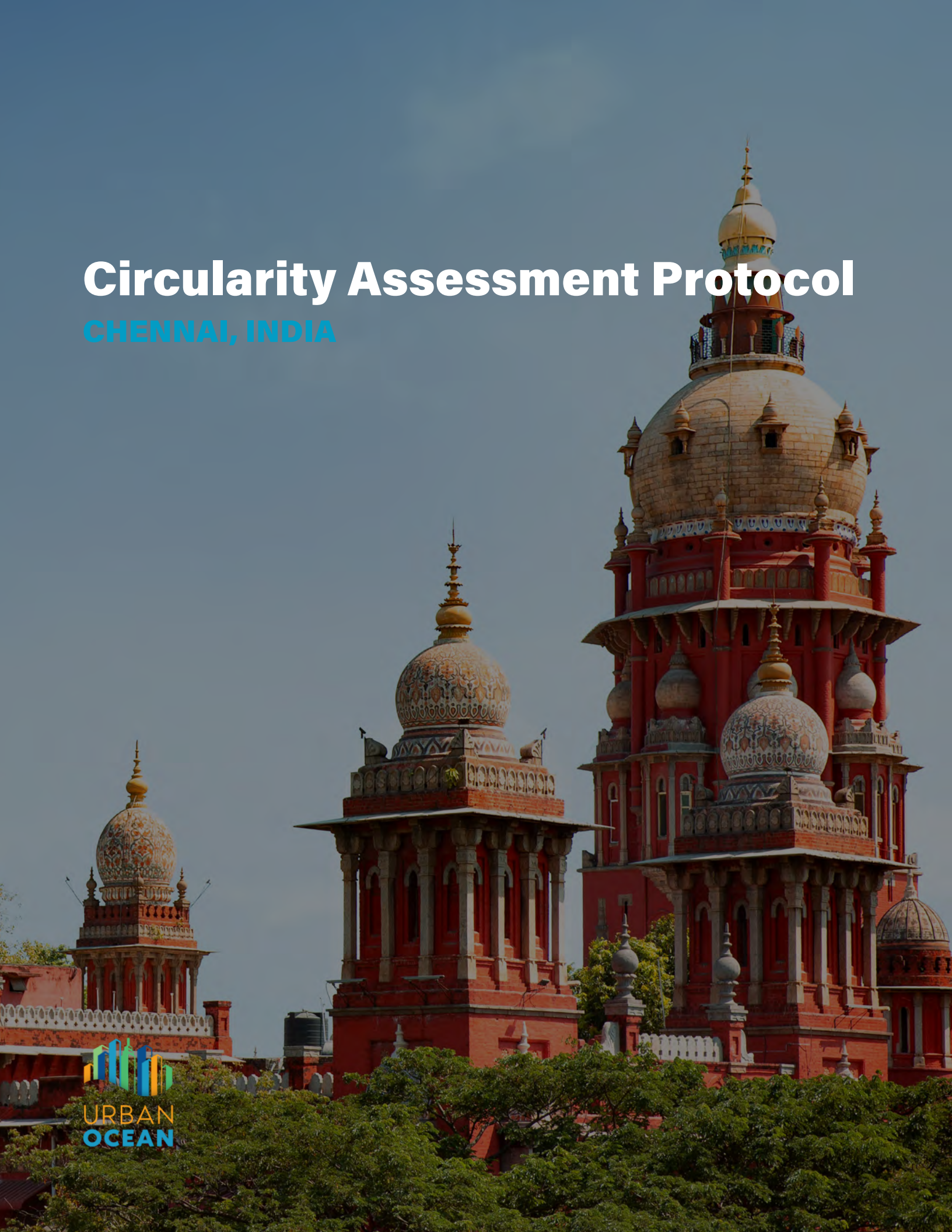
Circularity Assessment Protocol

CHENNAI, 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 the 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 can help 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:
Okapi Advisory Services Pvt Ltd., Tamil Nadu, India

Authors:
Taylor Maddalene (CIL), Akshaya Ayyangar (Okapi), Lindsay Coats (CIL), Quinn O'Brien (CIL), Parama Roy (Okapi), Kathryn Youngblood (CIL), Jenna Jambeck (CIL)

Contributors and Reviewers:
Keri Browder (OC), Katrin Bruebach (RCities), Luciana Cardoso (RCities), Saurabh Gaidhani (RCities), Ashwin Mahalingam (Okapi), Ellen Martin (TCI), Nini Purwajati (RCities), A Ramachandran (Okapi), Alvaro Soldevila (RCities), N Srimathi (Okapi), Radhakrishnan Subramaniam (Okapi), Chever Voltmer (OC)

Recommended Citation:
Circularity Informatics Lab, August 2022. Circularity Assessment: Chennai, India. University of Georgia, Athens, GA, USA.

Design/Layout:
Deeds Creative, Athens GA

Photo Credits:
Page 19, 20, 22, 23, 25, 26, 29, 30, 31, 32, 33, 38: Okapi Research & Advisory

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

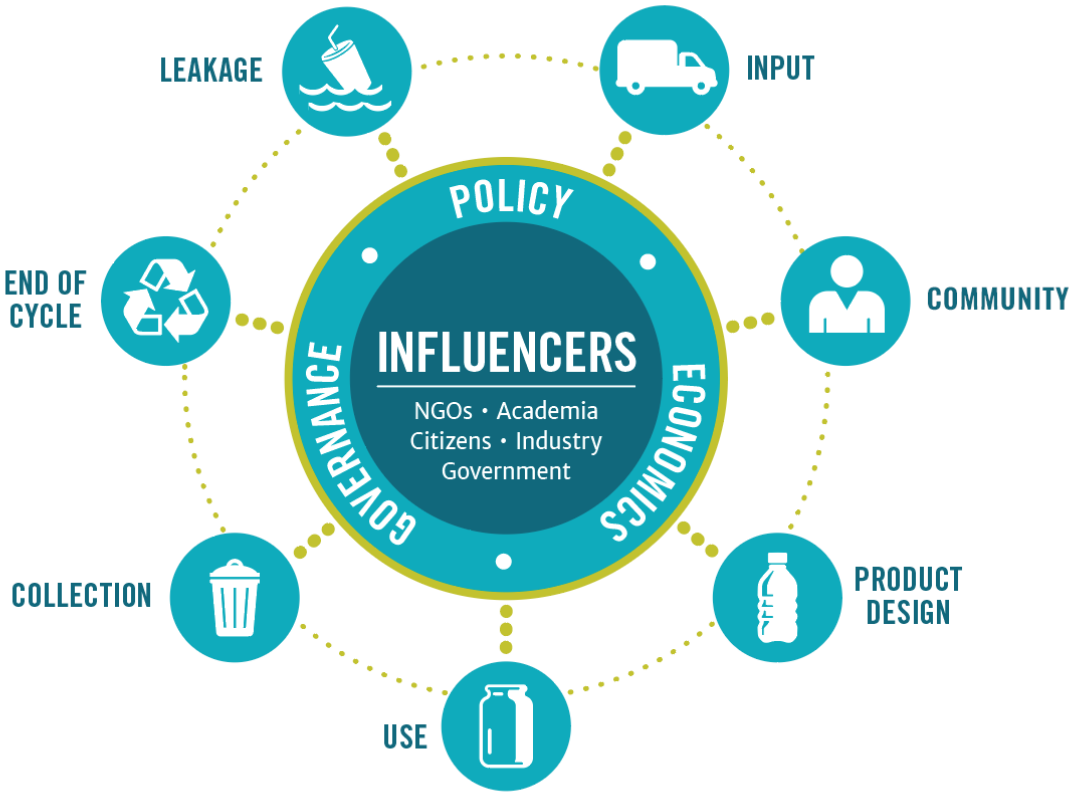
Athens, GA, August 2022

Contents

Figures & Tables

Executive Summary

Developed by the Circularity Informatics Lab at the University of Georgia, the Circularity Assessment Protocol (CAP) is a standardized assessment protocol to inform decision-makers through collecting community-level data on plastic usage. 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, is comprised 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 2021 and December 2021, a team from Okapi Advisory Services (Okapi), with guidance and support from the Circularity Informatics Lab, conducted fieldwork in the city of Chennai, 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 (RCN) 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.

Chennai is one of four cities in the second cohort of Urban Ocean learning cities. The CAP in Chennai, 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 Chennai 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 committed to solving the ocean plastic pollution challenge by supporting the incubation of circular, inclusive and investible waste management and recycling systems in South and Southeast Asia. We achieve this by collaborating with key stakeholders across the sector, and by producing insights to support and accelerate investment and scale across the value chain.

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.

Key Findings and Opportunities

INPUT

Findings: Among top convenience product categories, beverage, candy, and chip/snack items all had some manufacturers and parent companies that were less than 20km from Chennai, which could present opportunities for EPR. For all top products sampled, 58% had parent companies located in India and 86% had manufacturers located in India, including 26% with parent companies in Chennai and 16% with manufacturers in Chennai. Biscuit, candy, and chip/snack items are most often packaged in multilayer plastic, which is difficult to recycle and holds little to no value in informal waste sectors. Brands of those types of products with manufacturers and parent companies near Chennai should be targeted for pilot EPR projects under the latest set of EPR rules.

Opportunities

- Chennai could be a leader in working with top local brands and producers to create the EPR Action Plans as mandated by the EPR Guidelines from 2020, targeting first the manufacturers and parent companies that are domestic to India or to the South Asia region.
- There are opportunities for EPR schemes and revenues to increase both collection of low value materials and improve informal sector health, safety, incomes, and well-being.
- Ensure the city has resources available for effective implementation and enforcement of EPR Guidelines and rules that result from those guidelines.
- Awareness campaigns on existing buy-back initiatives available to consumers, such as Aavin milk packets, and any refill or reuse schemes that may be available in the future would be beneficial to the city.

COMMUNITY

Findings: Stakeholders emphasized the importance of consistency to produce results in waste management and plastic regulation. Interviewees expressed that government policies need to be clear in their intent and restrictions, consistently enforced and applied to all stakeholders, including manufacturers. Many expressed frustration with the lack of transparency and clarification for policies such as EPR, and there were polarized opinions of how these policies were being implemented. The high value and yet underrepresentation of the informal sector when decisions are made regarding waste management and policies in the city was also expressed.

Opportunities

- The health and wellbeing of the informal waste sector should be prioritized by the city and incorporated into decisions that are made regarding waste management.
- The informal waste sector should be involved in the Opportunity Assessment process following the Gap Assessment as part of Urban Ocean.
- Awareness and education are needed for the public and waste workers alike on processes, protocols, and the bigger picture of the value in waste collection and processing for building city resilience.
- Clear communication and instructions involving waste segregation from the point of household segregation through collection and disposal is critical for adoption.
- Positive behavior change has been observed (ie. following single-use plastic item bans), but these are not sustained due to inconsistent implementation and enforcement — citizens need to see the benefits of the changes they are making.

PRODUCT DESIGN

Findings: Of the 272 convenience items sampled in Chennai, nearly 50% had some form of multilayer plastic film packaging, and 15% had packaging that consisted of combinations of single-layer plastic film with other materials. There is a wide variety of packaging materials used, which can make the economy of scale of recycling more challenging. The second most common packaging type among top consumer products was PET. Of the 104 to-go items sampled from 28 vendors, the largest proportion of material type (around 40%) was plastic, but there were also large proportions of organic and degradable items as well as high-value recyclable items such as aluminum. Continuous monitoring and enforcement are missing from policies related to problematic materials, including EPR, bans, and others.

Opportunities

- The abundance and nomenclature around material type and the associated disposal can make recycling challenging and be confusing to consumers — with high amounts of biodegradable, compostable, and oxo-degradable plastic in Chennai, this confusion could lead to higher litter quantities and improper waste management if it is not addressed.
- Multilayer plastic is not currently recyclable and does not have value in the informal sector (apart from select brands of milk packets) – it is recommended that Chennai either bolster EPR schemes like that of Aavin, work to explore alternative materials of value, or collaborate with the private sector where possible for product redesign.

USE

Findings: Among the 26 convenience stores sampled in Chennai, around the same percentage (34.5%) provided plastic bags as those that did not offer bags to consumers. Among those that did offer bags, a relatively large proportion offered paper or cloth alternatives. From the CAP survey, however, nearly 40% of to-go items documented were plastic, which indicates that existing levels of adoption and/or enforcement have not been sufficient. The majority of plastic to-go product alternatives available to customers from stores and food vendors were available at no additional cost to the consumer. Zero-waste stores are also gaining popularity in the city.

Opportunities

- Implement enforcement measures or public campaigns around rules that are in place or that will be implemented, and ensure that these are maintained over the long-term and are consistent.
- Explore incentives, policy opportunities, or methods of highlighting or supporting local businesses that are already switching to alternatives and have already banned bags.
- Consider adding incentives for consumers that are bringing/reusing their convenience items such as bags, utensils, and to-go containers where possible.

COLLECTION

Findings: Waste collection in Chennai has been largely privatized over the last several years, and now includes Urbaser Sumeet, Ramky Enviro Engineers Pvt. Ltd, and the Greater Chennai Corporation. There are several innovative models within those companies. The city also has existing regulations for source segregation and collection measures to match. With an estimated 80,000-100,000 waste collectors within Chennai, the informal sector plays a critical role, but can be overlooked when new regulations are put into place and lack support for worker safety standards and appropriate pay.

Opportunities

- Implement comprehensive monitoring of the different collection models (e.g., repeated litter transects or waste bin overflow assessments in all areas of the city that are managed by different private companies).
- Consider developing case studies for the different collection models and private enterprises around collection of solid waste in Chennai, so that lessons can be learned from what works/what does not.
- Improve working conditions for informal workers, including basic measures to ensure they are protected when working.
- Foster collaborations for micro-enterprises for recycling or civil society support for informal waste workers.
- Education for workers and outreach to the public are important so that people can see the benefits of what they are doing in the larger system, from segregating waste at the household level to operating collection systems.

END OF CYCLE

Findings: Chennai has one of the highest per capita waste generation rates in India at around 0.7 kg/day. Municipal solid waste generated in the city is largely inert (35%) (e.g. bricks and rubble) and green waste (32%), and the last third is consumer goods and industrial waste. Consumer and industrial plastic specifically comprise around 7% of the waste stream. The majority of solid waste generated in Chennai is destined for landfill, but both landfills that service the city are nearing capacity and have environmental concerns related to groundwater. Innovations in infrastructure are planned, but must be accompanied by community awareness, policies, and consistent enforcement.

Opportunities

- Continue to support and expand recycling in Chennai, 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.
- Explore reviving a decentralized management system involving the informal sector (incorporating learnings from Zero Waste Chennai) — the city has a clear need to divert items from landfill, and is heading in the right direction with source segregation and collection schemes, but there is a need for continued public outreach and awareness and ongoing monitoring of successes and needs of the program.

LEAKAGE

Findings: Of the 3,084 litter items documented in Chennai, the largest percentage by category was food packaging plastic (33%) followed by tobacco products (18%). The percentage of common plastic items found was 56% of the total items. Average litter density was around 1.08 litter items per m^2, which is low compared to other cities in India. The lowest litter density was in the lower population count areas, where organic waste was the most common type of litter found. Plastic food wrappers and plastic bottle caps were among the top five most common litter items in all three of the population count areas.

Opportunities

- Revisit litter transects based on zones and/or by areas that have different waste collection schemes, share best practices and learnings.
- Food packaging plastic is an issue, especially food wrappers — those materials should be prioritized for EPR and exploration of feasible alternatives, through regulation, funding, innovation, and other pathways.

Strengths

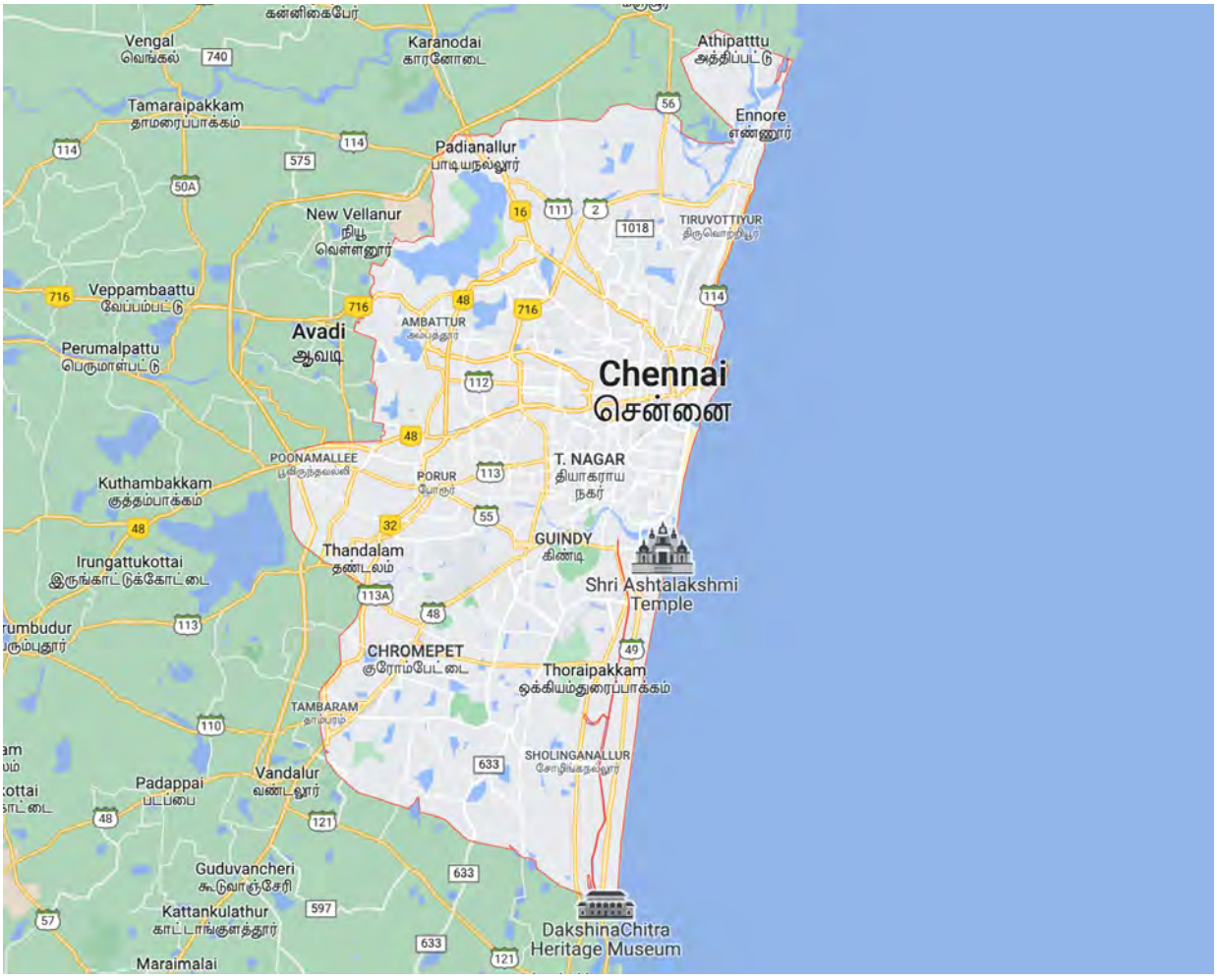
- Under the Swachh Bharat Mission, GCC has prepared a Chennai Action Plan which provides detailed information on the infrastructural gaps in solid waste management.
- SWM Rules were passed in 2016, and it is now mandatory for local bodies to ensure that the waste is segregated in Chennai.
- Urbaser Sumeet's model of door-to-door collection involving EVs with different types of disposal bins and prompt grievance redressal framework seems to be working well but needs strengthening and could be adopted by other service providers.
- GCC created Solid Waste Management bylaws in 2019 which enable local authorities to enforce the SWM Rules of 2016.
- EPR Framework was proposed in 2020, Chennai is taking steps towards implementation though the level of implementation and enforcement is varied. Existence of manufacturers and parent companies from the CAP survey close by present opportunities for developing effective EPR action plans, and a detailed timeline of EPR development is included below.
- Great deal of private innovation and civil society support for waste and circular economy (ie. Kabadiwalla Connect, Paperman, etc.)
- GCC has undertaken improvement projects for open dump sites in recent years and continues to put out proposals for infrastructure improvement.
- Privatization of waste collection has mixed feedback from the community but seems to have improved overall collection coverage and led to new community-led initiatives. A strong private/civic waste management ecosystem can be leveraged for increased impact.
- Zero-waste and Organic stores are starting to open in Chennai, though still very few in number, and plastic alternatives are gaining popularity.
- The Tamil Nadu Government is actively pushing usage of cloth bags, targeting large vegetable and fruit markets through their Meendum Manjapai Campaign.
- 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
CMA – Chennai Metropolitan Area
HDPE – High Density Polyethylene
GCC – Greater Chennai Corporation
GDP – Gross Domestic Product
IWC – Independent Waste Collector
LIP – Local Implementing Partner
MCC – Micro-Composting Centers
MPs – Microplastics
MSW – Municipal Solid Waste
MSWM – Municipal Solid Waste Management
NMI – New Materials Institute
OC – Ocean Conservancy
OMSW – Ordinary Municipal Solid Waste
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
TCI – The Circulate Initiative
UGA – University of Georgia

Introduction

Chennai is the capital city of the state of Tamil Nadu, located on the Coromandel Coast near the Bay of Bengal in Southeastern India. Chennai's urban population size is estimated at 4.9 million people with a combined urban and suburban population estimated at 9 million. The population density is 26,553 people per square kilometer, making it the most densely populated city in Tamil Nadu. The most popular language spoken is Tamil, spoken by 75% of residents, with Telugu and English being the second most commonly spoken languages (World Population Review). Chennai's major industries include the automobile industry, electronic and information technology, as well as tourism with an estimated 39 million tourists in 2017 alone (TN, 2018). Estimates for waste generation in Chennai range between 4,500 – 6,400 metric tons of municipal solid waste per day, and the average per capita waste generation is the highest in the country at 0.71kg/day (Nileena, 2016).



Chennai, India

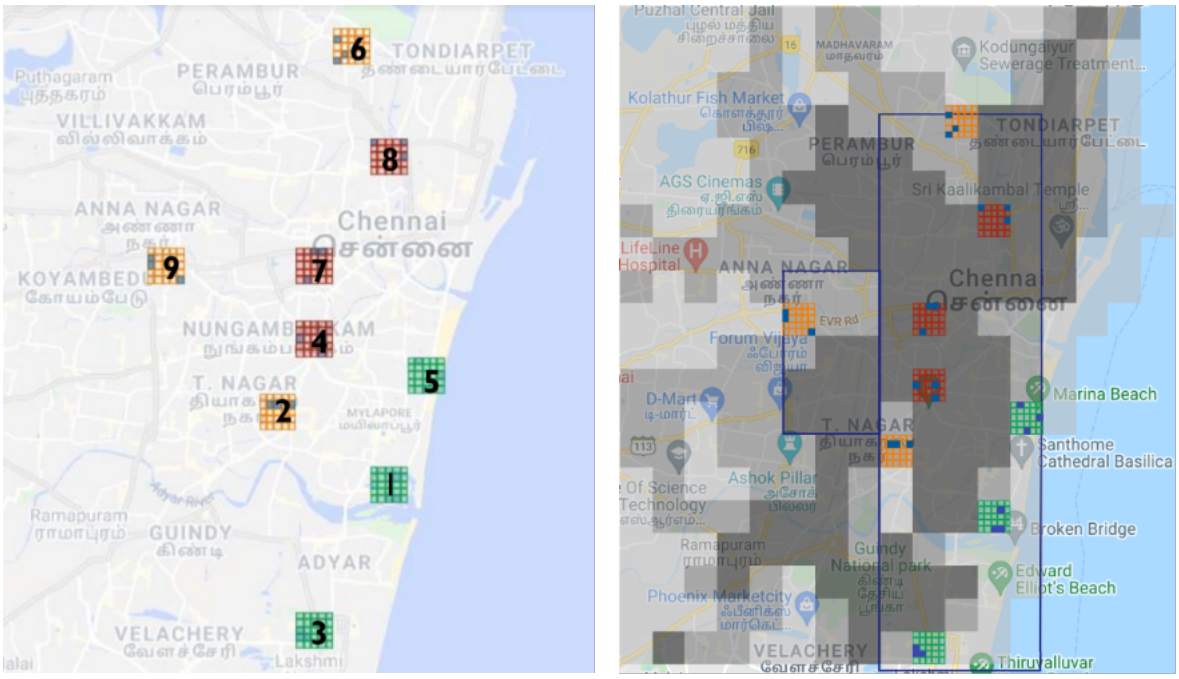
Chennai is divided into two administrative boundaries: the Greater Chennai Corporation encompasses 426 sq. km. and includes Chennai city, and the larger Chennai Metropolitan Area (CMA) encompasses 1189 sq. km. and contains the Chennai district and portions of other neighboring districts of Kanchipuram, Thiruvallur, Cuddalore, Ranipet and Vellore. 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 restricted to Chennai city limits administered by the Greater Chennai Corporation responsible for solid waste management in the city. The Chennai Metropolitan Area is rapidly urbanizing with an average annual growth rate of 1.15% according to the National Sample Survey Organization or 2% from 1971 onwards (Arabindoo 2011). This rapid growth has resulted in more than doubling of the population in the metropolitan area in four decades, increasing from 3.5 million in 1971 to 8.6 million in 2011. As a result, the demand for urban services such as drinking water, housing, sanitation, solid waste management has also increased significantly, causing a strain on socio-natural resources and local governments to meet the growing city needs.

Three rivers traverse the city of Chennai — the Adyar in the South, the Coum in the center, and the Kosasthaliyar in the North. All three rivers and their tributaries flow into the Bay of Bengal in Chennai city. The region is believed to contain 3,600 water bodies such as ponds, lakes, rivers, marshes and wetlands, yet rapid urbanization and land use change has severely compromised these natural ecosystems. The traditional "ery" system – a series of interconnected rivers, lakes and ponds designed to mitigate droughts and floods – has been largely lost in an urbanized Chennai. Many of the natural connections no longer exist, making the region vulnerable to both droughts and floods (Resilient Chennai 2019).

As a city surrounded by waterways, many bodies of water in the region have become dumping grounds for solid and liquid waste. During a series of major floods in 2015, it was estimated the Greater Chennai Corporation had to clear 1.32 million tons of solid waste from water bodies in the city. After heavy rains caused flooding of the Adyar River in 2021, the corporation collected 218 tons of plastic from a single location in the southern part of the city and is continuing to clear trash from other areas (Omjasvin 2021).

As one of the cities in the second Urban Ocean cohort, Chennai 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 Chennai — Okapi Research and Advisory, a IIT Madras incubated research organization — to conduct a circular assessment of the city.

Figure 1: CAP sampling map of Chennai



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 Results

Input

To get a snapshot of the characterization, scope, and source of common plastic packaged items entering Chennai, common convenience items were sampled within nine 1km^2 transects in Chennai—three within each tertile (relative groupings of high, medium, and low) of the population count representing societal activity. The LIP selected three convenience or grocery shops to sample within each 1km^2 sample area, except for one area that did not have enough shops available, totaling 26 total 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 as the most purchased brand based upon shelf space taken up and/or the shopkeeper's input. This yielded 272 product samples total, including 70 beverage items, 69 biscuit items, 63 candy items, 64 chip/snack items, and 6 tobacco items. The weight of both the plastic packaging and the product itself were measured for each item using the analytical balances in the university laboratory. There was comparable diversity of brands observed across the top categories in convenience stores sampled, including on average 13 brands of beverages, 15 brands of biscuits, 11 brands of candy, 12 brands of chips/snacks, and 1 tobacco brand available for purchase.

For each of the top products documented, the LIP noted the type of packaging (including polymer, if possible), the brand, and the parent company. From there, the team was able to document the manufacturing location, which was determined from manufacturing locations listed on product packaging or desktop research, as well as the headquarters location for the parent company of the brand (largely determined by desktop research). Table 1 contains the minimum, maximum, average, and median distance to both the manufacturing facilities and parent companies, and Figures 2 & 3 show maps of both manufacturer and parent company locations.

Table 1: Distances to parent company headquarters and manufacturing facilities for convenience products

	Distance Store to Parent Company (km)				Distance Store to Manufacturer (km)			
	Minimum	Maximum	Average	Median	Minimum	Maximum	Average	Median
Beverages	13	19,862	12,856	17,554	15	8,743	1,052	69
Biscuits	286	10,318	2,035	1,244	13	10,320	892	526
Candy	10	19,537	10,055	9,956	11	8,827	1,599	776
Chips/ Snacks	6	22,329	8,686	1,755	6	3,001	1,391	1,108
Tobacco Products	1,755	8,944	3,552	1,755	427	1,232	628	427

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

Among the convenience product categories, beverage products had the largest average and median distance between store and parent company locations, followed closely by candy items. Candy and beverage items median distances between stores and parent companies are nearly 10 times farther than the parent company locations for biscuit, chip/snack, and tobacco product parent companies. Biscuits had the lowest average and median distances between stores and parent companies. For manufacturers, candy products had the largest average distance between store and manufacturer while chips/snack items had the highest median distance between store and manufacturer. Tobacco products had the smallest average distance between store and manufacturer, while beverage companies had the smallest median distance between store and manufacturer. Beverage, candy, and chip/snack items all had some manufacturers and parent companies that were both less than 20km from Chennai. This could present opportunities for engaging these more local manufacturers in conversations around packaging design, extended producer responsibility (EPR), recapture and collection of manufactured items. For all top products sampled, 58% had parent companies located in India and 86% had manufacturers located in India, including 26% with parent companies in Chennai and 16% with manufacturers in Chennai.

Figure 2: Map of manufacturer locations by convenience product type

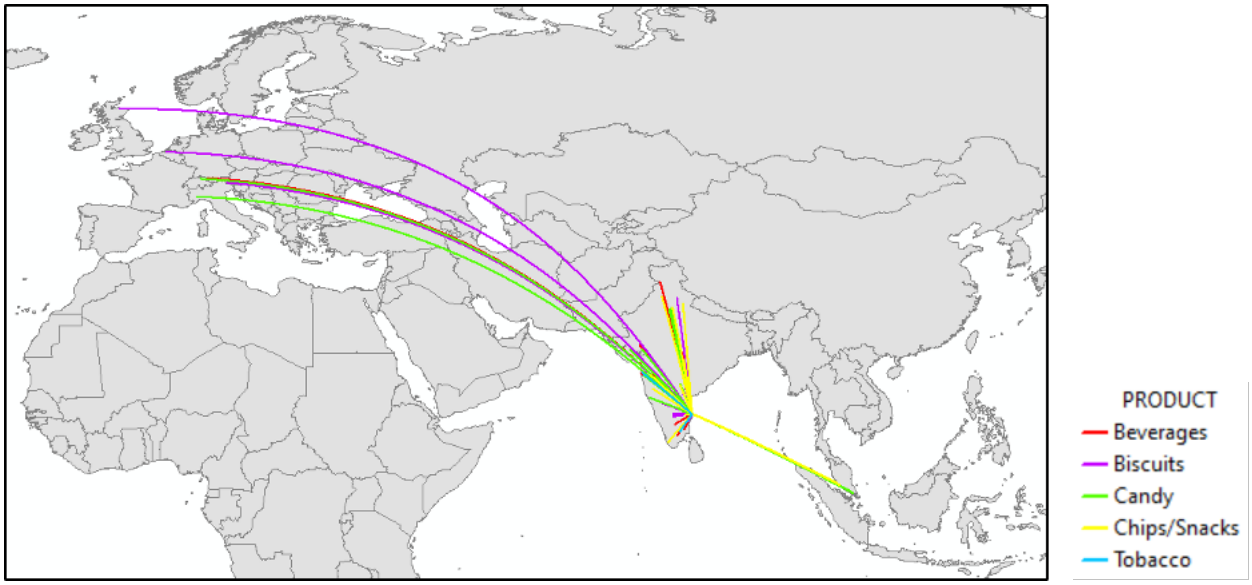
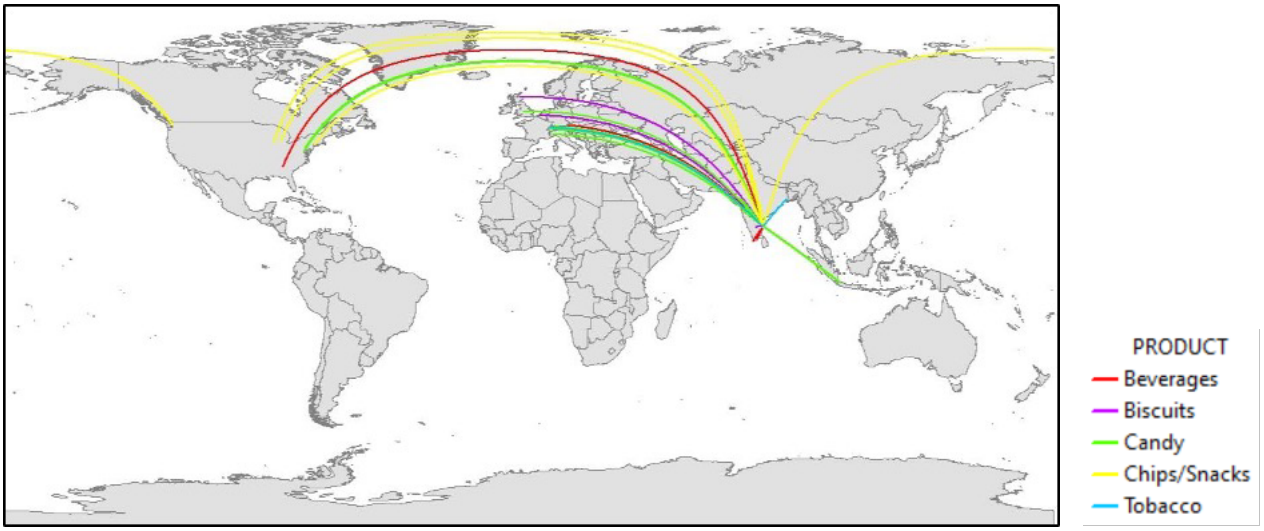


Figure 3: Map of parent company locations by convenience product type



Biscuit, candy, and chip/snack items are most often packaged in lightweight, multilayer plastic. While this can be beneficial for the carbon footprint of long-distance transport, these materials are most difficult to recycle and hold little to no value in informal waste sectors. Brands of those types of products with manufacturers and parent companies near Chennai should be targeted for pilot EPR projects under the latest set of EPR rules in India (MOEFCC 2020). Although some interviewees mentioned pilot projects in the region to incorporate multilayer plastic into cement kilns as a substitute for coal, this practice remains controversial because of potential air and ash pollution issues.

In May 2018, a group of organizations led by the Citizen Consumer and Civic Action Group (CAG) conducted litter brand audits in 250 sites across 15 cities in 18 Indian states. The top 5 international brand parent companies found in

litter items across all Indian cities sampled were PepsiCo, Perfetti van Malle, Unilever, Coca-Cola, and Mondelez. All of those top five brands except for Unilever were also found in the CAP store surveys, as the surveys largely focused on food products. The top 5 local brand parent companies found in litter items were Parle Products, Karnataka Milk Co-Op, Britannia, ITC, and Amul (Shekhar 2018). However, it is worth noting that when conducting brand audits based on litter items, it can be difficult to properly identify items and brands, particularly for items that have been in the environment for long amounts of time.

In 2020, a similar audit was conducted for household waste, whereby 200 students from two colleges in Chennai documented the plastic waste in their homes over the course of three weeks by brand name, type of product, type of plastic, layers (single or multilayer), and quantity (count). Of the nearly 14,000 plastic items logged in the audit, 32% were multilayered plastic, and the most common brands across all plastic products were Aavin (30%), Hindustan Unilever Ltd (13%), Britannia (6%), Nestle (4.48%), and ITC (3.5%). The majority of Aavin products were milk packets, and it was noted in the brand audit that Aavin announced in 2019 that it would purchase back milk packets from consumers at Rs 0.10 per packet, though many consumers surveyed were not aware of this program (CAG 2021).

There is context in India, and Chennai, for EPR discussions. Under the national Plastic Waste Management Rules of 2016, India's Ministry of Environment, Forest and Climate Change brought forward a draft national framework for Extended Producer Responsibility (EPR), which was made available for public comment in June 2020. This was built upon the Plastic Waste (Management and Handling) Rules of 2011, which first defined terms such as waste collectors, multilayer plastic, and EPR. In 2019, GCC also created the Solid Waste Management Bylaws for Chennai, which enabled them to enforce the Rules of 2016. The EPR 2016 framework clarifies that Urban Local Bodies have the main responsibility for setting up systems of plastic waste collection and segregation, but that the costs of this infrastructure should be shared with manufacturers, importers, and users. Under the framework, the policy is set at the national level by the central government and implementation is carried out at the state level by the state Pollution Control Boards (PCB), with responsibility on companies to report accordingly. All companies that use plastic packaging in India are required to register as a "producer" or "brand owner" and share information on plastic types, production, and distribution to help ensure that those waste management systems are matching the city's needs and that equivalent amounts of plastic are being collected and processed. If they operate in only one state then they report to the state PCB only, but if they operate in more than one state then they must submit EPR Action Plans to the state PCB as well as the Central PCB (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 urban local bodies (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).

Figure 4: Timeline of EPR regulations for India and the state of Tamil Nadu

At the time of their release, the Plastic Waste Management Rules of 2016 were praised for putting concrete definitions and requirements around EPR in India. However, the EPR Guidelines document has come under some criticism from civil society in India, citing challenges with varying levels of implementation, omission of explicit mention of some of the most problematic plastics, and lack of inclusion of the informal waste sector (Chandran 2021).

> **"I think I like a couple of things like the EPR plastic rules, they have this language on collecting accurate waste management baselines and things like that. Those kinds of things are positive, but it really comes down to the local implementation."**
>
> **— NGO**

As noted, there are several different models of EPR that were originally presented in the Framework in 2020 and are in different stages of negotiation and implementation in Chennai. Through the PRO model in Chennai, a company that distributes plastic products, such as PepsiCo, must prove that they have adequately managed/disposed of as much plastic as they are using, though the waste collected need not be from that same company. To do this, private companies often work with PROs such as Paperman or other recycling companies, whereby the plastic producers will pay the PROs to provide evidence that the equivalent amount of plastic waste has been managed on the ground. According to stakeholder interviews, low-value plastics such as multilayer plastics comprise about 65% of the material that they take in, largely received through waste pickers (or collectors) but also from residential complexes and local private waste companies such as Urbaser Sumeet. Those low-value plastics are still mostly incinerated in India. Higher value plastics such as PET will more often be retained within the informal waste sector. Some PROs interviewed reported that current EPR efforts and funding are too largely focused on high-value plastics that already have value and an established supply chain, and express that more EPR funding needs to be channeled towards those low-value plastics such as films. It is worth noting that PROs also accept different types of materials, and their success depends on the market, what they are able to process, and many other factors.

Regarding EPR enforcement, several interviewees noted that many companies are still unaware of the EPR registration process through the Pollution Control Board (PCB) or are adhering instead to their own internal sustainability goals.

> **"At end of 2019 December, I think they raided so much and they got so many fines collected. It is not consistent. One day the zonal officer will really fine. If we go to some places to see the infrastructure, he will fine. One day he suddenly saw plastic covers in a shop, he raided it. Next day, again, the shop had covers. He didn't notice it."**
>
> **— Local government**

One interviewee also noted that Coca-Cola, for example, did register through PCB as part of the EPR process, but was then subsequently fined for a violation, so other companies feel that there is a disincentive to register because of the potential for large fines and the lack of clarity around enforcement and consistency. It is clear through the interviews and survey data that transparency in the EPR process and more consistency with enforcement would be beneficial for policies across the board.

Community

In order to assess the attitudes towards plastic use, regulation, and disposal methods, 19 interviews were conducted with stakeholders throughout the Chennai community. Interviews revealed a wide variety of concerns about plastics within the community including implementation of policy, frustration around waste segregation, and lack of plastic alternatives, but stakeholders also included positives they have witnessed and hopes for the future.

Table 2: Interviewees by stakeholder group

Stakeholder	Interviews
Private Waste Companies	4
Shops	3
Waste Pickers / Scrap Shops	3
Industry	2
RWAs	2
Government	2
Academia	2
NGOs	1

Across interviews with stakeholders from various sectors, EPR was one of the policies brought up most often. The development of the EPR Framework in 2020, which was originally called for in India's Plastic Waste Management Rules of 2016, has brought about both positive changes and confusion within the community. EPR has created a market for plastics and plastic recycling that is beneficial and keeps plastics out of landfills and the environment. It has also started a conversation around looking at plastics as an alternative source material for certain products such as cement, increasing its circularity.

> **"Today, the lower-value plastic market is purely driven by EPR programs. There is a market for it because EPR has been funding the program. In a way, I think it's great because compared to before 2016, where these rules came in place, none of these plastics were being collected."**
>
> **— Private Waste Company**

> **"There is 21 Century Polymer who we've been working with to convert our collected waste into benches so that these benches can then be put in a public place. It drives the message of circularity and why waste segregation needs to be done at source and basically to drive the messages of effective waste management."**
>
> **— Industry**

Some feel, however, that implementation has fallen short, especially on a local level where enforcement would be most effective.

> **"In three months to six months companies have to submit a plan for their area, how they're going to implement it. We have asked after six months. We have asked Tamil Nadu Pollution Control Board through RTIs [Right to Information Act] as well as to Central Pollution Control Board asking how many companies have submitted the plan so far. They give a reply saying, 'As these details are included in the training and these are considered as trade secrets, these can't be given … ' Still zero. That is the status. But the rules, policies papers keep- the drafts keep coming for changes to EPR."**
>
> **— NGO**

Lack of effective implementation in the eyes of some stakeholders is coupled with changes to EPR that make it hard to understand exactly what the status of the program is.

> **"EPR came up around 2016 [when the] rules were implemented. I mean, came out first, but there is continuous change. For example, last year they wanted an umbrella EPR kind of policy … It was released last year. We gave the comments. After that there was no update on what the status is or whether it's being released. It went to a carbon credits model kind of thing. Then I think two weeks back, there was a new amendment for which a draft has been released, which is open for comments till 1st December."**
>
> **— NGO**

Stakeholders also commented that for a program like EPR to be effective, there needs to be cooperation across multiple industries. An effective EPR policy should include incentives and strategies for consumers, retailers, and manufacturers to work together.

> **"Across the board, the retailers have to be encouraged for the reuse of plastics and the manufacturer has to give that discount to the retailer. The retailer has to effectively work on it to get back the covers from the customer. Customers also have to cooperate."**
>
> **— Organic Shop Owner**

From an industry side, however, some stakeholders felt that EPR is being effective in its intent to have companies reclaim an equivalent amount of plastics as they produce.

> **"Primarily we work through waste management partners who collect plastic waste on our behalf and send it for recycling or send it for sustainable disposal depending on the kind of plastic it is."**
>
> **— Industry**

> **"… from a brand owner perspective, it is a highly regulated space. The requirements are very stringent. If you don't do it the reputational risks are very high. For example, if I am unable to meet my requirements my license gets canceled, or I get slapped with a show-cause notice."**
>
> **— Industry**

Despite companies participating in EPR, there is still confusion on whether government agencies on both the state and national level are being active in the monitoring of reports.

> **"But how much are they reading the report? How much are they really monitoring? That is something that remained to be answered. Then there are questions because there is push from NGT, CPCB on what state boards are doing. They get very agitated, and they start slapping notices and letters to brand owners. So, we are in a difficult position. We are sending the letters, informing them and the reading is their prerogative."**
>
> **— Industry**

This contradiction between stakeholders demonstrates the overall confusion around EPR. While some feel that implementation has been lacking, others that are directly involved such as companies feel that EPR is achieving its overall goal – or at least that they are meeting their obligations under the law. Transparency between the government on how it enforces EPR and from companies on how they are complying with EPR policy in addition to strategies to involve community members may help to mitigate confusion and frustration.

Along with EPR, the state government of Tamil Nadu has attempted to regulate plastics through a plastic ban that

was put in place in January 2019. This ban prohibited manufacture, sale, stocking, transport, and use of certain single-use and "throwaway plastics," including plastic carry bags, plastic film for food wrapping, plastic to-go plates, plastic coated teacups and tumblers, water pouches and packets, plastic straws (Environment and Forest Department, 2019). Stakeholders presented conflicting opinions on the validity and possible effectiveness of the ban. The ban seemed to result in an initial decline in use of plastics but was not effective in limiting plastic use on long term according to some interviewees.

> **"There was a difference at least in Chennai anecdotally when you're going to the market and the shops. There was a decrease in those extremely flimsy plastic covers that you see in these fruit and veggie markets. Now they're back with a vengeance. Everybody's gone back to that."**
>
> **— NGO**

Reasons for why the ban is seen as ineffective include inconsistencies in enforcement and lack of research into affected industries and everyday uses of plastics. The lack of available alternatives to plastics results in industries continuing to use plastics to keep operating. Until suitable alternatives are presented to replace the use of plastics in industries and everyday life, interviewees expected the use of plastics to continue even with the ban. Lack of enforcement and unpredictability in when police will levy fines for plastic use is also not discouraging industries or consumers from using plastics.

> **"We did [the brand audit] in 2019 and then we did again in 2021 to check how effective is the ban. We gave the data to the Greater Chennai Corporation. We submitted it personally to the Commissioner of Greater Chennai Corporation. We told them that the ban is absolutely not in effect, what are the things they can do, rather than just putting a blanket ban, how they can improve it."**
>
> **— NGO**

> **"It's just to get the public sentiments going. Practically, it's not possible to ban. Plastic is such a key part of our lives today. It's in every industry. Any plastic you ban today, it affects livelihood in a big way."**
>
> **— Private Waste Company**

Despite widespread concerns over the effectiveness of the ban so far, some stakeholders expressed that there might be a role for a ban or version of a ban in the future. Some interviewees placed emphasis on targeting manufacturers of plastics and holding them responsible for limiting plastic use.

> **"Police come to the shops and fine for the use of plastic carry bag, but they don't fine the manufacturing factories. They let them get away and fine the small shops owners."**
>
> **— Shop Owner**

> **"Only thing is, for the large companies, the big brands, they have to come out with some kind of alternative materials basically for packing."**
>
> **— Organic Shop Owner**

Other stakeholders, however, felt plastic bans were unnecessary as long as EPR was in place and effective. They also cited some plastics they felt were being dealt with effectively or were important in revenue streams and therefore didn't need to be included in a ban.

> **"We are part of several industry consortiums…where we brainstorm on the policy aspect and other related aspects such as when a ban comes in from a state then how do we need to go about doing the advocacy, telling the government that brands are anyways doing EPR collecting back plastics that they are putting out. Why do we need to go ahead with any ban?"**
>
> **— Industry**

> **"Similarly, for PET, it is not an issue at all. So why should you have bans in states in the name of single-use? Because that is not a plastic which is creating an issue at all. Lot of livelihoods are dependent on the recycling for PET."**
>
> **— Industry**

Stakeholders also mentioned the importance of having a solution before policies are put in place. Either there needs to be alternatives readily available both on the consumer side and manufacturing side or a system of circularity needs to be in place in order for policies that seek to limit plastics – particularly non-recyclable and single-use plastics – to be effective.

> **"Yes, there needs to be a ban on items which are not recyclable. Because we don't have a solution for these plastics when they both become a waste, unless something like what we are trying making it into. When we have more plants in Chennai to go big plastics into oil then it make sense. If you don't have a solution upfront or if you don't have an alternative, at least downstream if you can make it circular. Then it makes sense allowing these two. When you don't have both then it is difficult, but we were all used to that lifestyle."**
>
> **— Academic**

> **"Again, in terms of packaging, while for these brands we work on EPR side of it, we are also working in parallel on sustainable packaging. We have made a global commitment that 100% of our portfolio will be either biodegradable, compostable or recyclable. For India, we are really looking at recyclable opportunities."**
>
> **— Industry**

Furthermore, stakeholders have seen changes in customer behavior surrounding the use of plastics, specifically through the limited use of plastic bags. A shift toward reusable bags has been made and is occasionally enforced by local shop owners who provide alternatives to plastic. Voluntary use of cloth bags in substitute for plastics shows that the public could be receptive to change when it comes to more sustainable alternatives. The effectiveness to which that change is made would depend on policy implementation, incentives, and the widespread availability of effective alternatives to plastic products that can be properly disposed of or reused.

> **"Yes, there are many changes. There are customers who buy a single lemon or two and they have a carry bag with them for that. There are a lot of people who do that now. I even fought with a customer who wanted to get a plastic bag. There are still a lot of people who will bring the cloth bag. 99% of customers who do not use a plastic bag either bring their own bag or buy it from us."**
>
> **— Shop Owner**

> **"Fabric can be used. Anything can be used but people should get used to it. Plastic use will be reduced if plastic is banned a hundred percent."**
>
> **— Shop Owner**

> **"As long as the material can be used multiple times and for longer duration, then all the carbon and water footprint which went into it makes sense. That way I think cotton bags should be popularized, can be reused, washed then reused."**
>
> **— Academic**

Interviewees also highlighted that changes in behavior can be encouraged through education of both citizens and employees of the waste sector.

> **"In terms of solid waste management, if you are asking me, first priority by the Greater Chennai Corporation should be given to educating the citizens, first and foremost. I think the second one is educating the staff, right from zonal officers to your conservancy inspectors, conservancy workers, and people who are working in this MCC."**
>
> **— NGO**

> **"I think that education is missing for the lowest level employees and all. I think with all the climate change also they should make them understand why we are doing this. More like look at it as a resource management work than a waste management work"**
>
> **— NGO**

> **"We've conducted programs where we have recognized the best school who have collected**

> **the most volumes of waste, recognize the children, exhibit the leadership in that space and have asked them not to litter but collect plastic waste from their households and also deposit it in a dust bin in schools, which is then collected by our waste picker."**
>
> **— Industry**

Education could also play a major role in helping advance the complexities of the waste management system of the city. Interviewees expressed frustration over the lack of progress the city has made stating that the focus of waste management has been on collection, to the detriment of, for example, the reduction of waste or waste disposal possibilities in public spaces.

> **"Like you said, we've had Ramky, Onyx, the corporation itself, and then now Urbaser Sumeet, and fundamentally nothing has changed from what I see largely because they're following the same basic process. They're focused on collecting everything that they can and taking it away from the street. That's sort of superficial — ensure that the streets don't look dirty and the people don't get upset by garbage on the roads kind of situation."**
>
> **— NGO**

> **"They're not seriously looking to understand the waste and break it down to how do we reduce our waste and how do we handle the waste that we have in an appropriate manner. Both in terms of environment and health."**
>
> **— Local government**

A major concern about waste collection is the segregation of waste at the source. There is a disconnect between segregation efforts done at the individual level in the household and municipal policy of segregation for collection. Some interviewees felt individual efforts to segregate were null due to mixing during collection, and that uncertainty of whether waste is actually kept separate only further discourages individuals to continue to segregate waste. Additionally, if not all residents are required to segregate, efforts from the collection side to keep waste segregated become ineffective.

> **"Segregation is a challenge, but then a bigger challenge, and people are losing interest in segregation because they see the ways to get it mixed up. The biggest challenge is developing these technologies to take care of the segregated based completely to its end of life."**
>
> **— Academic**

> **"It's always seen like somebody is segregating. There is a segregating division that complains about the collection system, the collection system complains about the segregation system. This is an ongoing war that goes all over this."**
>
> **— Private Waste Company**

> **"They're not going to worry about the label on the bin saying Wet Waste, Dry Waste and all of that. You peek into the bin and it's all mixed anyhow. Then the compactor anyway comes at 10:00 in the night and takes everything. Then you become the idiot for doing all this segregation kind of work."**
>
> **— NGO**

Existing efforts from both individuals and collectors in Chennai to keep waste separate indicate that there is indeed community support for waste segregation. Collaboration and clear instructions on how and when individuals should separate their waste could help increase the number of households that segregate. In addition, collection agencies should be transparent in how segregated waste is handled, especially when collection bins for entire streets are used. Having clear communication and instructions involving waste segregation from the point of household segregation through collection and disposal on the other end might help mitigate confusion around waste segregation.

However, opportunities for improvement in waste management do not end at including waste segregation into the collection process. The use of the informal sector has the potential to increase recycling and the control of plastics in the community in Chennai.

> **"I think there's no real, serious recycling happening from the formal sector through these kinds of projects. It's really informal recycling, that's waste pickers going and picking up the materials from the dump sites and things like that. Whereas the formal infrastructure's just purely doing that thing. This new Urbaser contract in Chennai, at least, they're supposed to be doing some recycling, but I'm not sure. Somebody has to visit their site and do some numbers, I don't know."**
>
> **— Private Waste Company**

> **"...there is a dependence on the informal sector which is the waste picker."**
>
> **— Industry**

The deep knowledge of waste collection and recycling among informal waste workers means they are essential members of the waste management community that can provide advice on recycling and mitigating plastic waste. Because they already collect valuable materials for their livelihoods, they could be important drivers in the expansion of the waste collection system, and their knowledge of the waste stream and their experience could be valuable for making improvements. Currently, however, the informal waste sector is largely underrepresented in decision-making and their contributions are not widely recognized. There are barriers to getting them involved in more formal waste collection and incorporating them into waste collection schemes, such as legal barriers due to the lack of formal recognition or organizing groups.

> **"If we prioritize data collection, if we prioritize integrated solid waste management principles, and really look at the informal sector in a decentralized network, that's very powerful to do**

certain things. You use them the way they are working already or you leverage them. I think that is very exciting. India can have its own narrative on a circular waste management system."

— Private Waste Company

"I think the bigger problem you see in the bylaws is you have to incorporate them. It's easy for them, but when they have also a legal loop, which says they're not formally recognized, so we can't put them in the systems which government has paid. If you don't formally recognize them and give ID cards or something, until then you can't include them in any government schemes or something."

— NGO

"...there is something underway that we are working on, primarily to drive economic resilience of the waste picker network because they are the ones who are the most vulnerable section of the value chain. They are the ones who are most critical. They are the backbone of the entire waste collection industry. We are trying to do a pilot for them working out on entrepreneurship opportunities and how you really provide them financial inclusion, social inclusion, so those sort of things."

— Industry

It is critical to note, however, that the quality of life for informal waste workers is often poor and that they work in extremely challenging environments. Workers in the informal waste sector that were interviewed identified the lack of health services as a major obstacle for their work. In order to capitalize on their knowledge and maximize their efforts, certain measured should be put into place to ensure their health and safety through their livelihoods.

"Our health is in constant decline. During the vaccination camp they gave us vaccination twice. Apart from that we have nothing with regards to health services."

— Waste Picker

"They also do not allow those who want to come and support or help ragpickers. They don't offer us any corporation jobs. Those jobs are available only to those who have the recommendation of the authorities."

— Waste Picker

Throughout interviews stakeholders emphasized the importance of consistency to produce real results in waste management and plastic regulation. Government policies need to be clear in their intent and restrictions, consistently enforced, and applied to all stakeholders including manufacturers. Increased transparency will also allow for clarification when policies such as EPR are being followed. Additionally, it is important to consider the availability of plastic alternatives when drafting such policies and consider how alternatives or lack thereof will affect either an industry

or consumers. Cooperation and clear communication are important between collection agencies and households so that waste segregation can be accomplished effectively. The informal sector, their livelihood, knowledge of waste, and their health and safety should also be considered when developing new waste management strategies and they are an important stakeholder in the decision-making process. Looking at policies and enforcement holistically so that solutions can be in place before policies are implemented will result in more effective waste management and plastic reduction throughout the city.

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 Chennai as described in the Input section.

Figure 5: Examples of commercial areas and convenience stores sampled

(Photo Credit: Okapi Research & Advisory)

The average weight of both the packaging and the product itself were collected for all 272 samples (Table 3). Biscuits were added as a separate category for product analysis in Chennai as they were an abundant proportion of goods sold in grocery stores and shops in the city.

Table 3: Average weight of products and their plastic packaging for common convenience items (not including unknown products)

Product Type	Product Count	Average Weight of Plastic Packaging (g)	Average Quantity of Product (g)
Beverages	70	576.62	25.23
Candy	63	29.97	1.71
Snacks	64	69.29	4.43
Tobacco	6	13.50	2.70
Biscuits	69	94.91	4.20

Among the top brands in convenience stores samples, there were 15 different categories of materials observed (Figure 6). A wider variety of packaging materials are more common in very urbanized environments, which can be a challenge for recycling which required volume to achieve economies of scale. Multilayer plastic film was the most abundant material type for packaging. Nearly 50% of products had some form of multilayer plastic film, with varying plastic polymers included, and combinations of materials that included single-layer plastic film comprised over 15% of top items. The second most common packaging type among top consumer products was PET, which typically has a relatively high value in the informal waste sector. Overwhelmingly, the top consumer products were packaged in multi-material packaging, which can make it difficult for sorting and waste management, both from the consumer and the practitioner perspective.

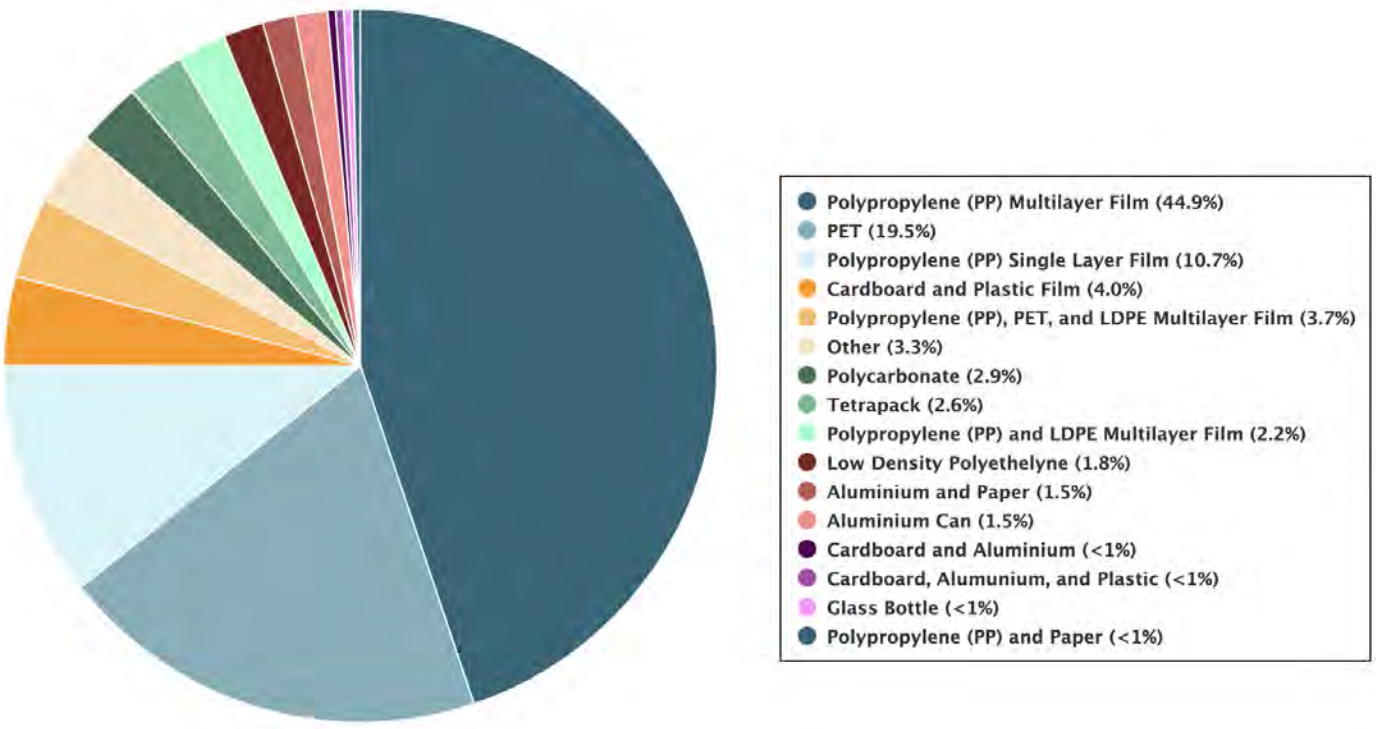
Figure 6: Examples of top (left to right) biscuit, tobacco, beverage, and chip products in convenience stores in Chennai

(Photo Credit: Okapi Research & Advisory)

Of the top beverage products, 51% were packaged in some form of plastic bottle, while 36% were in aluminum containers, 8% in Tetrapak, 4% in glass, and the rest had multiple types of packaging. Of the candy products, 43% were packaged in multilayer plastic film and 22% were in clear plastic film. Only 5% of the candy products were packaged in a material that didn't contain any type of plastic, which was plain cardboard without an aluminum and plastic coating. Of the snack products category, which includes chips, bars, cookies, and nuts, the vast majority (90%) were

packaged in multilayer plastic film and another 8% were in clear plastic film. Only 1% of snack products were not packaged in plastic, which were chip products from Pringles brand packaged in cardboard, but these did contain a plastic lid, metal bottom and the paper was coated in plastic, which is a design that is typically not recyclable. Popsicles were another popular convenience item and they were all packaged in either multilayer or clear plastic film. Among the containers for yogurt, another popular convenience item, half were made of PP and the other half were split between HDPE and PS. All of the top tobacco products were packaged in cardboard and wrapped in plastic film.

Figure 7: Breakdown of material type for convenience item packaging

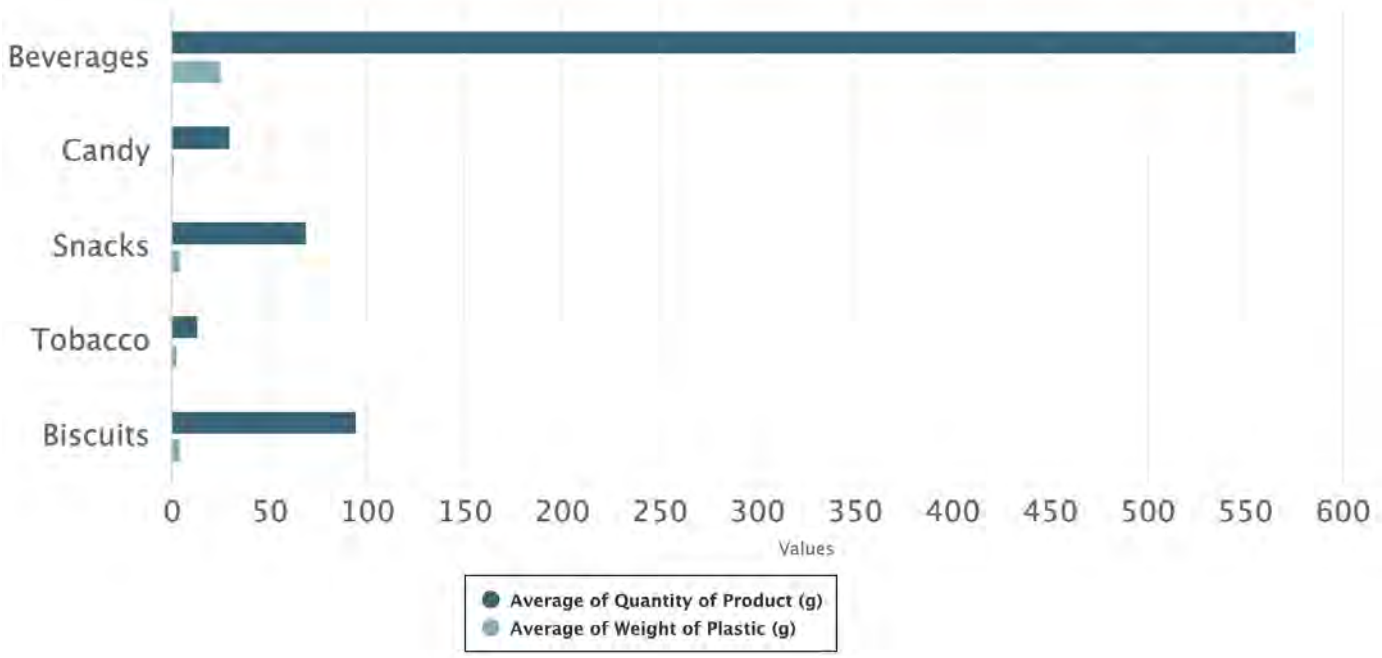


From the CAG brand audit conducted in 2018, 68% of the 3,073 packaging litter items documented in Chennai were multilayer/composites/laminates. The majority (73%) were categorized as food packaging, which also accounted for 90% of plastic litter items audited across all cities in India that were sampled (Shekhar 2018). From the 2020 household plastic waste audit conducted by CAG in collaboration with colleges in Chennai, 32% of the plastic items collected by count was multilayer plastic. Half of all the household plastic waste was comprised of the most commonly recycled plastics, including PET, HDPE, LDPE, and PP. Of that half, 78% (or 40% of the total) was LDPE, which were predominantly milk packets. It was also noted that 15% of the items collected did not have a resin number associated with them. The report emphasizes that, according to this data, there may be an opportunity to divert over ⅓ of household plastic waste from the dump if LDPE food packaging such as milk packets were readily recyclable or if there were effective EPR measures in place for brands to collect those items back (CAG 2021). Currently, however, there are not many methods of readily processing packets apart from incineration, and not all informal waste systems are able to handle them.

> **"Milk packets can be usable, but we hardly get any milk packets. There is no person to process all this. We don't have a system."**
>
> **— Scrap Shop Owner**

Among the top convenience brands sampled in the CAP, beverage items had the highest average weight of both packaging and product and had the lowest proportion of packaging to product weight among convenience items. Tobacco items had the lowest average weight of packaging and the lowest proportion of packaging to product weight. Candy products had the lowest average weight of plastic packaging overall.

Figure 8: Convenience store plastic to product ratios, shown in grams (not including unknown products or tobacco as there is no weight data for tobacco)



Within each of the selected nine 1km^2 transects in Chennai, the LIP also visited at least three randomly selected food vendors or to-go restaurants to sample the food packaging and utensil types that were being distributed, totaling 28 vendors sampled. The LIP collected 104 to-go items from those vendors and documented their weight, material type, and brand, where possible (Table 4).

Figure 9: Examples of eateries samples for to-go products

(Photo Credit: Okapi Research & Advisory)

Among the to-go items sampled in Chennai, there were multiple types of materials identified, including a wide range of degradable plastic and organic alternatives. While the largest proportion of material type was plastic (around 40% of to-go items sampled), there were also large proportions of organic and fully degradable (ie. degradable in a properly managed landfill) items such as natural fibers, as well as high-value recyclable items such as aluminum. Cloth, glass, and compostable plastic were noted as being provided at an additional cost to consumers, whereas single-use plastic items were consistently offered at no cost.

Figure 10: Breakdown of material types for to-go items

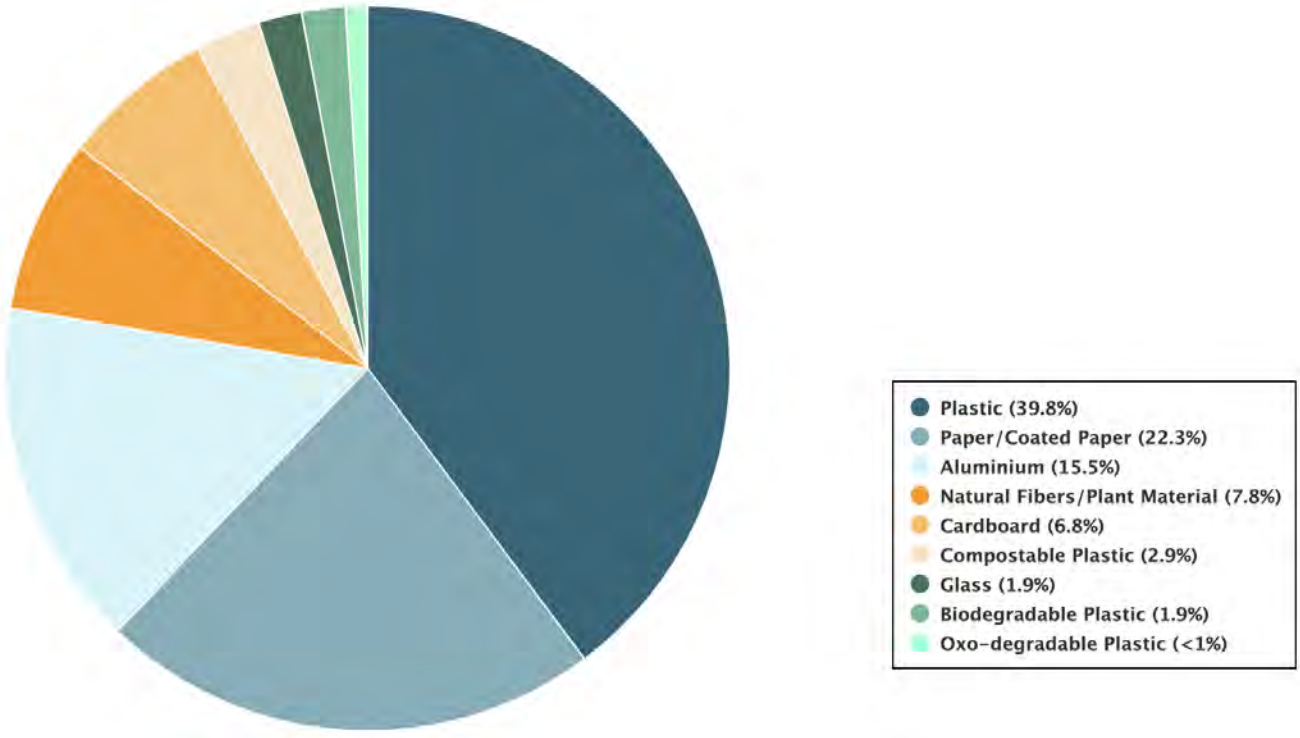
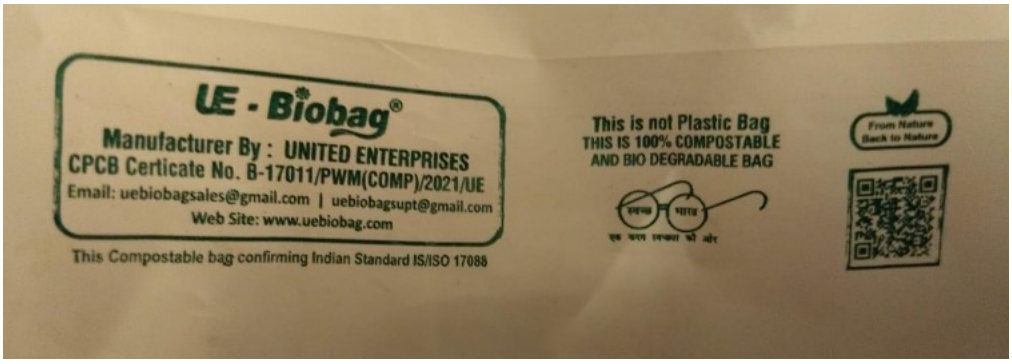


Figure 11: Examples of plastic to-go ware from surveys in Chennai

(Photo Credit: Okapi Research & Advisory)

It is worth noting that confusion can be caused by the misleading nomenclature and lack of clear labeling on the different types of plastic, particularly pertaining to biodegradable vs. compostable vs. oxo-degradable. Based on the CAP survey, compostable plastics were often clearly made of natural and organic material, though those that did have clear labels didn't necessarily indicate the best mode of disposal (such as backyard compostable vs. industrially compostable). Oxo-degradable and biodegradable plastics were often denoted with a label or stamp to explain what they were, though some labels like the one shown below would indicate that the material was both compostable and biodegradable. While some items such as plastic bags did have appropriate material type labeling, consumers may be confused about how best to sort and dispose of these items, both if the material itself is unclear and if the disposal method associated with the material is unknown. These issues present opportunities for discussions and collaborations with manufacturers.

Figure 12: Example of compostable labeling on certified plastic bags from a food vendor in Chennai



(Photo Credit: Okapi Research & Advisory)

Table 4: Material type and average weight of common packaging items from food vendors and restaurants in Chennai

Product / Material	Number of Samples	Average Weight of Packaging (g)
Bag	**17**	**15.65**
Plastic	6	4.43
Paper/Coated Paper	6	34.61
Compostable Plastic	3	5.04
Biodegradable Plastic	1	10.11
Oxo-degradable Plastic	1	6.60
Bottle	**2**	**186.88**
Glass	2	186.88
Bowl	**2**	**115.00**
Plastic	1	115.00
Plastic	1	6.70
Box	**13**	**22.78**
Cardboard	5	29.17
Aluminium	4	12.67
Plastic	4	24.93
Cover/Envelope	**4**	**2.88**
Aluminium	2	3.55
Plastic	1	0.52
Biodegradable Plastic	1	3.91

Product / Material	Number of Samples	Average Weight of Packaging (g)
Cup	**14**	**6.56**
Paper/Coated Paper	10	3.91
Plastic	4	13.18
Food Container	**8**	**12.76**
Plastic	4	12.71
Aluminium	3	10.26
*Natural Fibers/Plant Material	1	20.46
Pouch	**8**	**10.80**
Aluminium	5	16.94
Plastic	3	0.56
Sheet	**4**	**4.71**
Paper/Coated Paper	3	5.09
Aluminium	1	3.55
Spoon	**4**	**1.79**
Plastic	2	1.43
*Natural Fibers/Plant Material	2	2.16
Straw	**3**	**1.06**
Paper/Coated Paper	2	1.32
Plastic	1	0.55
Tray	**14**	**55.55**
Plastic	10	60.58
Paper/Coated Paper	2	3.08

Product / Material	Number of Samples	Average Weight of Packaging (g)
Cardboard	1	140.80
*Natural Fibers/Plant Material	1	25.00
Other	**8**	**21.87**
Plastic	4	22.95
*Natural Fibers/Plant Material	2	27.02
Banana Leaf	2	Unknown
Aluminium	1	12.57
Cardboard	1	16.56

*Natural Fibers/Plant Materials include products made of the following materials: banana leaves, corn-based fiber, jute fiber, sugar cane fiber, or wood.

Use

There are several policies in place regarding the use and disposal of solid waste and specifically plastic in India, including the Plastic Waste Management Rules of 2016, the Municipal Waste Management and Handling Rules of 2020 and the Recycled Plastics Manufacture Usage Rules. Bodies exist to advise on this work as well, including the National Plastic Waste Management Task Force and the Committee on Urban Solid Waste Management in India (Aiyavoo 2018).

Figure 13: Example of plastic bag from convenience store in Tharamani

(Photo Credit: Okapi Research & Advisory)

From the CAP fieldwork, the LIP noted that there are some visible changes being made based on the plastic ban, though adoption has been varied. Some shops reportedly used sugarcane containers, though the cost became difficult to manage after the COVID-19 pandemic. Some shops are changing to aluminum items (15.5% observed in CAP), which has a high value in the informal sector. Banana leaves and other natural alternatives are also seen in the city (7.8% observed in CAP). From the CAP survey, however, nearly 40% of to-go items documented were plastic, many of which are included in the Act of 2002, which indicates that existing levels of adoption and/or enforcement have not been sufficient. Some interviewees noted that while some changes were seen when the ban initially went into place, the changes were not sustained.

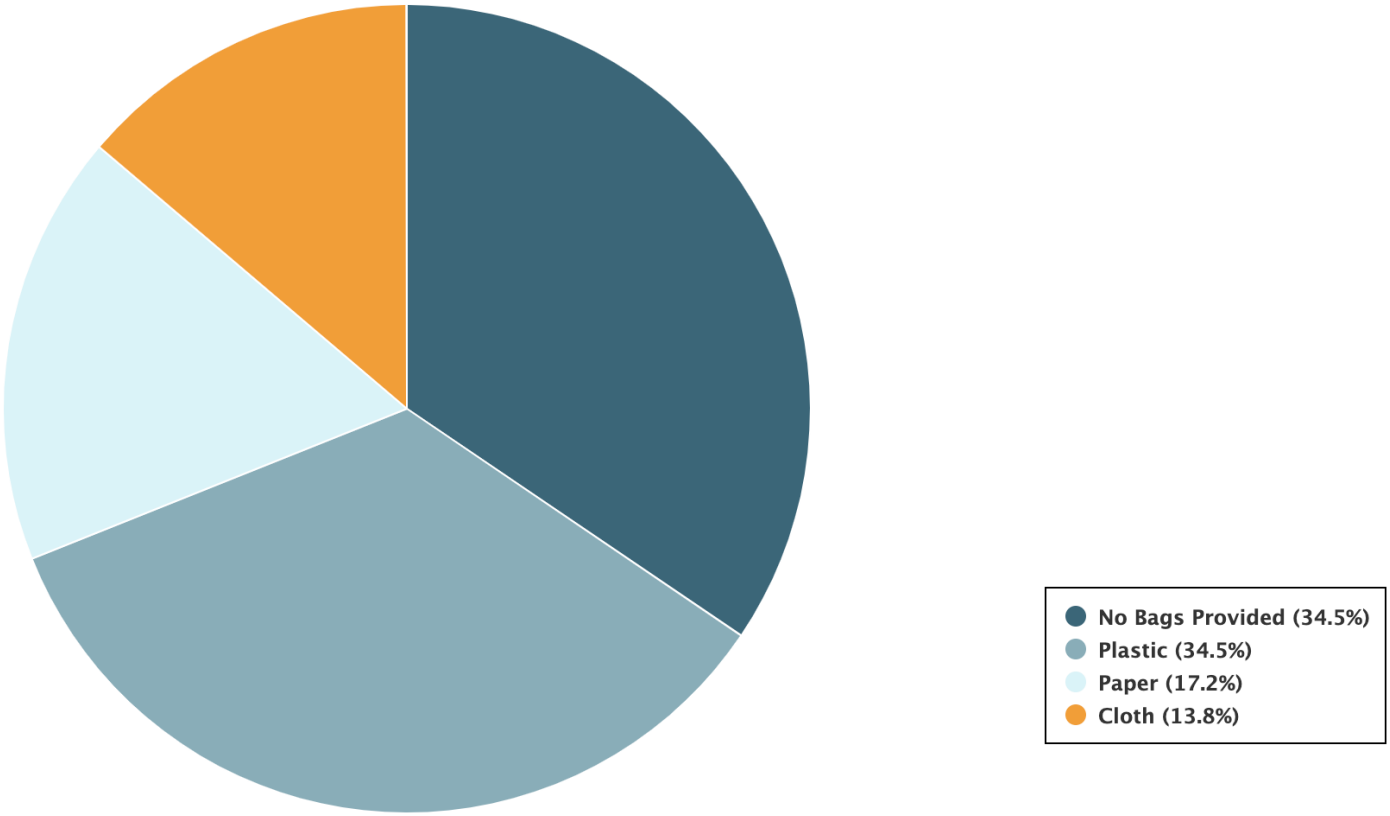
> **"There was an initial two months decline in usage [following the plastic ban]. But it did not last long."**
>
> **— Shop Owner**

Several others expressed frustration that more was not being done to reduce plastic waste at the manufacturing level. The need for viable, affordable, and readily available alternatives in the face of a plastic ban was also noted.

> **"It [plastics] can be [banned], but we need to find a solution before we do that."**
>
> **— Shop Owner**

> **"Stopping manufacturing is the best way forward, but nobody's willing to do that. Stopping the ones which one time use plastics, then people will automatically find a solution."**
>
> **—Academic**

Figure 14: Material breakdown of bags from convenience and grocery stores



Among the 26 convenience stores sampled in Chennai, around the same percentage (34.5%) provided plastic bags as those that did not offer bags to consumers. This could be a promising sign for phasing out single-use grocery bags, as part of existing mandates in Tamil Nadu. Among those that did offer bags, there was also a relatively large proportion of vendors that offered paper or cloth bags, suggesting that a switch away from plastic may be plausible for consumers in the city. Zero-waste grocery stores have also started opening in Chennai in recent years, such as EcoIndian and Madras Soapery, and local transportation infrastructure has also been working towards becoming more circular, such as the plans for the Chennai Division of the Southern Railway' Chengalpattu railway station to become a model for zero waste (The Hindu 2021).

Figure 15: Examples of plastic to-go ware from surveys in Chennai

(Photo Credit: Okapi Research & Advisory)

The Indian Ministry of Environment's Standard Guidelines for Single Use Plastics (2019) include examples of legal and policy options for prohibiting single use plastics and case studies where successfully implemented. However, the guidelines do not offer options for multi layered packaging (MLP), as it notes that no adequate replacement technology exists (Chandran 2021). As this is the most common packaging among top convenience items in Chennai and also among the most abundant litter items, it is worth the city exploring targeted ways of addressing multi layered 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 Chennai could explore.

Table 5: Cost of alternatives to plastic from stores and food vendors

Alternative Material Type	Cost to Consumer
Aluminum	No Cost to Consumer
Banana Leaf	No Cost to Consumer
Cardboard	No Cost to Consumer
Cloth	RS 8 – 18
Glass	RS 0 – 12
Paper/Coated Paper	No Cost to Consumer
Biodegradable Plastic	No Cost to Consumer
Compostable Plastic	RS 0 – 10
Oxo-degradable Plastic	No Cost to Consumer
Wood	No Cost to Consumer

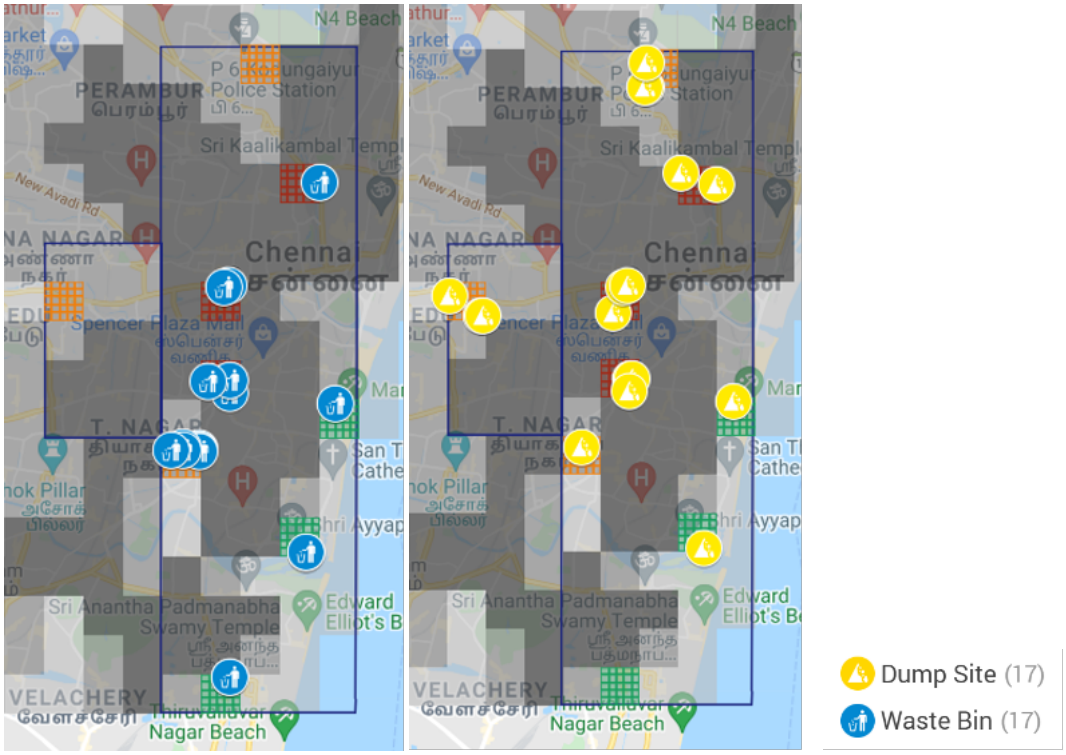
Alternative Material Type	Cost to Consumer
Sugar Cane Fiber	No Cost to Consumer
Corn-based Fiber	No Cost to Consumer
Jute Fiber	No Cost to Consumer

From the CAP surveys, it was noted that the majority of plastic to-go product alternatives available to customers from stores and food vendors were available at no additional cost to the consumer. The exceptions were for products that included cloth, glass, and compostable plastic, where the additional cost ranged from 0 to 18 rupees. This demonstrates buy-in from vendors to phase out certain single-use items and an availability of alternative options, ideally with little to no additional cost for consumers. As the implementation of relevant rules and regulations continue in Chennai, there could be opportunities for sharing of lessons learned among companies that have successfully made the transition and that have found a way to profit from the transition as well.

Collection

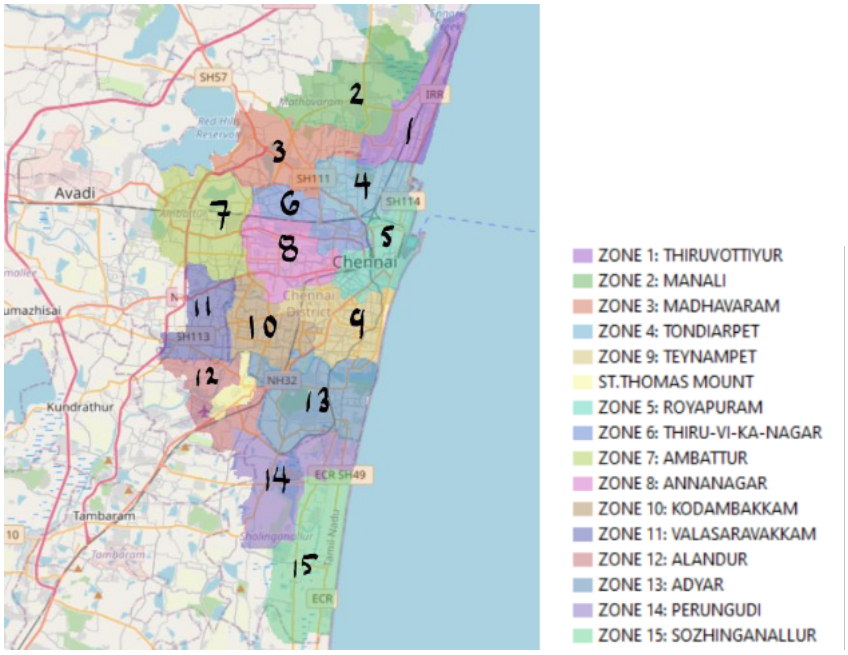
During the litter transects as part of the CAP fieldwork, the LIP documented whether there were any existing waste bins, recycling bins, ash piles, or dump sites within the study area. No public recycling bins or ash piles were documented as part of the transects. A total of 17 public waste bins and 17 dump sites were documented, as shown on the map below.

Figure 16: Locations of public waste bins and dump sites from litter transects in Chennai



Solid waste management in Chennai is managed by the Municipal Corporation of Chennai, which is known officially as the Greater Chennai Corporation (GCC) and was formerly known as the Corporation of Madras. GCC employs 5,686 permanent and 4,427 contract workers for solid waste management activities, and private operators have 9,505 workers for carrying out these operations. Solid waste in Chennai is collected from 200 wards in the 15 zones in the city, both door-to-door and from community bins, which according to the GCC covers 95% of households overall, or the equivalent of roughly 5,100 tons of waste per day (Nileena, 2016; GCC 2021). Estimates for waste generation in Chennai range between 4,500 – 6,400 metric tons of municipal solid waste per day, with an average per capita of 0.71kg/day, the highest in the country (Nileena, 2016). GCC operates 293 battery-operated vehicles, 97 battery-operated tricycles, 136 HMV/LMV compactors, 18 HMV/LMV tippers, and 16 mechanical sweepers. Other private waste companies in Chennai operate 3,071 battery-operated vehicles, 130 HMV/LMV compactors, 80 HMV/LMV tippers and 39 mechanical sweepers. GCC also reportedly has special equipment such as amphibian vehicles and robotic multipurpose excavators for clearing floating garbage in canals as well as vehicle-mounted machinery for clearing stormwater drains (Government of Tamil Nadu, 2021).

Figure 17: Waste Collection Zones in Chennai



GCC has been in the process of privatizing waste collection in Chennai since 2000, when the first private contract for waste collection in the city was awarded to Onyx Private Limited for the duration of five years (Kumar, 2017). However, the benefits and drawbacks of privatization are debated among the citizens of Chennai, and the contracting entities have changed over the years. Zones 1-3 and 7 are currently managed by Ramky Enviro Engineers Pvt. Ltd (Figure 19), Zones 9-15 are managed by Urbaser Sumeet (Figure 18), and Zones 4-6 and 8 are managed by GCC (Figure 20). All processing and waste treatment, including micro-composting centers (MCCs), material recovery facilities (MRFs), and landfills, is still managed by GCC.

Figure 18: Examples of waste collection by Urbaser Sumeet in Tharamani

(Photo Credit: Okapi Research & Advisory)

The most recent private contract for solid waste management was awarded to Urbaser Sumeet from GCC initially

for seven zones in Chennai in 2020 for an eight-year period. Upon launch, Urbaser Sumeet announced that it would install over 8,800 garbage bins and deploy over 6,000 workers, 92 compactors, 21 mechanical sweepers, and nearly 2,000 e-rickshaws for door-to-door household waste collection (The Hindu 2020; See Figure 18). According to interviews, Urbaser Sumeet currently uses 125 compactor trucks with three different capacities that cover 10,704 bins, with 438 drivers and helpers. The company estimates that 10,066 tonnes of carbon are saved by the use of their electric collection vehicles every year. They also reportedly use 38 mechanical sweepers and a series of street sweepers.

Figure 19: Example of waste receptacle owned by Ramky Enviro Engineers Pvt. Ltd in Arumbakkam from Zone 2

(Photo Credit: Okapi Research & Advisory)

Based on a study in 2018, it was estimated that 32% of waste in Chennai was compostable matter, and recyclable components included paper at 6.6%, plastics at 1.5% and metals at 2.5% (Aiyavoo, 2018). Interviewees provided more recent estimates, stating that 45% of MSW in Chennai is biodegradable, around 19% is recyclable, and another roughly 20% is dry waste that is not recyclable. Other studies have found that the majority (68%) of municipal solid waste generated in Chennai is residential waste, 16% is commercial or store waste, 14% is institutional waste from offices or other businesses, and the remaining 2% is industrial or C&D waste (Nileena, 2016). GCC services include door-to-door collection, street sweeping, and removal of specific public bins (see Figure 20).

In 2016, a provision was made to the Solid Waste Management Rules mandating source-separation of waste at the household level for the city of Chennai. In 2017, GCC launched an initiative in support of that provision, requiring its workers to collect only biodegradable waste daily and collect separated recyclable waste weekly. Awareness drives were held in each zone by GCC to support outreach of these new practices (Kumar, 2017). Source-separated waste was planned to be collected at the household level in zones managed by GCC via tricycles or light motor vehicles, whereby wet waste would be collected on a daily basis and sent to a decentralized waste processing facility, and the dry waste would be collected weekly and sent for recycling, to transfer stations, or to dump sites (GCC website). However, interviewees noted that implementation and enforcement of source-segregation is not consistent across the city, and that the system is not always convenient or straightforward to residents. The Chennai City Action Plan

for 2021 reported a segregation rate of around 44.6%, but most interviewees agreed it was likely closer to 25% (GCC 2021).

> **"There is also no mechanism. Even if there's multiple bins, you don't have a mechanism to ensure that everybody's putting it in the right bin. Even they're just segregating the dry stuff from the wet waste. Even if your wet waste is going in a plastic bag or whatever, just keeping that dry and wet separate, you don't have a mechanism and you have bins at the end of the road."**
>
> **— NGO**

> **"Segregation is a huge issue. Much of the waste because its unsegregated ends up in the landfills. We need higher capacity of infrastructure to treat and sort the waste. The current capacity of Micro Composting Centres (MCCs) and Material Recovery Facilities (MRFs) is not enough. The efficiency of sorting and managing at these treatment facilities also needs to be stepped up."**
>
> **— Local Government**

Figure 20: Example of coastal waste collection by GCC at Marina Beach in Zone 9

(Photo Credit: Okapi Research & Advisory)

There are 7 transfer stations available to GCC in Chennai that receive 3,600 tons of waste daily. Waste is either transferred directly from street collection to the appropriate disposal site or from a transfer station to disposal site (GCC website).

Several private companies and civil society groups that support waste management and zero-waste efforts also operate within Chennai. Among these groups is Earth Recycler, Waste Winn, Paperman, Bintex, and several others. RWAs such as ROKA are also often engaged for awareness and outreach. Saahas Zero Waste, which also provides

services in Bangalore, Goa and Hyderabad, operates in Chennai as well for waste management solutions and education and outreach efforts to corporations, residential areas, and schools within Chennai (SZW 2020).

The informal waste sector plays a critical role in solid waste management and recycling in Chennai. This includes sweepers, collectors or pickers (sometimes locally called 'rag pickers'), waste dealers, and informal recycling industries. It has been estimated that there are between 80,000-100,000 informal waste collectors within Chennai — and as many as 3,000 within one given area, as they often operate exclusively within a given geographic location within the city — and that they recover about 400 tons of waste per day (Aiyavoo, 2018; CMD 2008). A survey conducted in 2018 found that 44% of the collectors in Chennai were female and 66% were male (though the paper notes that the time of day when the survey was conducted may have skewed the results); 45% were above the age of 25, 31% were between the age of 16 to 25, and 24% were below 16 years of age. The same study found that the majority of the waste collectors in Chennai were migrants from rural areas outside of the city, and that 97.5% of migrants reportedly came to Chennai looking for employment and ended up collecting waste as a means to survive (Aiyavoo, 2018). However, it is important to note that the makeup of waste workers in urban areas in India may have changed considerably since the COVID-19 pandemic.

Figure 21: Example of a scrap shop in Tharamani

Photo Credit: Okapi Research & Advisory)

There are reportedly four different types of waste collectors within Chennai (Aiyavoo, 2018):

1. Waste collectors who stay within their respective localities and hand-collect waste that has resale value from streets, drains, municipal waste bins, and open dumps
2. Waste collectors who use a bicycle with a partitioned sack affixed to collect and separately sell only specific items such as glass or plastic bottles
3. Waste collectors who use a tricycle to collect on average over 50 kgs/day of mixed waste, and who often travel long distances to sell the waste
4. Waste collectors who are committed to sell their daily collection to the waste dealers who employ them, and who also often sort waste for waste dealers and in return receive food and shelter

Table 6: Price of plastic sales for waste collectors in Chennai

Waste Material	Price at which waste is sold to scrap shop
Plastic Buckets	₹ 15 – 18 / kg
Paper	₹ 12 – 15 / kg
PET Bottles	₹ 10 – 12 / kg
Plastic Milk Packets	₹ 6 – 8 / kg
Plastic Carry Bags	₹ 1 – 2 / kg
Beer Bottle	₹ 1 / kg
Brandy Bottle	3 bottles for ₹1
Medicine Bottles	50 paise for 1 kg

(from stakeholder interviews)

Reportedly, the informal sector is often paid less than the standard rate for higher priced products, such as hard plastic bottles and glass. Waste collectors in Chennai also face a wide range of health threats, such as physical harm from hazardous waste collected, airborne diseases from landfill and dump areas, chemical poisoning, and many others. From a series of interviews in 2018, almost all the waste collectors reported occupational related health problems — 30% said they had respiratory problems, 51% had fever and skin diseases, and 19% said that they experienced all three problems. Almost all waste collectors interviewed collect waste on a daily basis and 85% said that they had no option but to do so as it was their only source of livelihood (Aiyavoo, 2018). The value of certain types of plastic in the informal recycling sector also appears to be in decline.

> **"My grandmother was a ragpicker and my mom is also a ragpicker. When my dad left my mom we came to this garbage mound. We started collecting waste here and that's become our life. I didn't even go to school. Not only me but everyone here is the same. The children who didn't have a father or a mother are the ones who became ragpickers. The plastics and bottles used to pay us well. Our work has become very difficult after the legal plan brought by Prime Minister Modi. Plastic items sell at ₹ 10, bottle at ₹5, card, notebook, iron, plate, water bottles all fetch us maximum of ₹500. For this we have to start work at 4 AM."**
>
> **— Waste Picker**

> **"Coconut shells go for ₹3 per kg. That's what they want to buy now. Plastics don't give us much these days. So we collect coconut shells. I would sell this and keep the cost for a meal. Now there is no one to buy it. The shopkeeper does not sell the goods in plastics or he'll get in trouble."**
>
> **— Waste Picker**

From the stakeholder interviews, adult waste collectors earn around Rs 600 per day. Unfortunately, children also reportedly collect waste at Rs 80-100 when they are assisting their parents. A waste collector with a tricycle reportedly earned Rs 200- 400/day in the early 2000s. After several years in this profession, they do not acquire any special skills and are not equipped for other occupations therefore they live in poverty and debt forcing them to continue with waste picking (Aiyavoo, 2018).

Figure 22: Waste collector in MRC Nagar

(Photo Credit: Okapi Research & Advisory)

Waste trade activities performed by informal sector stakeholders result in very significant waste material recovery and recycling. Almitra Patel of the Supreme Court committee for SWM estimates that waste that is source segregated could potentially earn Chennai up to 1 crore (or ten million) rupees a month and urged the Corporation of Chennai to formally employ waste collectors to clean up the city (Aiyavoo, 2018). This could present a significant opportunity for both the informal sector and the city to maximize waste collection and reduce waste leakage.

Chennai is also home to several entrepreneurs and innovators who have developed strategies to maximize waste collection and management in the city. One such example of Kabadiwalla Connect. According to their website, the organization is "determined that leveraging the already existing informal infrastructure towards a more efficient waste management system and it has potential to decrease the amount of waste sent to landfills in Indian cities by 70%." Their four main products include mapping of recycling supply chains, digitalization of the buying and selling of materials in the informal waste sector, procurement guarantees between waste collectors and buyers, and dignifying the field of waste collection and the individuals that work in the sector.

> **"Kabadiwalla Connect, that aspect was born from this journey where we realized that there were some business opportunities for us to pursue and develop this idea of a social enterprise where the goal was to holistically work with the informal sector and provide them a whole suite of solutions, try to solve the tough problems of waste pickers choosing between livelihood and their health."**
>
> **— Private Company (Kabadiwalla Connect)**

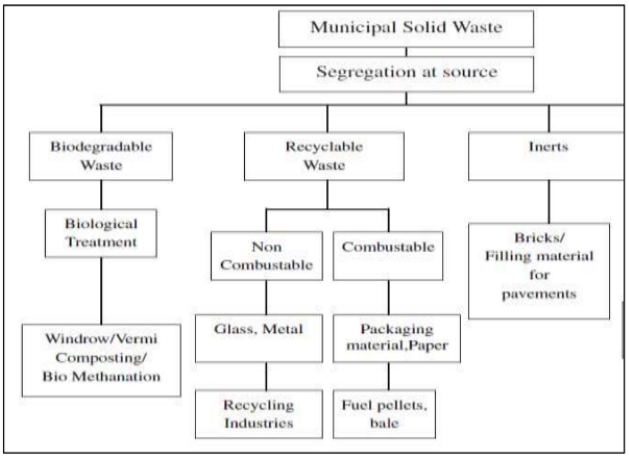
The privatization of waste collection in Chennai has reportedly had some positive effects, including several innovative models within private companies. The city has existing regulations for source segregation and collection measures to match, though effective implementation and enforcement is needed across the city. The informal sector plays a critical role but can be overlooked when new regulations are put into place and with respect to worker safety standards and pay. Many opportunities exist for both innovation and stricter adherence to policies and practices that are already in place to help reduce waste leakage.

End of Cycle

Every day, an estimated 4,500 – 6,400 metric tons of municipal solid waste are generated in Chennai (Nileena, 2016). Municipal solid waste generated in the city of Chennai is largely inert (35%) — which includes bricks, rubble, and material for paving — and green waste (32%), with both consumable and industrial plastic comprising around 7% of the waste stream in 2016. The vast majority, around 68%, comes from residential sources. E-waste is also a concern in Chennai, as over 26,000 tons of e-waste are generated in Chennai every year. The GCC Chennai City Action Plan of 2021 estimated that an average of 5,100 tons/day of solid waste is collected in the city, 4,428 tons of which on average go to landfill, which means that around 772 tons or 15% of solid waste in the system is either recycled or ends up as leakage. Of that 15%, an estimated 7% doesn't reach material sorting or recovery facilities while 8% is processed through official waste processing centers (GCC, 2021). With a booming tech industry, Chennai is one of the highest producers of e-waste in the state of Tamil Nadu, and proper management of e-waste is also becoming an increasing challenge (Government of Tamil Nadu, 2016).

Of the waste disposed of in Cerro Patacón, approximately 1,000 tons are from the Panama district and 350 tons are from the San Miguelito district. Other large components of the waste, totaling around 500 tons, are: waste from private businesses, sludge, tires, and hospital waste. A smaller fraction, around 50 tons, includes waste from street sweeping, park and garden maintenance, and bulk waste (Banco Interamericano de Desarrollo 2015).

Figure 23: Categorization of MSW in Chennai



(Government of Tamil Nadu, 2016)

Chennai has the largest land area of landfill when compared to all other Indian cities, over twice that of any other (Swati et al. 2018). There are two official landfills that service Chennai and are owned and operated by GCC. Local demolition waste is used as a covering layer for both facilities. The Kodungaiyur Landfill, which has been in use for over 40 years and covers an area of around 257 acres, receives an estimated 2,200 to 2,400 metric tons of waste daily from Zones 1-8, or around 45% of the total solid waste generated in the city. The Perungudi Landfill, which has been operating for over 30 years and has an area of 225 acres, receives a similar 2,600 to 2,800 metric tons of waste per day from Zones 9-15 (GCC website) (see Figure 25 for all Zones and Wards). Bio-mining (separation and use of the biodegraded material from other materials) has started at this landfill and is expected to be completed in three years, and bio-mining is being explored at Kodungaiyur as well. Bio-mining is not without controversy — the organic material needs be tested for chemical content and the non-biodegradable materials need to be managed again after separation.

> **[On biomining from landfills] "Basically the legacy waste, they dig it out and they sort it into different categories. Whatever is left behind after several years, they assume it is composted organic material and the ones which cannot biodegrade … They were segregating basically the decomposed waste and sending it to different places. The compost was sent to the farming community. They had a lot of rubble construction, and demolition waste also. They were sending it for landfilling. Then the plastic and other waste they were planning to have an incinerator. I don't know whether it is operational … There is no proper solution to the plastics they are digging out, the rubber they are digging out, the C&D waste they are digging out. This is the biggest challenge."**
>
> **— Academic**

Both landfills have been in operation for several decades and are reportedly nearing their maximum capacity (Nileena, 2016). Concerns have been raised regarding nearby groundwater contamination from the aging landfills to sensitive nearby environments. The total collection arriving at both landfills is around 5,400 tons daily, which — based on daily waste generation estimates for the city — means that very little waste is processed through other methods such as recycling. However, GCC has made some improvements to these existing landfills in Chennai in the last decade, including leveling, compound walls, 'green belts' and perimeter garden areas, construction of compost yards, and additional roads for transportation (Esakku et al., 2007; Government of Tamil Nadu, 2021).

> **"The problem is, a lot of material that people (including kabadiwallas) think is not recyclable ends up in the landfill, when they actually are. The aluminum boxes, plastic pouches used to tie sambar, masala packets, brown cardboard if stained etc. ends up in landfill. But most of these can be recycled. If you see the garbage bins — even the garbage liners are recyclable but ends up at landfills. If you look at it like that a lot of products that are recyclable end up in the landfill."**
>
> **— Private Waste Company**

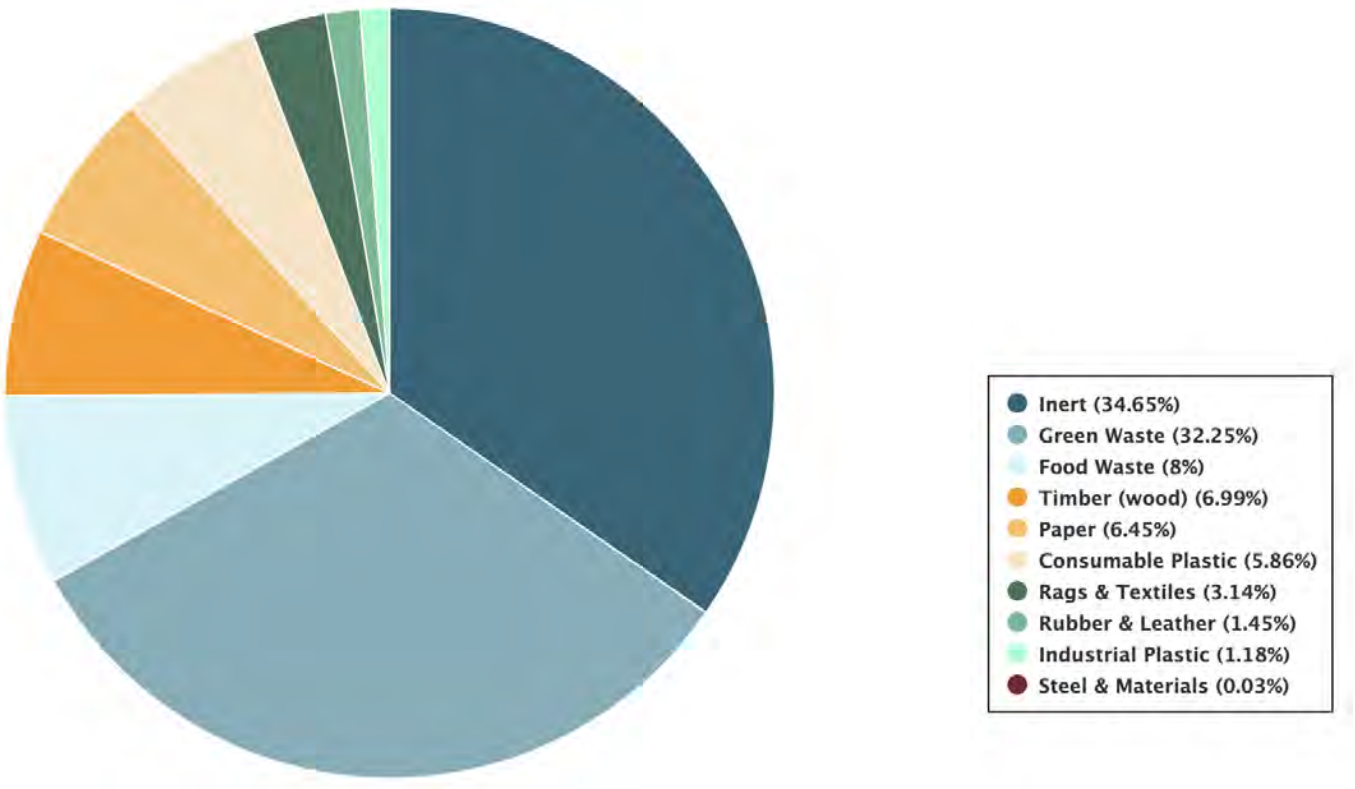
> **"We recommended [to GCC] that we cannot just let the groundwater flow into the adjacent, we have the Pallikaranai marshland. In the northern side that was also a marshland, but now**

> **I think, most of it has gone, occupied by the dumpsite. Everywhere sensitive water bodies nearby rivers and lakes and all those are getting under groundwater primarily."**
>
> **—Academic**

Non-recyclable and combustible dry waste such as multilayer plastic and film plastic is often sent to cement factories to use as fuel in the area. An average of 50 metric tons of this waste is sent for co-processing every week in Chennai (Government of Tamil Nadu, 2021). Some of those thin plastics from the dry waste collection are reportedly shredded and used specifically for bituminous road laying (pavement) in Chennai (GCC website).

> **"MLP [multilayer plastic] is not recyclable but can be reused to make boards. Cement factories also used MLP instead of burning coal. Instead of burning 1kg coal you burn 3kg plastics to get the same calorific value."**
>
> **—Private Waste Company**

Figure 24: Waste characterization in Chennai from 2016



(Government of Tamil Nadu, 2016)

Wet waste that is source-segregated in Chennai is composted in a decentralized manner. An estimated 245 wet waste processing facilities are operating in the area. There are a reported 166 compost plants that service Chennai — including micro composting centers, vermi-composting centers, windrow composting centers, bio-gas plants,

bio methanation plants, and bio-CNG plants—with a total capacity of around 1,218 metric tons/day. Some of the product is used for GCC parks and greeneries, including an estimated 400 metric tons of compost manure, and is also made available for sale to the public. An additional six bio-CNG plants with a combined capacity of 600 tons per day are under construction to process the wet waste in the city as well (Government of Tamil Nadu, 2021). From stakeholder interviews, there are mixed perceptions as to the functionality of these composting and biogas-to-energy plants in the city. In total across all different "phases," there are between 1 and 7 private service providers that provide solid or wet waste recycling to GCC (GCC website). Several interviewees noted that, with the constantly changing landscape in solid waste, the city still struggles to effectively manage its waste, and education is needed to ensure that new infrastructure is used correctly.

> **"Swachh Bharat has brought the focus on SWM. However, we still don't have the right know-how to deal with and manage the waste. The ecosystem is constantly evolving."**
>
> **— Local Government**

Figure 25: List of Zones and corresponding Wards within Chennai

LIST OF WARDS IN CHENNAI

#	ZONE	ZONE NAME	WARD NUMBER
1	I	THIRVOTRIYUR	1 - 14
2	II	MANALI	15 - 21
3	III	MADHAVARAM	22 - 33
4	IV	TONDIARPET	34 - 48
5	V	ROYAPURAM	49 - 63
6	VI	THIRU-VI-KA NAGAR	64 - 78
7	VII	AMBATTUR	79 - 93
8	VIII	ANNA NAGAR	94 - 108
9	IX	TEYNAMPET	109 - 126
10	X	KODAMBAKKAM	127 - 142
11	XI	VALASARAVAKKAM	143 - 155
12	XII	ALANDUR	156 - 167
13	XIII	ADYAR	170 - 182
14	XIV	PERUNGUDI	168 - 169 183 - 191
15	XV	SOZHANGANALLUR	192 - 200

*Figures mentioned here are those given by the Greater Chennai Corporation

(Break Free From Plastic 2020)

In 2019, the GCC and the Citizen Consumer and Civic Action Group (CAG) in Chennai signed a Memorandum of Understanding to start the Zero Waste Chennai project. The program was largely developed in response to the two landfills in Chennai approaching capacity, and a pilot project was proposed in Ward 100, Anna Nagar, as a test case. Through the MOU, waste management in Chennai is proposed to be further decentralized into sub-systems among the zones in Chennai, and the wards themselves would be able to take ownership of their waste collection and processing. Waste would be segregated at the household level into wet waste or organic waste, dry waste or

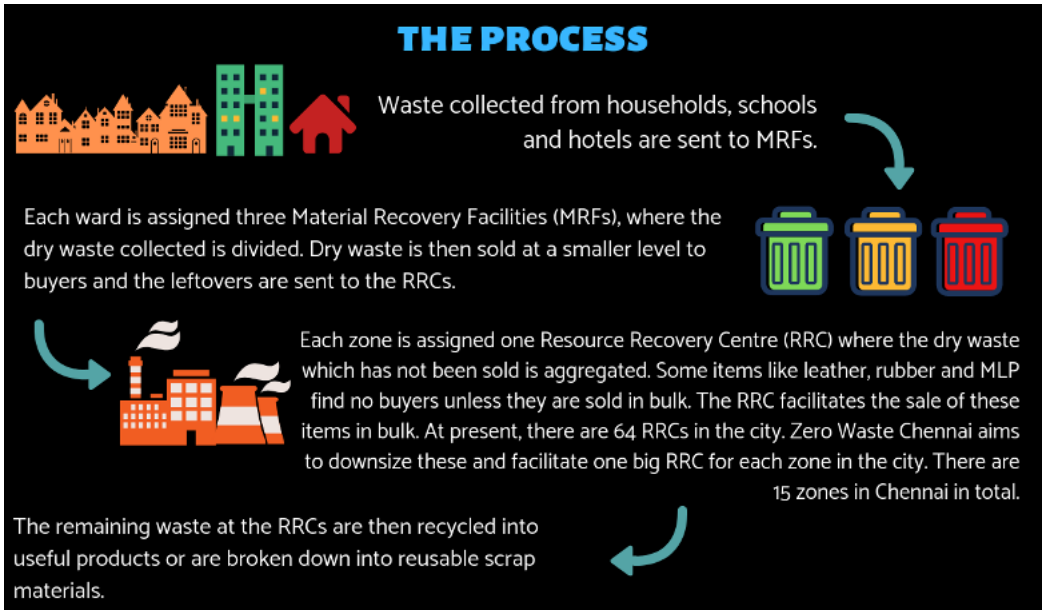
non-biodegradable waste and sanitary waste (Figure 24). Each ward would be assigned an MRF for division and sale of dry waste, and each zone would be assigned a Resource Recovery Center (RRC) for dry waste that has not been sold. The original project proposal also notes that it aims to specifically address challenging items such as multilayer plastic and sanitary products that do not currently have recycling options. Through the partnership, CAG is responsible for planning and management while GCC handles the execution. Ultimately, the project hopes to expand to all 15 zones and 100 wards in Chennai, and their target is to 100% of wet waste through composting and 70% of dry waste in the city (Break Free From Plastic 2020).

However, according to stakeholder interviews, the Zero Waste Chennai project has effectively come to a halt. Several reasons were cited, including changeovers in the government. While the program appeared to have a promising start at its inception, implementation has not been carried out as planned, and it would seem that the future of the program is currently in question. Conversations with GCC officials indicate that the government is not comfortable with the term zero waste and would prefer to focus on building a decentralized SWM model. There may be an opportunity in the future for the city to bring in a contractor or other third party to implement a program drawing on the learnings from the Zero Waste model.

> **"Zero Waste Chennai project is where we did a pilot in ward 100 and then obviously we worked with different RWAs…to tell them how to go about the strategy to make the people segregate. Once they segregate, what are the different ways you can treat this waste, like have your compost pit and the non-biodegradable waste, send it to the MRFs, and empanel the service provider for digging your biodegradable or the domestic hazardous waste solid waste management."**
>
> **— NGO**

> **[After the pilot, are people still adhering to the program?] "No. I think, again, the change of commissioner is one thing, fundamentally. The main thing is the coming of Urbaser into the scene. If you see, at least, in my area so far they haven't come and told me that I should segregate and all. So far. Absolutely zero [importance] has been given for IEC. Even if you give one week break, the people will lose interest. Because once you segregate and even for one week, you don't collect the waste or you collect the mixed waste, all your effort goes down the drain."**
>
> **— NGO**

Figure 26: Visual of the Zero Waste Chennai process



(Break Free From Plastic 2020)

There are several new proposals for infrastructure and development in process by the Solid Waste Department of GCC:

- Collection and Transportation of Solid waste in zones 1, 2, 3 and 7 (Package-1) through PPP model.
- Collection and Transportation of Solid waste in zones 11, 12, 14 and 15 (Package-2) through PPP model.
- Remediation / Reclamation & Rehabilitation of the dump site at Kodungaiyur for Zones 1 to 8 — (Package-III A).
- Waste to energy processing plant in existing dump site at Kodungaiyur for Zones 1 to 8 (Package -IIIB).
- Remediation/Reclamation & Rehabilitation of the dump site at Perungudi for Zones 9 to 15 (Package –IVA).
- Waste to energy processing plant [as defined by GCC] in existing dump site at Perungudi for Zones 9 to 15 (Package – IVB).
- Collection & Transportation of Construction and Demolition waste to Kodungaiyur from Zones 1 to 8 and Perungudi from Zones 9 to 15.

Plans for combustion facilities with energy recovery in Chennai are currently in development and discussion. There are proposals for dry waste disposal centers (such as combustion facilities and pyrolysis units) with a capacity of 655 tons per day. On completion of these facilities, the total capacity of decentralized facilities will be around 3,300 tons per day (Government of Tamil Nadu, 2021). Several proposals have been rejected in the past due to environmental concerns related to emissions and lack of public support, such as a proposal for a facility at the existing dump site in Kodungaiyur in Northern Chennai in 2017 (Nileena 2016). The GCC notes that five Waste to Energy plants are currently operating in the greater Chennai area with the total feeding capacity of 8.80 MT of biodegradable waste and an electrical energy generation of 54 kwh per day, which is used for city infrastructure such as streetlights. Currently, an additional facility has been proposed in Perambur and the proposal for the plant at Kodungaiyur is in revision (GCC website).

> **"Again, segregation becomes key. We have found that it is a profitable business with a three-year payback period. We've done some economics on this. The issue, why it is not there is that a lot of people came up with such systems in a very haphazard manner. They were not working. They didn't design it scientifically, and again, just incineration if the right people are not doing it, they don't give a complete solution. Emissions were an issue in the first plants. People started resisting … The whole technology pyrolysis itself, it had a very bad reputation."**
>
> **— Academic**

Source segregation is a solution that has been supported by several different grassroots initiatives, local and national policies, and many interviewees felt strongly that this was critical to effective end-of-cycle management of waste. However, barriers still exist for adaptation of source segregation, and awareness and education remain a challenge. While promising developments in infrastructure may come in the near future, the city should ensure that society, users, and stakeholders are aware of the implications and the role that they play in making the waste system in Chennai functional, as well as insuring that legitimate environmental and social concerns around emissions and other impacts are fully accounted for in decision-making.

Leakage

In total, 3,084 litter items were recorded across 27 100m^2 transects in nine different square kilometer areas sampled in September 2021. Litter transect locations were selected using a stratified random sampling method, in which transects were randomly selected in nine square kilometers which were distributed across three groups of population count (upper, middle, lower) representing societal activity based on LandScan ambient population data. Litter items were recorded using the open source Marine Debris Tracker app.

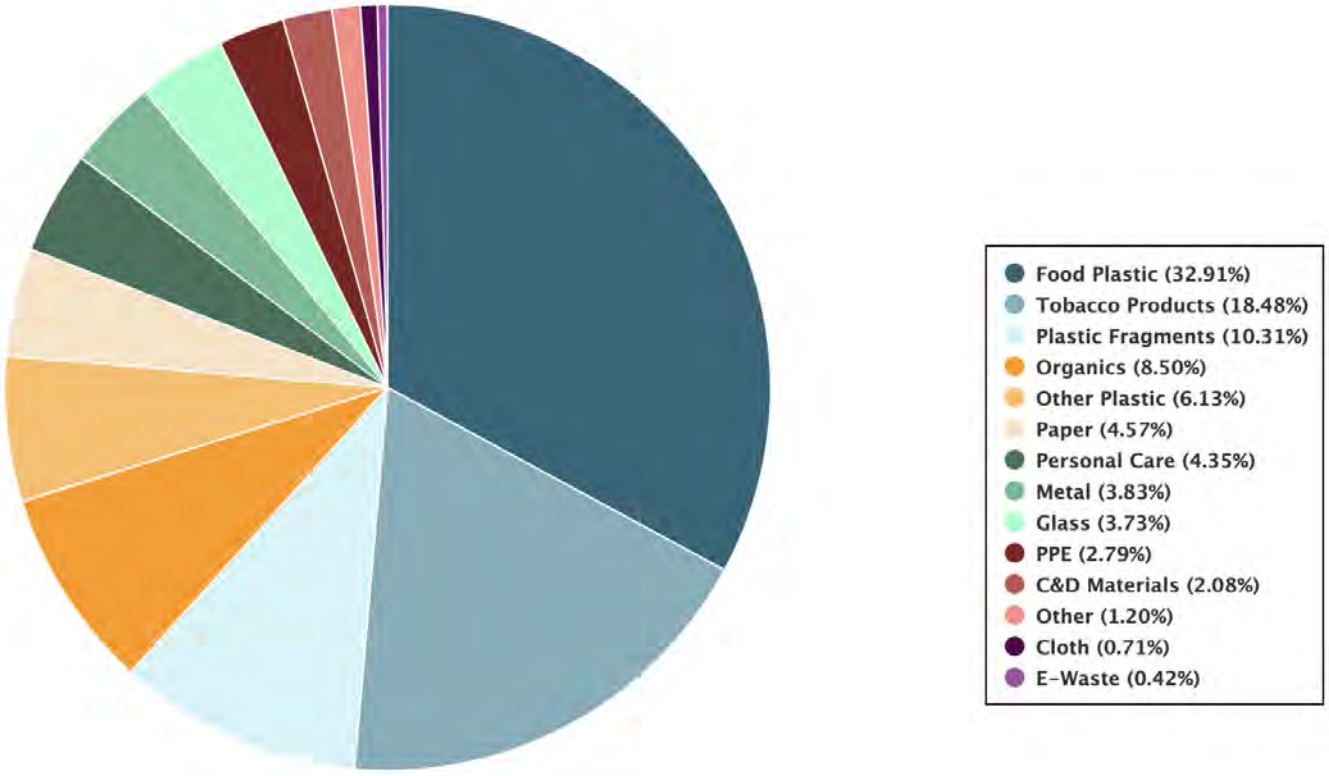
Figure 27: Common litter items found in Chennai during litter transects

(Photo Credit: Okapi Research & Advisory)

Across all transects, the largest percentage by category of litter item was food packaging plastic, representing 33% of all litter items documented. The second largest category was tobacco products with 18% of all litter items, followed by plastic fragments at 10%, organics at 9%, other plastic at 6%, and the remaining categories represented 5% or

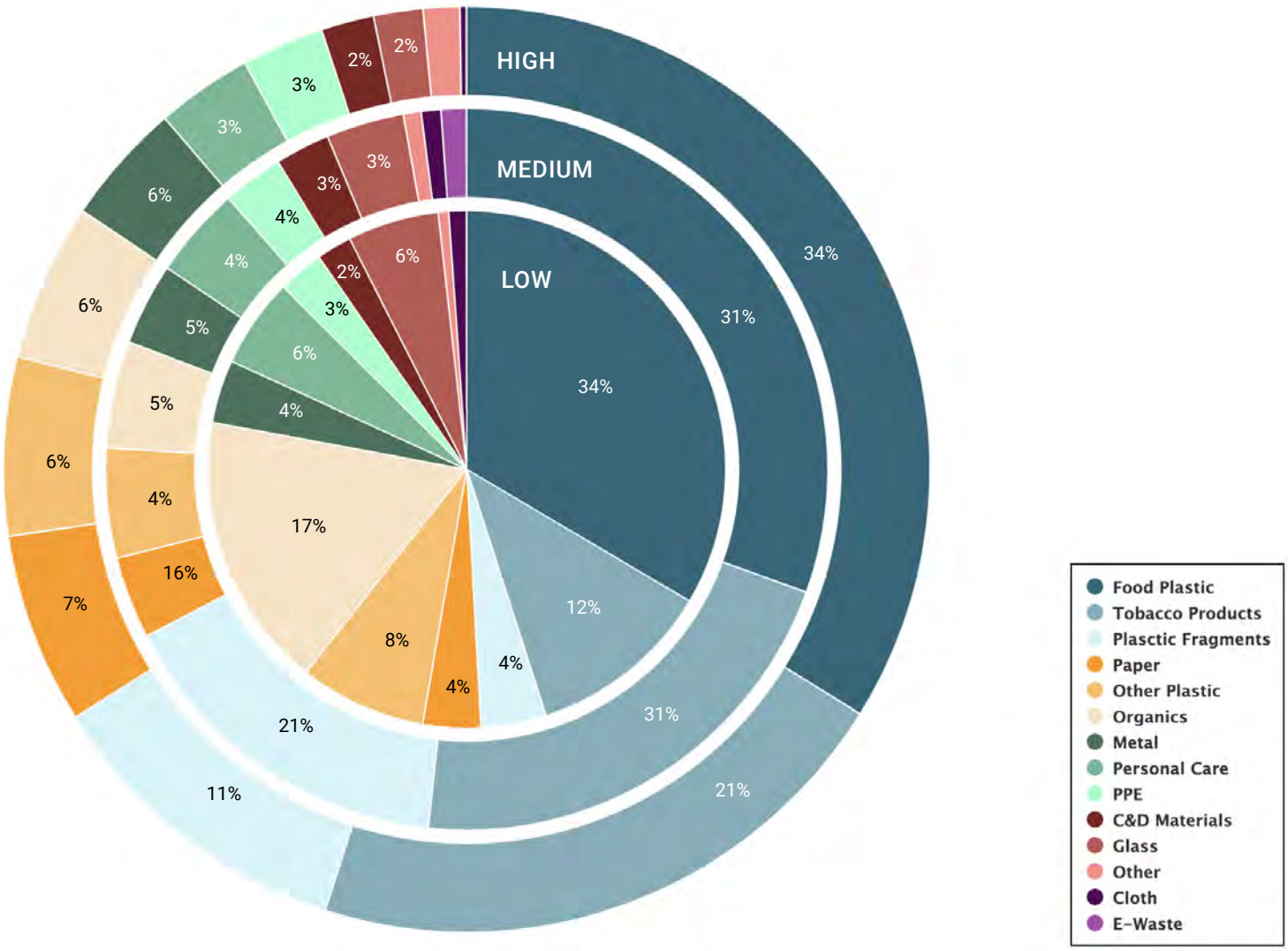
less of all litter items. The total percentage of common plastic items (the sum of food packaging plastic, other plastic, PPE, plastic fragments, and personal care items) found was 56% of the total items, compared to 30% found in Pune and between 40-50% in other Southeast Asian cities (Circularity Informatics Lab, 2021).

Figure 28: Litter material breakdown for Chennai



When examining the litter characterization based on the population count, some similarities and distinctions can be seen between the three groups. Food packaging plastic remained the most common material type of litter items found in all three population count areas. The upper and middle population count areas followed a similar pattern to the compiled city-level data, with tobacco products as the second most common category and plastic fragments as the third. In the lower population count areas, however, organic litter items were the second most common material category, representing 17% of all litter items found in those areas. Comparatively, the percentages for organic litter items were 5-6% in the middle and upper population count areas. The representative amount of plastic fragments also differed between the groups and was much lower (around 5%) in the lower population count areas compared to the middle and upper population count areas (11-16%). This could be indicative of more plastic use in the middle and upper population count areas and less food packaging being used in lower population count areas.

Figure 29: Litter material breakdown for upper (outer), middle, and lower (inner) population areas in Chennai



The most common individual litter items and overall litter density also differed between the three population count areas. The highest litter density was found in the middle population count areas, while the lowest was found in the low population count areas, though an ANOVA test showed that the difference in litter density between the three population count areas was not statistically significant. The lowest density found in the lower population count areas also coincided with areas where organic waste was the most common type of litter found. Plastic food wrappers and plastic bottle caps were among the top five most common litter items in all three of the population count areas. Cigarettes were among the top items in the upper and middle population count areas while tobacco sachets were among the top items in the middle and lower population count areas. Film fragments were among the top items in the upper and middle population count areas. Foam and plastic cups or lids were also common litter items and were among the top items found in the upper and lower population count areas.

Table 7: Top litter items and litter densities for population tertiles in Chennai

Population Tertile	Top 5 Litter Items	Litter Density (count/m²)
Upper (20,670 – 85,724 persons/sq km)	1) Cigarettes, 2) Plastic Food Wrapper, 3) Film Fragments, 4) Foam or Plastic Cups or Lids, 5) Plastic Bottle Cap	1.01
Middle (9,262 – 20,670 persons/sq km)	1) Film Fragments, 2) Plastic Food Wrapper, 3) Cigarettes, 4) Plastic Bottle Cap, 5) Tobacco Sachets	1.27
Lower (0 – 9,262 persons/sq km)	1) Other Organic Waste, 2) Plastic Food Wrapper, 3) Plastic Bottle Cap, 4) Foam or Plastic Cups or Lids, 5) Tobacco Sachets	0.96

While litter data was not collected during the CAP for each of the fifteen waste collection zones in Chennai, we are able to generate averages based on the transects that were within those zones. Based on the litter data, the zone with the highest average litter density was Zone 4 and the zone with the lowest litter density was Zone 9. Across all litter transects in Chennai, the average litter density was around 1.08 litter items per m^2. Among transects within zones managed by GCC, 73% had litter densities higher than the average observed for the city. Among transects within zones managed by Urbaser Sumeet, 31% had litter densities higher than the average observed for the city. Unfortunately, there were no transects within zones that are managed by Ramky Enviro Engineers Pvt. It should be noted again, however, that there were varying numbers of litter transects within each zone, as shown in the table below, and not all zones were represented. It would be useful to conduct litter transects in all fifteen zones on an ongoing basis to get a more complete picture of the litter status within each.

Table 8: Litter densities for City Zones in Chennai

City Zone	Litter Density (count / m²)
1	No data (n=0)
2	No data (n=0)
3	No data (n=0)
4	1.60 (n=3)
5	1.11 (n=3)
6	1.55 (n=1)
7	No data (n=0)
8	1.34 (n=4)
9	0.79 (n=8)
10	0.8 (n=2)
11	No data (n=0)
12	No data (n=0)

City Zone	Litter Density (count / m^2)
13	1.03 (n=6)
14	No data (n=0)
15	No data (n=0)

As a coastal city with a large tourism economy, there have been many studies on and attention paid to plastic waste leakage and environmental pollution in Chennai. Several papers have investigated the abundance and characteristics of microplastics and larger plastic debris along the beaches in Chennai, particularly around the popular Marina Beach. Through these studies, polyethylene and polypropylene were identified as the most abundant plastic polymers, and microplastics were found in 10.1% of fish species sampled. Plastic fragments were also more abundant on beaches that were adjacent to river outflows, suggesting that the rivers and canals in Chennai play a role in the transportation of environmental plastic. These studies also suggested that such plastic particles may act as a vector for the transportation of metals such as arsenic, chromium, copper and lead into the marine environment (Karthik et al., 2018; Suman et al., 2020). Beyond the marine environment, microplastic studies have been conducted in the Red Hills Lake in Chennai as well, with similar results for concentrations and characterization of polymers (Gopinath et al., 2020). Studies have even suggested that about 90% of cattle in Chennai have plastic waste in their guts from eating litter (TNN 2019).

Plastic waste leakage is clearly of serious concern in the city, and solutions are being explored — In December 2017, GCC introduced eight 'trash boom barriers' along different stretches of the Cooum river. These barriers with nets, prevent trash from entering the sea. GCC had also used excavators to remove trash from the Cooum river and other water bodies. In terms of the waste collected (between December 2017 and December 2018), it was estimated that 21,665 tonnes was removed from the Cooum river of which 10% was plastic, 50% – 60% sludge, 30% – 40% hyacinth, tree branches, thermocol and discarded household items. The waste that was removed was transported to Kodungaiyur dump yard (Lakshmi and Ramakrishnan 2019). As such, reducing plastic waste leakage requires solutions across a wide range of sectors.

Opportunities

We recommend exploring the following opportunities to expand and enhance circularity in Chennai 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 Chennai within each spoke. The purpose of the forthcoming Opportunity Assessment Workshop in Chennai 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 a holistic system framework.

INPUT

- Chennai could be a leader in working with top local brands and producers that operate in the state of Tamil Nadu to create the EPR Action Plans as mandated by the EPR Guidelines from 2020, with a particular focus on biscuit, candy, and chip/snack items 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 Aavin milk packets, would be valuable for the long-term success of those initiatives.

COMMUNITY

- There is clearly a great deal of confusion and polarizing opinions regarding the EPR rules in Chennai — public education and outreach coupled with consistent enforcement and capacity building for relevant stakeholders is needed to ensure that the city is executing the policies adequately and meeting the needs of stakeholders in Chennai. This should be a top priority at the city and national level to ensure an integrated and effective EPR system going forward.
- The informal sector is providing much of the actual recycling that is happening. The city, working within the broader Urban Ocean network (including with mentor city Pune), could explore how to better connect the infor-

mal sector to city service providers in a way that also improves the health and wellbeing of the informal waste sector.

- Awareness and education are needed for the public and waste workers alike on processes, protocols, and the bigger picture of the value in waste collection and processing for building city resilience.
- Positive behavior change has been observed (e.g., following bans), but these are not sustained due to inconsistent implementation and enforcement — citizens need to see the benefits of the changes they are making and have easy access to alternatives.

PRODUCT DESIGN

- The abundance and nomenclature around material type and the associated disposal can make recycling challenging and be confusing to consumers. With high amounts of biodegradable, compostable, and oxo-degradable plastic in Chennai, this confusion could lead to higher litter quantities and improper waste management. Chennai could consider developing a streamlined certification/singular material nomenclature across the city and build awareness among citizens and recyclers/waste collectors.
- Despite some items such as plastic bags having appropriate material type labeling, consumers may be confused about sorting and disposal, both if the material itself is unclear and if the disposal method associated with the material is unknown — this may also present an opportunity for discussion and collaboration with manufacturers.
- Multilayer plastic is not currently recyclable and does not have value in the informal sector (apart from select brands of milk packets) – there is a need to either bolster EPR schemes like that of Aavin, or work to explore alternative materials that will have value. The city could also leverage multilayer plastic availability to attract specialized treatment facilities under EPR Policy.
- Alternatively, the city could explore directing EPR revenues to informal sector workers to incentivize them to collect these materials they otherwise would not.

USE

- Enforcement measures or public campaigns are needed around policies (e.g., bans and restrictions) that are in place or that will be implemented.
- 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 that are introduced in light of the single-use ban need to be readily and easily reused or have a viable disposal option within the context of Chennai.

COLLECTION

- 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 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 collec-

tion. Potentially Urban Ocean city team could partner with local organizations such as Kabadiwalla Connect on maximizing Data Monitoring capabilities.

- The city should consider developing case studies for the different collection models and private enterprises around collection of solid waste in Chennai, 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 Aivayoo et al. 2018). Chennai can also derive lessons for worker safety and safeguarding mechanisms along with Pune, another Urban Ocean city with similar informal waste presence and scope.
- The city should foster collaborations for micro-enterprises for recycling or civil society support for informal waste workers (also mentioned in Aivayoo et al. 2018).
- Waste collectors in Chennai should continue to track data on their collection as well as their environmental footprint (ie. through the use of electric vehicles), potentially using The Circulate Initiative's PLACES calculator if desired.

END OF LIFE

- Increase support for projects which reduce dumping waste, such as Zero Waste Chennai — 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 needs to set clear goals around waste reduction and diversion, continue public outreach and awareness, and continuously monitor successes and needs of the program. There may also be an opportunity for the city to bring in a contractor or other third party to reinvigorate and restart the initiative.
- Continue to support and expand recycling in Chennai, 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

- The city and local partners should revisit the CAP litter transects based on zones and/or by areas that have different waste collection schemes, so that there is comparable data and best practices can be shared between them.
- Food plastic is a major issue in the city, especially food wrappers. Those most problematic materials should be prioritized for EPR and exploration of feasible alternatives, through regulation, funding, innovation, and other pathways. To maximize impact, the city could consider developing their project proposal through Urban Ocean in a way that addresses both EPR and the challenges of multilayer plastic.

References

Aiyavoo, I. (2018). Urban Poverty: Rag Pickers in Chennai City. PESQUISA, Vol.3, Issue-2, ISSN-2456-4052 (online), May 2018.

Arabindoo, P. (2011). Mobilising for water: hydro-politics of rainwater harvesting in Chennai. International Journal of Urban Sustainable Development, 3(1), 106-126.

Balasubramanian, K.L. (2020). What will it take to make Chennai's new waste management system a success? Citizen Matters. https://chennai.citizenmatters.in/chennai-waste-management-decentralised-private-contractor-urbaser-sumeet-ramky-20541

Break Free From Plastic (2020). Zero Waste Chennai: Planning for a garbage-free city. https://www.breakfreefromplastic.org/2019/08/07/zero-waste-chennai/

CAG - Citizen and Consumer Civic Action Group (2021). CAG Brand Audit: Who's the biggest plastic polluter in Chennai? https://www.cag.org.in/newsletters/public-newsense/cag-brand-audit-whos-biggest-plastic-polluter-chennai

Census 2011: https://www.census2011.co.in/census/city/463-chennai.html

Chandran, P. (2021). Empower (ing) informal recycling chain to get Extended Producer Responsibility moving. Hasiru Dala, Special Series on Extended Producers Responsibility and Inclusion. https://images.citizenmatters.in/wp-content/uploads/sites/2/2021/09/23120018/Empower-ing-informal-recycling-chain-to-get-Extended-Producer-Responsibility-moving.docx_.pdf

Circularity Informatics Lab, June 2021. Circularity Assessment: Can Tho, Vietnam. University of Georgia, Athens, GA, USA. <www.circularityinformatics.org/urban-ocean>

Circularity Informatics Lab, August 2021. Circularity Assessment: Melaka, Malaysia. University of Georgia, Athens, GA, USA. <www.circularityinformatics.org/urban-ocean>

Circularity Informatics Lab, August 2021. Circularity Assessment: Pune, India. University of Georgia, Athens, GA, USA. <www.circularityinformatics.org/urban-ocean>

Circularity Informatics Lab, April 2021. Circularity Assessment: Semarang, Indonesia. University of Georgia, Athens, GA, USA. <www.circularityinformatics.org/urban-ocean>

CMD (2008). Chennai metropolitan development area volume 1,3, from second master plan 2008. <http://www.cmdachennai.gov.in/smp_main.html>

Dutta, A., Jinsart, W. (2019). Waste generation and management status in the fast-expanding Indian cities: A review. Journal of the Air and Waste Management Association. 70(5), 491-503. https://doi.org/10.1080/10962247.2020.1738285

Government of Tamil Nadu. (2016). Database on Solid Waste Management in Tamil Nadu. http://www.tnenvis.nic.in/WriteReadData/UserFiles/file/swm.pdf

Government of Tamil Nadu. (2021). Municipal Administration and Water Supply Department. Policy Note 2021-2022. https://cms.tn.gov.in/sites/default/files/documents/masw_e_2021_22_pn.pdf

Environment and Forest Department, (Aug 25, 2019), G.O. (Ms) No. 84, Government of Tamil Nadu, https://tnpcb.gov.in/pdf_2018/G.O_84_BanPlastic3718.pdf

Esakku, S., Swaminathan, A., Parthiba Karhtikeyan, O., Kurian, J., and Palanivelu, K. (2007). Municipal Solid Waste Management in Chennai City, India. Proceedings Sardinia 2007, Eleventh International Waste Management and Landfill Symposium. Margherita di Pula, Cagliari, Italy; 1 - 5 October 2007

Gopinath, K., Seshachalam, S., Neelavannan, K., Anburaj, V., Rachel, M., Ravi, S., Bharath, M., Achyuthan, H. (2020). Quantification of microplastic in Red Hills Lake of Chennai city, Tamil Nadu, India. Environmental Science and Pollution Research (2020) 27:33297–33306. https://doi.org/10.1007/s11356-020-09622-2

Greater Chennai Corporation https://chennaicorporation.gov.in/gcc/department/solid-waste-management/

Greater Chennai Corporation (2021). Chennai City Action Plan.

InforMEA (2021). Tamil Nadu Plastic Articles (Prohibition of Sale, Storage, Transport and Use) Act, 2002. FAO / FAOLEX / ECOLEX. https://www.informea.org/en/legislation/tamil-nadu-plastic-articles-prohibition-sale-storage-transport-and-use-act-2002

Karthik, R., Robin, R.S., Purvaja, R., Ganguly, D., Anandavelu, I., Raghuraman, R., Hariharan, G., Ramakrishna, A., Ramesh, R. (2018). Microplastics along the beaches of southeast coast of India. Science of The Total Environment. Volume 645, 2018, Pages 1388-1399, ISSN 0048-9697,

Kumar, B.K. (2017). Chennai's garbage crisis - challenges and road ahead. Citizen Consumer and Civic Action Group. https://www.cag.org.in/blogs/chennais-garbage-crisis-challenges-and-road-ahead#_ftn1

Lakshmi, K, Ramakrishnan, D.H. (2019). A mountain of trash fished out of Cooum. The Hindu. https://www.thehindu.com/news/cities/chennai/a-mountain-of-trash-fished-out-of-cooum/article26115438.ece

MOEFCC - Ministry of Environment, Forest and Climate Change (2020). Guideline Document Uniform Framework for Extended Producers Responsibility (Under Plastic Waste Management Rules, 2016). Government of India. https://moef.gov.in/en/guideline-document-uniform-framework-for-extended-producers-responsibility-under-plastic-waste-management-rules-2016/

Natarajan, A. (2019). Pioneering RWAs felicitated with Green Awards. Citizen Matters. https://chennai.citizenmatters.in/tnpcb-green-awards-for-sustainable-apartment-communities-10559

Nileena, MS. (2016). Chennai's garbage: Long journey ahead to sustainable waste management. Citizen Matters. https://chennai.citizenmatters.in/chennais-garbage-long-journey-ahead-to-sustainable-waste-management-129

Omjasvin, MD (2021). Chennai: Over 200 tonnes of garbage cleared from Broken Bridge. Times of India. https://timesofindia.indiatimes.com/city/chennai/chennai-over-200-tonnes-of-garbage-cleared-from-broken-bridge/articleshow/88082773.cms

Resilient Chennai (2019). Chennai City Resilience Strategy 2019. https://resilientchennai.com/wp-content/uploads/2019/06/Resilience-Strategy_Final_20190625.pdf

Shekhar, S. and Shah, D. (2018). Are Businesses Ready to Beat Plastic Pollution? Citizen Consumer and Civic Action Group. https://www.no-burn.org/wp-content/uploads/GAIA-Full-Report-Final.pdf

SZW - Saahas Zero Waste (2020). Waste Management in Chennai. Saahas Zero Waste Website. https://saahaszerowaste.com/waste-management-services-chennai/

Suman, TY, Li, W-G., Alif, S., Faris, V.R.P., Amarnath, D.J., Ma, J-G., Pei, D-S. (2020). Characterization of petroleum-based plastics and their absorbed trace metals from the sediments of the Marina Beach in Chennai, India. Environmental Sciences Europe, 32:110, https://doi.org/10.1186/s12302-020-00388-5

Swati, Thakur I.S., Vijay V.K., Ghosh P. (2018) Scenario of Landfilling in India: Problems, Challenges, and Recommendations. In: Hussain C. (eds) Handbook of Environmental Materials Management. Springer, Cham. https://doi.org/10.1007/978-3-319-58538-3_167-1

Tamil Nadu, TN (2018). Ministry of Tourism publication 'India Tourism Statistics . Source: Commissioner of Tourism, Chennai-2. https://www.tn.gov.in/deptst/tourism.pdf

The Hindu (2020). CM launches solid waste management project in 7 zones. https://www.thehindu.com/news/national/tamil-nadu/cm-launches-solid-waste-management-project-in-7-zones/article32736896.ece

The Hindu (2021). Model station for 'zero waste.' https://www.thehindu.com/news/national/tamil-nadu/model-station-for-zero-waste/article37890747.ece

TNN (2019). How Chennai's plastic waste is killing its cattle. Times of India. https://timesofindia.indiatimes.com/city/chennai/how-chennais-plastic-waste-is-killing-its-cattle/articleshow/71437488.cms

World Population Review: https://worldpopulationreview.com/world-cities/chennai-population

Appendix

Table 9: 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 10: 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
Adyar Ananda Bhavan Sweers India Pvt. Ltd.	Chennai, India
Amul	Gujarat, India
B.S. Award Food Products	Chennai, India
Bisleri International Pvt. Ltd.	Mumbai, India
Britannia Industries Ltd.	Bangalore, India
Brown Tree	Chennai, India
Cadbury	Birmingham, UK
Cavinkare Private Ltd.	Chennai, India
Coca Cola Beverages Pvt. Ltd	Georgia, USA
ConAgra Brands Inc.	Illinois, USA
Dev Snacks	Kerala, India
DFM Foods Ltd.	Delhi, India
Drums Food, DSG Consumer Partners	Ebene, Mauritius
Ferrero Rocher	Alba, Italy
Haldiram's	Nagpur, India
Hershey Company	Pennsylvania, USA
ITC Limited	Kolkata, India

Manufacturer	Manufacturing Location
Jumbo Foods	Washington, USA
Kali Aerated Water Works(P) Ltd.	Thoothukudi, India
Kellogg's	Michigan, USA
Lindt & Sprungli	Kilchberg, Switzerland
Loacker	South Tyrol, Italy
Lotus Bakeries Belgie NV	Lembeke, Belgium
Mars International	Virginia, USA
Mayora	Jakarta, Indonesia
Mondelez International Foods Pvt. Ltd.	Illinois, USA
Nestle	Vevey, Switzerland
Parle Products Pvt. Ltd.	Mumbai, India
Pepsico	New York, USA
Perfetti Van Melle	Lainate, Italy
Phillip Morris International	Neuchâtel, Switzerland
Rajaram's	Chennai, India
Rakyan Beverages Pvt. Ltd.	Mumbai, India
Red Bull	Fuschl, Austria

Manufacturer	Manufacturing Location
Relish Snacks Pvt. Ltd	Chennai, India
RP-Sanjiv Goenka Group Pvt. Ltd.	Kolkata, India
Sai Ram Snacks	Chennai, India
Sepoy Beverages LLP	Delhi, India
Sri Akshay Foods	Chennai, India
Subham Polymers	Chennai, India
Tamil Nadu Cooperative Milk Producers Federation	Chennai, India
True Care Snacks	Chennai, India
Unibic Foods India Pvt Ltd.	Bangalore, India
Vidura Snacks Pvt. Ltd.	Chennai, India
Walkers Shortbread Ltd.	Aberlour on Spey, Scotland

END OF DOCUMENT