengers and animals/birds could scatter the waste leading to pollution. Additionally, light waste can quickly become airborne, and spread to areas outside the landfill leading to pollution.

Pollution by plastic waste: As plastic bags are light, these travel long distances by water and air, thus polluting the environment. Plastic bags are made of polypropylene and take years to break down. Even other plastic products, such as packaged drinking water bottles, disposable Styrofoam, and thermocol products, such as disposable plates and other cutlery, are non-biodegradable and non-recyclable. All such products clog waterways, fast fill up dump yards/ landfill sites, and release toxin laden leachates, thus contaminating the water in the surrounding areas. In 1990, due to a heavy rainstorm in Sikkim, a lot of plastic got washed down (due to excessive usage of plastic bags) and blocked several drains, causing a huge landslide[15]. Usage of all plastic bags, packaged drinking water, Styrofoam, and disposable thermocol plates and cutlery are now banned in Sikkim.

Air pollution: In Gangtok, mixed waste (both wet and dry waste) which is not collected for processing/disposal at the landfill site, is many a times openly dumped and burned. Such unscientific and illegal burning of waste pollutes the air and soil thus leading to unhygienic conditions in the city and leading to the release of harmful gases such as methane, GHG's and other pollutants in the environment.

High odor levels: Odors emanating from the landfill site at Martam is a nuisance for local residents who complain about the characteristic smell emanating from the site particularly during the monsoon and summer seasons. As the landfill site receives a significant volume of unsegregated waste, the waste received at the site needs to be kept for at least 45 days before it is ready for recycling and dumping. The waste produces a strong odor during this time, more so during the rainy season.

Water pollution: Several times water accumulates and stagnates at the landfill site, thus leading to incidence of water borne diseases, such as dengue, malaria, etc. The stagnant water at the landfill site also leads to organic and microbial pollution of the ground water table. The impact from the effects of wastewater is high and leads to long term irreversible effects beyond the boundaries of the landfill site. Apart from the landfill site, some waste generators dispose their waste into jhoras, thus polluting them and posing a threat to communities living nearby.

Clogging of storm water drains: Only 24% area of Gangtok is covered by a storm water drainage network. Roadside drains cover 3,774 km of which ~28% are still earthen or below the required capacity16. Some waste

14http://www.tmiindia.org/index.php/hidden-module/16-climate-change-impacts-mitigation-reviving-drying-springs-in-the-dry-areas-of-sikkim
15 https://www.unenvironment.org/news-and-stories/story/how-indian-state-sikkim-working-end-plastic-pollution
16 Rapid Climate Vulnerability Assessment of Gangtok, Sikkim

generators dispose their waste into the storm water drains, thus resulting in their clogging and posing a threat to communities living nearby.

Noise pollution*:* Movement of garbage collection vehicles may create noise pollution for citizens living in nearby residential areas. The movement of vehicles and the usage of heavy machinery at the landfill site may also increase the level of noise and vibration in the local environment near the landfill site. The effect will cause health problems, such as respiratory diseases for the inhabitants near the landfill site.

6.3 Greenhouse emission estimates

In 2016, major Indian cities generated an average of 0.366 tonne Co2 equivalent of GHG emissions, per tonne of solid waste that was disposed at the landfill site[17]. Considering the above mentioned value, and considering the fact that ~39 TPD of solid waste is disposed at the landfill site in Gangtok on a daily basis, the GHG emissions from the Martam landfill site account to ~5,210 tonnes Co2 equivalent of GHG emissions per year. The above calculations are based on the assumption that one tonne of solid waste disposed at landfill in Gangtok, releases 0.366 tonne Co2 equivalent GHG emissions.

[17] *https://think-asia.org/bitstream/handle/11540/8143/Working_Paper_356.pdf?sequence=1*

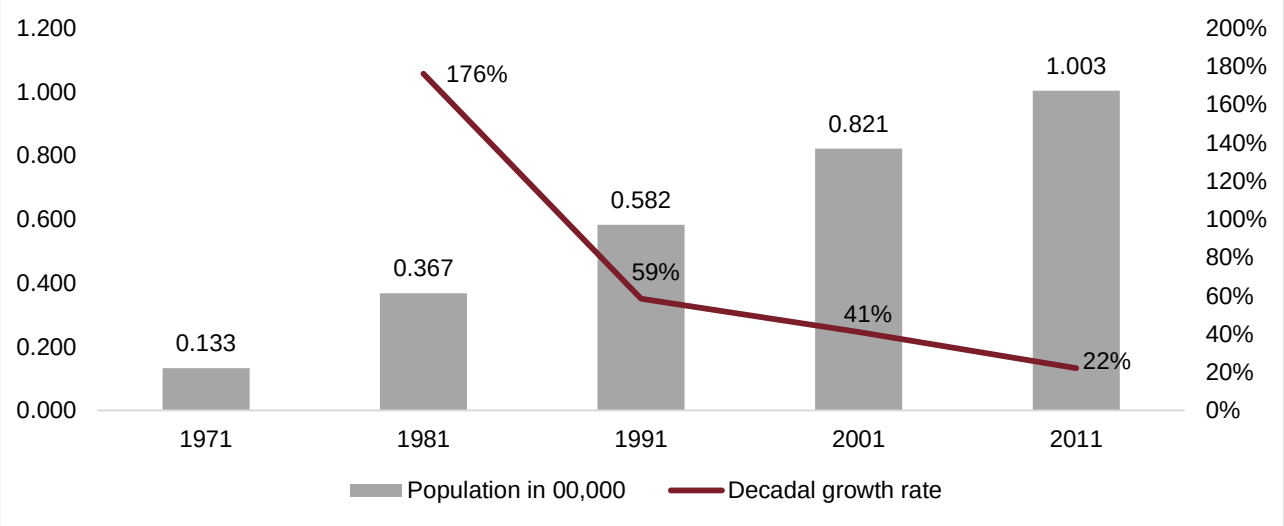
7 Future trends

This chapter presents demographic trends in Gangtok by estimating the decadal growth rate of population in Gangtok, and projecting the population of Gangtok city for the next three decades. The chapter further explains the macroeconomic trends in Gangtok followed by estimating the solid waste that would be generated in Gangtok over the next three decades.

7.1 Demographic trends

Gangtok's population as per the 2011 census was 100,286 with males constituting 52% of the population and females 48%. Of the total population ~9% were children in the age group 0-6 years. Apart from the resident population, the city also witnesses a large influx of tourists and thus results in a floating population of 30,000-40,000 people per day during the tourist season (September to mid-December and March to May). The city had a decadal population growth of 22.1% during 2001 – 2011. The city's growth in population is high as compared to Sikkim's decadal growth of 12.9% and the country's decadal growth of 17.64% during the same period.

Figure 10: Population growth of Gangtok city



Source: Census of India

The Gangtok city development plan (CDP)[18] was referred to, for the population projections for the city. The population projection under the CDP has been based on the population trends during the past four decades and has been carried out using various methods, such as arithmetic, incremental, geometrical, exponential, power method etc. The population projected using various methods, as described above has been compared with the population projections under all existing studies for Gangtok such as the first generation CDP, the water supply project etc. The power method population projection is similar to the population projections under the water supply project and therefore the CDP considered the power method as the most appropriate to estimate population projections for Gangtok city for the next three decades. The power method is thus chosen as the recommended method for projecting the population of Gangtok city. As per this method the population of Gangtok is estimated to increase to 164,000 in 2021, 194,000 in 2031 and 225,000 in 2041 as shown in the table below.

18 The CDP was prepared under capacity building for urban development project, a joint partnership program between the MoUD and the World Bank.

Table 3: Population projections for Gangtok city as per CDP

Year	Arithmetic	Incremental	Geometrical	Exponential	Power method (recommended)
1971	13,308	13,308	13,308	13,308	13,308
1981	36,747	36,747	36,747	36,747	36,747
1991	58,242	58,242	58,242	58,242	58,242
2001	82,149	82,149	82,149	82,149	82,149
2011	100,286	100,286	100,286	100,286	100,286
2021	121,000	125,000	162,000	328,000	164,000
2031	142,000	155,000	263,000	532,000	194,000
2041	163,000	188,000	425,000	864,000	225,000

Source: Gangtok CDP – Capacity building for urban development project – MoUD and World Bank

7.2 Macroeconomic trends

Tourism and hospitality: The service sector in Gangtok is largely dominated by tourism and hospitality. Many of the city's residents work in hotels and restaurants. Hence, majority of the income of Gangtok comes from tourism. Ecotourism is an important activity in Gangtok and the surrounding areas, which involves trekking, river rafting, mountaineering, etc.

Wholesale trade: Cardamom, one of the oldest spices in the world is the third most costly spice, after saffron and vanilla. Sikkim has the largest production of large cardamom in India, with Gangtok forming the major trading share of cardamom export from India. Apart from cardamom, Gangtok also exports other types of spices, wool and fur. Gangtok lies at a strategic location on the Indo-China trade route through the Nathula pass which is located 50 km from Gangtok.

Agriculture: Wheat, maize, finger millet and barley are some of the major agricultural crops grown in and around Gangtok. Around 2% of the working population in the city is employed in agriculture and agriculture-related activities. However due to hilly terrain and difficult landform, expansion of area under cultivation in Gangtok is limited.

Industries: Gangtok does not have a large manufacturing base but has cottage industries for making watches, handicrafts and country made alcohol. Micro, small and medium industries for making handicrafts out of paper, vegetable fiber and cotton are prevalent. Less than 2% of working population of Gangtok is employed in cottage industries. The Directorate of Handicrafts and Handloom (Institute of cottage industries) in Gangtok produces, promotes and teaches the ancient crafts of Sikkim such as mask making, painting, weaving and wood carving etc. The institute also produces hand woven Tibetan carpets, shawls, blankets, Sikkimese style wooden tables, handmade rice papers etc.

Commercial activities: Mahatma Gandhi (MG) Road in Gangtok is one of the main shopping and cultural activity streets in Gangtok. The road has shops, commercial establishments, hotels and restaurants lined up on both its sides and is a prominent shopping area. The road is well maintained, has seating arrangements and has the presence of a lot of tourists and residents on a daily basis. Additionally, Lal bazaar located near MG road is another local market which is full of shops. There is also informal commercial activity in Gangtok in the form of street vending.

7.3 Solid waste generation estimates

As described above, the resident population in Gangtok is projected to increase to 164,000 in 2021, 194,000 in 2031 and 225,000 in 2041, as per the Gangtok CDP. Also as per the CDP, Gangtok generated 390 grams

per capita or 39 tons of solid waste per day in 2011, population of Gangtok being 100,286 as per the 2011 census. The population figure of 2011 and the per capita waste generation in 2011, refer to old data and therefore cannot be used to accurately estimate the solid waste that will be generated in Gangtok in the next three decades. Therefore for accurately estimating the solid waste that will be generated in Gangtok in the upcoming years, the latest residential and floating population of Gangtok and the latest per capita waste generation in Gangtok will be required.

8 International & national best practices

The following chapter analyzes three international cases studies - Vienna (Austria), Ljubljana (Slovenia), Copenhagen (Denmark) - and three case studies from India, in order to assess the best practices, technologies and processes in plastic waste management. The chapter seeks to explain how key learnings from international and national best practices, and case studies can help shape an efficient PWM in Gangtok.

8.1 Experience of PWM from Vienna, Austria

Vienna – City profile: Vienna is the capital and the largest city in Austria. It is the most populous city in Austria, with a population of 1,897,491 as of 2019. It is the sixth-largest city by population in the EU. Vienna lies in the country's east on the Danube river and is famous for its imperial palaces, cultural events, wine taverns, coffee houses etc. Vienna The city has a robust economy and produces more than half of Austria's capital goods, and almost half of its consumer goods.

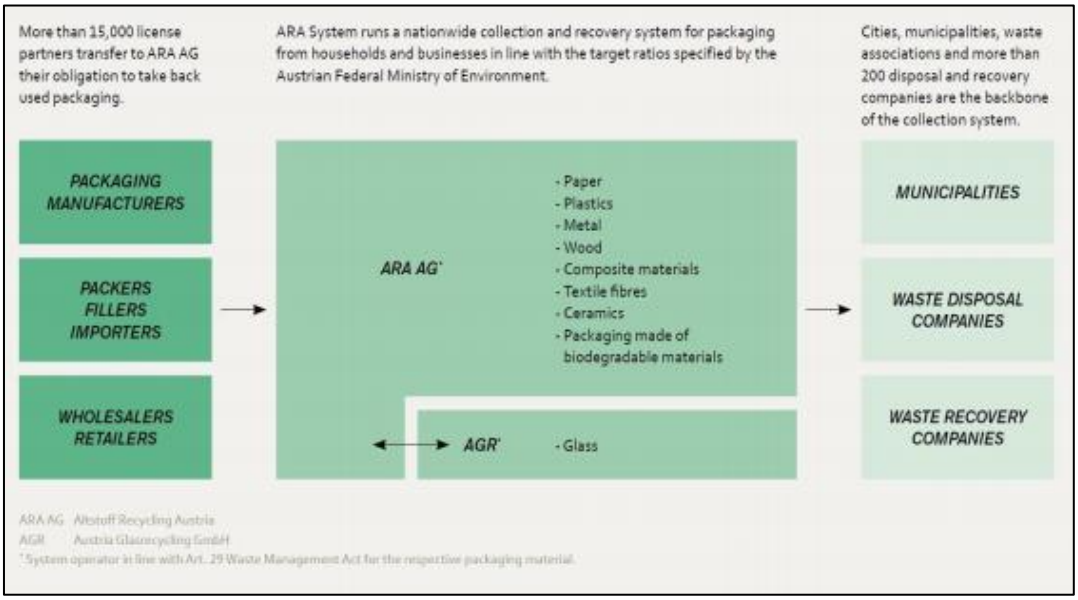
Waste management in Vienna: The Municipal Department 48 (MA 48), part of Vienna city administration, is responsible for MSW collection and treatment, and street cleaning in Vienna. However, collection, sorting and recovery of packaging waste is managed by Altstoff Recycling Austria AG, (ARA), which is Austria's leading collection and recovery system for packaging. Packaging waste is the main plastic waste fraction generated in Austria, and is also the major plastic waste fraction being recycled. As per the National Waste Management Plan, 2017, the recycling rate for MSW as a whole in Austria was 65% whereas the recycling rate of the plastic waste fraction was 33.6%.

Legislation related to plastic waste: The packaging ordinance of Austria mandates that producers, distributors, packagers and importers undertake measures, such as recycling and recovery for the plastic packaging and packed foods that are placed by them in the market. As per the landfill ordinance, waste with organic content of 5% or more is prohibited from being landfilled. Therefore, such waste has to be either incinerated or pre-treated by mechanical biological treatment before landfilling. Also, in Austria, the waste sent to either the landfill or sent for incineration incurs a tax, with the tax rates depending on the type of waste. Additionally, the packaging ordinance provides for separate collection of packaging waste by producers, distributors, packagers, importers, or third-party authorities as per extended producer responsibility.

ARA system of packaging waste collection and recovery: The packaging ordinance also specifies that producers, distributors, packagers and importers who are mandated to take measures, such as recycling and recovery for their packaging and packaging waste, may transfer those obligations to collection and recovery systems having the required authorization.

- Establishment of ARA: ARA is a major scheme for packaging and packaging waste in Vienna and in Austria. The ARA scheme was established by private stakeholders of packaging production business and the retail industry to handle management of packaging waste resulting from their day-to-day operations.
- Stakeholders of ARA: While waste disposal companies cannot join the ARA system, any company manufacturing or importing the packaging or trading in packaged goods are welcome to be a part of the ARA system. ARA system is divided into three major stakeholder groups related to packaging: (i) manufacturers, (ii) packers/importers/fillers, and (iii) retailers/wholesalers. Such stakeholder groups, which are licensed partners of ARA, transfer to the ARA their obligation to take back used packaging waste.
- Responsibility of ARA: The ARA runs a collection and recovery system throughout Vienna and Austria for collecting (taking back) packaging waste from businesses and households, in line with targets specified by the Austrian Ministry of Environment, and recovering/recycling it through its network of waste disposal and waste recovery companies.

Figure 11: ARA operational structure



Source: ARA, 2012

Collection of plastic waste*:* Though, a large proportion of plastic waste generated in Vienna is packaging waste, the process of waste collection followed in Vienna for both packaging waste as well as other types of plastic waste is stipulated below.

- Collection of packaging waste**:** ARA organizes and finances sorting, collection and recovery of packaging waste in Vienna and throughout Austria. ARA, in collaboration with its partners provides a well-developed collection infrastructure for households and businesses. Vienna focuses on separate collection of plastic bottles, wherein residents dispose plastic bottles (beverages, cleaning agents, food, cosmetics, etc.) in yellow bins and bags. Only a minor part of Vienna is covered by door-to-door collection of plastic bottles (yellow bins and bags), and majority of the plastic bottles (yellow bins and bags) are collected through a bring system (bring the waste to a collection point collecting plastic bottles). There are more than 2,300 containers in Vienna for collection of plastic bottles. These plastic bottles are then directly sent to the recycling facility and are turned into new products. Other types of light weight packaging are collected together with the MSW collection, and are used for conversion into valuable industrial fuel or for energy recovery with ARA paying the associated cost.

Figure 12: Yellow bags/bins system for PET bottles in Vienna

Source: Plastic-zero

- Collection of other plastic types: The collection of plastic waste, apart from packaging, is low in Vienna and Austria as a large proportion of plastic waste generated comprises packaging waste. Plastic waste, apart from packaging, includes hard plastic material (baskets, crates, tables, plastic garden furniture, etc.),

plastic tubes (gas, water, plumbing sewage, drainage, etc.), plastic foils (non-packaging), compact disks, PVC flooring, wall panels, insulation material, etc. These types of plastic waste (non-packaging) generated from households and businesses are delivered to recycling centers for recycling.

Treatment of plastic waste: The process of waste treatment followed in Vienna for both packaging waste and other types of plastic waste is stipulated below.

- Treatment of packaging waste: In Vienna, packaging waste generated from households and businesses is either recycled or incinerated with energy recovery at municipal incinerators. Landfilling is out of question due to landfill ban in Austria. The packaging waste is treated as stipulated below.
    - *Sorting of packaging waste*: Sorting of plastic packaging waste collected in the ARA system takes place at sorting plants. Sorting is done to separate the packaging from other types of waste, and also to sort the packaging into different types of plastics. There are sorting plants with manual sorting and/or automatic sorting (using infrared light to sort out different plastic packaging types). The plastic packaging is sorted in over 20 plastic fractions and a mixed plastic fraction
    - *Energy recovery through incineration*: Under the ARA system of waste collection, after sorting and removal of other types of waste, light weight packaging material is either sent for energy recovery through incineration, or for recycling. The light weight packaging material collected from households as described above is sorted into recyclable and non-recyclable fractions, and the non-recyclable but combustible fraction is sent for energy recovery through incineration, and the energy, thus, recovered is used in public buildings and district heating networks.
    - *Recycling*: The recyclable fraction of light weight packaging as well as PET bottles are recycled. For recycling, the plastic waste is shredded, washed, dried, melted, and then processed into granules, which is used as raw material for manufacturing new products. Plastic packaging needs to be sorted carefully and thoroughly before it can be recycled, as different packaging types have different melting points and do not mix upon melting. Sometimes, it is possible to recycle even unsorted plastic packaging waste; however, it allows manufacturing of only massive products in simple shapes.
- Treatment of other plastic types: Plastic types, other than packaging material, are also recycled. For e.g., as of 2012, in the upper Austria region, the waste management company, Landes-Abfallverwertungsunternehmen GmbH (LAVU), operates recycling centers that collect source-separated waste in 80 different fractions. As of 2012, there were 185 recycling centers in the upper Austria region, serving 550,000 households all over Austria. The system in upper Austria is based on the idea of source-separated waste and efficient logistics. The source-separated waste is transported from Vienna and other parts of Austria to a logistic center situated in the middle of upper Austria. At this center, the source-separated waste is sold to different recyclers.

Conclusion: ARA is Austria's leading collection and recovery system for packaging. Vienna uses the ARA system for managing the packaging waste resulting from day-to-day operations of the packaging production business and the retail industry. Manufacturers, packagers, importers, retailers are obliged to take back used packaging waste from consumers as per extended producer responsibility. However under the ARA scheme, these stakeholders transfer to ARA their obligation to take back the used packaging waste. ARA therefore collects packaging waste from businesses and households and sends it for recycling/recovery through its network of waste recycling and waste disposal companies.

8.2 Experience of PWM from Ljubljana, Slovenia

Ljubljana - City profile: Ljubljana is the largest city, and the capital of Slovenia. The city covers an area of 164 sq. km, and is located about 320 km south of Munich, 477 km east of Zurich and 250 km east of Venice. The city with a population of about 288,307 as of 2016, is known for its university population and green spaces. Ljubljana being the geographical, political, cultural and scientific center of Slovenia is an important driver of

economic growth and innovation for the country. Ljubljana became the holder of the title 'European Green Capital' in 2016.

Waste management in Ljubljana: Public company, Voka Snaga, is the biggest waste management company in Slovenia, providing waste management facilities in Ljubljana and 10 other municipalities in Slovenia. Among other waste management services, Voka Snaga is also responsible for waste collection. While packaging, paper, glass packaging, and bio waste are collected door-to-door or from bring points, hazardous household waste, WEEE and bulky waste are disposed free of charge at either the bring points or civic amenity centers. Of the 98,410 tonne of waste generated in Ljubljana in 2014, 22.8% was bio waste, 12.4% was packaging waste, 12% was paper, 5% was glass, and the rest 47.8% comprised hazardous waste, bulky waste, etc. In 2017, Slovenia had the fourth-highest recycling rate of plastic packaging, at 60% (Eurostat, 2017). In 2018, Slovenia had a recycling rate of municipal waste at 58.9% (Eurostat).

Best practices related to waste segregation

- Zero waste city – Ljubljana: Ljubljana is the first European capital committed to being a zero waste city. The reform in waste management in Ljubljana began in 2002, with introduction of segregation of waste. Paper, glass and packaging was collected separately in roadside container stands. In 2008, separate collection of biodegradable waste was introduced on a door-to-door basis, and in 2013, bins were provided to all households for collection of packaging and paper waste, both of which are collected door-to-door. As of date, six different colored containers are used to separate and collect six different waste fractions – (i) organic (biodegradable), (ii) mixed, (iii) packaging, (iv) paper, (v) plastic, and (vi) glass. As of 2008, the city recycled only ~29% of its waste; but the figure reached 68% in 2019. Between 2004 and 2018, Ljubljana saw a 10-fold increase in separate collection of waste, and the amount of waste sent for disposal reduced by 95% while keeping costs the lowest in Europe. The city currently produces only 115 kg of per capita residual waste annually.

Best practices related to prevention and reuse

- Prevention and reuse: After achieving efficient segregation, Voka Snaga moved its efforts from raising awareness on segregation to encouraging residents to reduce the amount of waste they generate, raise awareness on waste reduction, promote reuse, and ensure responsible and sustainable consumption. The company launched a campaign 'Get used to reusing'.

- Reuse centers: At the end of 2013, a reuse center was opened in Ljubljana. The reuse center comprises a shop, workshop and collection center. The objective of the reuse centers is to provide work to the elderly, disabled and other disadvantaged people, along with encouraging reuse of old, redundant but reusable items. It includes technical devices, pieces of furniture, clothing, and plastic items - practically everything that can be found in a flea market. There are eight reuse centers in Slovenia.

- Packaging-free vending machines at reuse center: Voka Snaga, runs its packaging-free vending machines, at reuse center for sale of basic household items. The vending machine sells cleaning supplies, shampoos, vinegar, oil and other household items to customers who bring their own reusable packaging. The appearance of the vending machine itself promotes recycling and reuse. All the equipment at the vending machine is made up of recycled plastic. All the products of the vending machine are either made from organic ingredients, or manufactured by local companies, produced by 100% natural processes, and do not contain artificial ingredients.

- Zero plastic waste stores: Zero waste retail stores are on the rise in Slovenia, wherein stores sell environment-friendly products in reusable packaging. Such stores are increasing in number in Slovenia. Rifuzl is a plastic-free grocery shop in Ljubljana, which focusses on living with less plastic and shopping sustainably. Shoppers bring their own glass jars and fill these with grocery products at Rifuzl.

Figure 13: Zero waste plastic store and packaging-free vending machine in Ljubljana

Source: Total-slovenia-news.com, Vokasnaga.si

Best practices related to waste collection

- Reduced frequency of waste collection: To encourage residents to separate waste more efficiently, scheduled collections of residual waste were cut by half in Ljubljana. Though frequency of collection of recyclables and compostable was kept the same, the frequency of collection of residual waste was reduced. This was based on the principle that if compostable and recyclables are collected more often than residuals, residents who did not want waste to be there for a long time, had an incentive to separate it. Similar to this Ljubljana has taken various measures and has been successful in implementing effective segregation of waste.

- Underground waste container bins: In the city center, Voka Snaga has installed underground waste containers and the bins open with an identity card issued to residents. This waste collection system helps keep the city center waste and litter-free.

Best practices related to **waste treatment/processing**

- Recycling in Slovenia: As discussed above, six different colored containers are used to separate and collect six different waste fractions. While packaging, glass, paper, and plastics are taken directly to recycling companies, mixed waste and organic (biodegradable) waste are treated at a modern waste management center called the Regional Waste Management Center (RCERO) situated in Ljubljana. It is a modern center, and one of the largest in Europe. It handles the waste of 58 municipalities and treats more than 170,000 tonne of waste per year. 98% of the waste is recycled into objects, compost or fuel. In 2017, Slovenia had the fourth highest recycling rate of plastic packaging at 60% (Eurostat, 2017).

Conclusion: Voka Snaga provides complete SWM services in Ljubljana. The city is known as 'zero waste city', and has an efficient system of waste segregation at source into six different waste streams stored in differently colored bins. Between 2004 and 2018, the city saw a 10-fold increase in waste segregation, and as of 2019 the city recycled 68% of its waste. Also, the amount of waste sent for disposal reduced by 95% while keeping costs the lowest in Europe. Ljubljana is its initiative to manage plastic waste more efficiently has implemented some innovative measures, such as reuse centers, packaging-free vending machines, zero waste plastic stores, etc.

8.3 Experience of PWM from Copenhagen, Denmark

Copenhagen– City profile: Copenhagen is the capital and the largest and most populous city in Denmark. As of January 2020, the city had a population of 794,128 with 632,340 people residing in the Copenhagen municipality. Copenhagen is part of the Oresund region, which consists of Lolland-Falster, Zealand and Bornholm in Denmark, and Scania in Sweden. Copenhagen is located on the eastern shore of the island of

Zealand. It is a major financial and economic center of Denmark and its economy is largely based on services and commerce.

Waste management in Copenhagen: As per the environment protection law of Denmark, the responsibility for waste management in Copenhagen, including waste collection and assignment lies solely with the municipalities. The municipalities are in-charge of regulation and control of waste generators, waste carriers, and treatment plants and are responsible for environmentally sound waste handling. The municipalities are also responsible for the establishment and operations of recycling centers. The responsibility for source separation of waste, as suitable for recycling or recovery rests with the waste generators but under supervision of municipalities.

Plastic waste generated: Most of the plastic waste collected from households in Copenhagen and in Denmark comprises packaging made of high-density polyethylene (HDPE), low-density polyethylene (LDPE), polypropylene, polyethylene terephthalate (PET), polystyrene (PS) and expanded polystyrene (EPS). Almost 340,000 tonne of plastic waste is generated from Danish businesses and households on an annual basis.

Legislation related to plastic waste: Danish legislation states that waste sent to landfills incurs a tax of euro 62.56/tonne, while waste sent for incineration incurs a tax of euro 6.69/tonne. It is illegal in Denmark to send any waste to the landfill, which can be incinerated or recycled. There is also a packaging tax levied on any new packaging placed in the market, which thereby provides an incentive to use reusable packaging.

Collection of plastic waste

- Collection of plastic waste from households**:** The plastic waste collected in Copenhagen is mainly packaging waste and also various types of rigid consumer plastic waste. Source separation of recyclable waste fractions is a central part of waste management in Copenhagen. Household plastic waste is collected by the respective municipalities, in accordance with specific waste regulations and collection schemes. The residual plastic waste generated from households apart from rigid plastic waste and bulky plastic waste is collected either directly from households, or through kerbside collection. Kerbside collection is established in localities having detached households. In Copenhagen plastic waste is also collected from apartment buildings. Collection frequency varies from weekly to bi-weekly.

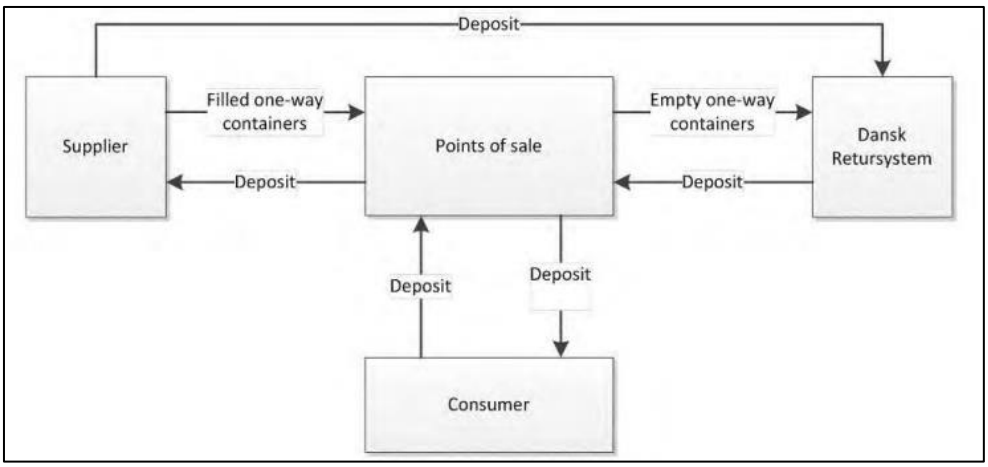
- Nem Affaldsservice: Nem Affaldsservice is a waste service facility in the city of Copenhagen. If residents need more information on garbage collection at their residence, including collection dates, ordering extra bins, ordering collection of bulky waste, reporting problems and issues or giving any kind of message to the municipality of Copenhagen, they can use the Nem Affaldsservice by typing in their address at the website.

- Recycling centers and manned waste collection centers: Flexible and rigid plastic waste and bulky plastic waste (such as rigid and flexible PVC, garden furniture, plastic foils etc.) are collected at Copenhagen's four recycling centers (Borgervaenget, Bispeengen, Kulbaneve and Vermlandsgade) or at the manned waste collection centers. The waste collection centers are smaller than recycling centers, accept only certain types of plastic waste and are accessible by foot only. Both the types of centers are manned/staffed and at both these centers, the different plastic waste fractions are collected separately. Most of these centers have a swap stand where one can donate or collect items which are still usable. While flexible and rigid plastic and bulky plastic originating from households is the responsibility of municipalities, wherein municipalities collect this fraction at the recycling centers, the ones originating from businesses is the responsibility of the companies wherein the companies bring the relevant plastic waste fractions to the recycling centers. Flexible plastic waste is collected both from households and is also delivered at the recycling centers. At these centers the bulky waste is collected, compressed into bales and is sent to the sorting facilities mainly in Germany and Sweden, though a few facilities exist in Denmark as well.

- Deposit and return system for PET bottles: Departing from the general rule in the EU, Denmark has no packaging producer responsibility scheme for plastic packaging. However, in Copenhagen as well as the

rest of Denmark, a deposit and return system exists for bottles having carbonated drinks, mineral water, beer and other beverages etc. While selling beverages in Copenhagen, the producer charges the price of the product as well as a deposit related to beverage containers and the return system. Danks Retursystem, the operator of the deposit and return system receives the deposit from the producers, which goes into the maintenance of the system. In most Copenhagen supermarkets, grocery stores, and gas stations there are local reverse vending machines installed wherein the consumer can return their used and deposit marked bottles and cans. The reverse vending machine accept the bottles and cans and scan the deposit mark and barcode and calculates the amount of money to be refunded. The machine then empties the bottles and cans into containers that are transported to the Danks Retursystem centers, wherein the items are registered, counted or sorted. The bottles and cans are then recycled, melted and turned into new bottles and cans. Post this process, the Danks Retursystem pays a refund back to the shops and supermarkets, which then refund it back to the end consumer. Danks Retursystem covers the recycling costs of the participating stores. To increase the recycling rates, the Danish government is expanding the deposit and return system, wherein post 2020, consumers will be able to return juice, concentrate bottles and other deposit marked bottles at their local reverse vending machine.

Figure 14: Deposit and return system for PET bottles



Source: Danks Retursystem

Treatment/processing of plastic waste: Non-recyclable and non-combustible plastic waste is landfilled. All landfilled material has very low plastic content. Flexible PVC is the only plastic waste that is sent to the landfill site. While 63% of plastic waste from households and businesses is incinerated in Denmark, 36% is recycled. Waste incineration with energy recovery has dominated the Danish waste management. Waste incineration is a well-organized business and a well-developed district heating system wherein 20% of district heating and 5% of electricity supply in Denmark comes from these plants. It is difficult to recycle plastic waste as it contains a mixture of different types of plastics that contain different additives and are often contaminated with non-plastics or food residues. To counterbalance this a Co2 tax on fossil content in the waste has been implemented which creates incentives for owners of waste incineration facilities to avoid plastics in the waste being incinerated.

- Amager Bakke incinerator: The plastic waste from Copenhagen is treated at the incinerator Amager Bakke at the Amager Resource Center (ARC). The Amager Bakke is one of the cleanest waste to energy plants in the world, due to the use of advanced filter technology used for filtering its emissions. Particles and pollutants from the smoke are removed and a process called selective catalytic reduction breaks harmful nitrogen oxide into nitrogen and water vapor.

- Sydhavn recycling center: The city of Copenhagen and the ARC will establish a new and state-of-the-art recycling center in Copenhagen taking another step towards a circular economy. The recycling center will

be open to residents of Copenhagen where they will be able to see that their waste has been converted into a resource. At the entry to the center residents would be able to hand in plastic items that are suitable for reuse and recycling. This initiative is in line with Denmark Government's strategy – "Denmark without waste".

Danish government's action plan: Danish government launched an action plan in 2018 with the objective of reducing the use of plastic, increasing recycling and preventing plastic litter. The main elements of the action plan are encouraging more recycling as compared to incineration, ban on lightweight plastic carrier bags, establishment of a national plastic center, better sorting of plastic waste, mapping business opportunities for Danish plastic companies, extended producer responsibility for packaging, circular loop for plastic consumption in which plastics are used over and over again through recycling and reuse, cleaning up of Danish beaches of plastics, reduction of single use plastics at major events, ban on micro plastics in cosmetics etc.

Conclusion: SWM regulations in Denmark impose a tax on waste that is landfilled or waste that is incinerated. Sending waste to landfill which can be either recycled or incinerated is banned. Also a packaging tax is levied on any new packaging placed in market. The residual plastic waste generated from households in Copenhagen is either collected directly from households or through kerb-side collection. Flexible and rigid plastic and bulky plastic waste is collected at Copenhagen's four recycling centers and manned waste collection centers wherein different plastic waste fractions are collected separately, compressed into bales, processed and sent for further use. Copenhagen also has a deposit and return system wherein PET bottles are returned back to the point of sale or reverse vending machines, in exchange for a refund that is deposited by the consumer while purchasing the material.

8.4 Experience of PWM from Indore, India

Indore - City Profile: Indore the commercial capital of Madhya Pradesh is located 200 km west of Bhopal, the state capital of Madhya Pradesh. Indore city has a population of 1,964,086 as per the 2011 census. Textile industry is an important industry in the city as there are a number of textile mills around the city. The city has also seen the rise of companies in the IT domain in the recent past. The city is well connected by rail, road and air and has several religious as well as tourist spots.

Waste management in Indore: Indore has been adjudged as the cleanest city in India consecutively for four years by the Ministry of Housing and Urban Affairs, Government of India. To accomplish this feat Indore Municipal Corporation (IMC) has ensured that efficient long-term plans were adopted to address the city's SWM problems. The IMC, which governs 85 wards implemented a series of carrot-and-stick measures that has led to the position the city finds itself in now. Indore city was conferred with the PWM award in 2020. Some features of the PWM and the best practices followed by IMC in the PWM domain are outlined below.

Plastic waste generated in Indore: Indore used to be the biggest plastic generator in Madhya Pradesh and out of 1,100 tonne of waste generated per day in 2017, 400 tonne used to be plastic waste. Plastic is non-biodegradable and non-recyclable and Indore city used to burn its plastic waste resulting in smog in the city due to burning of large amounts of plastic. Indore was literally choking on its plastic waste, and the condition of Indore's plastic was despicable.

Waste segregation: To curb the menace of plastic waste, the IMC implemented a simple plan of managing plastic waste by segregation - the act of separating dry and wet waste. Every household was required to strictly and diligently segregate waste. The IMC provided door-to-door waste collection service and also efficiently treated the waste. Once people started segregating the dry waste, it became easier for waste pickers appointed by the IMC to remove plastic from it. Once removed from the dry waste, the IMC was ready with the necessary infrastructure to treat the plastic waste. Four months into the plan, in September 2017, Indore was able to cut down on its plastic waste reaching the landfill site by 50%. Indore, which used to be one of the largest plastic waste generators in India, now sends zero plastic waste to landfill.

Plastic collection centers (PCCs): The IMC has set up PCCs in the city to recycle and reuse the plastic waste generated in Indore. These PCCs have been set up in collaboration with local NGOs. Waste pickers pick up the plastic waste from the dry waste, as segregated by waste generators and sell the plastic that can be recycled. The remaining is carried to the PCCs, where it is shredded and purified and is bundled in blocks of 100 kg and sent to cement plants, to be used as fuel for boilers. Some part of the shredded and purified plastic is also sent to the Madhya Pradesh Road Development Authority for road construction.

Other best practices related to PWM: Plastic waste is non-biodegradable and non-recyclable and takes nearly 1,000 years to break down. Therefore, just segregating waste and picking up plastic from dry waste and storing it, is useless unless the plastic is reused or recycled. Working on this mandate, the IMC facilitated making bins out of discarded plastic (which are distributed to the backward sections of the city for free or at a subsidized rate) and used shredded plastic for road construction. The IMC has tied up with the Madhya Pradesh Road Development Authority for the construction of roads using shredded plastic. The IMC has also banned plastic carry bags under 50 microns.

Conclusion: Indore has implemented an efficient plan for PWM by segregating waste at source into wet and dry waste. Every household is required to practice waste segregation. Plastic collection centers have been set up in collaboration with local NGOs, to recycle and reuse plastic waste generated in the city. At the PCCs, plastic waste is shredded, purified, and bundled into blocks which are sent to cement plants or used for road construction. Discarded plastic in Indore is utilized for making bins, which are distributed to backward sections of the city, either for free or at subsidized rates.

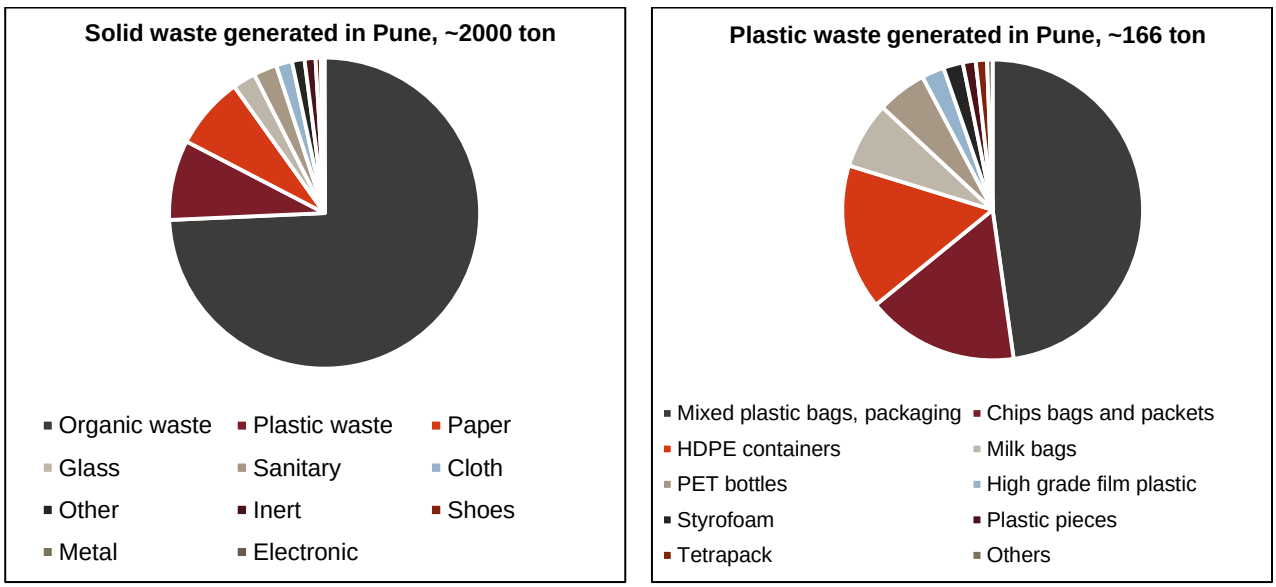
8.5 Experience of PWM from Pune, India

Pune - City profile: Pune is the second largest urban agglomeration in Maharashtra and Pune city is the ninth most populous city in India. The city, with a population of 3,124,458 (2011 census), is a part of the Pune urban agglomeration, with a population of 50, 57,709 (2011 census). Pune city is spread over 331 sq. km and is under the jurisdiction of the Pune municipal corporation (PMC), which was established in 1959. Average literacy in Pune is 95% for men and 87% for women as per the 2011 census. Additionally, average per capita income in the city is INR 111,637 per annum.

Waste management in Pune: Recyclable waste management (including plastics) in Pune follows a hybrid model, which involves informal workers (waste pickers). Informal workers thus undertake plastic waste collection, sorting, recovery and recycling activities at a much lower cost as compared to conventional/traditional, formalized and mechanized waste management approaches. Waste pickers thus save around INR 9,000 lakh (EUR 10.6 million) on an annual basis in labor, processing and transportation costs.

Solid and plastic waste generated in Pune: As per 2018 data, the waste generators in Pune generate ~2,000 TPD of solid waste, of which, 70% is generated by households, while hotels, restaurants and other commercial units made up the remaining 30%. Out of 2,000 tonne of waste generated on a daily basis, 8.3% (166 tonne) is plastic waste. The plastic waste stream includes mixed plastic bags and packaging (48%), plastic chip bags and packets (16%), HDPE containers (16%), milk bags (7%), PET bottles (5%), etc.

Figure 15: Solid and plastic waste generated in Pune

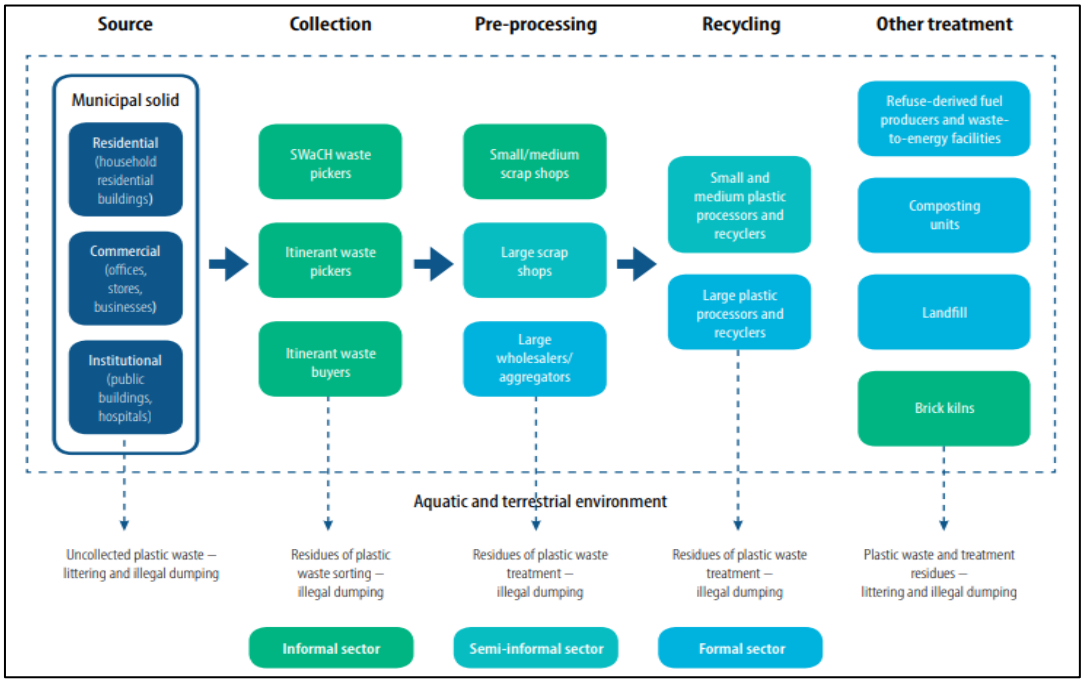


Source: www.unescap.org

Solid Waste Collection and Handling (SWaCH) model in Pune: SWaCH is India's first cooperative society owned by self-employed waste pickers. In 2008, the PMC authorized SWaCH to provide door-to-door waste collection and other waste management services for a period of five years. The waste pickers received user charges for waste collection, were accountable to both the PMC as well as residents and were supposed to perform in accordance with performance indicators as laid down in the memorandum of understanding (MoU) signed with the PMC. In 2014, the SWaCH model continued even in absence of the PMC administrative support. In 2016, the PMC renewed the MoU with SWaCH for another five years, and in 2018, SWaCH expanded to 640,000 properties and had 3,000 plus waste pickers. All members of SWaCH are working members, not just shareholders, and SWaCH has more than 80% representation from women. While SWaCH provides workforce in terms of waste pickers, the PMC provides the workers with waste, equipment and covers the administrative cost of SWaCH. The SWaCH waste pickers collect waste door-to-door, segregate the recyclable waste and dispose the remaining at secondary collection centers. They thus fill an important gap by reclaiming recyclable waste such as plastics and providing raw material for the recycling chain.

Plastic waste recycling value chain in Pune: The plastic waste recycling value chain in Pune comprised of plastic waste collection and segregation, pre-processing and recycling as depicted in the figure below.

Figure 16: Plastic waste recycling value chain in Pune



Source: www.unescap.org

- *Plastic waste collection and segregation:* Of the total waste generated in Pune about 87.5% is collected each day, wherein 52.5% of the waste is collected by the SWaCH waste pickers, 17.5% by government waste collection vehicles, 10% by private non-affiliated operators and the remaining 7.5% is collected through community waste bins and containers. The 3,000 plus SWaCH waste pickers, collect the plastic waste on a door-to-door basis and sort it manually at the premises of the waste generator in sorting sheds (550 of the 3,000 waste pickers have access to sorting sheds – Pune leads all other cities in terms of sorting sheds provided to waste pickers), or wherever they find a space. They receive fee (waste collection user charges) from waste generators and from scrap shops and itinerant buyers to whom they sell the plastic waste. Non-affiliated itinerant waste pickers (4,000 of them) collect recyclable material from businesses, dump sites and from streets. The waste pickers play an important role in the PWM value chain in Pune as they collect and segregate plastic waste from various sources such as households, commercial units, landfills, dump sites, streets, slums etc. which traditional waste collection systems cannot do. ~30,000 tonne of plastic waste is collected on an annual basis by the SWaCH waste pickers, of which 15,000 tonne is segregated and is sent for recycling by them, thus saving 52% of plastic waste from Pune from ending up in landfills. Because of this plastic waste diversion from landfills, ~50,000 tonne of CO2 equivalent of GHG emissions are reduced on an annual basis, which is equivalent to removing 10,000 cars from the road and saving 21 million liter of petrol.

- *Trade and pre-processing*: The next link in the PWM value chain in Pune is small scrap shops which purchase recyclable material such as plastics from waste pickers or directly from waste generators. Pune has ~600 small and medium-sized scrap shops, 50 large scrap shops and 30 large wholesalers and aggregators. The owners of scrap shops are mostly small informal traders earning marginally more than waste pickers, and often belonging to families of waste pickers. Scrap shops sort and compress the collected plastic waste which is further resold by weight or unit for further processing and/or recycling. Sorting is often conducted by color, quality, and polymer. In Pune plastic waste collection and segregation is purely commercial in the sense that waste pickers collect heavy weight and low volume plastics on priority such as HDPE, PET, and hard plastics as they can be sold at higher value. Less valuable plastics such as mixed plastics and low weight and high volume plastics sometimes remain uncollected and are

not recycled. Price paid for plastic depends on its quality and quantity and value can be added to collected plastic by washing, cleaning, classifying, compacting and aggregating.

- *Recycling*: The next step in the value chain is further processing of plastic waste, which involves further sorting (segregation), cleaning, flaking or pelletizing the plastic waste. Small and large plastic recyclers, carry out processing of the plastic waste and then send it to final users of recycled plastic both in India and abroad. Plastic waste recycling and processing units are located in Pune as well as in whole of Maharashtra, of which certain areas and cities are specialized in certain specific processing activities of the value chain. The recycling and processing units specialize in specific plastic and polymer types. Also while some units are advanced in terms of technology some have basic equipment that provides little scope for quality control. Many of the units are informal and often not registered with the state pollution control board and do not comply with labor laws or environmental laws and regulations.

Plastic ban: In March 2018, the Government of Maharashtra imposed a ban on plastic products such as plastic bags, disposable plastic products such as cups, cutlery, glasses, bowls, containers, polystyrene foam, thermocol items, and plastic decoration products. The ban is imposed for all types of waste generators. The ban has imposed various penalties on those handling or using the banned items. The government also introduced a buy-back system for PET bottles and milk packets.

Conclusion: PWM in Pune follows a hybrid model involving waste pickers. SWaCH, a co-operative society of self-employed waste pickers, undertakes waste collection, sorting, recovery and other SWM services in Pune. While these waste pickers receive user charges from waste generators and from scrap shops to whom they sell the plastic waste, the waste is provided by the PMC. Waste pickers not only save tonnes of waste from ending up at landfills, but also collect waste from landfills, dumpsites, slums, etc., which traditional waste collection systems cannot do. The waste pickers sell plastic waste to scrap shops, where it is pre-processed and then sent for recycling and processing by small and large recyclers.

8.6 Plastic waste recycling and management centers at Surat

Surat - City profile: Surat, located in the western state of Gujarat, is the eighth largest city and the ninth largest urban agglomeration in India. Known as the diamond city of India and famous for its diamond and textile industries and as a shopping center for apparels and accessories, Surat is located 289 km north of Mumbai and 284 and 265 km south of Gandhinagar and Ahmedabad, respectively. As per the Ministry of Housing and Urban Affairs, Government of India, Surat was the fourth cleanest city in India in 2017. Surat has a population of 4,466,826 as per the 2011 census and has an area of ~327 sq. km. The SMC is the civic body responsible for the administration of Surat and was formed under the Bombay Provincial Municipal Act, 1949.

Plastic waste generated in Surat: Surat generates ~1,800 TPD of waste, of which, ~95% (1,720 TPD) is reprocessed, while the remaining (80 TPD) is dumped at the Khajod waste disposal site. 10% of the waste generated per day in Surat, is plastic waste.

Plastic waste treatment/processing: Surat has a plastic waste recycling plant that was built and run on PPP mode since 2017 and a new plastic waste management center is set to be built in Surat by the central government.

- Plastic waste recycling plant operated by Eco-vision: A PWM facility (recycling plant) was built and is run on PPP mode in Surat, since 2017 by M/S Ecovision Environmental Resources LLP, which is a special purpose vehicle of the Envision group of companies. A build-own-operate (BOO) concession of 15 years was awarded to Eco-vision for the development of the PWM facility as per Plastic Waste (Management and Handling) Rules. SMC has provided a two acre land on token rent and Eco-vision has invested around INR 800 lakh for phase 1 of the project. Operations and management of the facility rests with Eco-vision. The plant recycles around 35 TPD of plastic waste at the waste recycling plant situated at Bhatar in Surat,

as of 2019. Once the capacity is expanded to treating 100 TPD of plastic waste, the SMC will look at converting shredded plastic into diesel in Phase II of the project.

- New plastic waste management center: The Government of India has identified four cities for setting-up of PWM centers, which are Surat, Bengaluru, Varanasi and Patna. The government will provide grant of INR 600 lakh to each of the four cities for the development of the PWM centers. While the SMC would bear the construction costs, Central Institute of Plastics Engineering and Technology (CIPET) – Chennai will provide machines and equipment for recycling and disposal of plastic waste. At the PWM center, training on plastic management and research work on plastic recycling and disposal will also be undertaken. An awareness program on disposal of plastic items, its impact on environment and reuse of plastic will also be conducted for citizens. The PWM center will therefore handle all activities related to reducing harmful effects of plastic waste in the environment.

Conclusion: Surat has a plastic waste recycling plant which was built and run on PPP mode by a private company M/S Ecovision. The plant currently recycles 35 TPD of plastic waste and is scheduled for a capacity expansion up to 100 TPD in phase II of the project. A new PWM center is set to be built in Surat by the central government, through INR 600 lakh grant. Machines and equipment will be provided by the CIPET. The PWM center will also conduct training and awareness programs on PWM and recycling.

8.7 Key learnings

The key learnings from the analysis of case studies are as follows.

Key comparative points for the case studies evaluated: The six case studies showcased in the section above highlight the processes, technologies and best practices used for an efficient PWM system. The case studies illustrate the innovative approaches implemented to tackle the PWM issue. The following tables present a comparative analysis of the case studies presented in the previous section:

Table 4: Comparison of case studies

City	Innovative practices
Vienna	• Landfill tax, incineration tax, landfill ordinance and packaging ordinance • ARA system of handling packaging waste • Treatment of packaging waste by recycling and energy recovery (incineration)
Ljubljana	• Dedicated public company providing waste management facilities • Efficient waste segregation into four different waste fractions • Reuse centers, packaging-free vending machines, zero plastic waste stores
Copenhagen	• Landfill tax, incineration tax and packaging tax • Collection of waste at 4 recycling centers and manned waste collection centers • Deposit and return system for PET bottles
Indore	• Waste segregation at source into dry, wet waste preventing plastic to end up at landfill • PCCs to recycle and reuse plastic waste generated in the city • Discarded plastic used for making bins and for road construction
Pune	• SWaCH model – Co-operative society of waste pickers providing SWM, PWM services • Collection of waste by SWaCH waste pickers, government and private operators • Sorting and pre-processing of plastic waste by scrap shops • Recycling and processing by small and large recyclers
Surat	• Plastic waste recycling plant operated by Ecovision

City	Innovative practices
	• Establishment of a new PWM center • Awareness program on PWM at the PWM center

Legislation and regulations: The SWM regulations could impose a tax on waste that is sent to the landfill and waste that is incinerated. Sending waste to landfill which could be either recycled or incinerated could be banned. Also a packaging ordinance could be implemented mandating producers, distributors, packagers and importers to undertake recycling and recovery for plastic packaging and packed food etc. placed by them in the market (extended producer responsibility).

Waste segregation: Every household and waste generator should be required to strictly and diligently practice waste segregation at source. The waste segregation should begin by the simple act of separating waste into dry and wet waste which could then progress to separating waste into different waste fractions such as organic waste, mixed waste, plastics, paper, packaging, glass etc. Differently colored bins/containers could be provided to waste generators to segregate waste into above mentioned waste fractions.

Plastic waste collection: Some key learnings, best practices and efficient processes in plastic waste collection and transportation, as derived from national and international experiences are highlighted below.

- PWM by waste pickers: A co-operative society of waste pickers could be set up to provide door-to-door waste collection and other waste management services. The waste pickers would receive user charges from waste generators for waste collection and fee from scrap shops to whom they sell plastic waste. Waste pickers would reclaim plastic and other recyclable waste, thus preventing tonnes of plastic waste from ending up at landfill. Another advantage of using waste pickers for waste collection is that they are able to collect and segregate plastic waste from various sources, including landfills, dump sites, streets, slums etc., which traditional waste collection systems cannot do.
- Recycling centers or plastic collection centers: Recycling centers or plastic waste collection centers could be set up in the city wherein, different plastic waste fractions would be collected separately. These centers would be manned and would accept only recyclable plastic waste. At these centers, the plastic waste would be shredded, purified and bundled to be further sent for various uses such as road construction, usage in boilers in cement plants, etc.
- Scheme for handling packaging waste: The ARA system as implemented in Vienna is very effective in handling the management of packaging waste resulting from day to day operations of packaging production business and retail industry. Under this system manufactures, packers, importers, retailers and other licensed partners of ARA transfer to ARA their obligation to take back used packaging waste. ARA collects packaging waste from businesses and households and sends it for recycling/recovery through its network of waste recycling and waste disposal companies.
- Deposit and return system for PET bottles: A deposit and return system could be implemented in Gangtok for combating litter rates and increasing PET bottle collection and recycling rates. In this system, carbonated drink bottles, PET bottles etc. are returned to the point of sale or reverse vending machines, in exchange for a refund that is deposited by the consumer while purchasing the material.
- Reuse center: A reuse center comprising a shop, workshop and collection center could be opened in the city. The reuse center could employ elderly, disabled and other disadvantaged people and with encourage reuse of old, redundant but reusable items. People could donate or collect items at these centers.
- Packaging-free vending machines and zero plastic waste stores: Packaging-free vending machines and zero waste plastic stores could be set up in the city, for selling environment-friendly products to customers who bring their own reusable packaging and glass jars.

Plastic waste disposal, recycling, treatment and processing: Some key learnings, best practices and efficient processes in plastic waste disposal, recycling and treatment, as derived from national and international experiences are highlighted below.

- Zero landfill: Cities to strive to achieve zero or very less landfill. Only non-recyclable, non-combustible waste should be landfilled. Also, all landfilled material should have very low plastic content.
- Plastic waste recycling plant: A plastic waste recycling plant could be developed in the city wherein the recyclable fraction of plastic waste would be washed, cleaned, sorted, classified, compacted, aggregated, shredded, flaked and/or pelletized and sent to various industries for further use.
- Energy recovery facility (incineration): To prevent non-recyclable but combustible fraction of plastic waste from ending up at the landfill site, an energy recovery facility or incinerator could be developed in the city The energy produced at the facility could be utilized for energy generation or district heating.

9 Key challenges and solutions

This chapter provides potential challenges detrimental to the SWM value chain in Gangtok, including the processes of waste segregation, collection, transportation, disposal and processing/treatment. The chapter also provides possible solutions to such challenges.

9.1 Key challenges

Solid waste segregation

- Low waste segregation rate**:** Gangtok faces a challenge in terms of waste segregation. The waste segregation rate was 45% in 2018 and 55% in 2019. This poses problems for waste management and processing as the best of technologies for treatment and processing will be useful only when waste is properly segregated at source. The challenges that GMC faces in implementing and enforcing waste segregation at source are: non-cooperation from general public, lack of enforcement, lack of awareness and lack of public support.
- Low plastic waste segregation rate: Segregation of plastic waste is not very efficient in Gangtok. Some portion of plastic waste is segregated by safai karamcharis at source and the remaining unsegregated waste is collected from the waste generators and is transported to the landfill site. A certain portion of plastic waste is again segregated at the landfill site by waste pickers at the site. The remaining unsegregated plastic waste is then dumped at the landfill site.

Solid waste collection

- Difficult terrain: Effective SWM including waste collection is a challenge in the hills, due to landform variations, rugged terrain and scarcity of flat land. Heavy rainfall, snowfall, landslides, glacial lake outburst floods, and flash floods are prevalent in hilly areas and might pose several problems in collecting, transferring and disposing the solid waste. The landfill site at Martam is not a flat land and has a hilly terrain with Ranikhola river flowing close to the site.
- Improper design of waste collection trucks: The waste collection trucks in Gangtok are such that they do not have separate compartments for segregated waste. Therefore even if segregated waste is loaded onto the trucks, the waste gets mixed up on its way to the landfill site.
- Ineffective collection of plastic waste: In Gangtok, items delivered by e-commerce websites come wrapped in plastic packaging whereas television sets and other electronic items come wrapped in Styrofoam packaging. Such types of packaging are not properly segregated and collected for treatment/disposal at the landfill site. Additionally tourist friendly plastic waste collection points do not exist in the city due to which the tourists throw plastic waste into jhoras, rivers, valleys and streets. They therefore cause littering and pollution by plastic waste in the city.
- Open burning of waste and pollution of jhoras, valleys and streets: In Gangtok, uncollected mixed waste, i.e., both dry and wet waste, is often openly dumped and burned thus leading to the release of harmful gases and pollutants, contributing to air pollution**.** Many a time, waste is indiscriminately thrown into valleys, jhoras (springs) and streets, resulting in solid waste pollution.

Solid waste disposal

- Unscientific management of the landfill site: The landfill site at Martam has odors emanating from the site, which is a big nuisance for the local residents as well as passers-by who complain about the characteristic smell emanating from the site particularly during monsoon and summer seasons. As the landfill site receives mostly unsegregated waste, the waste received at the landfill site needs to be kept for at least 45

days before it is ready for recycling and dumping. This leads to a strong odor, during this time, more so during the rainy season. Additionally, water accumulates and stagnates at the landfill site, leading to incidence of water borne diseases such as dengue and malaria. The landfill site is located close to the Ranikhola river, which results in contaminates and waste water flowing freely off the site into the river.

- Low capacity of the landfill site: Initially, the landfill site was meant to cater to the waste generated by Gangtok alone and was designed for a period of 15 years. But now waste from various gram panchayats and other cities in Sikkim is also disposed of at the site, which has drastically reduced its life such that operations at the site can continue for another 5-6 years. Besides, of 4.2 hectare land at Martam, only ~ 1 hectare is the landfill area due to various constraints such as hilly terrain, Ranikhola river flowing near the site etc. Additionally, the waste reaching the landfill site is not segregated and as of 2019, 80% of the area under the landfill is already covered. If this goes on, Gangtok will face a severe waste management problem in the next few years.

Solid waste processing/treatment

- Incomplete utilization of the Martam compost plant: The compost plant is designed to treat only segregated organic waste, with unsegregated waste resulting in the machine getting locked and hence incurring high maintenance cost. As the waste reaching the Martam facility from Gangtok is not properly segregated, the compost plant is not operating to its full capacity and currently processes only ~5 TPD of segregated organic waste.

- No revenue from compost generated at the Martam compost plant: The Martam compost plant is not operating at its full capacity. Also the compost produced by the plant is used by Sajong farmers society on a trial basis till the quality of compost is certified by a registered laboratory. Therefore, though the plant is operational it still does not earn revenue for GMC through sale of compost.

- Improper plastic waste treatment: The plastic waste generated in Gangtok is not properly segregated. The portion of plastic waste which is segregated by waste pickers at the landfill site, is sent to the recycling plant in West Bengal and some of it is handed over to NHIDCL for road construction. There is no recycling plant or energy recovery (incinerator) in Gangtok or nearby areas and there is no systematic procedure for handling plastic waste in the city.

Plastic ban

- Challenges in imposing the plastic ban: Sikkim has banned the use of single-use plastics, while multi-use plastics are still in circulation. In spite of the ban on single use plastics, items delivered by e-commerce websites come wrapped in plastic packaging, whereas television sets and other electronic items come wrapped in Styrofoam packaging. Tourists visit the city year round, and cause littering and pollution by plastic waste in the city. They tend to throw waste such as plastics, paper, wrappers etc. in jhoras, rivers, valleys and streets. It is quite challenging to impose the plastic ban and levy fines on tourists as they may not be very sensitive to PWM.

9.2 Possible solutions

Solid waste segregation

- Fines and incentives to ensure segregation**:** GMC has already stipulated fines for waste generators not providing segregated waste to the waste collectors. GMC has to ensure strict enactment of fines and that fines are levied on those not providing waste in a segregated manner. Additionally, GMC could tie some incentives/rewards for those who provide segregated waste. For example, a waste generator who provides segregated waste regularly for a month may be given a discount of 10-20% in their waste collection fee.

- Awareness programs to promote segregation: GMC could conduct awareness programs on waste segregation through Information, Education and Communication (IEC) activities in order to sensitize the public and other stakeholders about the advantages of waste segregation at source, and how it could prevent tonnes of waste from ending up at the landfill site.

Solid waste collection

- Reduce, reuse and recycle to combat challenges created by hilly terrain: To combat challenges, posed by SWM in hilly terrain, it is important, to implement the 3Rs of waste management, that is reduce, reuse and recycle. GMC must support at source reduction and reuse to enable waste minimization (reuse carry bags) and promote sustainable/ multi use of products (packaging jars, etc.). GMC could also promote recycling and processing of inorganic waste to recover commercially valuable material (such as plastic, paper, metal, glass etc.). When majority of the waste is reduced, reused and recycled at source, less of it will need to be collected and transported to the landfill site, thus combatting challenges posed by hilly terrain.

- Effective design of waste collection trucks: The waste collection trucks in Gangtok need to have separate compartments for different fractions of solid waste, thus collected from waste generators. Separate compartments will ensure that the segregated waste loaded onto the trucks, does not get mixed up on its way to the landfill site.

- Measures to collect plastic waste: GMC may install a recycling vending machine at all major tourist spots in the city to encourage tourists and residents to recycle their plastic and packaging waste. A deposit and return system could also be implemented wherein tourists and residents would return back the PET bottles and packaging waste at the point of sale, in exchange for a refund that is deposited by them while purchasing the products. GMC could make it mandatory for manufacturers, packagers, distributors and importers to collect back the packaging waste from consumers as per extended producer responsibility. Additionally, GMC could from an organization wherein the manufacturers, packagers, distributors etc. could transfer to the organization their obligation for collecting packaging waste from consumers. This organization could therefore collect the packaging waste and send it for recycling or energy recovery. Also packaging-free vending machines or zero plastic waste stores could be set-up Gangtok, to sell products to consumers in reusable packaging brought by the consumers themselves.

- Measures to prevent pollution**:** GMC needs to increase the waste collection rate in Gangtok to prevent any uncollected waste being dumped openly in jhoras, valleys, streets etc. GMC needs to ensure that the fines are levied on the perpetrators irrespective of whether they are local residents or tourists in order to prevent pollution in Gangtok. GMC could appoint some workers or station existing workers at some important locations such as markets, tourist spots, near water bodies to enable them to levy fines, there and then, on those who pollute the environment. GMC currently undertakes street sweeping and jhora desilting activities on a regular basis. GMC could outsource the sweeping and jhora cleaning activities to local cooperative groups/NGOs/CBOs or to a private party.

Solid waste disposal

- Scientific management of landfill site**:** The landfill site at Martam should be upgraded so that it is able to function in a scientific manner with complete control over the odor, developed in the landfill (preventing air pollution) and limited access of vectors and flies to the waste. Odor control measures such as spraying waste with an organic culture solution and maintaining waste storage area at negative pressure must be carried out. Care should be taken to ensure that water does not accumulate/ stagnate at the landfill site. Adequate controls and processing systems should be in place so that waste water and contaminates are not able to flow freely into the nearby Ranikhola river.

- Alternate site with higher capacity for landfill: The SWM rules, 2016 require construction of landfill on hills to be avoided, with plain, level land being required for construction of sanitary landfills within a distance of

25 km from the city. GMC should find an alternate site for the landfill which has a more flat topography and has adequate capacity to accept the waste being generated from Gangtok, for years to come. GMC has already received offers from a few players for the construction of a new landfill site.

- Prolong the lifespan of the Martam landfill site: Another solution to prolong the lifespan of the Martam landfill site is to allow it to accept only segregated waste for disposal. Plastic and other recyclables end up taking a lot of space at the landfill and therefore should not be allowed to be disposed at the landfill.

Solid waste processing/treatment

- Segregated waste for the Martam compost plant: The GMC should ensure that segregated organic waste reaches the Martam facility so that the Martam compost plant is able to operate at its full capacity.

- Revenue from compost at Martam compost plant**:** The GMC should ensure, that compost produced by the Martam compost plant is certified by a registered laboratory soon, so that it can market and sell the compost, thus earning revenue from the sale**.** This revenue could further be utilized towards SWM activities or for awareness campaigns etc.

- Setup of plastic waste treatment facility: GMC needs to ensure that only non-recyclable and non-combustible plastic waste reaches the landfill site. To ensure this a plastic waste treatment facility could be built in Gangtok, either through PPP or EPC mode, wherein the recyclable fraction of the plastic waste would be recycled while the non-recyclable fraction could be utilized for energy recovery (incineration), which could be further utilized for generating electricity or for district heating.

Imposing the plastic ban

- Measures to impose plastic ban: GMC to ensure strict enactment of fines on both tourists as well as residents to ensure that they do not use banned plastic products in the city. Awareness programs need to be conducted through IEC activities for residents to develop good PWM practices and to sensitize them to mitigate harmful effects of plastic waste on the environment. Additionally information campaigns could be conducted, roping in eminent personalities from different backgrounds, for raising awareness on the importance of PWM.

Figure 17: Key challenges and possible solutions

Key challenges	Possible solutions
Waste segregation	
• Low waste segregation rate	• Fines and incentives for waste generators to ensure segregation
• Low plastic waste segregation rate	• Awareness programs to promote waste segregation
Waste collection	
• No compartment for segregated waste in collection trucks	• Separate compartments for segregated waste in waste collection trucks
• Ineffective collection of plastic waste	• Recycling machine at tourist spots and deposit and return system for PET bottles
• Ineffective collection of packaging waste	• Packaging free vending machines, zero – plastic waste stores
• Open burning of waste, pollution of jhoras, valleys & streets	• Increase waste collection, ensure strict fines levied on those burning/ dumping waste
Waste disposal	
• Unscientific management of the landfill site	• Ensure current landfill site operates in a scientific manner
• Low capacity of the present landfill site	• Allow segregated waste at landfill, look for alternate landfill site with higher capacity
Waste treatment	
• Incomplete utilization of Martam compost plant	• Only segregated waste to be allowed as input at the compost plant
• No recycling/energy recovery facility at Gangtok	• Plastic waste treatment facility could be built at Gangtok
Plastic ban	
• Challenges in imposing single-use plastic ban	• Strict enactment of fines for both tourists and residents
	• Awareness programs to be conducted for residents to develop good PWM practices

10 Next steps/Way forward

Having established the need for an efficient SWM in Gangtok and the need to manage plastic waste more effectively, the following chapter lists outs the important steps as the way forward for relevant stakeholders.

Next steps/ way forward: Having established the need for an efficient SWM in Gangtok and the need to adapt and implement best practices from India and abroad, the GMC should undertake a detailed feasibility study in this regard. The feasibility study should cover in detail the following:

- Technical feasibility: This part of the feasibility report should cover all technical aspects, including upgrading and streamlining the SWM value chain, including PWM in Gangtok. The technical feasibility should comprise of identification and assessment of best practices and processes used for waste segregation, collection, transportation, disposal, and processing/treatment, along with an estimation of feasibility and costs related with each new process or best practice thus added to the value chain. For the SWM value chain, the input and output specifications, performance standards, social and environmental assessment, and risk assessment would also need to be conducted.

- Financial feasibility: The feasibility study should undertake a detailed financial assessment of streamlining the SWM value chain, including PWM thus covering a detailed estimation of capital expenditure, operational expenditure and revenue, sensitivity analysis, and value for money analysis.

- Project structure: The study should cover the feasibility of appointing the private sector for integrated waste management in Gangtok covering processes of waste segregation, collection, transportation, processing and disposal at the landfill site. This would include roles and responsibilities of various stakeholders, particularly that of the private developer and the implementing agencies, mode of contracting such as PPP or EPC, mode of payment, and contract duration. The study should also explore modes of financing.

- Bid-process management: The feasibility study should also provide details regarding the next steps in project preparation and execution, i.e., bid process management. This part should explain in detail the number of stages that will be employed for the procurement process, bidding parameters including technical and financial parameters, appointment of transaction advisors, formation of data rooms, and customization of bidding documents.

11 References

The chapter lists the documents provided by the IUC, GMC, and links to various news articles, publications, policy documents, research papers, company reports, and case studies that were referred to during the preparation of this study.

Table 5: Table of references

Date	Title	Author	Link
Case studies			
24.07.2012	Report on plastic waste in Copenhagen	-	http://www.plastic-zero.com/media/20281/action_1-2_copenhagen_final.pdf
-	Making the most of waste in the city of Copenhagen	-	https://stateofgreen.com/en/partners/city-of-copenhagen/solutions/making-the-most-of-waste/
-	Copenhagen - Welcome to Denmark	-	https://international.kk.dk/artikel/recycling-copenhagen
-	Packaging free BERT	-	https://www.vokasnaga.si/en/packaging-free-bert
10.11.2013	Reuse center	-	https://www.ljubljana.si/en/news/reuse-centre/
2018	The story of Ljubljana	-	https://zerowastecities.eu/wp-content/uploads/2019/09/zero_waste_europe_CS5_the_story_of_Ljubljana_en.pdf
24.09.2018	How the most modern waste treatment centre changed Slovenia	Aurora Velez	https://www.euronews.com/2018/06/20/how-the-most-modern-waste-treatment-centre-changed-slovenia
-	Capital factsheet on separate collection	-	https://www.municipalwasteeurope.eu/sites/default/files/SI%20Ljubljana%20Capital%20factsheet.pdf
-	From no recycling to zero waste: How Ljubljana rethought its rubbish	-	https://www.theguardian.com/cities/2019/may/23/zero-recycling-to-zero-waste-how-ljubljana-rethought-its-rubbish
-	Report on technologies and options for plastic waste prevention	-	http://www.plastic-zero.com/media/36518/Action%202.1%20Report%20on%20technologies%20and%20options%20for%20plastic%20waste.pdf
-	Review of plastic waste in the municipal waste stream, Austria	-	http://www.plastic-zero.com/media/62429/annex_d20a_-_action_1.3_-_review_on_plastic_waste_in_the_municipal_waste_stream_-_austria_final.pdf
-	Altstoff Recycling Austria	-	https://www.ara.at/en/kreislauf-wirtschaft/verpackungsrecycling
-	Solid waste management – city profile	-	https://www.waste.ccacoalition.org/sites/default/files/files/city_profile_vienna_rev.pdf
06.09.2017	Indore's Swachh Turnaround: Recycling 50% Of Its Plastic Waste	Gopi Karelia	https://swachhindia.ndtv.com/indores-swachh-turnaround-recycling-50-plastic-waste-6673/
04.06.2018	Waste Segregation A Day Keeps Plastic Waste Away: Indore's Mantra Since	Gopi Karelia	https://swachhindia.ndtv.com/indore-plastic-waste-management-success-story-20287/

Date	Title	Author	Link
	#WorldEnvironmentDay 2017		
-	Closing the Loop	UNESCAP	https://www.unescap.org/sites/default/files/Closing%20The%20Loop_Pune%2C%20India%20Case%20Study.pdf
06.01.2020	Surat processes 95% of the solid waste city generates in one day	Times of India	https://timesofindia.indiatimes.com/city/surat/surat-processes-95-of-the-solid-waste-city-generates-in-one%20day/articleshow/73113398.cms
20.11.2019	Surat to have plastic waste management center	Times of India	https://timesofindia.indiatimes.com/city/surat/surat-to-have-plastic-waste-mgmt-centre/articleshow/72133308.cms
20.11.2019	Plastic waste management: Surat among four cities chosen for central project	-	https://indianexpress.com/article/india/plastic-waste-management-surat-among-four-cities-chosen-for-central-project-6127752/
07.07.2017	Road to a plastic free city: Surat aims to produce diesel out of plastic waste	-	https://swachhindia.ndtv.com/road-plastic-free-city-surat-aims-produce-diesel-plastic-waste-9665/
06.02.2020	Surat processes 95% of the solid waste city generates in one day	-	https://timesofindia.indiatimes.com/city/surat/surat-processes-95-of-the-solid-waste-city-generates-in-one-day/articleshow/73113398.cms
-	Eco – vision	-	http://www.eco-vision.co.in/
20.11.2019	Surat to have plastic waste management center	-	https://timesofindia.indiatimes.com/city/surat/surat-to-have-plastic-waste-mgmt-centre/articleshow/72133308.cms
Documents provided by IUC India and GMC			
11.08.2020	SWM of GMC	GMC	-
23.07.2013	Report on technologies and options for plastic waste prevention	-	http://www.plastic-zero.com/media/36518/Action%202.1%20Report%20on%20technologies%20and%20options%20for%20plastic%20waste.pdf
Existing reports and studies			
2015	City development plan for Gangtok – 2041, under capacity building for urban development project (MoUD, Government of India and World Bank)	-	-
2011	Initial Environmental Examination	-	https://www.adb.org/sites/default/files/project-document/61682/35290-033-ind-iee-02.pdf
29.04.2019	State Policy and Strategy on Solid Waste Management (Action Plan)	-	http://udhdsikkim.org/184_Action%20plan.pdf
29.04.2019	Bye-laws of solid waste (management & handling) cleanliness and sanitation for urban sector of Sikkim	UDHD	http://udhdsikkim.org/185_Byelaws.pdf
-	THE SIKKIM STATE ACTION PLAN ON CLIMATE CHANGE	Government of Sikkim	http://sikenvis.nic.in/WriteReadData/Publication/Sikkim%20State%20Action%20Plan%20on%20Climate%20Change%20web.pdf

Date	Title	Author	Link
29.09.2019	Gangtok Municipal Corporation	GMC	http://www.gmcsikkim.in/images/slb2.pdf
29.09.2018	Gangtok Municipal Corporation	GMC	http://www.gmcsikkim.in/images/slb.pdf
-	State-wise status of implementation of Plastic Waste Management Rules, 2016 for the year 2017 annual report format	-	http://sikenvis.nic.in/WriteReadData/UserFiles/file/PWM%202016-17.pdf
-	State-wise status of implementation of Plastic Waste Management Rules, 2016 for the year 2018 annual report format	-	http://sikenvis.nic.in/WriteReadData/UserFiles/file/PWM%202017-2018.pdf
-	The Smart City Challenge – Stage 2	-	http://smartcities.gov.in/upload/uploadfiles/files/3%20SCP%20Gangtok.pdf
-	Slum-Free City Plan of Action for Gangtok	-	http://mohua.gov.in/upload/uploadfiles/files/44Sikkim_gangtok_sfcp-min.pdf
-	Solid waste management	-	http://www.sikkimforest.gov.in/soer/Solid%20Wate%20Management.pdf
14.09.2018	EOI to design, build, finance maintain & operate a waste processing plant with an energy generation component on PPP mode	-	https://www.gmcsikkim.in/images/EEOI.pdf
	City resilience strategy: Gangtok	The Rockfeller foundation	
2018	Rapid climate vulnerability assessment of Gangtok, Sikkim		
News articles and other relevant publications			
29.09.2019	Improper waste management augmenting a hazardous future for Gangtok	Yougan Tamang	https://www.thesikkimchronicle.com/improper-waste-management-augmenting-a-hazardous-future-for-gangtok/
21.05.2018	Push for “Zero Waste” in India’s mountain states	Sahana Ghosh	https://india.mongabay.com/2018/05/push-for-zero-waste-in-indias-mountain-states/
26.04.2018	How the Indian state of Sikkim is working to end plastic pollution	-	https://www.unenvironment.org/news-and-stories/story/how-indian-state-sikkim-working-end-plastic-pollution

12 Annexure A: Waste collection fee rates

Sr no	Type of waste generator	Rate (INR per month)
1	Households	50 (extra if involves head loads)
2	Small shops	50
3	Big shops	100
4	Garage / fabrication shops	500
5	Small hotels - up to 5 rooms	250
6	Hotels – 6 to 10 rooms	500
7	Hotels – 11 to 15 rooms	750
8	Hotels – 16 to 20 rooms	1,000
9	Hotels - more than 20 rooms	1,500
10	Offices with separate building (including of central government)	1,000
11	Secretariat – home department	1,000
12	Others	500
13	Online lottery shops	200
14	Petrol pumps	500
15	Private hostels - up to 10 beds	100
16	Private hostels - 11 to 20 beds	150
17	Private hostels - 20 and above beds	300
18	Private tutorials	100
19	Schools up to secondary level	300
20	Schools - senior secondary level	300
21	Schools with hostel	500
22	Transport companies	250
23	Carpenters shops	150
24	Cinema halls	500
25	Small restaurants / fast food	100
26	Medium restaurants	500
27	Large restaurants	1,000
28	Luxury hotels	5,000
29	Big bazaar	5,000
30	Hospitals	2,000
31	Clinical laboratories	300
32	Casinos	2,500
33	Factories / manufacturing industries	500