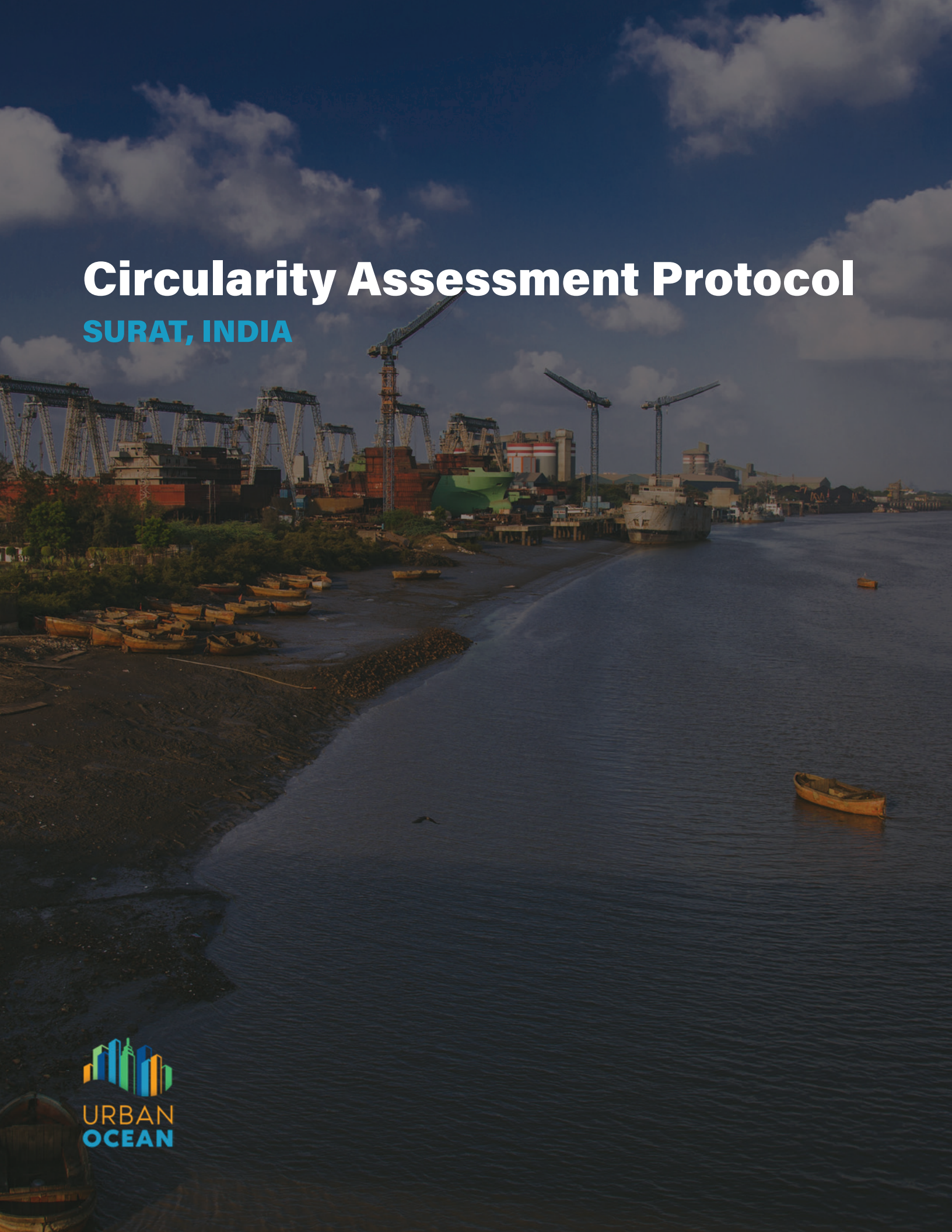
Circularity Assessment Protocol

SURAT, INDIA



URBAN OCEAN

Foreword

The Circularity Assessment Protocol (CAP) was born out of an effort to define the concept of the circular economy in our cities and communities. While plastic pollution continues to be discussed at the highest levels of government and global organizations, cities and communities are on the front lines. Local knowledge and expertise are the foundation of the information that the community uses, with additional data collected in partnership with CAP collaborators. Partners and teams build capacity through learning methods together. Open data collection is an important part of the process; leakage data contributes to a global open dataset. Trends across cities, countries and regions can illuminate global narratives.

Data is power to communities and enterprising individuals who are recognized for their role in materials management through CAP but are often marginalized in society. CAP data can catalyze economic development through business opportunities and subsequent interventions. The issue of plastic pollution is not for outsiders to solve, but for communities to address by collaboratively collecting data to lead themselves through the context-sensitive design of their own desired circular economy. Communities are empowered by local and global CAP data to inform their decisions about what is working, or where and how to intervene to increase circularity. Communities that participate in CAP can better define resource needs and participate in knowledge exchange.

Urban Ocean, a partnership of The Circulate Initiative, Resilient Cities Network and Ocean Conservancy, works with city leaders to bring new ideas, partners and resources together to solve interrelated problems around materials management, including addressing key priorities such as public health and economic development. A critical step in the Urban Ocean process is the Gap Assessment, which maps challenges, risks, and vulnerabilities within materials management systems and helps to develop a unique, integrated picture of the materials and circular economy related challenges and opportunities faced by each city. The CAP, developed in our Circularity Informatics Lab (CIL) at the University of Georgia, was chosen as an ideal tool to deploy as part of the Urban Ocean Gap Assessment.

The interconnected nature of complex urban systems and the value of circular economy in building resilient cities was starkly evident when the COVID-19 pandemic began just following the launch of the first Urban Ocean cohort. As a team, we immediately transitioned to online global work, with our local implementation partners becoming even deeper collaborators, conducting all field work with virtual training. This allowed for embedded ownership of the data at the local level and ultimately created a powerful network of collaborators and supporters across learning cities to drive scientifically informed decision making. Local implementation partners have then continued to work with the Urban Ocean team through stakeholder workshops and into the proposal phase, as advocates for the science and key contributors in their own cities.

Urban Ocean and its partnerships provide an ideal platform to support resilient cities. CAP data helps guide interventions, create a baseline to measure success, and put essential data in the hands of the local community to drive change. We believe piecemeal solutions that are not contextually grounded are insufficient to create a systemic shift. Communities need to be involved, not just as stakeholders, but as the powerful change-makers they are.

— Jambeck Research Group, Circularity Informatics Lab, University of Georgia

Dr. Jenna Jambeck, Dr. Amy Brooks, Taylor Maddalene, Jenni Mathis, Kathryn Youngblood

The Circularity Informatics Lab at the University of Georgia is committed to information sharing, data analytics, empowering communities, and systems change related to circular materials management.

Published by:
The Circularity Informatics Lab (CIL)

Location:
New Materials Institute
University of Georgia
Athens, GA
USA 30602
www.circularityinformatics.org

Contact:
Dr. Jenna Jambeck
jjambeck@uga.edu

Local Implementation Partner:
Centre for Environment Education (CEE), Pune, India

Authors:
Amy Brooks (CIL), Lindsay Coats (CIL), Kunal Jaiswal (CEE), Taylor Maddalene (CIL), Avinash Madhale (CEE), Sanskriti Menon (CEE), Avadhut Abhyankar (CEE), Kathryn Youngblood (CIL), Jenna Jambeck (CIL)

Contributors and Reviewers:
Katrin Bruebach (RCN), Luciana Cardoso (RCN), Edith Cecchini (OC), Annerieke Douma (TCI), Saurabh Gaidhani (RCN), Shweta Nagarkar (RCN), Daniel Padilla Ochoa (OC)

Recommended Citation:
Circularity Informatics Lab, August 2023. Circularity Assessment: Surat, India. University of Georgia, Athens, GA, USA.

Design/Layout:
Deeds Creative, Athens GA

Photo Credits:
Page 32, 45, 46, 48, 49, 56, 57, 60, 61: CEE
Page 25: Navsarjan Trust

URL Links:
This publication contains links to external websites. Responsibility for the content of the listed external sites always lies with their respective publishers.

Maps:
The maps printed here are intended only for information purposes and in no way constitute recognition under international law of boundaries and territories. CIL accepts no responsibility for these maps being entirely up to date, correct, or complete. All liability for any damage, direct or indirect, resulting from their use is excluded.

On behalf of:
The Urban Ocean Program, a three-way cooperative partnership among The Circulate Initiative (TCI), Ocean Conservancy (OC), and Resilient Cities Network (RCities). Funding for this work was provided by TCI.

www.circularityinformatics.org

Athens, GA, August 2023

New Materials Institute
UNIVERSITY OF GEORGIA

URBAN OCEAN

The Circulate Initiative

Ocean Conservancy

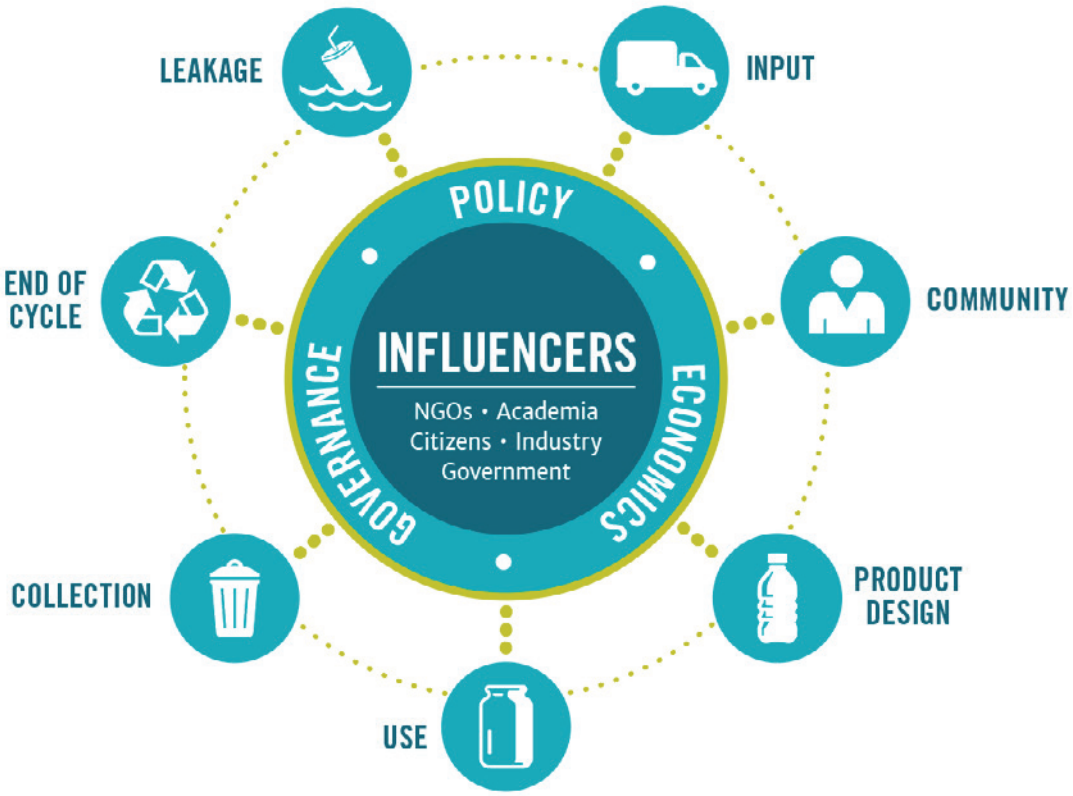
RESILIENT CITIES NETWORK

Contents

Figures & Tables

Executive Summary

Developed by the Circularity Informatics Lab at the University of Georgia (UGA), the Circularity Assessment Protocol (CAP) is a standardized assessment protocol to inform decision-makers through collecting community-level data on plastic usage and management. Grounded in materials flow and systems thinking concepts, the CAP uses a hub-and-spoke model to holistically characterize how consumer plastic flows into a community, is consumed, and flows out, either through waste management systems or leakage into the environment. The model, shown below, consists of seven spokes: input, community, material and product design, use, collection, end of cycle, and leakage. At the center, the system is driven by policy, economics and governance with key influencers including non-governmental organizations, industry, and government.



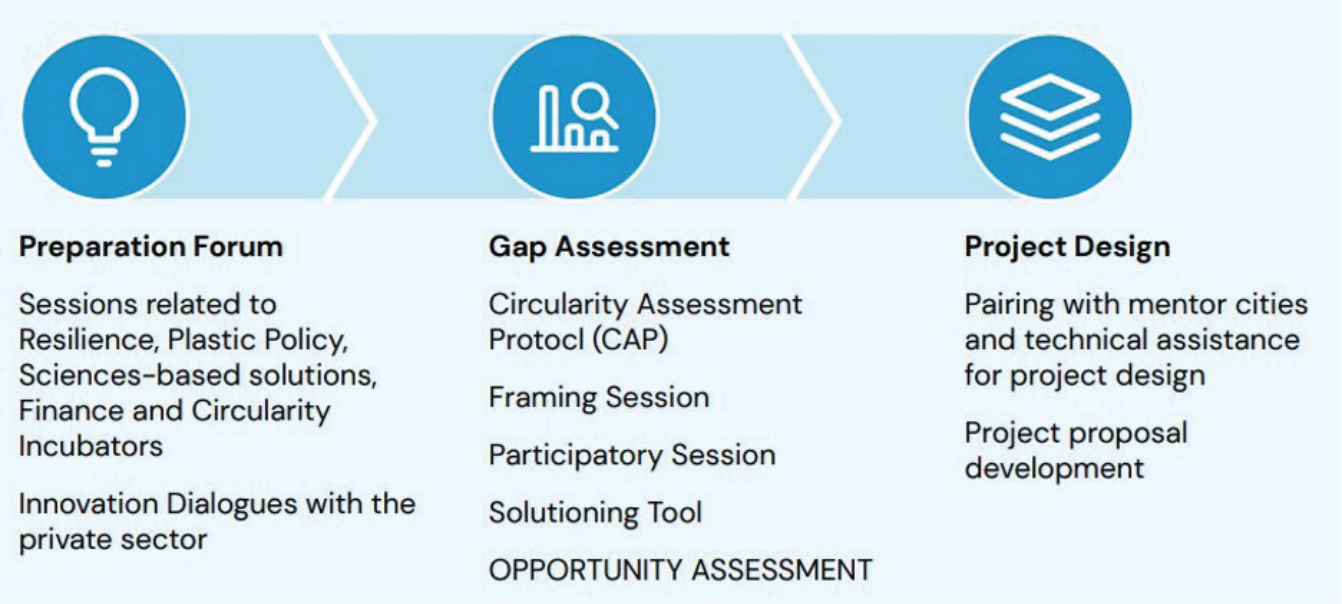
Between September 2022 and January 2023, a team from The Centre for Environment Education (CEE), with guidance and support from the Circularity Informatics Lab, conducted fieldwork in the city of Surat, India. The CAP was conducted with support from the city's local government, the Chief Resilience Officer (a top-level advisor in the city that is responsible for leading, coordinating and developing a city's resilience strategy and policy), and the larger

Urban Ocean team. Field work included product and packaging assessments in stores across the city; key stakeholder interviews with government, industry, and non-profit organizations; material type characterizations for consumer plastic items; cost analysis of reusable products and alternatives to plastic available in the city; visual audits of recycling contamination; identification of public waste and recycling collection bins; and litter transects in three categories of population. Key findings from each spoke are summarized in the table below.

Urban Ocean Program

Urban Ocean is a three-way cooperative partnership among The Circulate Initiative (TCI), Ocean Conservancy (OC), and Resilient Cities Network (R-Cities) that works with city leaders to bring new ideas, partners, and resources together to solve interrelated problems around waste management. It aims to demonstrate how actions to improve waste management and recycling can provide holistic, resilient, and sustainable solutions that not only reduce ocean plastic pollution but also address key city priorities such as improving public health, promoting innovation, supporting economic development and job growth, and reducing greenhouse gas emissions through a capacity building and accelerator program for cities.

Surat is one of four cities in the second cohort of Urban Ocean learning cities. The CAP in Surat, coupled with the upcoming Opportunity Assessment Tool, represents Stage 2 of the Urban Ocean Initiative which involves a comprehensive Gap Assessment to map challenges, risks and vulnerabilities within the cities' critical waste management systems. The data gathered from the CAP in Surat will contribute to three workshops where stakeholders will discuss findings and develop proposal(s) for interventions that will then be brought to an Accelerator Summit for review and support, as shown by the timeline of the program below:



Get to know the partners:

Ocean Conservancy is working to protect the ocean from today's greatest global challenges. Together with our partners, we create science-based solutions for a healthy ocean and the wildlife and communities that depend on it. Since the formation of the International Coastal Cleanup in 1987, Ocean Conservancy has mobilized millions of volunteers to remove trash from beaches and waterways around the world while pioneering upstream solutions to the growing ocean plastics crisis. Ocean Conservancy invests in cutting-edge scientific research, implements on-the-ground projects, and works with conservationists, scientists, governments, the private sector and members of the public to change the plastics paradigm. To learn more about our Trash Free Seas® program visit oceanconservancy.org/trashfreeseas, and follow Ocean Conservancy on Facebook, Twitter and Instagram.

The Circulate Initiative is a non-profit organization that works to solve the plastic pollution challenge and build circular and equitable economies across emerging markets. It delivers cutting-edge research, builds high-impact programs, and drives collective action with industry stakeholders including businesses, investors, and policymakers. For more information, please visit: www.thecirculateinitiative.org

The Resilient Cities Network consists of member cities and Chief Resilience Officers from the former 100 Resilient Cities - pioneered by The Rockefeller Foundation program, sharing a common lens for holistic urban resilience. The Resilient Cities Network in partnership with its global community continues to deliver urban resilience through knowledge sharing, collaboration, and creative action, seeking to inspire, foster and build holistic urban resilience around the world. For more information, please visit: www.resilientcitiesnetwork.org

Key Findings and Opportunities

INPUT

Findings: Most (95%) convenience products (i.e., chips, candy, beverage products) surveyed come from domestic manufacturing companies and parent companies.

Opportunities

- The abundance of domestic producers and manufactures combined with the substantial manufacturing industry in Surat may provide access to strategic co-development and enforcing of Extended Producer Responsibility (EPR) schemes.
- Explore opportunities to coordinate improved product packaging and disposal mechanisms, particularly for tobacco and food packaging that are delivered in multi-layer plastic packaging systems.

COMMUNITY

Findings: Major industries in Surat include manufacturing (diamonds, textiles, plastics, etc.) and information technology, and is expected to see some of the most significant economic growth in the world over the coming decade. Further, the community is experiencing an influx of migrant workers who may not be equipped with local knowledge and practices around plastic consumption and waste management - new residents to any location often come into their new community without immediate knowledge of the local norms, such as public services. Several community members were interviewed to elicit understanding and awareness across a range of stakeholder perspectives. Early insights indicate challenges with local awareness met with attitudes that SMC handles waste sufficiently and the tendency for community members to follow behaviors observed in others (i.e., 'everyone does it'). With the community's geographic location at the delta of the Tapi River, there were some indications that upstream waste may impact the community, further compounding challenges with local waste generation and management. In terms of local policy, some suggestions from participants involved implementing local policies that incentivize better management of plastic waste through tax benefits and careful design of policies that encourage citizens to take responsibility.

Opportunities

- Given the expected growth in the community, urgent action focusing on education and awareness may have the greatest impact in the long term. Conduct an awareness campaign for citizens and incoming residents, which could further prioritize education around personal management of tobacco and food packaging waste.
- Consider policy design that carefully examines tradeoffs. Rewarding policy and incentivization may be most effective.
- Coordinate efforts with the Resilient Cities Network Surat Resilience Strategy

PRODUCT DESIGN

Findings: 131 top convenience products were sampled from grocery and convenience stores and food vendors in Surat. 100% of these items comprised at least one plastic component in the packaging and most (63%) were categorized as multilayer plastics (MLP), which are hard to recycle due to the integration of non-uniform material types. Further, tobacco and food package items surveys also consisted mostly of MLPs. This packaging type is similar to Chennai, India, which also had a high proportion of MLP packaging. In contrast, Pune, India saw mostly PET packaging (e.g., plastic bottles), which are more easily recycled. Only 1% of surveyed items in Surat were made of PET, which is suggestive of the significant presence of the informal waste management sector. Unlike grocery and convenience items, most (31%) of the surveyed to-go items were paper with plastic coating, followed by items made of paper (27%).

Opportunities

- MLPs (e.g., tobacco sachets and plastic wrappers) are particularly challenging to recycle. Further, these items are generally packaged in small formats which deliver less product in relation to the amount of plastic packaging. Prioritize investments that reduce widespread vending of MLPs, incentivize redesign of product packaging, and increasing value in recapturing after they are used.
- Expand upon the use of non-plastic and biodegradable (paper) products in to-go items to engage with other restaurants and vendors that are still using plastic, possibly using tools such as SWM Rules.

USE

Findings: Single use plastics, particularly those that are MLPs, are ubiquitous to the community, posing challenges to waste management and pollution. Most stores and vendors (71%) distribute single use plastic bags to customers, while only 4% supply paper bags. There are very few incentives for businesses to switch to alternative or reusable materials, which should be assessed on a case-by-case basis given the low cost of single use plastics. However, a quarter of the surveyed stores did not provide bags at all, motivating customers to bring their own and re-use bags. Beyond bags, there are opportunities for cost effective alternatives for other plastic items such as paper bidi wrappers, wooden spoons, paper food wrappers, or other appropriately reusable containers.

Opportunities

- Explore local plastic bag ban or fee and develop incentives for businesses to use reusable items.
- Encourage businesses to incorporate reusable and/or refillable means of purchasing items, particularly for bulk items. Top grocery and convenience items could be prioritized.
- Investigate the stores that refrain from providing bags to customers to determine how the practice is (or is not) encouraging customers to bring their own bag or reusable containers.

COLLECTION

Findings: Reported municipal solid waste generation varies from 1,680 to 2,890 metric tons of waste daily. Source segregation of waste and recyclables prior to collection is expected at the household and individual level, though it is often not implemented or enforced, and the informal waste sector plays a large role in textile waste collection, cleaning, and processing in Surat (for domestic waste, contractors are the main source). Waste management is generally coordinated by the Surat Municipal Corporation. Waste collection coverage is high at 97% of the city, and operates across eight zones, which each have a designated transfer station. Several companies are contracted by the Surat Municipal Corporation to conduct door-to-door collection, which collects the most waste compared to other systems. In addition to door-to-door collection, there are 75 modern underground waste dustbins throughout the city. Plastic waste is consolidated at a single central center in each zone, and many informal workers and NGOs contribute to collecting street level plastic debris and sorting plastics at the collection stations. Street sweeping, transportation of recyclable waste, and other operation costs are covered in the annual Surat Municipal Corporation budget. Waste is generally transported from the eight transfer stations to final disposal sites.

Opportunities

- Source segregation is still a challenge for Surat, with much of the segregation occurring by the informal and NGO communities. Conduct public campaigns encouraging source segregation, and perhaps incentives, as well as clarity around how to sort waste items.
- Examine potential issues related to efficiencies such as bottlenecks and redundant processes, particularly at the underground dustbins and collection stations.
- Determine whether current infrastructure (e.g., transfer stations, dustbins, collection stations) is adequately sized for effective processing of the quantity of waste generated, temporarily stored, and processed.
- Explore integration and coordination with the informal sector through open dialogue between stakeholders. Focus could be on incentives and safety conditions.
- Expand upon existing Zero-Waste Pilots at the ward-level.

END OF CYCLE

Findings: Surat has made several enhancements to their waste processing infrastructure since 2017. About 2,890 metric tons of municipal solid waste, including 393 metric tons of plastic waste, are generated daily. Only 2,228 metric tons of municipal solid waste, including 290 metric tons of plastic waste, are landfilled; leaving a total of 662 metric tons per day, including 103 metrics tons per day of plastic waste, unaccounted for in the transportation of waste from source to landfill. The Khajod sanitary landfill, which has been the primary final destination for collected waste, has been accepting 600 metric tons of waste daily but is undergoing closure as it is reaching maximum capacity and is in the process of being converted to a green space. The Surat Municipal Corporation has recently designated an area called South Zone (B)/Sachin Zone for an

alternative disposal site, and the city is in the process of approvals from the Central Pollution Control Board. Though the current landfill is planned to be closed by the end of 2023, it may be an ambitious timeline given that the necessary approvals have yet to be received. Surat has seen an increase in recycling in recent years. Plastic waste management is run by Eco-Vision, which recycles over 30 metric tons of plastic waste daily. While there are MRFs at five transfer stations, there are ongoing efforts to construct MRFs at all zones. Waste burning was flagged as a significant issue in the city, and there are concerns about greenhouse gasses from open burning. Surat has made efforts to develop designated treatment facilities particularly for an abundance of organic waste. There are 25 organic waste converters located near municipal markets for vegetable and non-vegetable materials. There are also 50 organic waste converters accessible to residential areas. Additionally, construction and demolition debris is handled by a private company that processes 300 tons per day.

Opportunities

- The Surat Municipal Corporation is working toward ambitious goals for solid waste improvement, but there is an urgent need for procuring space for landfilling waste in combination with a reduction in waste generation. Continue to assess existing and planned processing infrastructure so that the infrastructure continues to match the needs of the city, while prioritizing waste reduction measures.
- Identify strategies to capture plastics that are being landfilled for processing and potentially recycling.
- Determine opportunities for coordination with efforts like Project Surat and Operation Stop Waste Burning which is targeting waste burning in Surat in the context of sustainable development.
- Encourage waste reduction and diversion through incentivizing businesses to reduce their waste-generating offerings and opt for alternatives and reusables. Examples include Chhindi waste reuse and upcycling initiatives.
- Explore opportunities for ward / society level organic waste processing infrastructure and services.
- Strengthen existing or set up new material recovery facilities (MRFs) through Public-Private Partnerships (PPP).

LEAKAGE

Findings: While Surat has been recognized nationally for its efforts toward city-wide cleanliness, litter remains an issue for the city to continue working toward addressing. Litter surveys showed that tobacco products (30%) and single use plastic food packaging (22%) were the most common litter categories in Surat, which mirrored litter compositions documented in other Urban Ocean cohort cities in India. Specifically, tobacco packaging and sachets as well as plastic food wrappers were the most common item types. Below tobacco packaging and plastic food wrappers, the next most common items were uncategorized litter fragments (6.7%), rubber bands (4.6%), and plastic bottle caps (4.5%). Litter density in Surat ranged from 2.3-3.5 items/m^2, with an average 2.64 items/m^2. This density was higher than Chennai (~1 item/m^2) and lower than Pune (4-5 items/m^2).

Opportunities

- Explore ways to reduce generation of single use plastic packaging waste, target improved collection of tobacco waste, and optimize collection of food waste.
- Consider opportunities to combine health campaigns with litter reduction efforts to address high amounts of tobacco related litter.
- If there is a desire to measure impact from interventions targeting opportunities to reduce plastic leakage, conducting litter transects over time is recommended.
- Expand upon existing community campaigns such as Litter-Free Surat. Examples of doing so may include targeting street food vendors associated with high use of single use packaging like takeout containers and plastic food items like plastic cutlery, plates, and cups.

Strengths

- Surat has been recognized by the Swachh Bharat Mission for several years in a row, suggesting strong existing foundations of investing in and developing environmental and sustainable infrastructure.
- SWM Rules were passed in 2016, and it is now mandatory for local bodies to ensure that the waste is segregated in Surat, however, enforcement has remained a challenge.
- The city has enlisted both incentivization schemes and engagement activities for encouraging public awareness around waste reduction, segregation, and proper disposal, as well as punitive actions like fines that aim to discourage litter and open dumping.
- The estimated per capita waste generation rate in Surat (0.33-0.45 kilograms per day) is lower than both global (0.74 kilograms per day) and national (0.57 kilograms per day) averages and is less than several other comparable cities in the region.
- Waste collection and transportation is widespread throughout the city, with a comprehensive waste collection system including door-to-door collection and several dustbins throughout the city and zones at targeted locations like roadways, food markets, and residential areas.
- The primary and secondary waste transportation system limits frequent handling of collected waste while also providing opportunities for secondary sorting, leading to more efficient waste processing, treatment, and disposal.
- There are a range of treatment outlets for various waste streams including a designated, centralized plastic waste management facility focused on recovery and recycling of plastic waste.
- There are several plastic recyclers that produce recycled synthetic fibers and yarns for use in textiles.
- The city has actively worked to divert waste from the Khajod landfill which is undergoing remediation improvements by increasing treatment and disposal options.
- Through public-private partnerships, the city has been able to fund efficient SWM activities operationalized by private contractors while also encouraging revenue streams driven from land leases. These strong private/civic relationships within the existing waste management ecosystem can be leveraged for increased impact.
- The Indian Government, in a recent amendment to the Plastic Waste Management Act of 2021, has prohibited single use plastic from July 1, 2022.

Glossary of Acronyms and Abbreviations

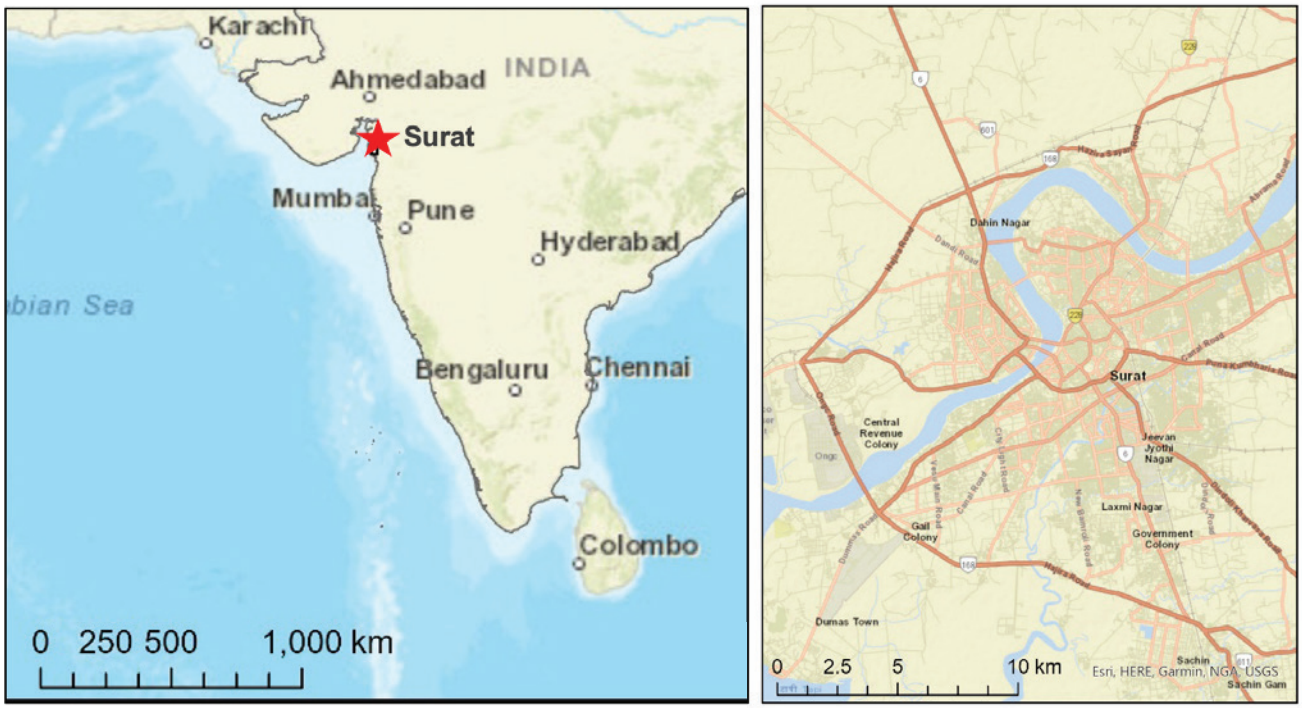
CAG – Citizen Consumer and Civic Action Group
CAP – Circularity Assessment Protocol
CE – Circular Economy
CIL – Circularity Informatics Lab
HDPE – High Density Polyethylene
GDP – Gross Domestic Product
IWC – Independent Waste Collector
LDPE – Low density polyethylene
LIP – Local Implementing Partner
MPs – Microplastics
MSW – Municipal Solid Waste
MSWM – Municipal Solid Waste Management
NMI – New Materials Institute
OC – Ocean Conservancy
PCB – Pollution Control Board
PE – Polyethylene
PET – Polyethylene terephthalate
PP – Polypropylene
PPE – Personal Protective Equipment
PRO – Producer Responsibility Organizations
PS – Polystyrene
RCN – Resilient Cities Network
SWM – Solid Waste Management
SMC – Surat Municipal Corporation
TCI – The Circulate Initiative
UGA – University of Georgia

Introduction

Surat is a large port city in western India, located on the banks of the Tapi River (Figure 1). With a population of around 6 million people, and 8.1 million including the metropolitan population (United Nations 2018), it is the second-largest city in Gujarat after Ahmedabad. The city also covers an area of 326 square kilometers (Surat Municipal Corporation 2019), resulting in a population density of approximately 24,700 people per square kilometer, making it one of the most densely populated cities in the country. The city has historically been and continues to be one of the fastest growing in the world, with an average of 9.2% annual growth estimated between 2019 and 2035 (World Economic Forum 2018). Surat has a rich history as an important center for trade and commerce during the Mughal era. As one of India's oldest municipal governments, the city was founded in 1852, and designated as the Surat Municipal Corporation in 1964 following consistent growth and development over time. Since that time, the city has continued to see significant urbanization such that the extent of jurisdiction has grown considerably from 8.18 square kilometers in 1961 to 326 square kilometers as of 2011. Today, the city is known for its textile and diamond industry and is known by many names — Silk City, Diamond City, Synthetic Materials City. Additionally, there is a vibrant culture and several notable festivals, including the Navratri festival, which is celebrated with great enthusiasm. Surat is also home to many temples, mosques, and other religious sites, and is known for its unique blend of Hindu and Islamic architecture.

Figure 1a: Geographic location of Surat in India

Figure 1b: Geographic location of Surat in India



Surat, Gujarat, India

As the city has grown, so too has the demand for urban services such as drinking water, housing, sanitation, and solid waste management, causing strain on socio-natural resources and local governments to meet the growing city's needs. Surat has historically been overseen by two administrative components which includes the Surat Municipal Corporation (SMC) and the Surat Urban Development Authority (SUDA), which encompasses both the SMC as well as 95 villages that are proximal to the city. Coinciding with the rapid urbanization in Surat, numerous unplanned settlements (often referred to as 'slums') have developed as well, often with characteristics such as lagging access to civil infrastructure and poverty. One 2017 survey conducted by SUDA documented 406 unplanned settlements throughout the SMC, many of which are located in the south and southeastern areas of the city and along major waterways (SUDA 2017). Geographically, Surat is located along the eastern side of the Gulf of Khambhat (Cambay), a bay that feeds into the northern Arabian Sea of the Indian Ocean. In addition to its coastal location, Surat is also considered a riverine community as the city is located along the Tapi River (Figure 1), which ultimately splits into the Mindhola River before meeting the sea.

Surat has been recognized for its innovative waste management practices, including its approach to managing plastic waste. The current waste management system was developed in reaction to a devastating plague event that occurred in 1994. At the time, many bodies of water in the city were historically dumping grounds for solid and liquid waste. Due to a significant rainfall event and backed up drainage, extreme flooding occurred, allowing for disease to develop and spread. As a result, a plague broke out in the city causing devastation among the population and in the environment. The outbreak was largely the consequence of rapid growth in Surat coupled with only 40% of the city's waste being managed by the municipality at the time (UNEP 2016). As a result, waste accumulated within water transportation infrastructure, ultimately clogging drains and sewers and driving widespread flooding. In turn, the

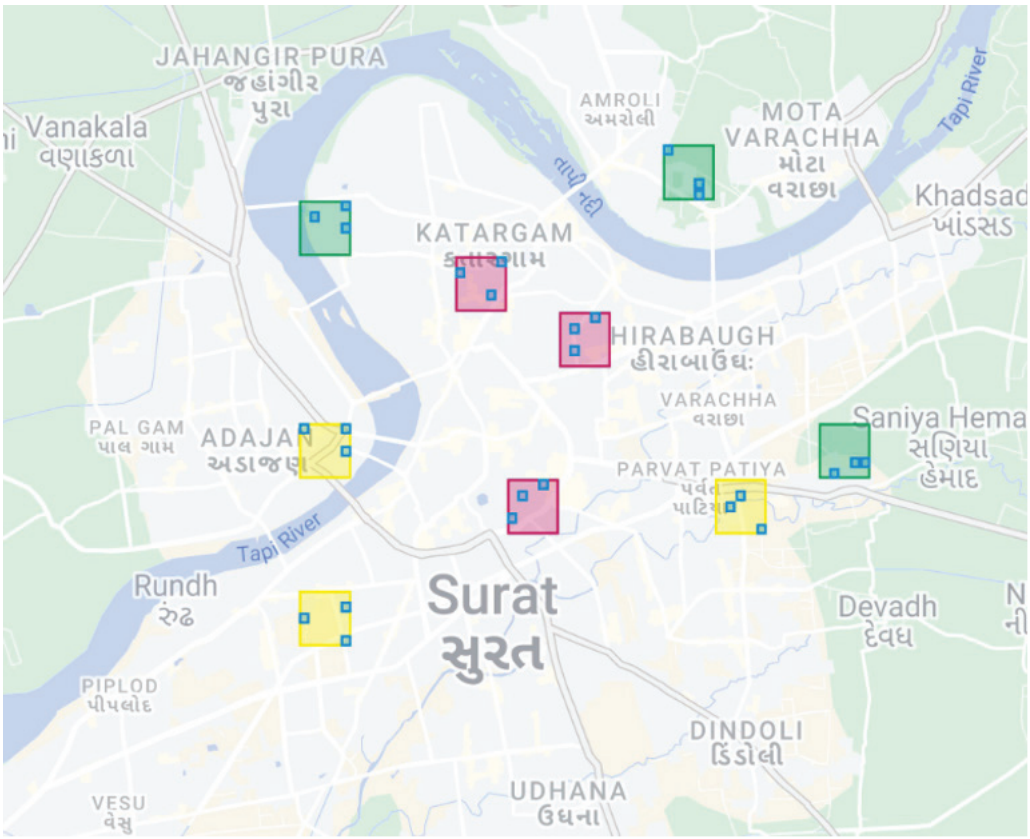
standing waters ultimately harbored disease-bearing mosquitos (Bharti et al. 2017). Impacts of the disease outbreak included 693 cases of the plague disease, 56 fatalities, and an estimated $2 billion USD in economic losses from suspended exports of goods and reduced tourism activity (UNEP 2016). In response to the devastation, the SMC has since invested heavily in improving the waste management system through enhanced monitoring schemes, infrastructure development, formation of public-private partnerships (PPPs), education initiatives, and litter prevention measures.

Following the city's efforts to minimize mismanaged waste through improved infrastructure, the city has made considerable strides. Most recently, the Swacch Survekshan, an annual comprehensive cleanliness competition run by the Swacch Bharat Mission across 4,354 Indian cities found Surat to be the second cleanest city in India (MHUA 2022). The reported waste generation per capita is between 0.33-0.45 kilograms per day (Suryavanshi et al. 2023), which is below the national average of 0.57 kilograms per capita per day in India and the global average of 0.74 kilograms per capita per day (Kaza et al. 2018). Despite the city's efforts toward sustainable waste management, the coastal and riverine city is located in a flood plain, leading to a continued risk of mismanaged waste reaching aquatic environments and beyond. Studies focused on Surat land- and aquatic-based debris are lacking; however, the Tapi and Mindhola rivers emit an estimated 1.8-10 metric tons of plastic waste to the ocean annually, with peak emissions occurring in September (Lebreton et al. 2017).

Surat district covers 7,660 square kilometers, while the Surat Municipal Corporation (SMC) covers 326 square kilometers. The city is divided into eight administrative zones and ultimately over 115 sanitation wards. This administrative boundary dictates governance in the region, such as provision and access to basic services such as water, sanitation, and solid waste management. The scope of this project is focused on the spatial extent of the SMC, which is responsible for solid waste management in the city.

As one of the cities in the second Urban Ocean cohort, Surat has set out to characterize and understand its materials flow and waste management systems and identify associated opportunities for collaborative solutions. As a first step in the Urban Ocean process, UGA partnered with a local implementing partner (LIP) in Surat — The Centre for Environment Education (CEE) in Pune — to conduct a circularity assessment of the city.

Figure 2: CAP sampling areas in Surat



by population size category (Green = low population; Yellow = middle population; Pink = high population)

The Circularity Informatics Lab at the University of Georgia has developed the Circularity Assessment Protocol (CAP), which is a standardized assessment protocol used to collect community-level data to inform decision-makers. The CAP characterizes seven community components:

1. **Inputs** — What products are sold in the community and where do they originate?
2. **Community** — What conversations are happening and what are the stakeholders' attitudes and perceptions?
3. **Product design** — What materials, formats, and innovations are found in products, particularly packaging?
4. **Use** — What are the community trends around use and reuse of product types?
5. **Collection** — How much and what types of waste are generated? How much is collected and what infrastructure exists?
6. **End-of-cycle** — How is waste disposed? What is the fate of waste once it is properly discarded? How is it treated?
7. **Leakage** — What waste ends up in the environment? How and why is it getting there?

CAP Findings

Input

Plastic production in Surat

India is the third largest consumer of plastic in the world following the USA and China and has similarly contributed to about 4.7% of global plastic production as of 2020. However, comparatively, the country generates substantially less waste per person than much of the world. For example, India produces an estimated 0.57 metric tons generated per person per day in India compared to 2.24 metric tons per person per day in the USA. Plastic production is a significant component of India's manufacturing industry with the plastic industry being worth Rs 7.1 lakh crore ($96 billion USD). In 2021, the country generated 18 million tons of thermoplastics, with polypropylene comprising a substantial fraction, and Western India (which includes the state of Gujarat, and therefore Surat) is the nation's regional leader in the industry, contributing to 61% of India's plastic production (Plastindia Foundation 2023). Surat is home to numerous plastic manufacturers, who produce a wide range of plastic products including packaging materials, consumer goods, and industrial products.

Growth of the plastic industry in Surat can be attributed to a number of factors, including the city's strategic location, access to raw materials, and a skilled workforce. In recent years, the industry has also benefited from government incentives and initiatives to promote entrepreneurship and industrial development in the region. Based on entries in the India Plastic Directory, there are at least 105 businesses in Surat that are involved across 36 different sub-sectors of the plastics industry ranging from manufacturing, recycling, and trading. The largest presence is bag, film, and lay flat tubing manufacturers (10%), followed by textile parts and accessories (8.6%), and packing materials (8.6%; Table 1). Other plastic products and manufacturing in Surat include plastic goods such as brushes, brooms, wires, cables, ropes, and imitation jewelry, as well as pigments and dyes, virgin plastic production, and printing for packaging. Further, there are some planned and/or proposed projects to develop PVC manufacturing plants in the state of Gujarat according to the PlastIndia Foundation 2023 report (Plastindia Foundation 2023), which is a highly problematic plastic, particularly in manufacturing and within packaging. In Surat, a PET manufacturing company called Garden is also in the planning stage for developing a PET manufacturing plant with a manufacturing capacity of 238,000 tons annually.

Table 1: Count and proportion of top 15 plastic production companies based in Surat by industry sub-sector

Plastics Industry Sector	No. Companies	Proportion (%)
Bags, Film & Lay Flat Tubing	11	10
Textile Parts, Accessories	9	8.6
Packing Materials	9	8.6
Adhesives & Tapes	7	6.7
Plastic Exporters & Importers	6	5.7
Plastic Machinery, Processing, Testing & Ancillary Equipment	5	4.8
Miscellaneous Plastic Items	5	4.8
PVC Compound	5	4.8
Woven Sacks	4	3.8
Molds & Dies	4	3.8
Plastic Recycling & Re-processors	3	2.9
Plastic Pipes, Hoses & Pipe Fittings	3	2.9
Dealers In Finished Plastic Goods	3	2.9
Additives & Chemicals	3	2.9
Nylon Products	3	2.9

(Data source: India Plastic Directory)

Common plastic goods in Surat

The LIP conducted field surveys across typical convenience stores within nine 1km^2 transects in Surat—three with-

in each tertile (relative groupings of high, medium, and low) of the population count representing societal activity (Figure 2)—to generate understanding of the characterization, scope, and source of common plastic packaged items entering and consumed within Surat. The LIP surveyed at least one convenience or grocery shop within each of the nine sample areas, totaling 16 shops sampled for the city. For each shop, the LIP collected the most popular brands of beverages, biscuits, candy, chips/snacks, as well as the most popular brands of tobacco products where possible. The most popular brand was determined based on the brand most frequently observed upon shelf inventories and/or the shopkeeper's input.

The surveys yielded 131 product samples total, including 32 chip/snack items, 29 beverage items, 27 candy items, 24 tobacco items, and 19 sachets. The mass of both the plastic packaging and the product itself were measured for each item using the analytical balances in the university laboratory. While the shops sell a wide range of products and brands, some brands were particularly common across the shops. For example, we recorded 32 snack brands, 29 different brands of beverages, 27 candy brands, 24 tobacco brands, and 19 sachet brands available for purchase across the shops.

For each of the top products documented, the LIP noted the type of packaging (including polymer, if possible), the brand, and the parent company. A total 72 manufacturing companies were recorded during the CAP surveys, all of which were located throughout India except for one that originated in Turkey. Almost half the manufacturing companies (44%) were located in Gujarat and ten were local to Surat. Most local documented companies produced beverage packaging such as Jenish Incorporation, Nexa Healthcare, Real Anmol Soda Factor, Soyso Hayoori Beverages Pvt. Ltd, and Surat Dist. Milk Producer Union Ltd. Several of the beverage companies manufactured milk products specifically. Four companies, JIJ Foods Pvt. Ltd, Mama Gruha Udyog, Raj Wafers and S.S. Snacks Pvt. Ltd manufactured snack items. One local company, Shreeji Vrundavan Masala, manufactured personal care sachets. Similarly, the surveys documented 55 manufacturing companies, of which 87% were located in India. Those that were located internationally were based in the United Kingdom, Switzerland, Turkey, and the United States.

Via desktop research or packaging labels, the team also determined the manufacturing and headquarter locations corresponding to each parent company of the brands. The coordinates of the locations were used to determine the distance between the stores and both the parent company and manufacturing locations (Table 4; Figure 3). Among the convenience product categories, parent companies for personal care products packaged in sachets had the largest median distance between store and parent company locations, followed by candy. In contrast, parent companies for snacks had the smallest median distance to stores. For manufacturers, candy products had the largest average distance between store and manufacturer, followed by personal care sachets and tobacco products. Given that there are several local and national producers and manufacturers contributing to Surat's plastic product input, there are opportunities for engaging these companies in conversations around packaging design, extended producer responsibility (EPR), recapture and collection of manufactured items.

Table 2: Distances from sampled stores to convenience products parent company and manufacturing facilities

	Distance Store to Parent Company (km)				Distance Store to Manufacturer (km)			
	Minimum	Maximum	Average	Median	Minimum	Maximum	Average	Median
Beverages	5	17,711	1,612	8,640	1	1,481	280	294
Candy	190	17,329	5,252	5,442	190	5,252	842	1,163
Sachets (personal care)	5	17,329	8,255	8,012	5	2,062	668	833
Snacks	4	17,329	283	1,841	4	8,52	105	221
Tobacco Products	123	8,579	1,186	1,233	123	2,068	484	693

*Note: Distances were projected using an Azimuthal Equidistant projection. Values have been rounded to nearest km.

Figure 3a: Map of manufacturer locations by convenience product type

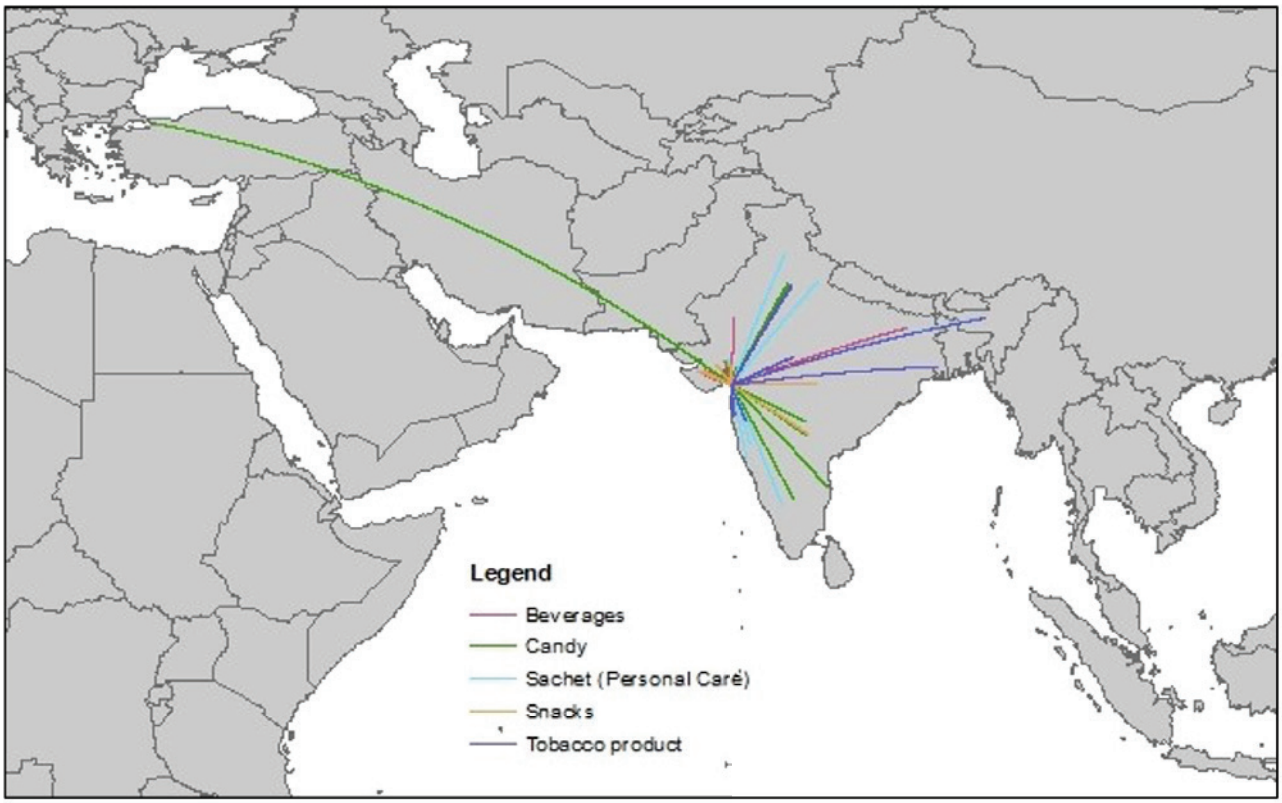
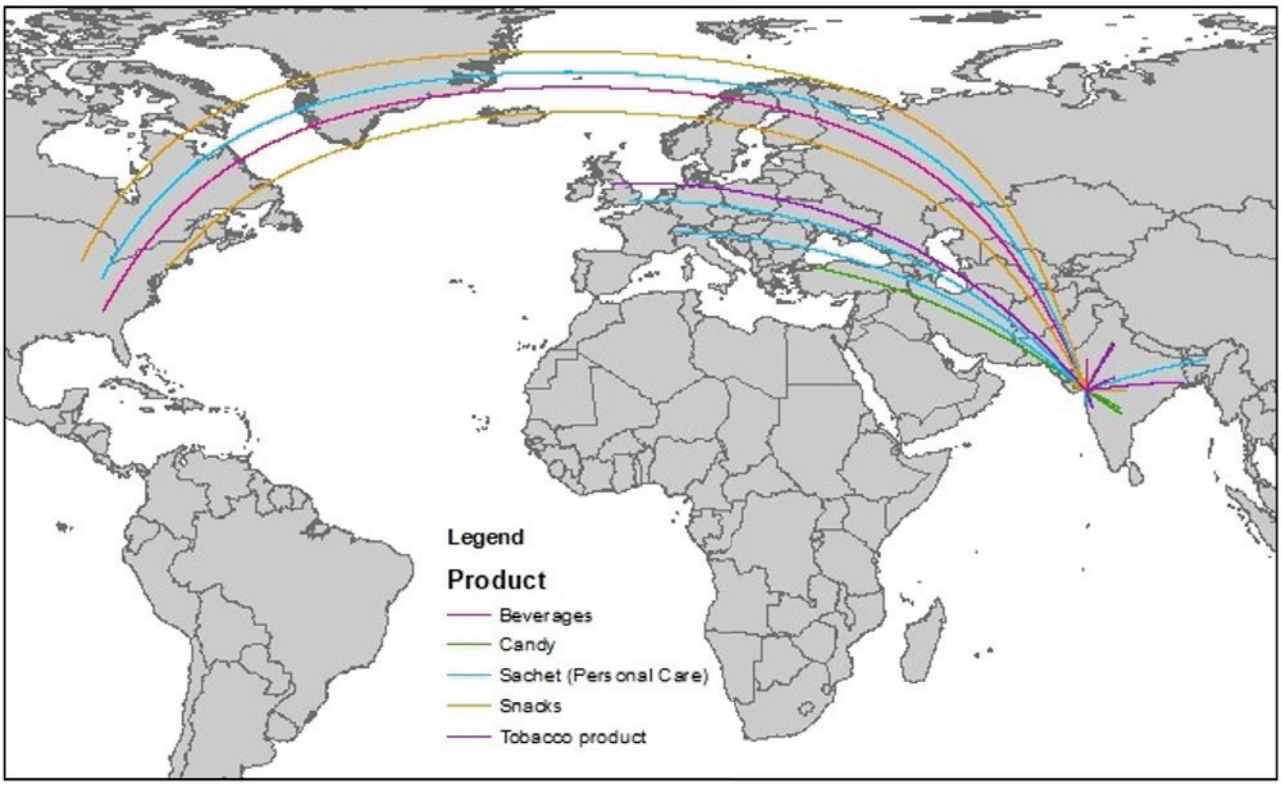


Figure 3b: Map of parent company locations by convenience product type



Products that are introduced into the community for consumption are eventually disposed of through the waste management system or leaked into the environment. Brands can be useful in tracking post-consumer packaging, particularly that which is littered, to inform potential outlets for development of EPR schemes. In May 2018, a group of organizations led by the Citizen Consumer and Civic Action Group (CAG) conducted litter brand audits [1] in 250 sites in 15 cities and 18 Indian states. International brands made up a third of the brands documented in the audit, with PepsiCo, Perfetti van Mallee, Unilever, Coca-Cola, and Mondelez making up the top five international brands. Of the total litter count, 62% were domestic brands, with Parle Products, Karnataka Milk Co-Op, Britannia, ITC, and Amul making up the top local brands (Shekhar and Shah 2018). Notably both the top five international and domestic brands produce beverages, candy, and snack foods that are typically wrapped in single use plastic packaging. Throughout the CAP store surveys in Surat, the team documented products from three of the domestic brands (Parle, ITC, and Amul) and all the top five international brands reported by the CAG audit except for Mondelez.

Biscuit, candy, and chip/snack items are most often packaged in lightweight, multilayer plastic material. While this packaging system can reduce the overall carbon footprint of long-distance transport, these materials are some of the hardest to recycle due to their complexity and therefore hold little to no value for both formal and informal waste recycling sectors (Moss 2017). Several brands for beverage, snack, and personal care products were located locally in Surat, all of which should be targets for piloting EPR schemes under the latest set of EPR rules in India (MOEFCC 2020). At present, there is no immediate evidence of EPR projects in the city, although one report from Biswas et al.

1. Brand audits can inform decision making regarding extended producer responsibility targets, however, they should only be considered as rough approximations as it can be difficult to properly identify items and brands that have been disposed of in the environment, particularly those that have significant degradation due to exposure to weather and abrasion over long periods of time.

(2021) describes an EPR scheme undertaken by Sumul Dairy in Surat, which has reportedly collected and processed 150,000 milk bags daily. As an example of a non-circular processing method of plastics, throughout Gujarat, plastic waste has been co-processed in cement kilns, with 86,500 metric tons having been treated this way in 2018 (INOPOL 2020). Notably, the practice of processing plastics in cement kilns has negative consequences because of potential air and ash pollution issues and not recovering any plastics for reuse or recycling. Urban Ocean partners recognize the need for implementable and circular solutions in Surat that hold plastics producers accountable for the full life-cycle of their products, cease the leakage of plastics into the environment, and incentivize reuse.

Under the national Plastic Waste Management Rules of 2016, India's Ministry of Environment, Forest and Climate Change (MOEFFC) proposed a national framework for EPR, building on previous definitions from the Plastic Waste (Management and Handling) Rules of 2011. These rules first defined terms such as waste collectors, multilayer plastic, and EPR. Expanding upon these definitions, the EPR 2016 framework specifies that waste collection and segregation programs are to be managed by Urban Local Bodies (ULBs), while sharing infrastructure costs with manufacturers, importers, and users. By this framework, the central government set the policy expectations and the states are charged with implementing them through the state-level Pollution Control Boards (PCB). Accordingly, local companies must report to these entities. Further, plastic packaging companies must register with the PCB as a "producer" or "brand owner" and share information on the types of plastics and products manufactured and distributed. In turn, the registration system provides utility in ensuring that local waste management systems meet local needs and acts as a balance sheet for checking that equivalent amounts of plastic are being collected and processed. Further, companies operating in only one state are required only to register with the corresponding state PCB. However, companies that work across state lines must submit EPR Action Plans to the state PCB as well as the Central Pollution Control Board (CPCB) at the national level (MOEFCC 2020).

The framework also suggests three EPR models — a fee-based model, a Producer Responsibility Organization (PRO) based model, and a plastic credit model — all of which the framework states could be part of EPR implementation in India. The fee-based model requires producers, importers, and brand-owners (PIBs) that use a certain quantity of plastic packaging to contribute a fee to an EPR Corpus fund that will be set up by the Government of India. The fee would be based on quantity of plastic waste generated compared against funding required by ULBs to handle plastic waste. Funds would be disseminated to ULBs for the use of waste handling, collection, segregation, treatment, and processing. The second model suggested is a PRO based model where PIBs can engage a PRO to collect, process and recycle a certain quantity of waste based on the required target. Through the plastic credit model, PIBs can purchase credits from accredited recyclers to ensure that equivalent amounts of packaging waste produced has been recovered or recycled (MOEFCC 2020). At the time of their release, the Plastic Waste Management Rules of 2016 were praised for clear definitions and thorough requirements for meeting EPR goals throughout the country. However, critics have cited that the EPR Guidelines call for inconsistent levels of implementation, omission of some of the most problematic plastics, and lacking inclusion of the informal waste sector (Chandran 2021).

Community

To assess the attitudes towards plastic use, regulation, and disposal methods, the team conducted interviews with 17 key stakeholders ranging from government and industry representatives, informal recyclers, and academic and

sustainability experts (Table 3). The interviews aimed to elicit participant descriptions of their general perceptions of plastic and waste management in the Surat community as well as insight around specific challenges, observations, and needs that related to the participants' specific background. The resulting interview data revealed a wide variety of perceptions of the barriers and affordances related to the effectiveness of the solid waste management system in Surat, opinions around local bans, policies, and laws, education issues related to plastic and textile waste, and rights of waste workers.

Table 3: Number of interview participants by stakeholder group

Stakeholder	Interviews
Government waste management	3
Academic	3
NGO	3
Sustainability expert	3
Informal recycling	2
Industry	1
Shop	1
Private waste company	1
Total	**17**

Figure 4: Photo of CEE team conducting stakeholder interviews in Surat

(Photo credit: Navsarjan Trust)

Effectiveness of SWM

Perceptions about the overall effectiveness of Surat's solid waste management system were mixed according to participant interviews. For example, regarding the overall function, one sustainability expert was optimistic while an academic participant felt that effectiveness is diminishing:

> **"I think… SMC's current practice for solid waste management is up to the mark. The collection, segregation, and the entire solid waste management process is quite well-established in Surat."**
>
> **— (Sustainability Expert, NGO)**

> **"The effectiveness of the door-to-door garbage collection program is gradually decreasing… The efficacy is declining as private players' interest grows. Previously, SMC was required to observe the 2000 Rules regarding the environment and plastic waste, which is not the case now."**
>
> **— (Academic)** [2]

Despite this participant's cynicism, they also were optimistic that opportunities for improvement of the SWM system in Surat are attainable if the city considers holistic and comprehensive strategies (India Ministry of Environment and Forests 2000):

2. '2000 Rules' refers to the "Municipal Solid Waste (Management and Handling) Rules, 2000," which formalized required waste management responsibilities at the municipal scale. (India Ministry of Environment and Forests 2000)

> **"Like me being into this waste management, and I'm a cyclist, so every morning I just go around the city and that is where I see a lot of waste just littering around along the streets. If they are actually taking care of the city in terms of solid waste management, then why do we see such type[s] of waste? Is it because the number of bins that are placed are less? Is it the design of the litter bins that are placed is faulty? Is the door-to-door collection system not adequate? What is the problem? I would say that everything is the problem. Because integrated planning is not done, everything is done in silos. It is done on the basis of funds."**
>
> **— (Sustainability Expert, Urban Planning)**

Perceptions of bans, policies, and laws

Like the mixed perceptions of the effectiveness of the SWM system in Surat, there were mixed opinions of the impact that bans, laws, and/or policies could have. One interviewee believed that laws could be effective, given sufficient political will:

> **"For me, the solution is political will and government action. The government needs to get serious about waste management. Only then will there be a visible change. The efforts made by environmentally conscious individuals and/or NGOs do not amount to anything… I think Pune Municipal Corporation has demonstrated this commitment with initiatives like KKPKP. Pune is doing a great job when it comes to ragpickers' welfare. If the city government is committed to making positive changes, things can change. Unfortunately, I don't think Surat has the same commitment."**
>
> **— (NGO Representative)**[3]

Other interviewees felt that any sort of regulations cannot be done without proper dialogue and awareness:

> **"To bring it into policy, you don't need funding. You need a dialogue, and dialogue is a capital-free tool. Nobody understands the power of dialogue."**
>
> **— (Academic)**

> **"First of all, if people don't have an awareness about the consequences of their reckless actions, rules or laws are not going to make any difference."**
>
> **— (Waste Management Representative)**

Enforcement and implementation were frequently brought up as being important factors in the effectiveness of any sort of ban, law, or policy:

3. "KKPKP" refers to a trade union for waste workers that is active in Pune (https://kkpkp-pune.org/)

> **"People are not going to voluntarily implement it in our country. You need force, you need fines."**
>
> **— (NGO Representative)**

> **"One way to make a difference is by providing education and the other one is to make strict laws."**
>
> **— (Waste Management Representative)**

> **"We don't implement the law stringently in India, so people take them for granted."**
>
> **— (Waste Management Representative)**

> **"We understood that laws cannot deter people from burning waste out in the open unless they are backed up by stringent enforcement. We told people, "Send us the photos, videos, time, date, and location details of those who burn waste in the open and we will initiate action on them." We started the documentation. In the past three years we have had more than 3,500 complaints of waste burning activity."**
>
> **— (NGO Representative)**

> **"From the work that I have done with the health and hospital department in Surat Municipal Corporation, I think they issue separate challans or penalties for discarding and disposing of waste in the open. They do keep all the records and data associated with all these challans where they file all these penalty documents, which are reported incidents of plastic waste throwing and waste burning in open. There is no loophole in the monitoring part of SMC's waste management. That is something I am quite sure of. They are trying their best to control incidents of plastic waste being thrown in open."**
>
> **— (Sustainability Expert, NGO)**

One interviewee shared that effective policy is dependent on peoples' willingness to comply:

> **"… A big part of the policy execution does come down to the behavior of people. You simply cannot police corporations and people all the time, but there has to be some portion of the policy that addresses the public which doesn't understand that the plastic is a nuisance and they should not be throwing it in the open."**
>
> **— (Sustainability Expert, NGO)**

Another interviewee noted that tradeoffs and "soft" policies might be more advantageous than stricter measures:

> **"See, at the policy level, it's — I've always believed that you could do a lot by tradeoffs that the government can introduce as policies that are basically soft rather than hard measures. At a policy level, supposing there was a rule that a builder or a society does this, you give them benefit in tax. These tradeoffs have to be designed in a manner that citizens take a whole lot of responsibility themselves rather than bringing it back to the government… If you tell the paanwallah, 'You can't litter within 100 meters of your shop,' what will you do for him in return? What facility would you give him? Something can happen… If he picks the litter up, screens it, doesn't let it go into the river. Many of these people can do that. Very small-scale simple tradeoffs can happen."**
>
> **— (Sustainability Expert, Architecture)**

This same interviewee argued that civic bodies might be better vehicles to enact localized bans, allowing community members to have more input than they would in any state-level decisions:

> **"… I feel that the civic body should not be dependent on any state or central-level agency when creating its policies. When you ban certain products, you face international pressure for it. You won't be able to execute the ban. A civic body, on the other hand, has that right. You have got the right to localize your rules, design tradeoffs, and implement them. I feel at the end of the day if the cities are going to be such mammoth machines to manage, city-centric solutions, solutions that are locally designed by the people of the city, will be more effective. In that approach, the role of citizens will have to be elaborated as much as possible."**
>
> **— (Sustainability Expert, Architecture)**

Public awareness and education

Through the Swachh Surat mission, there are efforts toward zero waste policies including advancements toward 100% door-to-door collection, segregation activities, and resource conservation as described by SMC officials. Additionally, the Clean Surat campaign leads several public awareness and education campaigns such as banners, street plays, media and social network marketing, incentivization prizes, and encouragement from NGOs and private organizations for public participation (SMC 2023c). For example, Swachh Surat has an active Twitter presence advertising education campaigns for public awareness (Figure 5). Another awareness campaign included a sculpture of a 'Plastic Monster' erected from plastic waste collected from Dumas Beach to provide a prominent display of aggregated plastic litter (Biswas et al. 2021). Lastly, public awareness is also diffused via punitive measures such as litter fines and warnings that ideally discourage improper disposal of waste.

Figure 5: Example tweets from Swachh Surat

When interviewees spoke about education measures, they tended to mention its general importance to waste management efforts rather than specific barriers or affordances. Some interviewees felt that more education is needed to display the interconnectedness of environmental and human health:

> **"The environmental factors and climate factors don't mean a thing unless you link them with public health. That's the only way people might be able to understand them."**
>
> **— (Academic)**

> **"It is essential to educate people about the fact that it's the same river water which is pumped into your homes. If you pollute it, you will face the consequences. You should not feed the fish in the river. The river is replete with vegetation and resources for the fish. When you try to feed tidbits to the fish, it's basically garbage, which is harmful to the environment and also harmful to the fish."**
>
> **— (Waste Management Representative)**

Other interviewees mentioned the importance of educating children within the school system:

> **"As the population multiplies, the cost of living also shoots up. Ultimately, who will bear this cost? The citizens. It'd be better to spend those funds on educating the citizens in the school."**
>
> **— (Waste Management Representative)**

> **"We are visiting several schools and educating the children about the various sources of water pollution. We are also educating them about household sources of water pollution."**
>
> **— (NGO Representative)**

Notably, one interviewee highlighted a gap in who is seen as responsible for ensuring education, suggesting that there may be opportunity for clarifying and strengthening roles related to awareness and education around SWM in the city:

> **"If you ask the SMC who is responsible for raising awareness and ensuring compliance, they will tell you that it is the contractor's obligation. The contractor must educate people about wet and dry waste segregation and print and distribute a waste collection awareness pamphlet. Sad to say, in the last 22 years, I haven't seen a single pamphlet. The last time I saw an awareness booklet or poster was in 2004-2005 when the door-to-door waste collection was first implemented. Following that, no contractor printed these flyers."**
>
> **— (Academic)**

Waste workers' rights

One theme that came up related to workers' rights, specifically labor rights of waste collection workers as they worked throughout the pandemic without much pay. Examples of these thoughts are shown below:

> **"My boss pays me the wages, but I think it is insufficient… One should be compensated fairly for his/her time."**
>
> **— (Private Waste Company Representative)**

> **"At the peak of the pandemic, we worked for three months in the field. Thank goodness, neither our staff nor our management became infected with COVID. Thank God and Mother Goddess for protecting us."**
>
> **— (Private Waste Company Representative)**

Some interviewees shared concern specifically for the informal sector, who work with few protections. One interviewer from academia described two categories of informal waste pickers in Surat: 1) those who collect and move waste, often women, and 2) those who buy larger masses of scrap for selling to scrap dealers.

> **"There are two categories of waste pickers. The first one is a person who collects trash from place to place. They are the ragpickers. The second is the kabadiwala who gets paid by the scrap dealer to collect and buy waste from households, businesses, and hospitals. He purchases waste paper and scrap metal on a per-kilogram basis. Given that kabadiwalas**

> **are required to pull a cart full of trash, it is obvious that men work as kabadiwalas while the women work as ragpickers."**
>
> **— (Academic)**

Despite their often lacking recognition, the informal sector plays a significant role in global waste collection and management. One interviewee from an NGO noted that the informal sector is largely responsible for waste collection in Surat:

> **"… Even though waste collection and handling of the waste is taking place, managing the waste in an efficient manner still remains a challenge. The informal segment is taking care of waste collection and handling so far … The handlers from the informal sector collect solid waste from the factories and load it up into trucks and unload it at the dumping area."**
>
> **— (NGO Representative)**

Other interviewees mentioned how the informal sector, specifically ragpickers (who tend to be women) are treated:

> **"It's a kind of rule of thumb in the scrap business that scrap dealers pay the ragpickers in advance and make them work like bonded labor. They wouldn't let the ragpickers work somewhere else until they have repaid the advance. The scrap dealers cheat them by shortweighting the waste or by paying them less than what they deserve. The ragpickers simply don't retaliate."**
>
> **— (NGO Representative)**

> **"Surat did not give waste pickers the recognition they deserved. … They have never been recognized. They should have got some kind of identity cards, but they didn't. … SMC has classified door-to-door waste collectors who work under contract as ragpickers, even though they do not technically fall under the informal sector. … They are employees of the municipal corporation. … The informal ragpickers can also benefit from certain schemes wherein if you deposit 10 kilograms of plastic daily, at the end of the month you are eligible to get ₹1,000. … Unfortunately, the door-to-door contractual employees are benefiting from these schemes while the informal ones are left out."**
>
> **— (NGO Representative)**

> **"That's a huge problem. There are a lot of ragpickers who would not want to be part of any association because they need advance money. We don't pay women ragpickers any advance, because we don't know whether or not they would sell their waste at our central scrap shop again. We are not businesslike people who will go after them, catch them, or abuse them if they don't repay the advance. We are an NGO and don't indulge in such activities.**

> **Nevertheless, there is an unwritten law in scrap traders that if someone has taken an advance from one of the traders, no other trader will buy waste from that particular ragpicker."**
>
> **— (NGO Representative)**

Effective SWM measures in Surat

Although Surat is experiencing complications in waste management related to illegal dumping, littering, and textile and coconut waste, there is immense interest and involvement from community members, as evidenced by successful initiatives that were formed to address waste burning, single use plastic water bottles, river plastics, etc. Examples of how these practices succeeded can illuminate how current issues might be approached, demonstrating that community members are willing and able to address these issues on their own terms. Understanding the specifics around why certain waste disposal methods emerged has previously helped community members to develop solutions in Surat. For example, one interviewee discussed how redirecting organic waste has deterred waste burning. Although conversion to biofuel is a controversial method of waste management due to its harmful impacts to public health and the environment, this quote highlights local efforts to actively seek understanding of how waste is managed in order to explore alternatives:

> **"We made efforts to understand people's compulsion to burn waste in the open. Many people used to burn organic matter, like branches and leaves that outgrow on trees. We helped in putting an end to that as well… In two residential societies we collected all the wood waste, loaded it up in tractors, and supplied it to the industries where it could be used as burning fuel. These locations had the official permission to burn wood waste. We thought, 'Why not convert the wood waste that people burn in the open into energy?' That's how we worked that out."**
>
> **— (NGO Representative)**

Additionally, putting together a petition, having significant engagement, and connecting the issue of waste burning to community health and aesthetic issues related to pungent odors helped advance this particular initiative. Although we note that the source of the 'stench' referred to by the interviewee below has not been officially identified, this quote demonstrates the grassroots efforts to organize a petition to actively address potentially waste relevant issues:

> **"The first step [in the campaign to deter waste burning] was to inform the people about the harmful impact burning waste out in the open has on their health. We started a petition on change.org, which has now been signed by 92,000 citizens of Surat. The petition stated that we want to impose a heavy penalty on waste burning activity. We tagged all the authorities in the petition, including the mayor and all responsible authorities. In the petition we also mentioned that during night the city gets enveloped in a pungent smell. All the authorities agreed to the fact that there is indeed a strange stench that can be smelled at night, but no one took action. I said to them, 'Burning waste in the open is the source of the stench,' because even I couldn't figure out what the actual source was."**
>
> **— (NGO Representative)**

Understanding how vendors and shop owners make money (such as vendors who sell plastic water bottles on the street) helped inform interventions by ensuring that those vendors continue to make money through providing plastic alternatives:

> **"Generally, selling water bottles is one of the prime sources of income for food stalls. We avoided that and placed huge earthen pots for drinking water and we provided them with compostable glass [made of rice husk] … We suggested they use a sustainable alternative. Then we took the initiative and stored 15,000 compostable glasses that we now supply to various events."**
>
> **— (NGO Representative)**

Connecting religious beliefs to environmental stewardship has been helpful in reducing how much plastic ends up in rivers as a result of religious ceremonies:

> **"What is specific to Surat is we have been able to tackle the problem of plastic waste being dropped into the river. We have been able to achieve this feat by using faith as a motivator. Our plan was to counsel the priests or pandits that since the river is sacred, it was inappropriate to dump litter into it … Faith is paramount to most people and faithful people can be educated to desist from littering the sacred river with paraphernalia after a ceremonial worship and a fire ritual. We understand that faith is crucial, but are the people who don't live near a sacred river and don't discard paraphernalia in that river any less faithful? Rivers are considered sacred. So, we placed lotus shaped urns at different places by the river and appealed to the people to drop flowers, garlands, and various paraphernalia [organic or artificial] into them after the ceremony. … We told them to just drop those items in the urn. Perform your ritual or pooja and then drop the paraphernalia into the lotus urn."**
>
> **— (Waste Management Representative)**

Product Design

To characterize material types used in common consumer products, samples of common convenience and to-go items were obtained within the given transects in the city of Surat as described in the Input section (Figure 6). For each item category, the average mass of both the packaging and the product itself were collected for 131 samples (Table 4).

Product formats at convenience and grocery stores

Figure 6: Example of surveyed convenience store

(Photo Credit: Kunal Jaiswal)

Across the five product categories, the average mass of plastic packaging ranged from 0.93 g for sachets to 13.4 g for beverages, with an average mass of 4.71 g (Table 4). The high mass of beverage bottles was likely due to the high-density properties of PET relative to other plastic materials. In contrast, sachets, commonly used for tobacco and personal care items, had the lowest mass of plastic packaging likely due to the small format. The average product mass similarly ranged from 6.5 g among sachets and 221 g among beverage bottles (Table 4). Like the packaging itself, the high product mass associated with beverages was likely driven by the density of liquid products. Products packaged in sachets, however, are likely loose tobacco or small quantities of personal care contents that would not lead to heavy mass relative to the other product formats.

Table 4: Average weight of products and their plastic packaging for common convenience items (not including unknown products)

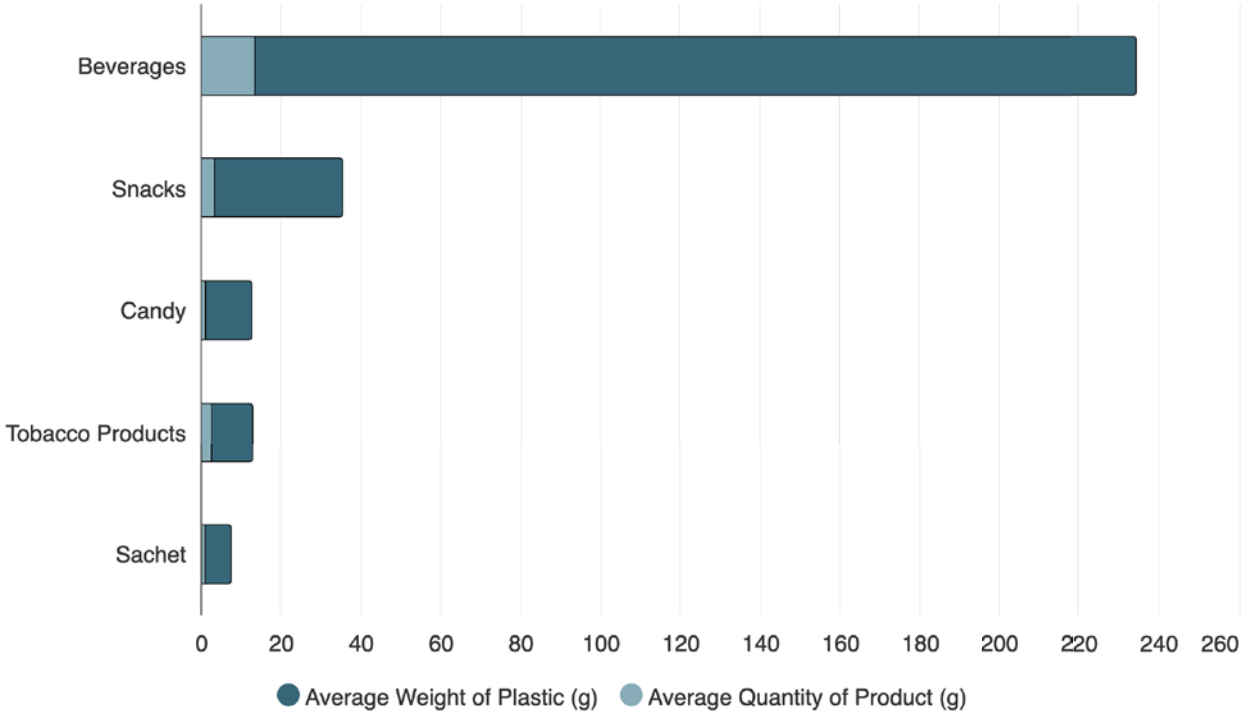
Product Type	Product Count	Average Mass of Plastic Packaging (g)	Average Quantity of Product (g or ml)
Beverages	29	13.4	221
Candy	27	1.01	11.7
Sachet	19	0.93	6.50
Snacks	32	3.33	32.2
Tobacco	24	2.59	10.2
Grand Total	**131**	**4.71**	**65.2**

Given these discrepancies in packaging and product masses, the surveys also determined that beverages had the highest product-to-packaging ratio, while sachets had the lowest. This ratio highlights how small quantities of products sold in sachets have disproportionately high packaging mass. In other words, more packaging is needed for products sold in the sachet format in comparison to the other product categories in which the products had higher masses relative to their packaging (For example, see Figure 7). Because of the density of liquid, beverages had the largest product-to-plastic packaging ratio, representing a more efficient format of product delivery (Figure 8).

Figure 7: Examples of common multilayer plastic packaging for snack and tobacco products in convenience stores

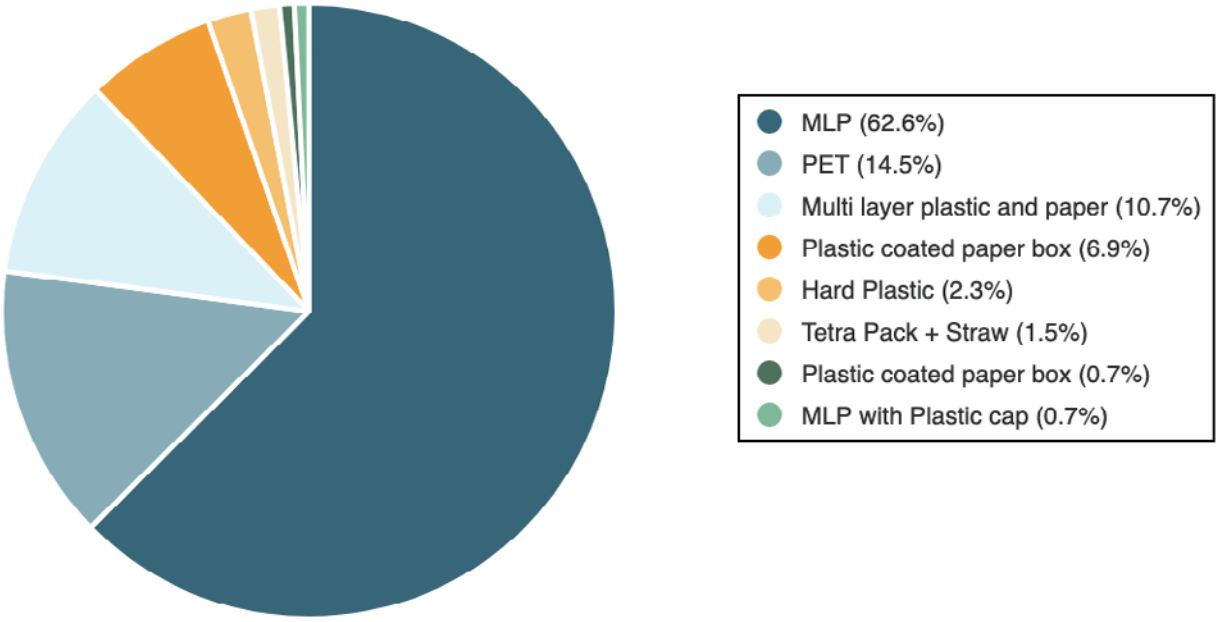
(Photo credit: CEE Team)

Figure 8: Convenience store plastic to product ratios, shown in grams



Among the top brands in convenience stores samples, there were seven different categories of materials observed (Fiure 8). Multilayer plastic (MLP) film was the most abundant material type for packaging, making up 63% of the surveyed items. Other products comprised MLP in combination with other materials such as paper (11%) and plastic caps (0.8%). PET was the next largest category of common packaging material, which typically has a relatively high value in the informal waste recycling sector. Overwhelmingly, the top consumer products were packaged in multi-material packaging (Figure 9), which can make it difficult for sorting and waste management, both from the consumer and the waste practitioner perspective.

Figure 9: Breakdown of material type for convenience item packaging.



MLP = multilayer packaging; PET = polyethyl terephthalate)

To-go ware from food vendors and restaurants

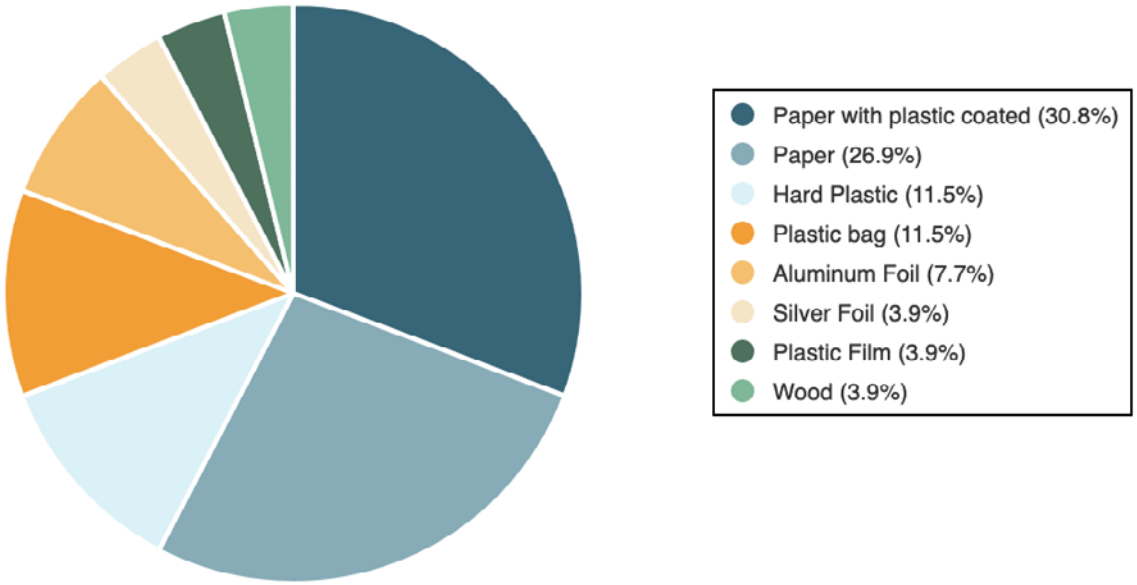
In addition to the convenience items, within each of the selected nine 1km^2 transects in Surat, the LIP also visited at least three randomly selected food vendors and/or to-go restaurants to sample the food packaging and utensil types that were being distributed (Figure 10), totaling nine vendors sampled. The LIP collected 27 to-go items from those vendors and documented their mass, material type, and brand, where possible.

Figure 10: Examples of food vendors and to-go restaurants surveyed in Surat (Photo credit: Kunal Jaiswal)

(Photo credit: Kunal Jaiswal)

Among the to-go items sampled in Surat, there were multiple types of materials identified, however, plastics were predominantly provided by the surveyed businesses, making up 50% of the collected items by count. Of these plastics, formats included plastic bags, plastic-coated paper containers, plates, and cups, and hard plastic containers and utensils. All items, which are typically designed for single use and immediate disposal, had some form of material alternative to plastic except for bags. These alternatives were mostly comprised of metal foil wrappers used for containers and food wrappers, paper used for plates and wrappers, and wood used for utensils. Additionally, butter paper (or parchment), often made of wood pulp and silicone, was an alternative for plastic food wrapping. Similarly, food wrappers were the only product category in which no plastic option was offered. Within the material groups, the most common plastic material was paper with plastic coating, which made up 31% of items, followed by paper (27%), and hard plastic and plastic bags (both 11%) (Figure 1).

Figure 11: Breakdown of material types for to-go items



The average mass of items ranged from 0.71 g for cups to 12.1 g for containers. While alternative materials offer sustainable options for common disposable to-go items, those items surveyed had a greater average mass than their plastic counterparts. For example, paper plate alternatives are 0.88 g heavier than the plastic-coated paper plates, wooden utensils were 0.76 g heavier than plastic utensils, and paper cups were 0.99 g heavier than plastic-coated paper cups. Hard plastic containers, however, had a substantially greater mass than other container types, with aluminum foil offering the most lightweight container system within that category (Table 5).

Table 5: Material type and average weight of common packaging items from food vendors and restaurants in Surat

Product / Material	Number of Samples	Average Mass of Packaging (g)
Plate	**7**	**5.45**
Paper	3	5.96
Paper with plastic coating	4	5.07
Container	**6**	**12.1**
Aluminum Foil	1	3.81
Hard plastic	2	27.0

Product / Material	Number of Samples	Average Mass of Packaging (g)
Paper with plastic coating	2	5.53
Bag	**4**	**5.47**
Plastic	4	5.47
Spoon/Fork	**3**	**1.51**
Hard plastic	1	1.01
Wood	2	1.77
Wrapper	**3**	**3.72**
Aluminum foil	1	3.32
Butter (parchment) paper	1	2.62
News paper	1	5.23
Cup	**3**	**0.71**
Paper	2	1.04
Paper with plastic coating	1	0.05

Notably, there were no recorded plastic items that were labeled as biodegradable (a problematic label) or oxo-degradable (a problematic property), suggesting that shops and vendors may not be using these type of material alternatives. While plastic alternatives that are considered compostable may provide a viable solution, they rely on appropriate infrastructure to ensure proper collection, segregation, and treatment of material. As such, misleading nomenclature and lack of clear labeling on the different types of plastic confusion can be caused by, particularly pertaining to labels such as biodegradable, compostable, oxo-degradable (Moss 2017).

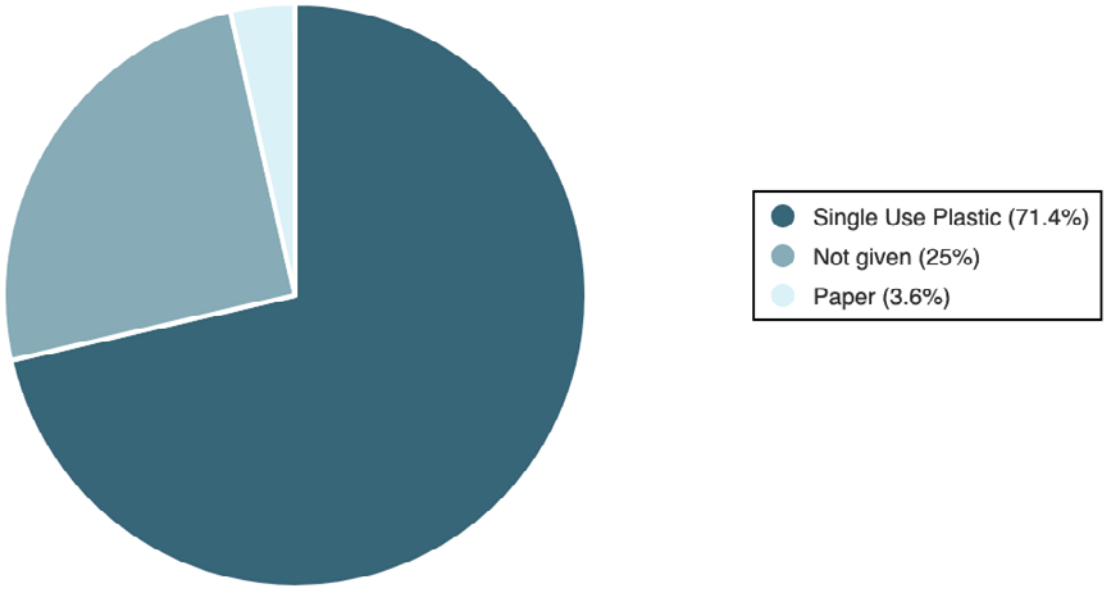
Figure 12: Examples of convenience items and to-go ware from surveys in Surat

(Photo credit: CEE Team)

Use

To investigate the distribution and use of disposable plastics, material alternatives, and reuse options, the LIP surveyed 28 shops to determine the typical distribution of carrier bags to consumers. Most shops (n = 20) provided single -use plastic bags at no cost to the customers (Figure 13), directly in opposition to the national and state-wide policies targeting bans on plastic bags. One restaurant distributed paper bags to customers, and five pan shops, which sell tobacco and related products, refrained from supplying bags entirely, likely due to product consumption occurring on site. While bag thickness was not recorded, the mass of the surveyed single -use plastic bags ranged from 0.5 to 22.4 g, with a mean mass of 5.8 grams. Grocery stores had the highest mean mass of plastic bags (11.5 g), while pan shops had the lowest mean mass (2.19 g). Notably, no alternatives to plastic bags or policies encouraging reusable bag use were reported by the LIP surveys, which indicates that existing levels of adoption and/or enforcement have not been sufficient.

Figure 13: Type of bags distributed at restaurants, shops, and grocery stores



The Indian Ministry of Environment, Forest and Climate Change's Standard Guidelines for Single Use Plastics (2019) include examples of legal and policy options for prohibiting single use plastics and case studies where they were successfully implemented. However, the guidelines do not offer options for multilayered packaging (MLP), as it notes that no adequate replacement technology exists (Chandran 2021). As MLP is one of the most common packaging among top convenience items in Surat and also among the most abundant litter items, it is worth the city exploring targeted ways of addressing multilayered packaging waste. The guidelines also make explicit mention of the need for increased public education and outreach on the topic by local governments, which is an avenue that Surat could explore.

Nearly all plastic to-go product alternatives documented during the CAP surveys of stores and food vendors were available to customers at no additional cost to the consumer. Only one food vendor charged customers for paper plate alternatives at 5 Rs. Among businesses in Surat, food vendors and restaurants may have the greatest opportunity in terms of transitioning to alternative product types. For example, the CAP surveys documented plastic plates and cups replaced with paper and food stands using newspaper or foil instead of plastic wrappers. Similarly, wooden utensils and foil containers can replace common plastic items that are difficult to recycle. Wherever possible, reusable containers and utensils should be encouraged and, ideally incentivized, as reuse is preferable to any single use material. However, the prevalence of single use plastic bags surveyed and limited alternatives for consumers in Surat illuminates an opportunity for the city to encourage vendor buy-in for phasing out certain single use items and integrating availability of alternative options, ideally with little to no additional cost for consumers. In order to sustain their high performance and ranking under Swachh Surveskshan, the city could leverage Information, Education, and Communication (IEC) as a way to encourage vendor buy-in and participation through targeted campaigns to reduce litter and encourage alternatives to single-use items. As the implementation of relevant rules and regulations continue in Surat, there could be opportunities for learning among companies and similar cities that have successfully transitioned away from single use plastics in a way that is cost effective.

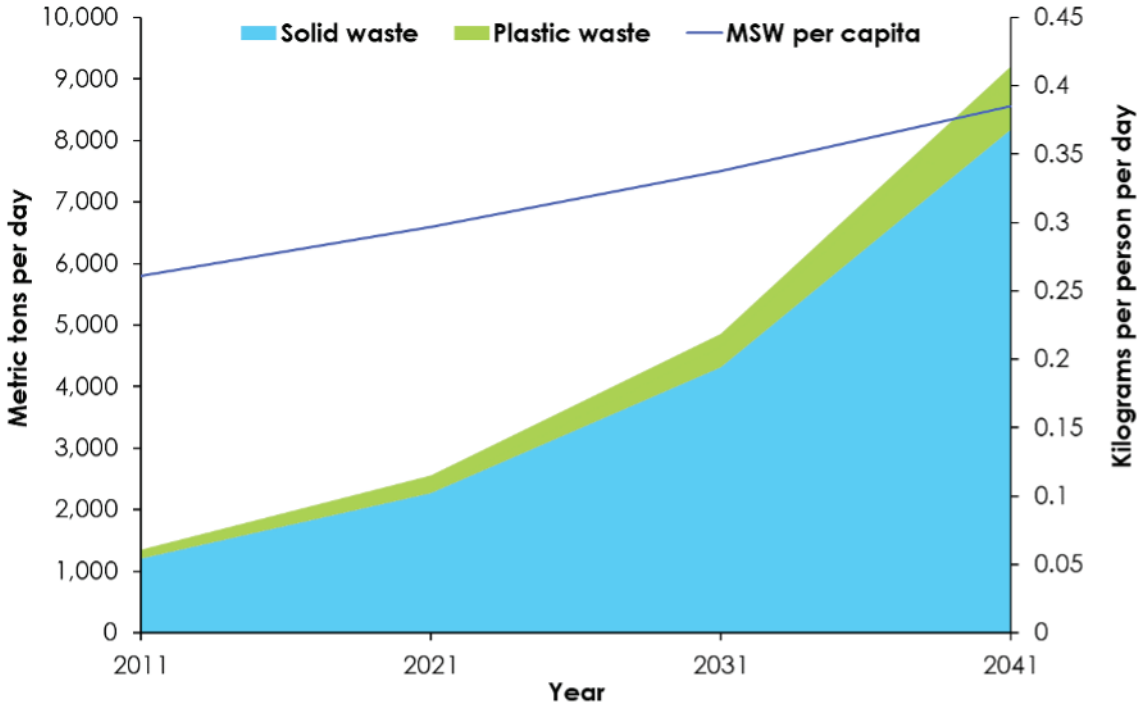
Policies banning consumption of plastic products

Product bans and incentive programs can be effective regulatory measures for reducing plastic consumption, reducing waste generation and management pressure, and reducing leakage into the environment (Maes et al. 2018, Schuyler et al. 2018). There are several policies in place regarding the use and disposal of solid waste and specifically plastic in India, including the Plastic Waste Management (PWM) Rules of 2016 and sequential amendments in 2018, the Solid Waste Management Rules, 2016 and the Recycled Plastics Manufacture and Usage Rules. These policies are advised under the Ministry of Environment, Forest and Climate Change by the National Plastic Waste Management Task Force and the Committee on Urban Solid Waste Management in India (Aiyavoo 2018). Nationally, the PWM Rules and respective amendments have targeted prohibitive measures to tackle challenges with plastic waste management. Specifically, there have been wide-reaching bans on plastic products, with urban local bodies (ULBs) charged with enforcing them (Karasik et al. 2020). One of the country's first targeted bans was toward plastic microbeads which can be used in cosmetic and household products like detergent (UNEP 2018). Additionally, some of the country's early bans targeted plastic bags specifically, with the Plastic Waste (Management & Handling) Rules of 2011 prohibiting retailers from distributing plastic bags to customers for free. Later in 2016, the Plastic Waste Management Rules resulted in several stipulations making the use of plastic bags more restricted. The rules specified that non-compostable plastic bags must be greater than 50 microns thick in order to improve their recyclability, required the phasing out of manufacturing of non-recyclable plastic bags over a two-year period, created a standardized marking and labeling system for bags, and made retailers liable to penalties for providing customers plastic bags that failed to meet standard requirements. Also, as per Plastic Waste Management Amendment Rules 2021, certain categories of single use plastic items have been banned across India with effect from July 01, 2022.

Waste generation

Waste generation in the South Asian region, which contributes to 17% of the world's waste, is expected to grow significantly in the coming decades with the average per capita waste generation rate increasing to 0.79 kg per day (Kaza et al. 2018). This growth is expected to follow in Surat where already there has been significant local growth in recent decades that has led to a staggering 2,172% increase in waste generation between 1971 and 2015 (Dutta and Jinsart 2020). Today, Surat generates between 1,680 to 2,890 metric tons of waste generated daily (Kumar and Agrawal 2020, Surat Municipal Corporation 2023b, Surat Municipal Corporation 2023c, Surat Municipal Corporation 2022). Based on the latter value, the SMC reports that 0.45 kg of waste are generated per capita daily, which is slightly less than the national average of 0.57 kg per capita per day and about 60% of the global average of 0.74 kg per capita per day (Kaza et al. 2018). Under business-as-usual (BAU) growth, Surat is expected to generate an estimated 8,200 metric tons of waste daily by 2041, of which an estimated 1,020 metric tons will be plastic waste (Figure 14). While this value will still make up a relatively small per capita waste generation rate of 0.39 kg per person per day, the significant growth in waste generation will continue to pressure the existing system, highlighting the need for integrating holistic waste reduction measures in anticipation of the forecasted increase.

Figure 14: Forecasted MSW and plastic waste generation in Surat between 2011 and 2041



(adapted from INOPOL (2021))

One report from the Solid Waste Department in Surat estimates that 55-58% of waste is generated from households, where there is some source segregation of organics and recyclable waste. Following household waste, another 12-15% is generated from food markets, 7-8% from hotels and restaurants, 6-8% from construction and demolition activities, and 6-7% from shops and business establishments (SUDA 2017).

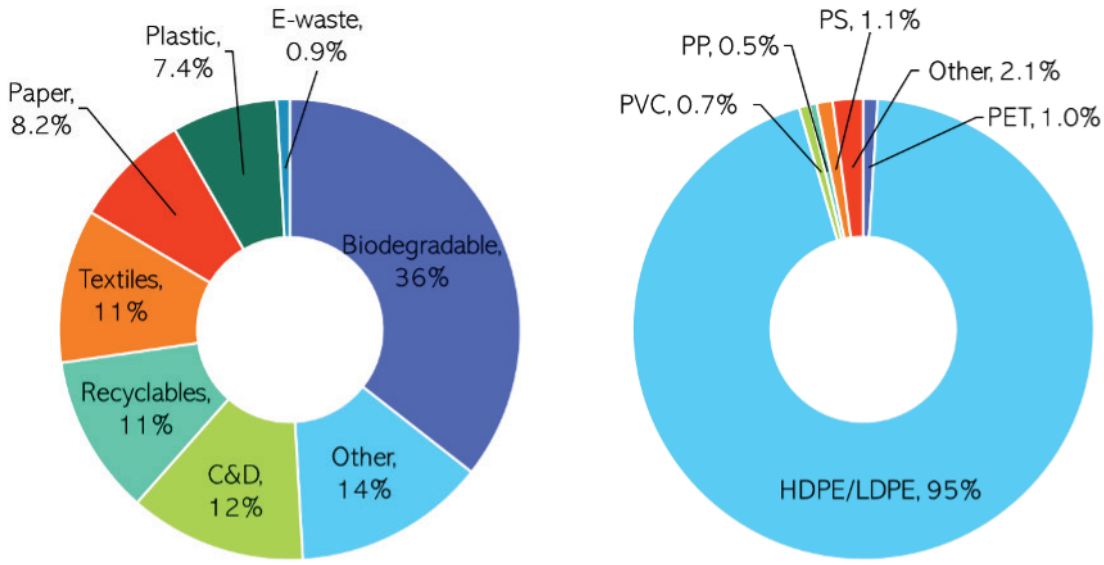
Waste composition and plastic waste generation

Reports vary in terms of Surat's typical waste composition, however, according to the Public-Health Bye-Laws 2015 for the SMC of Gujarat State, there are 32 different classifications for characterizing waste (SMC 2015). Among these classifications, there are two categories in which plastic waste can be classified including a 'Recyclable waste/Dry waste' category that lists beverage bottles, plastic bags, packaging, and all other plastics, and a 'Plastic Waste' category which encompasses, "any plastic products such as carry bags, pouches, or multilayered packaging, which have been discarded after use or after its indented life is over" ((SMC 2015), p. 10). Across all reported waste characterizations for the city, the largest proportion of waste comprises biodegradable waste like food and vegetation (Figure 15) (SUDA 2017, Biswas et al. 2021; Suryavanshi et al. 2023). Other notable sources of waste include general recyclable waste which make up 11 to 34% across the reports, construction and demolition (C&D) waste, which makes up 12 to 17% of waste, and cloth, textiles, and fabric which make up 8 to11% of waste in the city.

The proportion of plastic ranges from 7.4% in a recent waste characterization conducted by Suryavanshi et al. (2023) to 19% as reported by Biswas et al. (2021) in a comprehensive summary of SWM best practices across 28 Indian

cities. In comparison, the average plastic waste proportion is 8% in the South Asian region and 12% globally (Kaza et al. 2018), which corresponds to the lower estimate for Surat. Further, the recent 2020-2021 report by the Central Pollution Control Board of India estimated that 3.47 million metric tons were generated in India, while the state of Gujarat was one of three major state-level contributors, having contributed an estimated 12% of the country's total amount. Reported estimates of plastic waste in the Surat waste stream vary. In one 2015 study of plastic waste generation and composition across 60 cities in India conducted by the Central Pollution Control Board (CPCB), Surat generated the eighth largest amount of plastic waste daily with 149 metric tons per day (TPD) compared to 689 TPD in Delhi, 429 TPD in Chennai, 426 TPD in Kolkata, 408 TBD in Mumbai and 314 TBD in Bangalore (CPCB 2015). Further, although the city generated less waste compared to some of the larger cities in India, it had the highest proportion of plastic in the waste stream at 12.5% of all 60 cities examined in the study, followed by Kavaratti (12.1%), Kolkata (11.6%), Faridabad (11.3%), and Raipur (10.6%).

Figure 15: MSW characterization (left) and Plastic waste composition in Surat (right)



(left; adapted from Suryavanshi et al. (2023)); Plastic waste composition in Surat (right; adapted from CPCB (2015)).

Among plastic waste generated in Surat, high- and low-density polyethylene (HDPE and LDPE) items make up a substantial proportion of items (95%). These polymers are most commonly used in packaging, but are also utilized in building and construction material, agricultural, farming, and gardening supplies, and other sectors (Plastics Europe 2023). The next largest proportion was polystyrene (PS), commonly used in packaging, building and construction, and electrical and electronic items, and polyethyl terephthalate (PET), which is mostly used for beverage packaging. Notably, the study led by the CPCB in 2015 included 'metalized pouches' in the polyethylene category, which likely represent multilayer sachets used for personal care products, tobacco, etc. Further, the low occurrence of items like PET and polypropylene (PP) suggests that these items are being collected outside of the formal waste system where waste characterization procedures generally take place.

Textile waste

In addition to plastic manufacturing and waste generation in Surat, there is a substantial textile industry, which is estimated to contribute 40% of India's production and manufacturing of synthetic fiber (INOPOL 2020). Several community interviews pointed to the challenges related to the industry, frequently citing textile waste as a problem driven by the industry's prevalence in the city:

> **"Yes, so right before that you will see all the scrap dealers on the left and right. There are plastic drum[s] and wooden crates. And these are the ones with clothes. There are whole heaps of old cloth lying around."**
>
> **— (NGO Representative)**

> **"SMC is looking to find ways to recycle textile waste, or chindi, rather than just burning it. SMC is quite conscious about waste recycling. They regularly review their waste management exercises."**
>
> **— (Academic)**

> **"The clothes that are made—if this clothing article is made from one meter of cloth, then 10-20% waste is generated from it. That's one. Another is when people do dyeing processing in the mill, the cloth got stuck in the machine, or two filaments do not get dyed, that lot gets rejected. That is how this is generated. There is no question of awareness in this. Don't use clothes, don't wear clothes, that is one form of awareness. [chuckles] Because it's bound to generate waste. Surat is a manufacturing hub for cloth. Such reject lots come out in tons every day. … Yes. Not less than 30, 40, or 50 tons (of yarn). Because there are so many dyeing houses, finishing houses, weaving plants, weaving centers…"**
>
> **— (NGO Representative)**

Collection

Around 2,150 – 2,890 metric tons are collected and transported for treatment and disposal daily in Surat (Surat Municipal Corporation 2023b), leading to a 97% rate of collection across the city's wards (Kaza et al. 2018, Biswas et al. 2021). Globally, waste collection rates tend to correlate with income levels, and the regional waste collection rate across South Asia is 77% among urban areas and 40% among rural areas. By municipality, collection rates throughout India vary substantially with some rates as low as 25% to 100% in cities like Pimpri-Chinchwad, Nashik, and Greater Mumbai in neighboring state Maharashtra. Surat is well aligned with other Indian cities such as Pune, Lucknow, Jaipur, and Tenali which all are estimated to have 97% collection rates (Kaza et al. 2018). Contributing to the high rate of collection in Surat is the substantial efforts made by the SMC, which were spurred by the city's 1994

plague and have since led to the development of a comprehensive collection strategy. The waste collection and transportation system in Surat costs about Rs 11.295 crore ($1.4 million USD) per annum (Biswas et al. 2021).

The primary form of waste collection in Surat is via door-to-door services, with about 56% of waste collection carried out in this manner in 2014 (SUDA 2017). Within this system, citizens are expected to do some primary segregation by material type prior to collection (Surat Municipal Corporation 2023b). Door-to-door collection is a prominent waste collection approach throughout the South Asian region (Kaza et al. 2018), and in the case of Surat, the municipality operates the collection system, providing opportunities for the waste authorities to lead measures to spur improved waste segregation among individuals and households. At present, the SMC partners with local contractors who provide vehicles for doorstep collection and are required to undertake Information, Education, and Communication (IEC) activities during door-to-door waste collection. Generally, they have an audio which is played as the vehicle moves around the neighborhood, making people aware on waste segregation, though this is not very effective. In 2022, door-to-door collection of waste compiled an average of 1,780 metric tons daily (Surat Municipal Corporation 2023c). One example of a private local 'doorstep service' is the Bhangarvale, which offers pick up service for household inorganic/recyclable waste, offering cash for newspaper, iron, plastic books, copies, metal, etc. The organization then segregates waste and disposes of it in the most appropriate method including reuse, up-cycling, and reselling of scrap (http://www.bhangarvale.com/).

As a citizen-government partnership program, Anudan scheme was introduced by SMC in 1999. Under the scheme the registered Resident Welfare Associations (Housing Societies) can participate. Responsibilities of the participating society are primary waste collection, source segregation and maintaining cleanliness of common society areas. (Basu and Khanna) The program relies on society leaders to organize sweepers and waste equipment, and the SMC pays the societies based on completion of waste collection (Biswas et al. 2021). Residential societies are paid 0.8 Rs. per m^2 per month and mixed use industrial and residential societies are paid 0.65 Rs. per m^2 per month, with a minimum payable amount of 1,600 Rs INR per month (Surat Municipal Corporation 2023b). More than 800 housing societies in Surat participate in the program through agreements with the SMC, successfully engaging community members with local waste management efforts.

Waste is often segregated to some degree at the household or individual level, though many interview participants alluded to challenges associated with individual segregation. Difficulties associated with public participation in waste segregation was a common refrain among interviewees, who had an overall sense of dissonance around the effectiveness of the program. For example, one interviewee mentioned the disconnect in the effectiveness of waste segregation due to the disconnect between compliance and collection infrastructure like bins. This interviewee also expressed confusion around mandates in MOUs with door-to-door collection operators and SMC to collect mixed waste, which is contrary to the requirements in existing regulation for household segregation:

> **"On paper, every corporation, not just Surat, is 2000 Rules [Municipal Waste Management and Handling Rules from year 2000] compliant. It is regulated [by the MWMH Rules] that two garbage cans be placed, one for dry waste and one for wet waste. What is the point of placing two trash cans if the SMC is collecting mixed waste?"[4]**
>
> **— (Academic)**

4. '2000 Rules' refers to the "Municipal Solid Waste (Management and Handling) Rules, 2000," which formalized required waste management responsibilities at the municipal scale. (India Ministry of Environment and Forests 2000)

Another interviewee mentioned how the Zero Dustbin Policy had adverse effects on waste segregation, primarily in limiting the involvement of waste pickers who previously could access and segregate recyclable waste that is now ending up at the landfill:

> **"One of the main disadvantages of the Zero Dustbin policy is that there is a lack of segregation of waste. This means that all types of waste are being dropped into one dumping site. Households collect their waste in a plastic bag and put it outside their homes for the SMC to collect. However, now that plastic bag will land directly in the landfill. This is problematic because earlier when there were dustbins, the ragpickers would take out the plastic bag (which is recyclable) and segregate the waste in the process. Many things that could have been recycled are now being dumped, which creates more pollution and environmental issues. The policy also led to an influx of plastic being disposed of at the dumping sites."**
>
> **— (NGO Representative)**

Further complicating consistency among public participation in waste segregation is the challenge with maintaining awareness and understanding among a highly transient population.

> **"Segregation of waste is linked to change in behavior patterns. There is a 50% migrant [transient] population in the city, which is always in a state of flux. Consequently, it's very difficult to bring about behavior change here."**
>
> **— (NGO Representative)**

While these challenges in managing the waste segregation program exist, one interviewee felt that the public's interest and participation in waste segregation is growing, with visibility of unmanaged waste leading to action from the public:

> **"The general public doesn't care about segregating waste. All they care about is getting rid of their garbage… [but] public participation in waste segregation is growing. … If waste gets piled up in housing societies, we do get a complaint from them to collect it."**
>
> **— (Street Sweeper)**

Reliance on the public to effectively segregate waste can be challenging and ability to sort household waste may suffer from low awareness, lacking or confusing educational campaigns, complexity of sorting waste material (particularly plastics), changing regulations, inconsistent enforcement, etc. Though many of the interviewees' saw the public's ability to reliably segregate waste as a major challenge to the program, some participants offered insight into potential opportunities to enhance the segregation efforts in Surat through financial incentives, easily accessible depositories, and compulsory measures.

> **"Or like when all the NGOs held a meeting some time ago, they said to everyone, "We will pay you according to the weight of the paper or cloth if you separate it." If everyone gets money,**

then everyone will collect it separately at their place. They will separate paper, separate plastic. The collector would come every Sunday to collect plastic."

— (NGO Representative)

"[A separate value chain system for each kind of waste] … could be one of the best, yes. With proper deposition centers and aware — Like people should know. You put the information in SMC's app about where I can find glass deposition centers."

— (Sustainability Expert, Urban Planning)

"The second biggest problem is that of segregation. And it will be solved by making it compulsory. The corporation should not lift garbage from there. Do not lift the rubbish if it is mixed. End of story."

— (NGO Representative)

"Not everyone separates their trash … The regulations were recently put into effect. People will eventually get used to it and separate their household waste into wet and dry."

— (Government Waste Management)

In addition to door-to-door service, past efforts for municipal waste collection in Surat include stationary dustbins throughout the city during which there were 139 two-to-three cubic meter capacity bins and 1,120 four-to-five cubic meter capacity bins, making up a total dustbin capacity of 5,400 cubic meters (SUDA 2017). However, the city enlisted a Zero Dustbin Policy in 2018 that removed numerous dustbins that were previously used for waste collection. Additionally, Surat is one of 100 cities in India that is included in the country's Smart City Program administered by the Ministry of Housing and Urban Affairs (MHUA 2023). As a Centrally Sponsored Scheme run by the Government of India, the Smart City program aims to provide financial resources for promoting the development of advanced 'smart' infrastructure/innovative technological solutions that improves social, economic, environmental, and institutional quality of participating cities. In this vein, Surat has completed or begun 58 different 'smart' projects such as housing development projects, advancing information technology (IT) capabilities, transportation improvements, and upgrades to water management systems. Of these projects, two focused on the solid waste management (SWM) sector which included the introduction of a biogas plant for organic waste and a smart waste collection system. As part of a 130 million INR ($1.6 million USD) investment through the Smart City initiative (MHUA 2023), Surat installed several underground smart dustbins in 2018. At present, there are 75 smart dustbins installed across the South east zone and East zone — A (Surat Municipal Corporation 2023b) (Figure 16). The bins work by sensing when deposited waste has met a specific capacity threshold and then alerts the collectors. In 2022, the smart underground bins collected an average of 35 metric tons per day (Surat Municipal Corporation 2023c), often serving as disposal sources for vendors at vegetable and meat markets (Biswas et al. 2021).

Figure 16: Front (left) and back (right) of underground smart dustbins

(Photo credit: Kunal Jaiswal)

In addition to the household collection and smart underground dustbins throughout the city, there are also cradle dust bins typically located along roadways or high traffic areas (Figure 17), with an estimated 20 metric tons collected daily in 2022. Finally, street sweeping and scraping are conducted daily, and an estimated 16 metric tons of waste were collected daily in 2022. Through these collection methods, waste is aggregated and transported to the zonal transfer stations (Table 6) for further sorting, and transportation to final treatment, and/or disposal sites.

Figure 17: Examples of cradle waste bins

(Photo credit: Kunal Jaiswal)

Figure 18: Street sweeping and collection

(Photo Credit: Kunal Jaiswal)

Table 6. Door to door collection agency and transfer stations serving Surat administrative zones

Zone	Door to door collection agency	Name of transfer station(s)
Central	M/s Jigar Transport Co.	Katargam
North	Om Swachatha Corporation	Katargam; Kosad
East Zone A	M/s Jigar Transport Co.	Varachha; Kosad
East Zone B	M/s Jigar Transport Co.	Varachha; Kosad
South East	Om Swachatha Corporation	Anjana; Dindoli
South	Om Swachatha Corporation	Bhestan
South West	Global Waste Management Cell Pvt. Ltd.	Bhatar
West	Western Imaginary Transcon Pvt. Ltd.	Pal; Kosad

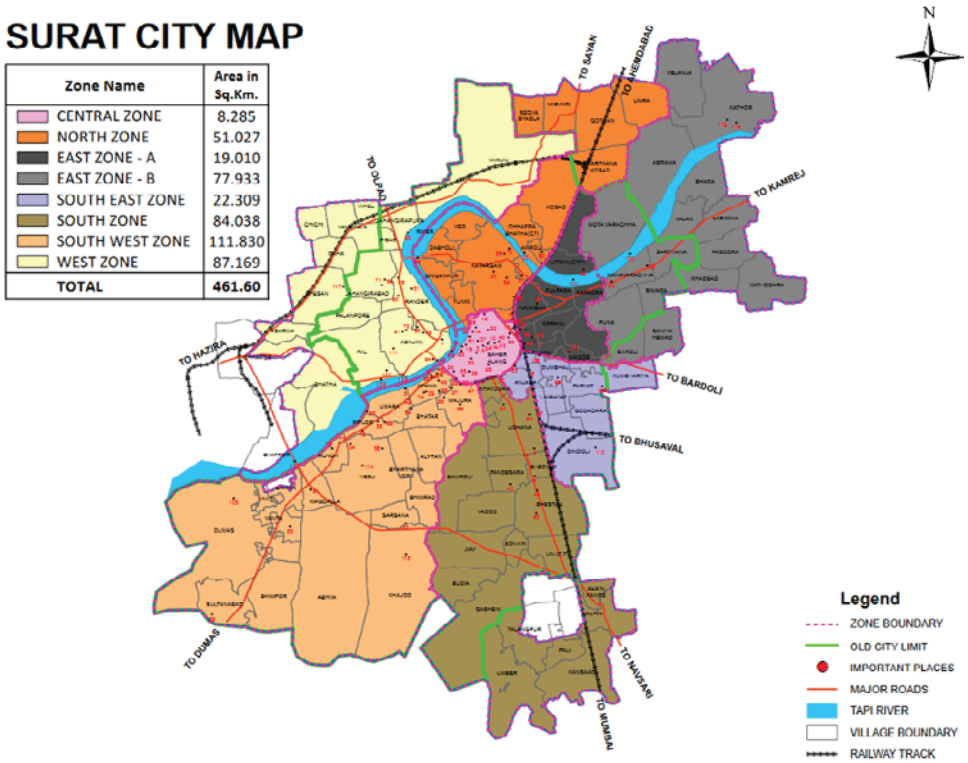
(Source: Surat Municipal Corporation (2023b))

Figure 19: Example of temporary storage at transfer station

(Photo credit: Kunal Jaiswal)

In addition to municipal waste collection, other significant waste streams from the medical, textile, and construction & demolition industries are targeted for collection and treatment. For example, 18 collection vehicles are tasked with collecting hotel and kitchen waste for about 300 participating businesses.

Figure 20: Boundaries of Surat zones



(Source: Surat Municipal Corporation (2023d))

Figure 21: Waste collection in Surat

(Photo credit: Kunal Jaiswal)

Informal waste management sector

As described in the Community section, the informal waste sector plays a critical role in solid waste management and recycling throughout India where it is estimated that 50-80% of plastic waste generated in the country is collected by the informal sector and diverted from the environment (Nandy et al. 2015). In Surat, the informal waste sector employs an estimated 7,000 (Kumar and Agrawal 2020) to 15,000 people (Biswas et al. 2021), ranging from sweepers, collectors or pickers (sometimes colloquially called 'rag pickers'), waste dealers, and informal recycling industries who all contribute substantially to the efficient process of collecting, sorting, cleaning, and recycling waste. Informal waste workers in Surat tend to source most of their plastic waste from the landfill, with households, community bins, and commercial spaces providing additional sources for plastic scrap collection (INOPOL 2020). However, it is important to note that the makeup of waste workers in urban areas in India has changed considerably since the COVID-19 pandemic. Prior to COVID-19, informal waste workers in Surat could collect 40 kilograms per day, but this value has reduced to 30 kilograms per day due to impacts from the pandemic, namely an increased informal waste workforce due to pandemic-related unemployment in other sectors. Notably effects have reduced some informal workers' earnings by 25% (INOPOL 2020).

Further, interviewees described the tenuous role that women waste collectors in the informal sector play in the city. One local humanitarian group called Navsarjan was established under the Bombay Public Trust Act of 1950 and has made efforts toward protecting workers rights among the informal waste sector in the city. Through this organization, ten women developed the Rag-Pickers Association in 1997 called Nari Pragati Mahila Mandal, Rasulabad (Navsarjan). Specifically, the group has supported women in the informal waste sector in Surat by encouraging fair pay for

their collected scrap. The participating women will bring their collected scrap to an assigned location and Navsarjan will help to sort and weigh items and assist in negotiating sales of scrap. Then, the participating women are paid and provided any extra funds from sales at the end of the year. Notably, the group initially started with 77 participating women, but have seen a reduction to 16 according to the website at the time of writing. The group attributes this reduction to the incorporation of door-to-door waste collection throughout the city brought on by SMC. According to one interviewee:

> **"The women approached us and asked for our help in earning their livelihood, which led to the formation of the Association. The goal of the Association is to safeguard the rights of the ragpickers and ensure that they can earn a fair wage without being exploited. They also said that they would help us in founding the association and that they wanted to run that association themselves."**
>
> **— (NGO Representative)**

Figure 22: Example of a scrap shop in Surat

(Photo Credit: Kunal Jaiswal)

Despite their substantial contribution to the effectiveness of the waste management system, the informal sector is often paid less for collected scrap material than what might be considered the standard rate for more valuable products like hard plastic bottles and glass. Further, because of reduced formal recognition, there is less regulation promoting safe working conditions. One study from Chennai, India found that local waste collectors were at risk for a wide range of potential health threats such as exposure to hazardous waste collected, zoonotic and airborne diseases from landfill and uncontrolled dumping areas, and chemical poisoning. These risks are exacerbated by the hot and humid weather in India, with many waste collectors refraining from using synthetic safety equipment (e.g., masks, face shields, gloves) that are uncomfortable in tropical climates (WaterAid 2020). From a series of interviews in 2018

with waste collectors, almost all participants reported occupational related health problems with 30% of recipients reporting respiratory problems, 51% reporting fever and skin diseases, and 19% reporting experiences with all three health issues. The participating waste collectors collected and segregated waste daily, and 85% perceived that doing so was their only reliable source of livelihood (Aiyavoo 2018). The value of certain types of plastic in the informal recycling sector also appears to be in decline, particularly following impacts to the waste system from pandemic-era changes in waste generation and management (INOPOL 2020).

Table 7: Example prices of scrap material purchased by scrap shops at time of surveys

Waste Material	INR per kilogram
Iron	₹ 32
Paper	₹ 22
Paper fabric packaging	₹ 23
Plastic	₹ 24
Copper	₹ 400
Brass	₹ 340

At present, there is lacking recognition of informal waste workers and without regulatory support and enforcement, there is ample opportunity for exploitation of waste collectors, particularly women. Surat's status within the Government of India's Smart City initiative provides an opportunity for advancing the informal waste sector in ways that uplift the community and secure fair wages while also encouraging waste diversion from landfills. One example of advanced technology is Kabadiwalla Connect based in Chennai, which provides mapping of recycling supply chains, digitization of buying and selling of materials in the informal sector there, facilitating agreements between waste collectors and buyers, and dignifying the field of waste collection and those that work in it. In addition to integrating technology into the informal waste sector in Surat, many opportunities exist for both innovation and stricter adherence to policies and practices that are already in place to help reduce waste leakage.

Challenges with waste collection

Interviewees had a variety of opinions about what complicates the waste collection process, including a lack of bins, scheduling, and routes. One interviewee mentioned that cigarette butt collection has room for improvement, while another noted that income differences can complicate single-service collection. Two interviewees spoke about how bins have either been removed or did not exist in the first place, driving harmful disposal methods like open dumping and burning:

> **"I think the main issue is that bins have been removed, right? The big container bins have been removed, and their immediate replacement has been done with a proper collection system. That is the biggest model. … Even today people are facing the problem that where do they dump their waste if there is no bin? At least when there were bins, they would dump**

> **their waste in them after missing the collection vehicle. Where should they dump it now? Here you make the collection system strong, that it goes twice a day to collect the waste, or goes at such a time when people are actually available in a region."**
>
> **— (Sustainability Expert)**

> **"Even today, I have sent a list of 50 locations to SMC, where waste is being disposed of irresponsibly, because there are no garbage bins. These are predominantly riverfront localities and slum areas. Since slum areas are unauthorized settlements, waste collection becomes tricky. People are bound to burn their waste at these places. If you want to stop that, you have to put bins there."**
>
> **— (NGO Representative)**

Regarding the waste collection routes and schedules, interviewees noted that inconsistent scheduling and routes also complicate the waste collection process, similarly resulting in inadequate disposal measures.

> **"Another problem is the erratic schedule of the waste collection vehicles. There are many places where the vehicle comes twice a day. Once in the morning and then in the evening. Then there are places where it comes only once a day, that too at an unscheduled time. Due to this discrepancy, people often discard their household garbage on road dividers or any such place at night. Hence, today there are no trash cans, yet garbage can be seen littered everywhere in the city."**
>
> **— (NGO Representative)**

> **"The second challenge we face is collecting waste from business routes. These are the locations where street food sellers set up their stalls. At any given moment, there would be 10 to 12 stalls operating at these locations where people would be standing, eating, drinking, and disposing of garbage in public."**
>
> **— (Waste Management Representative)**

One interviewee mentioned that differences in income can be attributed to different types of household waste generation, which in turn complicates a one-size-fits-all collection strategy:

> **"Two factors are linked to the growth of waste production. First is the expansion of cities. The volume of waste generated increases with the expansion of cities. The second factor is the state of the city's economy. The garbage grows in size as the city's economy develops. The areas in a city that have a larger upper middle class have more per capita garbage compared to the lower income communities… The third thing that came across in our study was that wealthy households produced more recyclable waste compared to kitchen waste because most of the food items in affluent households were not prepared at home. There was less**

> **vegetable or fruit waste in these homes… This realization made us wonder how a single service design could meet the needs of waste collection in a city where one zone produced 50% of the kitchen waste while the other produced 30% to 40%."**
>
> **—(Academic)**

End of Cycle

Waste that is collected in Surat is managed through diverse operations including both planned strategies like waste storage, recycling, and incineration and unplanned strategies such as open dumping, burning, and disposal in waterways. After waste in the city is collected, it is transported to a transfer station, of which there are eight located throughout the city. From transport stations, waste material is sent to either a treatment facility or final disposal via secondary transportation. Non-biodegradable waste is also sorted into high-, medium-, and low-grade material, with high-grade material converted to fuel, medium-grade material extruded into pellets for re-use, and low-grade material used as fill for road and rail support (Biswas et al. 2021). In 2020, non-biodegradable materials (64% of all MSW generated) that were processed and disposed in these ways primarily comprised paper, packaging material, non-recyclable material, and plastic, though exact proportions are not available. When treatment and conversion options are not feasible for waste material, it is typically disposed of via landfill storage.

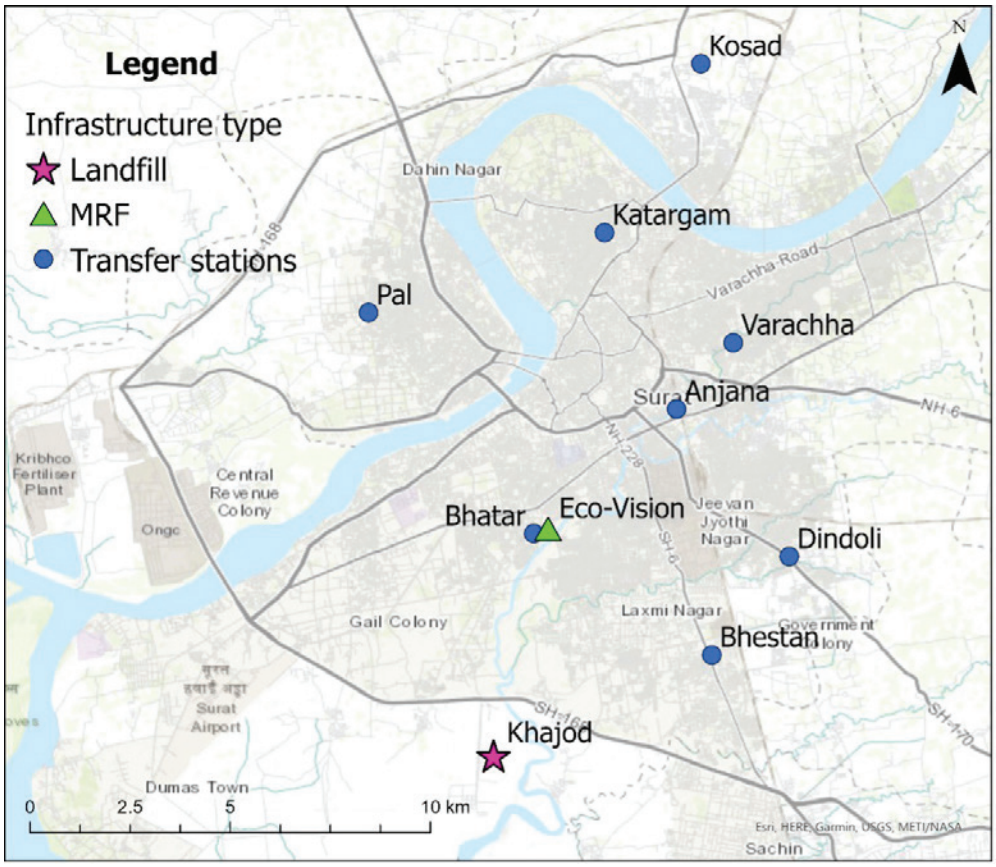
Landfilling and final disposal

The primary landfill serving Surat is the Khajod landfill which is about 10 km from city center (Kaza et al. 2018) (Figure 23) and covers 200 hectares of land as of 2017 (SUDA 2017). As a sanitary landfill cell, groundwater and leachate quality are monitored, but a recent study indicated that the monitoring of ambient air, compost quality, or volatile organic compounds is lacking (Kumar and Agrawal 2020). About 280 tons of non-removable, inert waste is disposed of at the Khajod landfill daily along with 225 tons of non-biodegradable textile waste, excluding other categories of standard MSW. Byproduct residues from incineration facilities are also disposed of in the landfill regularly, though exact quantities are not available (Suryavanshi et al. 2023). Due to reaching maximum capacity, Khajod is undergoing closure and is in the process of being converted to a green space. The Surat Municipal Corporation is actively seeking out procurement of land for an alternative disposal site.

Surat has been a leader among Indian municipalities by establishing public-private partnerships (PPPs) in the context of solid waste management following devastating impacts from the 1994 plague. As a result, the Khajod waste treatment center has been operated through a collaborative partnership between the SMC and a private organization called Saurashtra Enviro Projects Private Limited (SEPPL), which provides environmental services throughout India such as bioremediation and closure of MSW dumpsites, industrial and hazardous waste management, and municipal solid waste processing facilities (SEPPL 2023). Through a build-own-operate-transfer (BOOT) partnership, which grants SEPPL the right to finance, design, construct, own, and operate the program for a concession period of two years, the SMC maintains ownership of a 25-hectare parcel of land at Khajod that is rented to SEPPL for Rs. 1/m^2/year. SEPPL then performs the waste treatment operations for a minimum of 600 metric tons daily including waste

segregation of dry organic materials and recyclables and maintenance. During the concession period, the maximum capacity of the partnership operations is 5 million metric tons of MSW (Surat Municipal Corporation 2023b).

Figure 23. Locations and names of primary waste infrastructure in Surat



(MRF = Material Recovery Facility)

Recycling and reuse

Recyclable material constitutes a large fraction of the Surat municipal waste stream, typically making up 11-34% of waste based on various reported estimates (SUDA 2017, Kumar and Agrawal 2020). Surat also has a relatively high recycling rate compared to other economically comparable cities, with one UN report estimating the rate to be around 50% (UNEP 2016). Some recyclable material is exported from the city to be managed in other locations. Biswas et al. (2021) estimate that 4,000 metric tons of glass, metal, and rubber are sold to recycling entities in Ahmedabad and 6,700 metric tons of paper and cardboard are sold to paper mills in Baroda annually. Plastic waste, on the other hand, is generally recycled locally through the city's centralized plastic waste management facility in Bhatar. There are several plastic recycling facilities located in Surat, and an estimated 387 tons of plastic and recyclable waste are sent to a material recovery facility daily (Suryavanshi et al. 2023). These facilities process plastic waste and convert it into useful products such as granules, pellets, and sheets, which can be used as raw materials in the manufacturing of various plastic products.

While one study reported a total of three registered plastic recyclers in Surat (INOPOL 2021), recycling of plastics in the city is largely carried out by a private organization called Eco-Vision that works with the SMC through a public-private partnership to provide services including waste collection, segregation, treatment and disposal of plastic waste (Eco-Vision 2023). Once plastic waste is transferred to Eco-Vision's Material Recovery Facility (MRF), dust is removed from the plastic items which are then conveyed to manual operators for segregation by polymer and color, then systematically shredded, cleaned, and dried. Once dry, the material is melted, extruded, and cut into pellets which are ultimately sold for Rs 15-50 per kilogram. These recycled plastic pellets then provide feedstock for common recycled plastic goods such as plastic bottles, pipes, tarpaulins, and plastic furniture (The Economic Times 2022, Eco-Vision 2023). In terms of production of recycled plastic material, Eco-Vision generates 3,000 metric tons per month through extruding and shredding plastic waste, primarily from industrial sources (GPCB).

Given the substantial textile industry in Surat, there are also two additional recyclers in Surat that generate synthetic textile products from municipal plastic waste. J.B. Ecotex LLP generates over 5,000 metric tons per month of recycled polyester fabric from PET scrap. Alliance Fibres Private Limited also produces 1,500 metric tons per month of recycled polyester staple fiber and 500 metric tons per month of recycled polyester yarn from PET bottles (GPCB). While the services provided by these entities contribute significantly to keeping plastic waste out of the environment and diverting waste from the landfill, other reuse activities stem from informal and small businesses. One example discovered through the CAP surveys in Surat were recycled woven mats generated from extraneous textile waste (Figure 24).

Figure 24: Example of reuse for local crafts

(Photo credits: Kunal Jaiswal (left) and Avadhut Abhyankar (right))

Refuse-derived fuel (RDF)

Waste material that is deemed high-grade is generally sent for conversion to fuel (referred to as 'refuse-derived fuel' or 'RDF'), although we note that this practice is not a circular approach. According to a recent report by Biswas et al. (2021), each year about 4,080 metric tons of non-recyclable material and cloth waste generated by Surat are sent to refuse-derived fuel stations. Organic waste is also treated through both centralized and decentralized processers (Kumar and Agrawal 2020). Given the large proportion of biodegradable waste stream in Surat, the city invested 70 million INR ($851,000 USD) into the development of a centralized biogas plant for treatment of organic waste for conversion to fuel (MHUA 2023). Additionally, the SMC reports 25 organic waste converters located near municipal markets and slaughterhouses and 50 converters located in residential areas for managing household organic and garden waste (Surat Municipal Corporation 2023b). Additionally, one report describes the production of diesel from plastic waste management at the Bhatar plastic waste management plant, which although is not in operation, was reported to have a targeted processing capacity of 100 metric tons of plastic waste daily (Karelia 2017). Lastly, textile waste is a significant feedstock for

> **"According to the corporation, textile waste is used to produce RDF. However, there are no buyers for RDF, because it gets stuck at the bottom of the boiler … Secondly, its smell is so pungent that workers don't want to deal with it. Another type of textile waste is chindi or fabric shreds. Ragpickers buy chindi from textiles and burn them as fuel, which is extremely harmful to the environment."**
>
> **— (Academic)**

Open dumping and burning

Under business-as-usual scenarios, India is slated to become the largest generator of mismanaged plastic waste by 2035 largely due to the rapidly growing population and economy (Lebreton and Andrady 2019). Globally, about 33% of waste is disposed of via open dumping, with the practice more common among developing regions where storage and recycling infrastructure is not available or accessible in combination with public awareness inconsistencies, difficulties enforcing waste management, and low collection efficiency. In South Asia, open dumping is even more common with an estimated 75% of waste disposed of in this manner (Kaza et al. 2018). In addition to reduced aesthetic quality, degradation to the environment, and public health hazards, open dumping also contributes a substantial amount of greenhouse gas emissions, with an estimated contribution of 5% of global emissions in 2016 (Kaza et al. 2018).

Field surveys showed evidence of open dumping and burning throughout the city, and one report from Kaza et al. (2018) reports that 76% of the city's waste is managed via the Khajod landfill, which currently lacks sanitary landfill design requirements and so is considered by the World Bank to be a dumpsite. Contributing to the challenges with collection of commercial and industrial waste, there is also no waste treatment and disposal site available in the city for processing these types of waste, which can include a wide range of waste items such as building materials (e.g., masonry, concrete, scrap lumber), solvents, gasoline, paint, and various forms of plastics, papers, and metals, etc. One survey by the Gujarat Pollution Control Board estimates that 1,000 industrial units in the city generate more than

113,000 metric tons per year of industrial waste (SUDA 2017). However, in the absence of industrial waste treatment infrastructure, waste is often discharged into water bodies like the Mindhola River.

Some efforts to remediate dump sites are ongoing throughout India and the state of Gujarat largely led by efforts of the Swachh Bharat Mission. In Gujarat, 138 dumpsites have been documented throughout the state covering 980 acres. While remediation has been completed at 12 sites and is ongoing at three sites, another 120 are awaiting future remediation efforts with an approved action plan or funding source. Three dumpsites are yet to be considered for remediation. Notably, no dumpsites are located in Surat, however, neighboring urban local bodies (ULBs) of Bharuch and Navsari each have one dumpsite (Swachh Bharat Mission Urban 2.0 2022). Further, the SMC does collect some waste from surrounding villages; however, waste in those villages that are not served by the city is managed via burning and open dumping by households (SUDA 2017).

Figure 25. Examples of open burning documented during the CAP surveys in Surat

(Photo credit: Kunal Jaiswal)

Although several options exist for waste treatment and disposal, it was evident among several interviewees that open dumping and burning were common disposal methods in Surat.

> **"Every day, 12 to 15 tractors of garbage get dumped under the cable-stayed bridge. These tractors don't even have a number plate."**
>
> **— (NGO Representative)**

> **"We have identified some spots where the majority of dumping and waste burning activity happens. I have personally worked on these sites many times with the volunteers, but no**

matter how many times we stop the waste burning activity at these places, people will resume it after a few days."

— (NGO Representative)

"There is an issue of clogging of canals as well. The city has a river system and numerous local canals. These canals have become the primary sites where people dispose of a plethora of waste. That in turn chokes the canals. Clogging of the canals is a massive crisis in Surat."

— (NGO Representative)

"Air pollution is a salient issue in Surat. The city gets permeated with a pungent stench in the winters, especially at night. As soon as the monsoons are over, one can smell a foul odor percolating throughout the entire city. We haven't been able to backtrack the smell. As far as we know, the stench emanates from the river. The riverfront is a key site for illegal waste dumping. When the waste gets into the backwater, it gets imbued with this foul smell. You see, there is the upstream and the downstream water. The causeways are built in the areas around upstream freshwater. Then as you move downstream, you come to sea water or backwater. The backwater is reeking with foul odor, because this is the site where polluted water gets dumped and illegal emissions take place."

— (NGO Representative)

"And the small towns like I talked about, the cities of Surat and Navsari, Bilimora, Valsad, Bharuch, they all dump in the river. And this has been a problem ever since plastic was invented."

— (NGO Representative)

"Where does Surat go now? Surat will dump its waste into a distant place, which is rural India. So, those 200 trucks treat — Today it is 20 kilometers, tomorrow it will be 25 kilometers. So, your damage is increasing."

— (Academic)

"My house's garbage going to my village — What used to happen in rural India, they would dump the garbage at the end of an alley."

— (Academic)

Figure 26. Example of waste disposal in waterways canals

(Photo credit: Kunal Jaiswal)

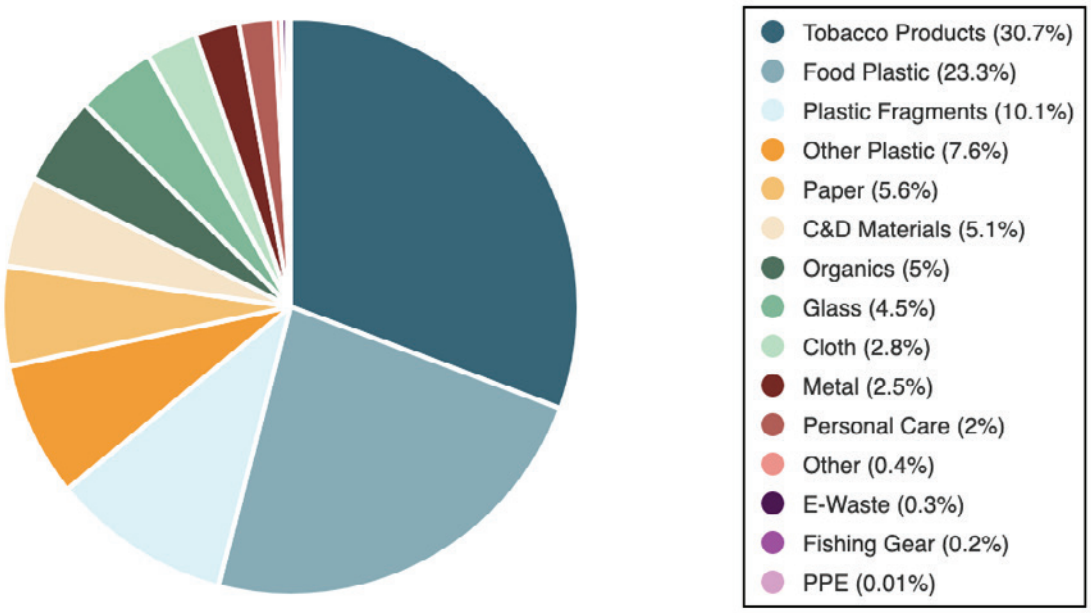
Leakage

In collaboration with the LIP, twenty-seven litter surveys were conducted using the Marine Debris Tracker (MDT) mobile application ("app") across nine 1-km^2 areas in Surat that were randomly generated based on three population categories (high, middle, and low) using stratified random sampling in ArcGIS 10.7. Debris items were recorded across the field surveys which were conducted in September-October 2022. Population data were sourced from LandScan ambient population data from 2021 (Sims et al. 2022). The MDT app has 15 material categories such as 'Plastic food products' and 'Glass', and 76 corresponding item types such as 'Plastic bottle' and 'Glass bottle' (See full list provided in the Appendix).

Overall litter count and composition

In total, 7,636 items were documented through the field survey, resulting in a mean litter density of 2.64 items per m^2 throughout Surat. Plastic made up 74% of items, followed by paper (5.6%), and construction and demolition (C&D) materials (5.1%). The least commonly recorded material categories were fishing gear and e-waste. Among the plastic litter items, the most recorded sources were tobacco products, food plastic, and plastic fragments, which made up 31%, 23%, and 10% of the total item count, respectively. Personal Protective Equipment (PPE) items made up the smallest fraction of plastic items at 2% of the total count (Figure 27.)

Figure 27: Count of litter items by product type



By specific item type, packaging and sachets for tobacco together made up 28% of the recorded litter items, followed by plastic food wrappers, unspecified fragments, and rubber bands (Table 8). This is similar to what was observed in Pune, where 27% of all litter items were tobacco products, predominantly tobacco sachets which represented the most or second most abundant litter item in all three of the population count areas in Pune. In Chennai, tobacco products made up 18% of all litter items, topped only by food plastic which comprised 33% of all litter items (largely plastic food wrappers, which were among the top five most common litter item found in all population count areas in Chennai).

Table 8. Top ten recorded debris by item type

Item types	Count	Proportion
Other Tobacco Packaging	1,142	15%
Tobacco Sachets	973	13%
Plastic Food Wrapper	720	9.4%
Other Fragments	510	6.7%
Rubber Bands	348	4.6%
Plastic Bottle Cap	340	4.5%
Glass or Ceramic Fragments	305	4.0%
Other Organic Waste	294	3.8%
Other Paper	287	3.8%

Item types	Count	Proportion
Other Food-Related Plastic	193	2.5%

(C&D = Construction & demolition waste)

Litter characteristics by population

When examining the litter characterization based on the population count, some similarities and distinctions can be seen between the three groups. Litter density was greatest in the higher population area and lowest in the middle population count area (Table 9). Average litter density overall (2.81 items/m^2) was higher than that observed in Chennai (1.08 items/m^2) but lower than that observed in Pune (3.21 items/m^2), comparatively.

Table 9: Top litter items and overall litter densities by population tertiles in Surat

Population Tertile	Top 5 Litter Items	Litter Density (count/m^2)
Upper (23,679 – 50,451 persons/km^2)	1) Other tobacco packaging 2) Plastic Food Wrapper 3) Other paper 4) Rubber bands 5) Other organic waste	3.53
Middle (13,174 – 23,679 persons/km^2)	1) Tobacco sachets 2) Other fragments 3) Other C&D 4) Glass or ceramic fragment 5) Other organic waste	2.33
Lower (313 – 13,174 persons/km^2)	1) Tobacco sachets 2) Other tobacco packaging 3) Other fragments 4) Plastic food wrapper 5) Rubber bands	2.59

By product category, tobacco products and food plastic made up sizable fractions across all three population groups (Figure 28). Tobacco products made up a third of the items recorded in the higher and lower population surveys, which was nearly twice that found in the middle population areas. The source of this variation in presence of tobacco-related litter could be driven by a number of reasons such as greater transient activity in the middle population areas resulting from people traveling between the high and low populated locations, less waste infrastructure or collection bins in the lower populated areas, and higher density of tobacco-related activity in the high population areas. Similarly, the higher population group had the largest percentage of food plastic (29%) compared to the other two areas. This prevalence of food plastic in the higher population area was also concurrent with the area having the

highest organic fraction of the three groups, with 8% of items being organic waste. The presence of food plastic and organic waste in the highly populated areas of Surat is likely driven by the co-occurrence of higher traffic and more retailers. Plastic fragments ranged from 7% of items in the higher population area to 13% in the middle population areas. The lower fraction of plastic fragments in the higher population area could be driven by larger items being collected by the informal sector and frequent street sweeping that collects fragments.

Figure 28: Composition of litter in lower (outer), middle, and higher (inner) population areas sampled in Surat

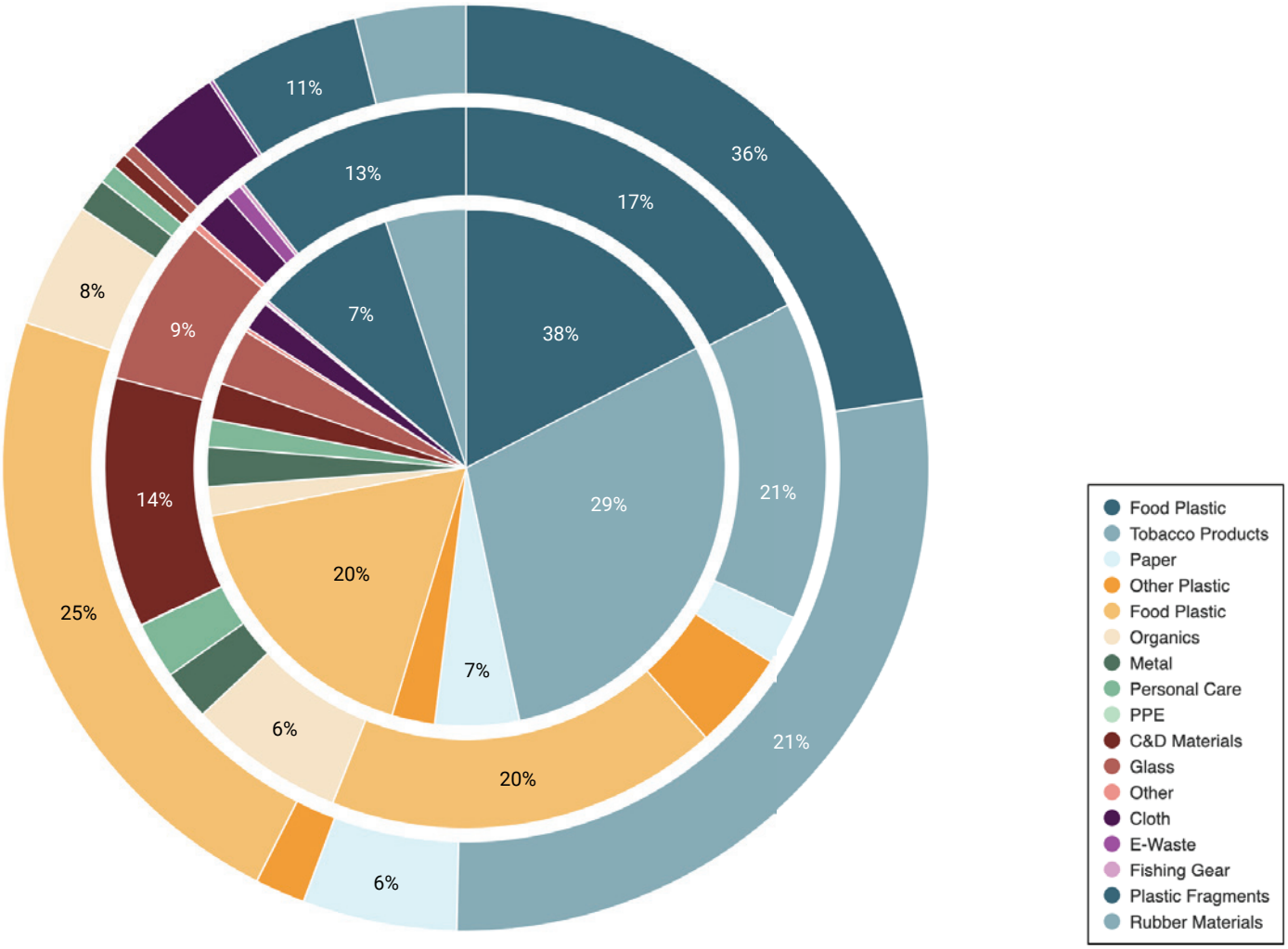


Figure 29: Organic litter

(Photo credit: CEE Team)

By specific item types, tobacco packaging was the most prevalent litter item across all three population areas, with sachets being most common in the middle and lower population count surveys. Notably, cigarettes and cigarette butts, which were commonly found in CAP surveys in Chennai, India (Circularity Informatics Lab 2022) were not regularly recorded in Surat. This difference could be driven by regional preference as well as pricing associated with tobacco formats, with sachets as the preferred tobacco choice as well as the cheaper option over cigarettes (Figure 30). However, one interviewee participant described how cigarette butts were overwhelmingly present during litter cleanups, highlighting a low-hanging target for intercepting litter through targeted collection schemes:

> **"Collection is paramount. We collect heaps of cigarette butts in our cleanup drives. Cigarette butts get discarded everywhere. They clog drainage and they are ultimately flowing into the river system, which is very harmful, because a single cigarette butt pollutes more than 1,000 liters of wastewater."**
>
> **— (NGO Representative)**

Figure 30. Tobacco sachet litter

(Photo credit: CEE Team)

Food wrappers were also common in the upper and lower population count areas but were not among the top five items in the middle population area which saw more presence of fragments, C&D waste, glass/ceramics, and organic waste. Among the three population count areas, C&D debris was only present in the top five material categories for the middle population area which may suggest that there was more activity related to building material in those locations. In alignment with the lacking industrial waste management options in Surat (SUDA 2017), several interview participants described the prevalence and impact of mismanaged C&D waste. One NGO representative and citizen of Surat described the contribution of C&D waste from builders and the managing of waste through burning activity:

> **"Construction waste is another biggest waste type… The plot beside my house here is three feet full of construction waste… If you want, I can show you when you leave. There's a large field and has three to four feet of dumped waste. All the reserved plots of the municipality which are not in use at present are full of three to four feet construction waste. Builders from nearby areas come looking for such plots and empty their waste there."**
>
> **— (NGO Representative)**

> **"Then there are those tiles from construction materials. Huge amounts of material come there. It all comes packed in plastic. And this whole material gets dumped at one place or the other, and it is also burnt there."**
>
> **— (NGO Representative)**

Similarly, one interview participant who was a sustainability expert described that "industrial waste gets dumped through many surfaces to the creeks as well." Behind this prevalence of industrial and commercial waste may be the fee structure of the SMC waste management system, with one NGO representative describing how commercial businesses are often disincentivized by door-to-door collection fees and instead dispose waste through open dumping in order to avoid the costs:

> **"Since these are commercial buildings, door-to-door waste collection is probably not free. They have to pay a fee to the municipal corporation for that. People dump their waste at these places to avoid paying the fee, because SMC's policy implementation for commercial waste collection isn't rigorous. We often find construction and demolition waste, sofas, and various furniture getting burned at these locations."**
>
> **— (NGO Representative)**

Litter characteristics by Surat administrative zones

While litter data were not sampled specifically across the eight administrative zones of Surat, we can generate approximations of variation between them based on the surveys conducted across the three population zones. CAP litter surveys corresponded with seven of the eight administrative zones of Surat (Table 10), with only the South Zone lacking representation. Zonal litter densities were roughly correlated with historical populations. East Zone A, which

has historically been the most populated zone, had the highest mean litter density of the zones, followed by the South East, which has historically been the second most populated zone, and the North zone, the third most populated zone historically (SMC 2023b). These zones also had relatively high plastic fractions as well, with the plastic fraction peaking at 81% in the North zone, ultimately generating the highest plastic litter density of all the zones. In contrast, the South West zone had both the lowest general litter density and plastic litter density. Variation in waste generation and management across the different areas of the city is driven by the different activities that occur there. For example, two interview participants spoke to the differences in inadequate waste management driven by low prices of goods that disincentivize proper disposal of items and inconsistent waste collection across planned and unplanned settlements, commercial areas, and roadways.

> **"On one of the riverfronts the vendors organize a Saturday market every week. By night the vendors just abandon unsold items in the market because they buy it from Bombay at dirt cheap price. If they can't sell them, they'll just discard them there. They don't care. Each area has a distinct waste management issue."**
>
> **— (NGO Representative)**

> **"The two main issues that we encounter in Surat's waste management system are waste collection and waste management in the city's slums and commercial areas. In slum neighborhoods, vegetable markets generate a lot of waste, which gets littered everywhere. The same is true for waste generated in business areas. People simply throw trash on business streets and roadways. On the other hand, people do not litter in apartment complexes and housing societies, thus waste collection is relatively easier."**
>
> **— (Waste Management Representative)**

As Surat continues to monitor and advance its waste management system, regular measurement of litter presence across the administrative zones of the SMC as well as the surrounding villages of the SUDA may generate a complete picture of the litter status and unique challenges experienced by each to ultimately inform effective strategies for intervention.

Table 10: Mean litter density and plastic composition by Surat administrative zones

Zone	No. surveys	Mean % plastic	Mean litter density (item/m^2)	Mean plastic litter density (item/m^2)
Central	3	78	2.15	1.68
North	6	81	3.10	2.88
East Zone A	6	78	3.69	1.97
East Zone B	3	76	2.62	2.56
South East	3	56	3.36	1.98
South	0	No data	No data	No data

Zone	No. surveys	Mean % plastic	Mean litter density (item/m²)	Mean plastic litter density (item/m²)
South West	3	62	1.66	0.99
West	3	55	1.90	1.19

Marine and riverine plastic pollution in Surat

In 2015, India was estimated to have the 12th highest input of plastic pollution into the marine environment, with an estimated .09-.24 million metric tons of plastic debris entering the ocean annually (Jambeck et al. 2015). Rivers play a significant role in these emissions (Lebreton et al. 2017; Schmidt et al. 2017), and India is estimated to be the second largest contributing country of riverine exports of plastic debris after the Philippines with an estimated 126,000 metric tons deposited from Indian rivers annually (Meijer et al. 2021). Some studies have found evidence of marine debris in the Arabian Sea and Indian Ocean (Mugilarasan et al. 2023), with one recent study finding that microplastics between 0.5 and 5 mm were the most prevalent marine debris item and that polypropylene, polyethylene, and nylon were the most common plastic materials, much of which were associated with fishing activities (Naidu et al. 2021). While these debris are not directly linked to Surat they do point to land- and sea-based activities that may be driving plastic marine debris inputs. For example, because of the location of the city, combined with the weather patterns and plastic waste generation, there is a severe risk of plastic loss from the Surat Sanitary Landfill (Yadav et al. 2022).

Despite being a largely populated coastal and riverine city with significant industrial activity, research investigating leakage of plastic waste and impacts of pollution in the natural, aquatic environments surrounding Surat is relatively limited compared to other Indian municipalities that have been the focus of scientific research. In one 2019 study of litter across 33 Indian beaches, Dumas Beach in Surat had the lowest concentration of litter, resulting in a clean coast index designation of 'very clean beach.' Among the Dumas survey, plastics comprised about 70% of the items, much of which was attributed to tourism and recreation activities (Mishra et al. 2023). Aside from the beach litter study, there is a gap in research targeting the area, signifying the need for monitoring, measuring, and reporting of pollution in the surrounding natural environment. While debris sources are primarily tobacco and food packaging, the fate of leaked waste in Surat threatens both the surrounding built environment as well as the proximal riverine and coastal ecosystems.

In addition to typical waste generating activities throughout the city, large public festivals may contribute to significant but acute contributions of leaked plastic debris in Surat. Specifically, large celebrations like Ganesh Chaturthi occur throughout Surat and Gujarat. As part of the celebration, Ganesh idols made of plaster of Paris and other celebratory items are immersed in water bodies, including the Tapi River. The presence of festival-related debris was also brought up by one waste management expert interviewed:

> **"We retrieved lots of idols of gods and garlands made of fresh flowers and plastic ones too [while cleaning a water hyacinth]. Usually, people drop plastic garlands into the river from**

> **a distance. We used to get all those things…. Plastic bags as well as slippers. A lot of such things."**
>
> **— (Waste Management Expert)**

While plastic waste associated with these activities has not specifically been targeted in existing research, one 2019 study found negative measures of water quality such as pH, dissolved oxygen, and temperature indicating that post-immersion water quality measures showed some evidence of impact from the festival events (Bengani et al. 2020).

Leaked plastic waste also threatens both domesticated animals and wildlife, and some studies in the city have documented examples of these impacts. For example one study showed evidence of plastic foreign body syndrome (i.e., plastic ingestion) among local cattle in Surat due to lessened food intake and inflammatory conditions emerging from exposure plastic debris (Dodia et al. 2014). Similarly, one recent study documented plastic ingestion by native Indian snakes in the city (Parmar and Patel 2022). Additionally, leakage of plastic debris into the environment in Surat introduces potential hazards through transport of waste to the sea, which contributes to wide-ranging, transboundary impacts of mismanaged plastic waste. India has one of the highest rates of plastic emissions to the sea, and the Tapi River is estimated to transport 1.8-10 metric tons of plastic waste to the ocean annually, with peak emissions occurring in September each year (Lebreton et al. 2017). This seasonal variation in ocean emissions was reflected in one interview with an NGO representative who noted that river waste was worse following monsoons:

> **"From 2019 to 2020, during which we had our initial gain-ups [heightened times of clean-ups of accumulated litter], there was actually plenty of waste that was flowing from the river. Post-monsoon things were worse. Slippers or footwear were one of the major types of waste we would get. Another was coconut waste. There were huge mountains of coconut waste on the riverfront. The third type of waste was that of milk packets and buttermilk packets. If you go to that spot in Dumas Nagar, you will find a minimum of 500 to 800 milk and buttermilk packets littered in that area."**
>
> **— (NGO Representative)**

Addressing litter in Surat

To address issues caused by leaked plastic waste, the city has made strides in the prevention and capture of litter through wide-ranging efforts. Although regulation and enforcement have been cited as challenges in Surat (Resilient Surat 2017), the SMC has tried to improve patrol of litter activity and enforcement of fines through the creation of the Littering Detection Squad, which brings together individuals to maintain areas that are historically vulnerable to litter (Wilson et al. 2015). Additionally, the city requires retail shops to ensure surrounding street areas are cleaned, requires both restaurant and hotel businesses to provide and maintain collection bins, and generates revenue through penalizing individuals or businesses who continue to litter. Uncollected waste can impair the surrounding aquatic systems through leakage via the stormwater drainage system, and the city has developed a fleet of 115 mechanized drainage cleaning devices that are used to clean storm drains throughout the city.

Lastly, there are local efforts to educate household managers on how to collect, support, and dispose of waste properly (Surat Municipal Corporation 2023a) and cleanup events have supported collection of otherwise leaked waste. Clean up events can provide outlets for education and raising awareness about the risks of mismanaged waste while also bringing community members together. For example, one Dumas Beach in 2020 led by Project Surat and Great Weekender involved 500 local women who removed almost 500 kg of plastic from the beach (TNN 2020). Lastly, to combat solid waste dumping in the river, SMC has embedded infrastructure throughout the city, including setting up nets on several bridges crossing the river to catch waste that would otherwise be dumped over them, barricading tributaries that feed into the river combined with scheduled cleaning, fabricating 43,000 catch pits for storm drains, and netting stormwater discharge outlets that discharge to the river (SMC 2023a). While Surat has led the nation through their action-oriented strides to reduce pollution, litter continues to persist in the city, demonstrating that more work is needed to make greater headway towards prevention.

Opportunities and recommendations

Based on our findings, the CIL recommends exploring the following opportunities to expand and enhance circularity in Surat based on the findings of this report. These opportunities are categorized based on the seven spokes of the CAP model and are roughly listed based on the level of potential impact to reduce plastic waste in Surat within each spoke. The purpose of the forthcoming Opportunity Assessment Workshop in Surat as part of Urban Ocean is for the city to further prioritize these opportunities based on impact, feasibility, and cost. It is important to note that the opportunities listed below are individualized based on the findings, but solutions cannot happen in a vacuum and are most impactful when strategically combined within the CAP system framework.

Across all spokes of the CAP, Surat could examine ways to streamline information.

INPUT

- Little evidence of EPR schemes was prevalent in the desk research for Surat. Given the presence of the plastic industry and expected growth of several plastic producers in the city, there is ample opportunity for engagement with local businesses and manufacturers.
- Surat could be a leader in working with top local brands and producers that operate locally as well as in the broader state of Gujarat to create EPR Action Plans as mandated by the EPR Guidelines from 2020, with a particular focus on beverage, snacks, and personal care sachets to ensure the EPR programs are achieving their target results.
- Ensure the city has resources available for effective implementation and enforcement of EPR Guidelines and rules that result from those guidelines. In addition, the city should be involved to the extent possible in crafting EPR Guidelines at the city and national level to ensure that they can be effectively implemented at the local level.
- Awareness campaigns on existing buy-back initiatives available to consumers, such as Sumul Dairy milk bags, may be valuable for the long-term success of those initiatives.

COMMUNITY

- There may be an opportunity to use local businesses and community hubs to improve waste disposal; this way, waste disposal can be incorporated into peoples' schedules and daily routines.

- Although Surat is considered a leader in solid waste management throughout India, some interviewees mentioned how effective Pune's waste management system is. There may be an opportunity to share and learn best practices from cities through city networks or collaborations.
- There may be opportunities to incorporate the informal sector into formal jobs and increase waste segregation, if this is something that those in the informal sector desire and deem to be beneficial. However, the formal incorporation of the informal sector should only be done if the informal is centered and included in those conversations. It should also be noted that many women ragpickers specifically do not want to be a part of an association, suggesting that there may be underlying issues of discrimination towards women waste collectors.
- Given the city's interest in technological advances and green infrastructure through its participation in the Smart City initiative, there may be potential outlets for increasing the digitization and connectivity of the solid waste management system. Some outlets may include incorporating continued monitoring, generation of smart networks between plastic producers, recyclers, and waste collectors, and waste reporting through mobile applications.
- Coconut waste was brought up by a few interviewees as a valuable material. Given the existing local interest in the material's value, there are opportunities for build upon the recycling or repurposing of coconut waste in the community.
- It is evident from the interviews that various groups are working on issues related to waste and community/environmental health. As such, there are abundant opportunities for groups to share resources and work together.
- Interviewees mentioned that waste segregation can be enhanced through financial incentives, easily accessible depositories, and through compulsory measures.

PRODUCT DESIGN

- While complex variations and nomenclature around material type and associated disposal can make recycling and composting challenging and confusing to consumers, there may be opportunities to generate recommended plans for introducing home-compostable or reusable alternatives to single use plastic. Given the popularity of these items seen in other CAP locations and beyond, Surat could get ahead of potential local business transitions to using these options. In particular, the city should determine whether alternative materials are able to be processed and treated sufficiently. Doing so creates additional opportunities for involving businesses in discussions of incorporating advanced materials, particularly among to-go food vendors and restaurants, and dedicating efforts to ensure proper education among the public.
- Multilayer plastic is not currently recyclable and does not have value in the informal sector in Surat (apart from select brands of milk packets). There is a need to either bolster EPR schemes or explore alternative materials that will add value. The city could also leverage multilayer plastic availability to attract specialized treatment facilities under EPR Policy. Another option would be to pilot reuse/refill options.
- Further, the high prevalence of multilayer plastic like food wrappers and sachets could lead to additional confusion with household and individual waste segregation. Public awareness efforts might target educating residents not just how to properly dispose of existing multilayer packaging formats but also the reasoning behind the need for disposing these items in ways that may seem counterintuitive given the misleading reputation of universal recyclability among plastics.
- Additionally, the city could explore directing EPR revenues to informal sector workers to incentivize them to collect these materials they otherwise would not.

USE

- Many efforts to address waste management and pollution prevention in Surat have been focused on downstream targets such as litter clean up and waste collection. Because disposal in the existing landfill is tenuous, the city could benefit from increased efforts at waste reduction and diversion. These efforts might include campaigns encouraging replacing single use plastic with reusable alternatives or buying goods in bulk, as well as education efforts around segregation that could include improved signage, education of school-age citizens, and household managers.
- Despite stringent bans on plastic bags, single use plastic bags were present in more than 70% of the surveys. Enforcement measures should be strengthened, and violations should be addressed and followed through to discourage continued use of banned items. Alternatively, incentivization programs at shops and vendors can encourage customers to use reusable bags (for example, by providing a small discount for those customers that bring their own bags).
- Incentives or ways of highlighting local businesses that are already switching to alternatives, or that have already banned bags, may be useful to increase buy-in for policy changes locally.
- Any alternatives (e.g., reusable bags or bottles, compostable alternatives, etc.) that are introduced in light of the bans on single use plastics must be readily and easily reused and/or have a viable disposal option within the context of Surat. At current, there is no industrial composting infrastructure, making compostable plastic goods equally as damaging as their typical, non-degradable plastic items that they are replacing.
- Explore opportunities to encourage buy-in from food vendors and restaurants to use alternatives to single use plastic.

COLLECTION

- As mentioned above, much of the city's efforts at waste management have targeted broad collection efforts, which can be the costliest fraction of municipal waste management. Based on desk research, the city is not adequately generating revenue. The city should examine potential cost-reduction strategies and review the expenses, revenue streams, and fleet logistics which may reveal areas for improvement.
- Industrial and commercial waste were prevalent among many of the field surveys, and interviews pointed to businesses being disincentivized by collection fees. Combining improved enforcement in these areas as well as investigating viable collection systems that would encourage business involvement may lead to improved collection of these wastes.
- Some evidence of the surveys indicated inconsistent bin placement and corresponding confusion among the public that drives unsound disposal practices like open dumping and burning.
- While waste segregation is mandated, implementation and public perceptions are varied. Clear communication and instructions involving waste segregation from the point of household segregation through collection and disposal is critical for adoption, together with consistent service that maintains waste segregation. Further, there may be efficient outlets for raising awareness through educating school children about waste segregation.
- Comprehensive monitoring of the different collection models (e.g., repeated litter transects or waste bin overflow assessments) would be useful to help evaluate which may or may not be effective for maximizing collection. Explore avenues for technological advancements for scrap collection and selling and maximizing related data monitoring by looking at innovative practices used in other cities.

- The city should consider developing case studies for the different collection models and private enterprises around collection of solid waste in Surat, so that lessons can be learned from what works/what does not.
- Informal waste workers need to have better working conditions, including basic measures to ensure they are protected when working (also mentioned in Aiyavoo (2018)). Surat can also derive lessons for worker safety and safeguarding mechanisms along with other Urban Ocean cities like Pune, Chennai, and Mumbai, which have similar informal waste presence and scope.

END OF CYCLE

- The city has a clear need to divert items from landfill and is heading in the right direction with source segregation and collection schemes. The city would benefit from setting clear goals around waste reduction and diversion and generating measurable outcomes over time. Additionally, the city should continue public outreach and awareness. There may also be an opportunity for the city to continue partnering with contractors or other third party entities to reinvigorate and expand on current initiatives.
- The city may consider conducting an updated waste characterization of what is actually landfilled (i.e., that could be captured for recycling or composting), if there is a desire to divert more from the landfill and become more circular.
- Continue to support and expand recycling in Surat, recognizing and acknowledging the contributions of the informal sector, improving working conditions and safety, and with appropriate policies and resources from the government and private sector.

LEAKAGE

- Litter density roughly correlates with population count throughout Surat, with the field surveys showing the largest litter density in the high population areas, as well as the historically most populated municipal zones (East-A, South East, and North).
- Tobacco packaging is a significant challenge in the city with sachets commonly littering the environment. Because tobacco packaging and material composition are multi-faceted, the city could consider advancing EPR efforts that specifically target multilayer plastic packaging that is associated with tobacco sachets. However, because of limited legislation powers within the city, the decision to form broad EPR policies rests within the broader state of Gujarat's Legislative Assembly. As such, the city might examine ways to encourage state-wide legislative efforts. Further, although cost constraints can limit how much an individual is able to purchase, loose tobacco could feasibly be sold in bulk formats, reducing the proportion of packaging relative to the product itself and the waste generated in association with consuming it.
- The city and local partners should revisit the CAP litter transects based on zones, wards, and/or by areas that have different waste collection schemes, so that there is comparable data and best practices can be shared between them.
- Building upon the Smart City initiative, the city could explore development of a mobile application for the public to report waste hot spots, open dumping offenses, and submit issues.

References

Lassen C, Foss Hansen S, Magnusson K, Norén F, Bloch Hartmann NI, Rehne Jensen P, Gissel Nielsen T, Brinch A (2015) Microplastics—occurrence, effects and sources of releases to the environment in Denmark. Environmental project No. 1793. Copenhagen: Environment Protection Agency, Ministry of Environment and Food of Denmark.

Aiyavoo, I. (2018). "Urban Poverty: Rag Pickers in Chennai City." PESQUISA 3(2).

Basu, A. M. and K. Khanna "Participation for whom? A study of Anudan Scheme for Solid Waste Management in Surat."

Bengani, R., N. Ujjania, K. Sangani and R. Lovely (2020). "Idol Immersion and its consequences on water quality of Tapi River, Surat (Gujarat)." Int. J. Adv. Res. Biol. Sci 7(10): 137-144.

Bharti, V., J. Singh and A. Singh (2017). "A Review on Solid Waste Management Methods and Practices in India." 10: 4065-4067.

Biswas, A., S. Parida, K. Chaudhary, R. Singh, S. Tewari and S. Singh (2021). Waste-Wise Cities: Best practices in municipal solid waste management. New Delhi, Centre for Science and Environment and NITI Aayog.

Chandran, P. (2021). Empower (ing) informal recycling chain to get Extended Producer Responsibility moving. Hasiru Dala, Special Series on Extended Producers Responsibility and Inclusion. .

Circularity Informatics Lab (2022). Circularity Assesment: Chennai, India. Athens, GA, University of Georgia.

CPCB (2015). Assessment & Characterisation of Plastic Waste Generation in 60 Major Cities. New Delhi, India, Ministry of Environment, Forest, & Climate Change.

CPCB (2019). Annual Report for the year 2018-2019 on Implementation of Plastic Waste Management Rules. Central Pollution Control Board. Delhi, Ministry of Environment, Forest and Climate Change, Government of India.

Dodia, V., N. Kelawala, D. Suthar and S. Prajwalita (2014). "Haematological and serum biochemical profile of cattle affected with plastic foreign bodies." Int. J. Sci. Res. Publica 4: 1-2.

Dutta, A. and W. Jinsart (2020). "Waste generation and management status in the fast-expanding Indian cities: A review." Journal of the Air & Waste Management Association 70(5): 491-503.

Eco-Vision. (2023). "Eco-Vision." from https://eco-vision.co.in/.

GPCB Plastic Waste Recyclers, Gujarat Pollution Control Board.

India Ministry of Environment and Forests (2000). Municipal Solid Wastes (Management and Handling) Rules, 2000. New Delhi.

India Plastic Directory. "Surat Plastic Companies." Retrieved March 12, 2023, from https://www.indiaplasticdirectory.com/surat.asp.

INOPOL (2020). Pilot study for plastic and biomedical waste management during the COVID-19 pandemic in Surat and Delhi, India-Norway Cooperation Project on Capacity Building for Reducing Plastic and Chemical Pollution in India.

INOPOL (2021). Baseline Report - Plastic Pollution in India, India-Norway Cooperation Project on Capacity Building for Reducing Plastic and Chemical Pollution in India.

Jambeck, J. R., R. Geyer, C. Wilcox, T. R. Siegler, M. Perryman and A. Andrady (2015). "Plastic waste inputs from land into the ocean." Science 347.

Karasik, R., T. Vegh, Z. Diana, J. Bering, J. Caldas, A. Pickle, D. Rittschof and J. Virdin. (2020). 20 Years of Government Responses to the Global Plastic Pollution Problem: The Plastics Policy Inventory. . Durham, NC, Duke University.

Karelia, G. (2017). Road To A Plastic Free City: Surat Aims To Produce Diesel Out Of Plastic Waste. NDTV-Dettol.

Kaza, S., L. Yao, P. Bhada-Tata and F. Van Woerden (2018). What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Urban Development Series. Washington, DC, World Bank.

Kumar, A. and A. Agrawal (2020). "Recent trends in solid waste management status, challenges, and potential for the future Indian cities – A review." Current Research in Environmental Sustainability 2: 100011.

Lebreton, L. and A. Andrady (2019). "Future scenarios of global plastic waste generation and disposal." Palgrave Communications 5(1).

Lebreton, L. C. M., J. van der Zwet, J.-W. Damsteeg, B. Slat, A. Andrady and J. Reisser (2017). "River plastic emissions to the world's oceans." Nature Communications 8: 15611.

Maes, T., J. Barry, H. A. Leslie, A. D. Vethaak, E. E. M. Nicolaus, R. J. Law, B. P. Lyons, R. Martinez, B. Harley and J. E. Thain (2018). "Below the surface: Twenty-five years of seafloor litter monitoring in coastal seas of North West Europe (1992–2017)." Science of The Total Environment 630: 790-798.

Meijer, L. J. J., T. van Emmerik, R. van der Ent, C. Schmidt and L. Lebreton (2021). "More than 1000 rivers account for 80% of global riverine plastic emissions into the ocean." Science Advances 7(18): eaaz5803.

MHUA (2022). Swachh Survekshan 2022: Ranking Report, Ministry of Housing and Urban Affairs.

MHUA. (2023). "Surat." Smart Cities Initiative, from https://smartcities.gov.in/node/108.

Mishra, P., T. Kaviarasan, M. Sambandam, K. Dhineka, M. V. R. Murthy, G. Iyengar, J. Singh and M. Ravichandran (2023). "Assessment of national beach litter composition, sources, and management along the Indian coast - a citizen science approach." Marine Pollution Bulletin 186: 114405.

MOEFCC (2020). Guideline Document Uniform Framework for Extended Producers Responsibility (Under Plastic Waste Management Rules, 2016). Delhi, Ministry of Environment, Forest and Climate Change, Government of India.

Moss, E., Eidson, A., and Jambeck J. (2017). Sea of Opportunity: Supply Chain Investment Opportunities to Address Marine Plastic Pollution. New York, New York, Encourage Capital on behalf of Vulcan, Inc.

Mugilarasan, M., R. Karthik, R. S. Robin, B. Subbareddy, G. Hariharan, I. Anandavelu, T. P. S. Jinoj, R. Purvaja and R. Ramesh (2023). "Anthropogenic marine litter: An approach to environmental quality for India's southeastern Arabian Sea coast." Science of The Total Environment 866: 161363.

Naidu, S. A., L. Mawii, V. Ranga Rao, G. Anitha, P. Mishra, B. E. Narayanaswamy, V. Anil Kumar, M. V. Ramana Murthy and G. Gvm (2021). "Characterization of plastic debris from surface waters of the eastern Arabian Sea–Indian Ocean." Marine Pollution Bulletin 169: 112468.

Nandy, B., G. Sharma, S. Garg, S. Kumari, T. George, Y. Sunanda and B. Sinha (2015). "Recovery of consumer waste in India - A mass flow analysis for paper, plastic and glass and the contribution of households and the informal sector." Resources Conservation and Recycling 101: 167-181.

Navsarjan. "Rag Pickers' Association." from http://navsarjan-surat.org/rag-picker-association.html.

Parmar, D. S. and V. D. Patel (2022). "Plastic ingestion by the Indian snakes Ptyas mucosa and Coelognathus helena helena (Serpentes: Colubridae)." Phyllomedusa: Journal of Herpetology 21(1): 91-94.

Plastics Europe (2023). "Plastics - the Facts 2022."

Plastindia Foundation (2023). Plastics Industry Status Report - India - 2021-22 & 1H 2022-23 Update.

Resilient Surat (2017). Surat Resilience Strategy. 100 Resilient Cities, Resilient Cities Network.

Schmidt, C., T. Krauth and S. Wagner (2017). "Export of Plastic Debris by Rivers into the Sea." Environmental Science & Technology 51(21): 12246-12253.

Schuyler, Q., B. D. Hardesty, T. J. Lawson, K. Opie and C. Wilcox (2018). "Economic incentives reduce plastic inputs to the ocean." Marine Policy 96: 250-255.

SEPPL. (2023). "Saurashtra Enviro Projects Private Limited (SEPPL)." from http://detoxgroup.in/company.php?i=10.

Shekhar, S. and D. Shah (2018). Are Businesses Ready to Beat Plastic Pollution, Citizen consumer and civic Action Group (CAG).

Sims, K., A. Reith, E. Bright, J. McKee and A. Rose (2022). LandScan Global 2021. Oak Ridge, TN, Oak Ridge National Laboratory.

SMC (2015). Chapter - III, Classification of Waste.

SMC. (2023a). "Activities Identified & Actions Initiated by the Authorities." Rejuvenation of Tapi, from http://tapirevival.suratmunicipal.org/TapiShuddhikaran/ActivitiesIdentifiedAndActions.

SMC. (2023b). "AREA, POPULATION, DENSITY, GROWTH RATE, SLUM HOUSE HOLD & POPULATION." from https://www.suratmunicipal.gov.in/TheCity/City/Stml3.

SMC. (2023c). "Key Activities." from https://www.suratmunicipal.gov.in/CleanSurat/Home/KeyActivities.

SUDA (2017). Surat Urban Development Authority Development Plan 2035.

Surat Municipal Corporation. (2019). "My Surat." from https://mysurat.in/my-surat.htm.

Surat Municipal Corporation. (2023a). "Key aspects instrumental in achieving the objectives." Solid Waste Management: Key Aspects Retrieved 27 February 2023, from https://www.suratmunicipal.gov.in/Departments/SolidWasteManagementKeyAspects.

Surat Municipal Corporation. (2023b). "Solid Waste Management Approaches." from https://www.suratmunicipal.gov.in/Departments/SolidWasteManagementApproaches.

Surat Municipal Corporation. (2023c). "Solid Waste Management Statistics." Retrieved February 27, 2023, from https://www.suratmunicipal.gov.in/Departments/SolidWasteManagementStatistics.

Surat Municipal Corporation (2023d). Surat City Map.

Suryavanshi, A. V., M. M. Ahammed and I. N. Shaikh (2023). "Energy, Economic, and Environmental Analysis of Waste-to-Energy Technologies for Municipal Solid Waste Treatment: A Case Study of Surat, India." Journal of Hazardous, Toxic, and Radioactive Waste 27(2): 04023005.

Swachh Bharat Mission Urban 2.0 (2022). Mission Progress.

The Economic Times (2022). How Surat Municipal Corporation makes money out of selling 'Plastic Waste', Youtube.com: 3:39.

TNN (2020). Surat's women force unite to clean up Dumas beach of plastic filth. The Times of India.

UNEP (2016). Global Waste Management Outlook, United Nations.

UNEP (2018). "Legal Limits on Single-Use Plastics and Microplastics: A Global Review of National Laws and Regulations."

United Nations (2018). World Urbanization Prospects: The 2018 Revision. P. D. Department of Economic and Social Affairs.

WaterAid (2020). Assessing the usability of personal protective equipment for sanitation workers in tropical countries. London, UK, WaterAid.

Wilson, D. C., L. Rodic, P. Modak, R. Soos, A. Carpintero, K. Velis, M. Iyer and O. Simonett (2015). Global waste management outlook, UNEP.

World Economic Forum. (2018). "The 10 fastest-growing cities in the world are all in India." from https://www.weforum.org/agenda/2018/12/all-of-the-world-s-top-10-cities-with-the-fastest-growing-economies-will-be-in-india/.

Yadav, V., M. A. Sherly, P. Ranjan, V. Prasad, R. O. Tinoco and A. Laurent (2022). "Risk of plastics losses to the environment from Indian landfills." Resources, Conservation and Recycling 187: 106610.

Appendix

Table 11: Full list of MDT litter items and associated material categories

Material	Items
C&D Materials	Aggregate & Brick Bolts, Nails, and Screws Building Materials Lumber Other C&D
Cloth	Clothing Fabric Pieces Other Cloth
E-Waste	Batteries E-Waste Fragments Other E-Waste
Fishing Gear	Buoys and Floats Fishing Line Other Fishing Gear Plastic Net or Net Pieces Plastic Rope
Glass	Glass Bottle Glass or Ceramic Fragments Other Glass
Metal	Aluminum Foil Aluminum or Tin Cans Metal Bottle Caps or Tabs Metal Fragments Other Metal
Organic Waste	Food Waste Other Organic Waste
Other	Other Popsicle Stick

Material	Items
Other Plastic Products	Bulk Bags Flip Flops Other Plastic Plastic String, Tape, or Packing Straps Rubber Bands Tires
Paper	Coated Paperboard Corrugated Cardboard Multi-material Paper Box Noncoated Paper Food Wrapper Other Paper Paper Receipts
Personal Care Products	Blister Pack Cotton Buds Other Personal Care Product Personal Care Product Sachet Shampoo or Other HDPE Container Toothbrushes Toothpaste or Other Product Tube
Plastic Food Products	Foam or Plastic Cups or Lids Other Food-Related Plastic Other Plastic Bag Plastic Bottle Plastic Bottle Cap Plastic Food Wrapper Plastic Grocery Bag Plastic Utensils Straws Street Food Bowl Styrofoam Container
Plastic Fragments	Film Fragments Foam Fragments Hard Plastic Fragments Other Fragments

Material	Items
PPE	Associated PPE packaging Disinfectant Wipes Disposable Gloves Face mask packaging Face Masks Face Shield Hair nets Hospital shoe covers Other PPE
Tobacco Products	Cigarette Packaging Cigarettes Other Tobacco Product Tobacco Sachets

Table 12: Full table of manufacturers of top convenience products

Manufacturer	Manufacturing Location
Aavin	Chennai, India
Adyar Ananda Bhavan Sweers India Pvt. Ltd.	Chennai, India
Agro Tech Food Ltd.	Kashipur, India
Amulfed Dairy	Gujarat, India
Anand Food Products	Hyderabad, India
AnuPriya	Chennai, India
Auro Food Pvt. Ltd.	Vanur, India
B.S Award Food Products	Chennai, India
Bisleri International Pvt. Ltd.	Mumbai, India

Manufacturer	Manufacturing Location
Brown Tree Retail Pvt. ltd.	Chennai, India
CavinKare Private Ltd.	Bhavani Taluk, India
Dev Snacks	Kerala, India
DFM Foods Ltd.	Ghaziabad, India
Drytech Processing(I) Pvt. Ltd.	Madhya Pradesh, India
FBP Parle Agro Pvt Ltd.	Sriperumbudur, India
Ferrero Industriale Italia S.R.L	Alba, Italy
Food Creations Private Ltd.	Bangalore, India
Gandour India Food Processing Pvt Ltd.	Hyderabad, India
Ghodawat Food international Pvt. Ltd.	Chipri, India
Godfrey Phillips	Mumbai, India
Haldiram Foods International Pvt. Ltd.	Nagpur, India
Hershey Malaysia Sdn. Bhd.	Johor, Malaysia
Hindustan Coca Cola Beverages Pvt. Ltd	Vellavedu, India
India Private Ltd.	Hyderabad, India
India Sweet Co (P) Ltd.	Chennai, India
International Bakery Products Ltd.	Vandalur, India

Manufacturer	Manufacturing Location
ITC Limited	Kolkata, India
ITC Ltd. — Foods Division	Haridwar, India
Jayanti Cold Storage	Rajasthan, India
Jumbo Foods	Madurai, India
K1 International Bakery Products Ltd.	Kancheepuram, Chennai
Kaira District Cooperative Milk Producers Union Ltd.	Gujarat, India
Kalis Sparkling Water(P) Ltd.	Sri City, India
Kellogg Asia Products	Negeri Sembilan, Malaysia
Kellogg India Pvt. Ltd.	Sri City, India
Lindt & Sprungli (Schweiz) AG	Kilchberg, Switzerland
Loacker	Tyrol, Austria
Lotus Bakeries Belgie NV	Lembeke, Belgium
Makson Pharmaceuticals (I) Pvt. Ltd.	Gujarat, India
Mars International India Pvt. Ltd.	Delhi, India
Mondelez India Foods Pvt. Ltd.	Sri City, India
Namobalaji Foods Pvt. Ltd.	Telangana, India
Nestle India Ltd.	Delhi, India

Manufacturer	Manufacturing Location
Paramount Nutritions India Pvt. Ltd.	Bangalore, India
Parle Biscuits Pvt. Ltd.	Raigad, India
Parsons Nutrionals Pvt. Ltd.	Kanakapura, India
Pepsi Co India Holdings Pvt. Ltd.	Pune, India
Perfetti Van Melle India Pvt. Ltd.	Gurugram, India
Red Bull	Espenstrasse, Switzerland
Relish Snacks Pvt. ltd.	Chennai, India
Sai Ram Snacks	Chennai, India
Schreiber Dynamix Dairies Pvt. Ltd,	Pune, India
Sri Akshay Foods	Chennai, India
Sunshine Bakery Foods Pvt. Ltd	Nilakottai, India
True Care Snacks	Chennai, India
Unibic Foods India Pvt. Ltd.	Karnataka, India
Varun Beverages Ltd.	Chengalpattu, India
Vidura Snacks Pvt. Ltd.	Chennai, India
Walkers Shortbread Ltd.	Aberlour-on-Spey, Scotland

Table 11: Full table of Parent Companies of top convenience products

Manufacturer	Manufacturing Location
Adadh Snacks Pvt. Ltd	Nikava, Gujarat, India
Amul Fed Dairy (A Unit of E LTD)	Gandhinagar, Gujarat, India
Bajaj Consumer Care Ltd	Mumbai, Maharashtra, India
Balaji Wafers Pvt. Ltd	Rajkot, Gujarat, India Valsad, Gujarat, India
Davat Beverages Pvt. Ltd	Shrinathgadh, Gujarat, India
Dazzy Products Pvt. Ltd	Vadodara, Gujarat, India
Dharampal Premchand Ltd	Noida, Uttar Pradesh, India
Dharampal Satyapal Foods Ltd	New Delhi, India
Dharampal Satyapal Manufacturing Ltd	Guwahati, Assam, India
Dhariwal Industries Pvt. Ltd	Pune, Maharashtra, India
Emami LTD	Guwahati, Assam, India
Ferfetti Van Melle India Pvt. Ltd	New Delhi, India
Force India Beverages	Rajkot, Gujarat, India
Godfrey Phillips India Ltd	Mumbai, Maharashtra, India
Gopal Snacks Pvt Ltd	Lodhika, Gujarat, India
Gundour India Food Processing Pvt. Ltd	Hyderabad, Telangana, India
Hector Beverages Pvt. Ltd	Not specified

Manufacturer	Manufacturing Location
Hindustan Coca Cola Beverages Pvt. Ltd	Ahmedabad, Gujarat, India
Hindustan Unilever Ltd	Ahmedabad, Gujarat, India Rajpura, Punjab, India
ITC Pvt Ltd	Kolkata, West Bengal, India
Jalani Enterprises Ltd	Jodhpur, Rajasthan, India
Jenish Incorporation	Surat, Gujarat, India
JIJ Foods Pvt. Ltd	Surat, Gujarat, India
Kaeser Food Products Ltd	Nagpur, Maharashtra, India
Kaipan Pan Products Pvt. Ltd	Bhopal, Madhya Pradesh, India
Laxmi Snacks Pvt. Ltd	Nadiad, Gujarat, India
Limark Health Care Pvt. Ltd	Ahmedabad, Gujarat, India
Lloyd Food Products	New Delhi, India
Mama Gruha Udyog	Surat, Gujarat, India
Marico Pvt. Ltd	Guwahati, Assam, India
Mondolez India Pvt Ltd	Sri City, Andhra Pradesh, India
Moyora India Pvt. Ltd	Hyderabad, Telangana, India
Nestle India Ltd.	Rudrapur, Uttarakhand, India Nanjangud, Karnataka, India New Delhi, India Usgaon, Goa, India
Nexa Health Care	Surat, Gujarat, India

Manufacturer	Manufacturing Location
Palicon Contectioners Ltd	Kheda, Gujarat, India
Parle Agro Ltd	Medak, Telangana, India Patal Ganga, Maharashtra, India
Parle Biscute Pvt Ltd	Mumbai, Maharashtra, India
Parsons Nutrition Pvt. Ltd	Chandigarh, Punjab, India
PepsiCo India Pvt. Ltd	Tarsali, Gujarat, India
Perfetti Van Melle India Pvt. Ltd	Gurugram, Haryana, India
Prayagh Nutri Products Ltd	Ramareddy, Telangana, India
Procter and Gamble Home Products Pvt. Ltd	Baddi, Himachal Pradesh, India
Raj Wafers	Surat, Gujarat, India
RCTI Pvt. Ltd	Bhopal, Madhya Pradesh, India
Real Anmol Soda Factory	Surat, Gujarat, India
S.S. Snacks Pvt. Ltd	Surat, Gujarat, India
Sam Foods	Jabalpur, Madhya Pradesh, India Surendra Nagar, Gujrat
Shreeji Vrundavan Masala	Surat, Gujarat, India
Shri Warana Sahakari Dudh Utpadak Sangh Ltd	Warananagar, Maharashtra, India
Singhaniya Food International Ltd	Hyderabad, Telangana, India
Soyso Hayoori Beverages Pvt. Ltd	Surat, Gujarat, India

Manufacturer	Manufacturing Location
Sukhdata Foods Pvt. Ltd	Ambarnath, Maharashtra, India
Sun Foods	Surendra Nagar, Gujrat, India
Surat Dist. Milk Producer Union Ltd	Surat, Gujarat, India
Swastik Gruha Udyog	Botad, Gujarat, India
Tayas Giba San Ve AS - Turkey	Kocaeli, Turkey
Trimurti Fragrance Pvt. Ltd	New Delhi, India
USQMA ITC Ltd	Kolkata, West Bengal, India
Varun Beverages Pvt. Ltd	Asurari, Bihar, India Bharuch, Gujrat, India
Vibrant Products	Valsad, Gujarat, India
Vinayak Industries	Vadodara, Gujarat, India
Whole Food Processor	Vadodara, Gujarat, India

Table 13: Full table of Parent Companies of top convenience products

Manufacturer	Manufacturing Location
Adadh Snacks Pvt. Ltd	Nikava, Gujarat, India
Anmol Industries	Kolkata, West Bengal, India
AVOLFLEX PVT LTD, SPCE	Hyderabad, Telangana, India
Bajaj Customer Care Ltd	Mumbai, Maharashtra, India
Balaji Wafers Pvt. Ltd	Rajkot, Gujrat, India Vajdi, Gujarat, India
Davat Beverages Pvt. Ltd	Rajkot, Gujrat, India
Dazzy Products Pvt. Ltd	Vadodara, Gujarat, India
Dharampal Premchand Ltd	New Delhi, India Noida, Uttar Pradesh, India
Dharampal Satyapal Ltd	New Delhi, India
Dharampal Satyapal Manufacturing Ltd	Noida, Uttar Pradesh, India
Dharampal Satypal Foods Ltd	New Delhi, India
Force India Beverages	Rajkot, Gujrat, India
Gonde Dhumala	Nashik, Maharashtra, India
Gopal Snacks Pvt. Ltd	Rajkot, Gujarat, India
Haladiram Food International	Nagpur, Maharashtra, India
Hector Beverages Pvt. Ltd	Gurugram, Haryana, India
HUHTANAKIPPL. LTD	Guwahati, Assam, India

Manufacturer	Manufacturing Location
ITC Pvt. Ltd	Kolkata, West Bengal, India
Jalani Enterprises Ltd	Jodhpur, Rajasthan, India
Jenish Incorporation	Surat, Gujarat, India
Kaipan Pan Products Pvt. Ltd	Bhopal, Madhya Pradesh, India
Laxmi Snacks Pvt. Ltd	Nadiad, Gujarat, India
Leamak Health Care Pvt. Ltd	Ahmadabad, Gujrat, India
Lloyd's Food Product	New Delhi, India
Makson Pharmaceuticals Pvt. Ltd	Bhesan, Gujarat, India
Mama Gruha Udyog	Surat, Gujarat, India
Manikchand	Pune, Maharashtra, India
Marico Pvt. Ltd	Mumbai, Maharashtra, India
Modi Enterprises	New Delhi, India
Mondelez Global	Chicago, Illinois, USA
Moyora India Pvt. Ltd	Rangareddy, Telangana, India
Nestle	Vevey, Switzerland
Nexa Health Care	Surat, Gujarat, India
Parle Agro Ltd	Ahmedabad, Gujarat, India

Manufacturer	Manufacturing Location
Parle Biscute Pvt Ltd	Nashik, Maharashtra, India
Pelican Confectioners	Pinglaj, Gujarat, India
Pepsico	Purchase, New York, USA
Prayagh Nutri Products Ltd	Ramareddy, Telangana, India
Procter and Gamble Home Products Pvt. Ltd	Cincinnati, Ohio, USA Katha Baddi, Himachal Pradesh, India
Raj Wafers	Surat, Gujarat, India
S.S. Snacks Pvt. Ltd	New Delhi, India
Shreeji Vrundavan Masala	Surat, Gujarat, India
Soyso Hayoori Beverages Pvt. Ltd	Surat, Gujarat, India
Sukhdata Foods Pvt. Ltd	Ambernath, Maharashtra, India
Surat Dist. Milk Producer Union Ltd	Surat, Gujarat, India
Swastik Gruha Udyog	Botad, Gujarat, India
Tayas Giba San Ve AS - Turkey	Kocaeli, Turkey
The Coca-Cola Company	Atlanta, Georgia, USA
Unilever	London, England
USQMA ITC Ltd	Kolkata, West Bengal, India
Vibrant Products	Valsad, Gujarat, India

Manufacturer	Manufacturing Location
Vinayak Industries Pvt. Ltd	Ahmedabad, Gujarat, Indi

END OF DOCUMENT