Circularity Assessment Protocol

SALVADOR, BRAZIL

URBAN OCEAN

Foreword

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

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

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

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

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

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

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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.

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www.circularityinformatics.org

Athens, GA, November 2024

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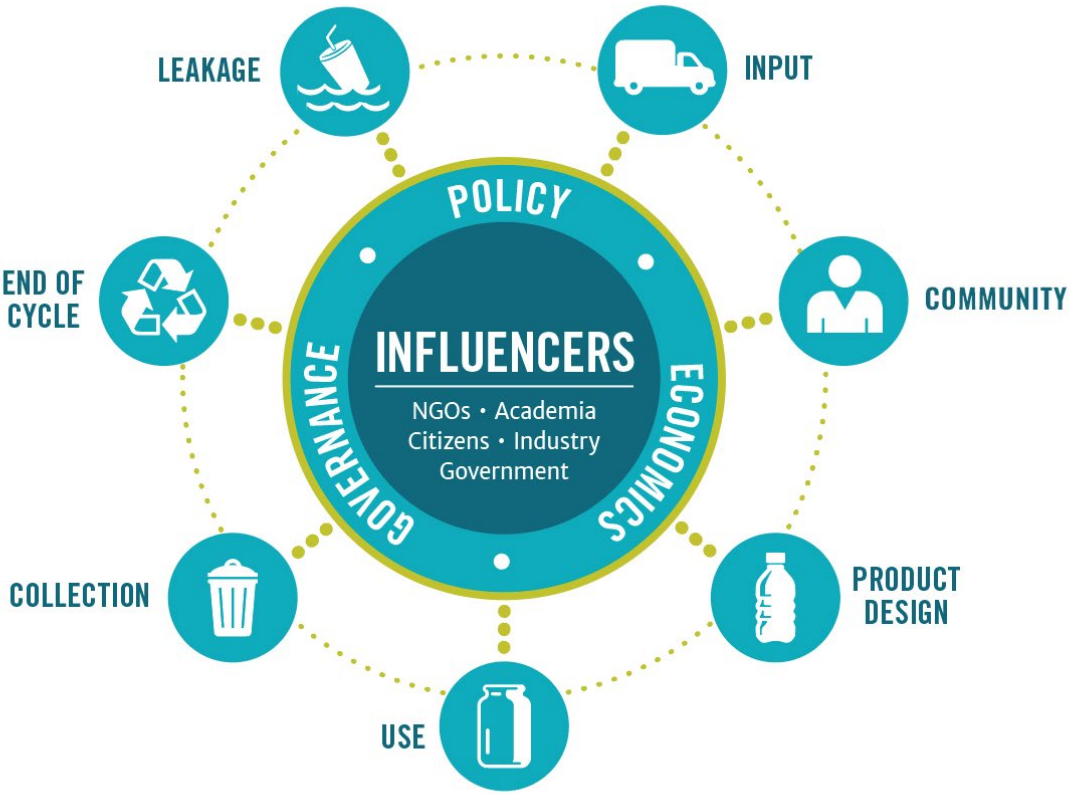
Executive Summary

Developed by the Circularity Informatics Lab at the University of Georgia (UGA), the Circularity Assessment Protocol (CAP) is a standardized assessment protocol to inform decision-makers through collecting community-level data on plastic usage. 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.

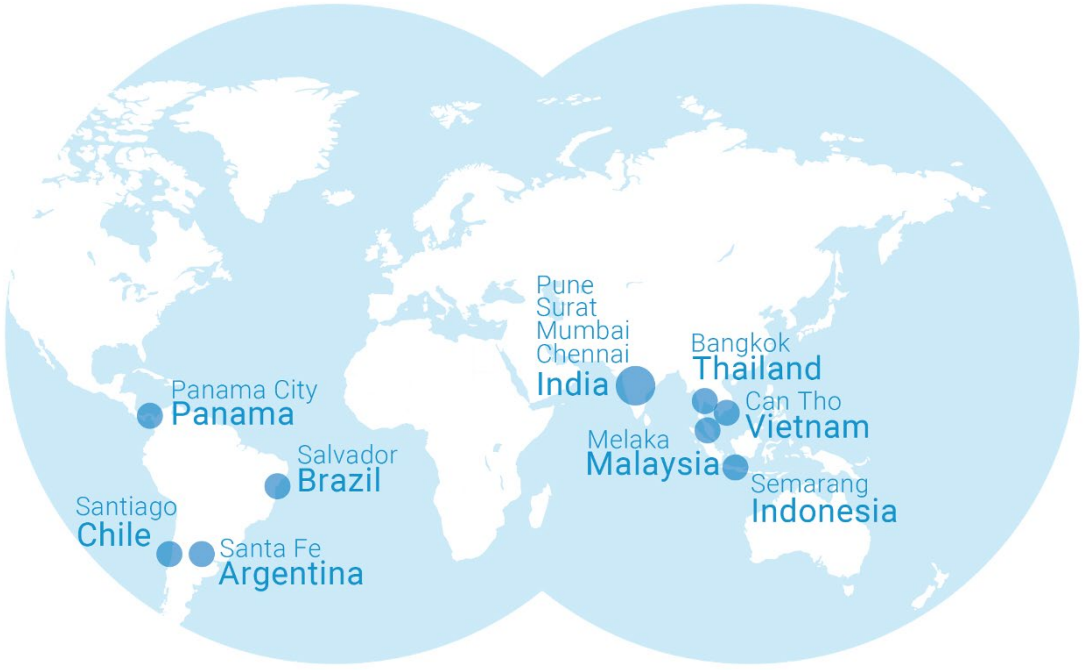


In September – November 2023, a team from Circularity Informatics Lab (CIL) started work with local partners in Salvador, Bahia, Brazil, with field support from the Ministry of Environment and the startup SOLOS (Soluções inteligentes de economia circular) in Salvador. The CAP was also conducted with support from Ocean Conservancy (OC) and the Resilient Cities Network. Fieldwork 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 (high, medium, and low activity over a 24 hour period). Key findings from each spoke are summarized in the table concluding this section.

Urban Ocean Program

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



Salvador is one of three cities in the third cohort of Urban Ocean learning cities. The CAP in Salvador, coupled with the upcoming Opportunity Assessment Workshop, 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 Salvador will contribute to a series of workshops where stakeholders will discuss findings and develop a proposal(s) for interventions, 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. TCI achieves this by collaborating with key stakeholders across the sector, and by producing insights to support and accelerate investment and scale across the value chain. For more information, please visit: www.thecirculateinitiative.org

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

Key Findings and Opportunities

INPUT

Findings: Around 97% of FMCGs (fast-moving consumer goods) surveyed had manufacturing locations within Brazil and 63% of FMCG parent companies were based in Brazil. Some Candy and Chip products had manufacturers and parent companies located within Salvador, implying potential opportunities for extended producer responsibility (EPR) laws and regulations development within city boundaries.

Opportunities

- With a large percentage of products manufactured in Salvador, creation and enforcement of EPR regulations (including those in the Federal Law No. 12,305 of 2010) could lend a significant plastic pollution reduction opportunity.
- Industry stakeholders of the most popular brands are open to collaborative work and potential solutions that allow them to accomplish state regulations and their own sustainability goals (e.g., potential investments on maintenance/safety of recycling sites including in stores locations).

COMMUNITY

Findings: The most needed points of intervention include education, regulatory Systems, and Infrastructure. Collaborative groups of different kinds of actors/stakeholders can decide the strongest paths and best use of resources (monetary/time/networks) toward education platforms/campaigns to promote public awareness. Regulatory systems, developments, and enforcement could offer specific steps to follow and target to support outreach from current interested parties (recycling cooperatives) towards the public. Infrastructure support could increase recycling efficiency (e.g., reducing contamination).

Opportunities

- Collaborative groups of different kinds of actors/stakeholders could benefit from having clear checklists on solid waste management (SWM) procedures based on government regulations and input, particularly surrounding any source separation guidelines.
- Collaborative groups of different kinds of actors/stakeholders that operate within Salvador can decide the strongest paths and use of resources from their own perspectives and needs to better educate the public.
- Informal recycling and composting cooperatives and actors could benefit from infrastructure improvements, particularly around accessibility and safety, and long-term contracting investments (including as educational actors).

PRODUCT DESIGN

Findings: Plastics in many forms are the most popular packaging in convenience items, food staples, and personal care/cleaning products. PET bottles and Multilayer plastic film account for 73% of all convenience items' packaging, even with the inclusion of alcoholic beverages increasing the percentages of glass and aluminum. Plastic and fossil-fuel derivatives are also the most used materials for to-go containers in the city's restaurants, accounting for more than 80% of the materials surveyed. Film, PET, and HDPE are the most popular on food staples and personal care/cleaning packaging.

Opportunities

- Continuous support to the informal recycling community could allow that sector to encourage source separation and recycling, thus acting as education and awareness agents.
- Regulation creation and enforcement could encourage the use of high demand recyclable or even alternative plastics options instead of plastics with low recovery indexes.

USE

Findings: Alternatives to petroleum-based plastics are making their way in the Soteropolitan packaging industry in the form of returnable glass, and biodegradable and recycled plastics, due mostly to sustainability industry goals and cultural trends. Despite the recent plastic ban in the city, the most common bags in stores are plastic with reusables bags offered for a fee in half of the surveyed stores. Refill sachets are available in common grocery stores but are offered in smaller presentations than their HDPE recyclable versions. Polystyrene is still a popular to-go container material in Salvador.

Opportunities

- Through emergent research and innovation, groups from waste collection, industry, and academic stakeholders can collaborate to address problematic and challenging materials like expanded polystyrene.
- The use of glass could feasibly be encouraged, promoted, and supported as a plastic alternative, given local context and projected national demands. [1]

COLLECTION

Findings: Collection points have been previously successful for the community and informal recycling sec-

1. MI Report (2024). Mordor Intelligence. Latin America Glass Packaging Market Size & Share Analysis — Growth Trends & Forecasts (2024 – 2029) https://www.mordorintelligence.com/industry-reports/latin-america-glass-packaging-market Accessed on March 2, 2024.

tors, if there is safety and maintenance around them. Source separation could help collectors streamline resource recovery according to their own specialties (recycling, compost, etc.). Static dumpsters (as seen in condominiums) for communities without current formal door-to-door waste collection access could offer a recycling option. Without official recycling, this type of collection is currently hindered by cost-effectiveness for cooperatives and informal recycling agents.

Opportunities

- Ensure that collection points are located in easily maintained safe areas and access is given to recycling cooperatives.
- Creating contracts or other types of formal agreements/partnerships with the recycling community could provide cost-effective recycling coverage.
- Placing static recycling bins beside dumpsters, coupled with public outreach and proper maintenance, could provide a path forward for source separation.

END OF CYCLE

Findings: With the current industry interest and sustainability goals, there is a potential market avenue for recycled PET and glass. Composting could be extremely beneficial not only for the 40% organic waste generated in Salvador, but for the emergent alternative plastics products. Composting companies are currently present in Salvador although most depend on willingness and investment from the public.

Opportunities

- Support for both recycling and composting cooperatives could divert a large percentage of landfill-bound waste and optimize existing SWM infrastructure.
- Diverting wet/organic/humid waste or compost towards compost stations, farms, or public gardens (depending on source separation) would be beneficial for waste diversion and optimization.
- Separation at the source could include wet/organic waste for compost collection to help make recyclable items cleaner.
- Programs that more effectively engage waste pickers and the informal waste community could be developed to optimize waste processing in the city.

LEAKAGE

Findings: The most common materials found in litter are food-related plastic packaging (e.g., plastic cups, plastic food wrappers), tobacco products (predominantly cigarettes), and plastic fragments (hard, film, and foam). Paper was the fourth most common litter material observed. Common plastic items (food plastic, other plastic, PPE, plastic fragments, and personal care items) represented 48% of litter, which is around the aver-

age compared to other UO cities. There are significant differences between litter densities in geographically similar areas (Periperi <1.80/highest and Rio Vermelho >0.63/lowest) perhaps related to economic factors.

Opportunities

- Observe key differences in areas of low litter densities (Rio Vermelho) and high litter densities (Periperi) to understand the nuances and develop systems to help them reach lower leakage levels.
- Outreach and education campaigns and materials related to littering, particularly for problematic and common litter items such as cigarette butts, should be considered for the city and tailored to local needs.
- Recommend that local partners revisit Leakage methods and measure impact of interventions over time, with a particular focus on food plastic and tobacco products.

Strengths

- Salvador has a strong commitment to circularity with a variety of stakeholders willing to work towards that goal (from the work of NGOs and academia to industry partnerships and sustainability policies).
- The informal recycling sector is strong and can be integrated into increasing circularity.
- Access to plastic alternatives has been increasing in the city because of manufacturing facilities in the region and partnerships between industry and waste/recycling companies.
- Materials like glass and metal are a relatively large part of the materials used for convenience items.
- Current research in the city, according to stakeholders interviewed, is addressing problematic materials for recovery.

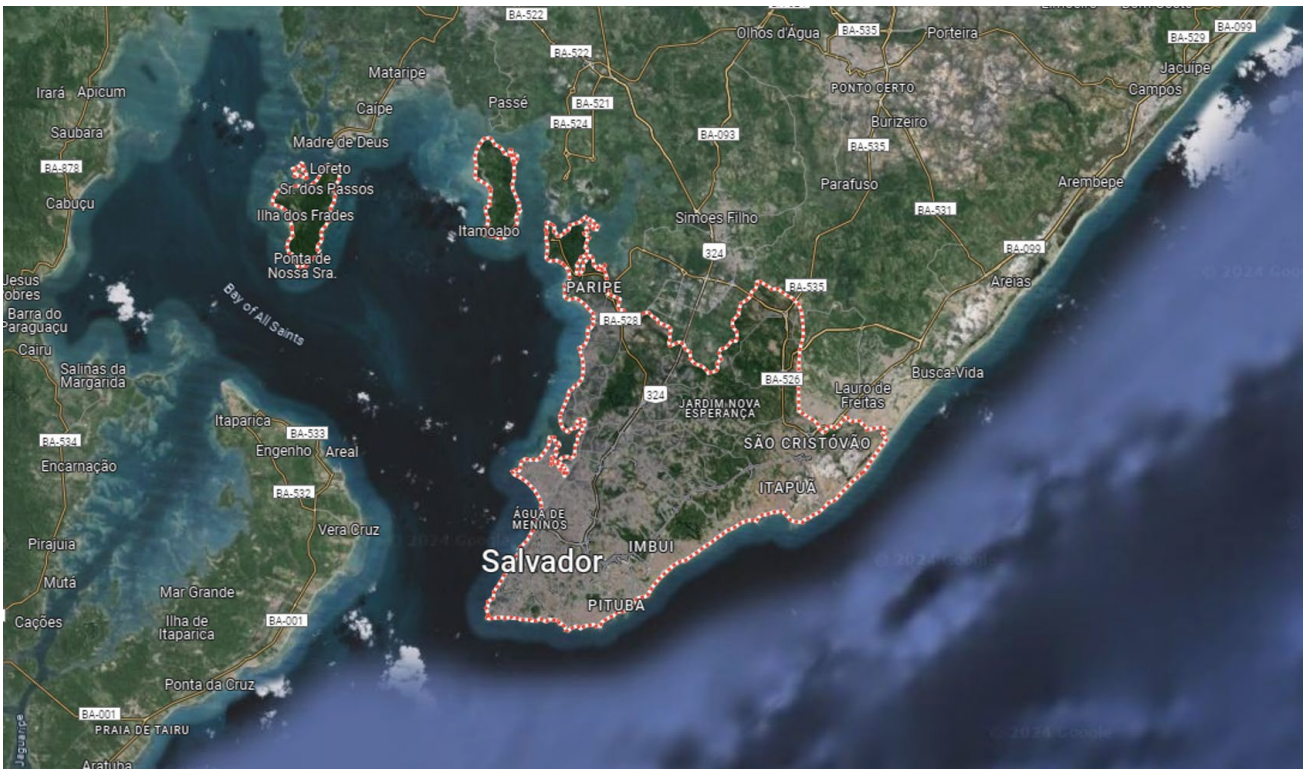
Glossary of Acronyms and Abbreviations

BMC – Brihanmumbai Municipal Corporation
AMC – Aterro Metropolitano Central
C&D – Construction and Demolition
CAP – Circularity Assessment Protocol
CIL – Circularity Informatics Lab
EPR – Extended Producer Responsibility
EPS – Expanded polystyrene
FMCG – Fast moving consumer goods
GDP – Gross Domestic Product
HDPE – High density polyethylene
MSW – Municipal solid waste
PET – Polyethylene terephthalate
PP – Polypropylene
RCN – Resilient Cities Network
SUP – Single-use plastic
TCI – The Circulate Initiative
UGA – University of Georgia
UO – Urban Ocean

Introduction

The third most populous municipality of Brazil, Salvador is the capital of the State of Bahia. It borders both the Atlantic Ocean and the Bay of All Saints. Salvador has a population of over 2 million people, generating an estimated average of 0.93 kg of waste per capita per day.[2] With Brazil having the highest Gross Domestic Product (GDP) among South American countries1, Salvador's economy thrives from tourism and international investments. Salvador is the second most touristic city in Brazil and has one of the most modern lodging infrastructures in the world. There are also several events and other tourist-attracting gatherings in the area, the most popular being Carnaval, and locally many religious and non-religious festivals like Iemanja's Day.

Figure 1: Geographic Location of Salvador in Brazil



Although Carnaval and the Bahian Carnival are not specifically celebrated in Salvador, the city does receive more

2. World Bank. World Bank Open Data Development Indicators. https://data.worldbank.org/ Accessed on October 1, 2022.

than 800 thousand[3] visitors from in and out of state and international visitors during the Summer. The Iemanja's day celebration, also in the Summer, attracts 80,000 people every year. During this event, participants will make offerings to the goddess of the salt waters by floating baskets into the sea. Other local festivals in Salvador include Lavagem do Bonfim and Festa de Santa Barbara/Iansa, which are celebrated in late Spring early Summer.

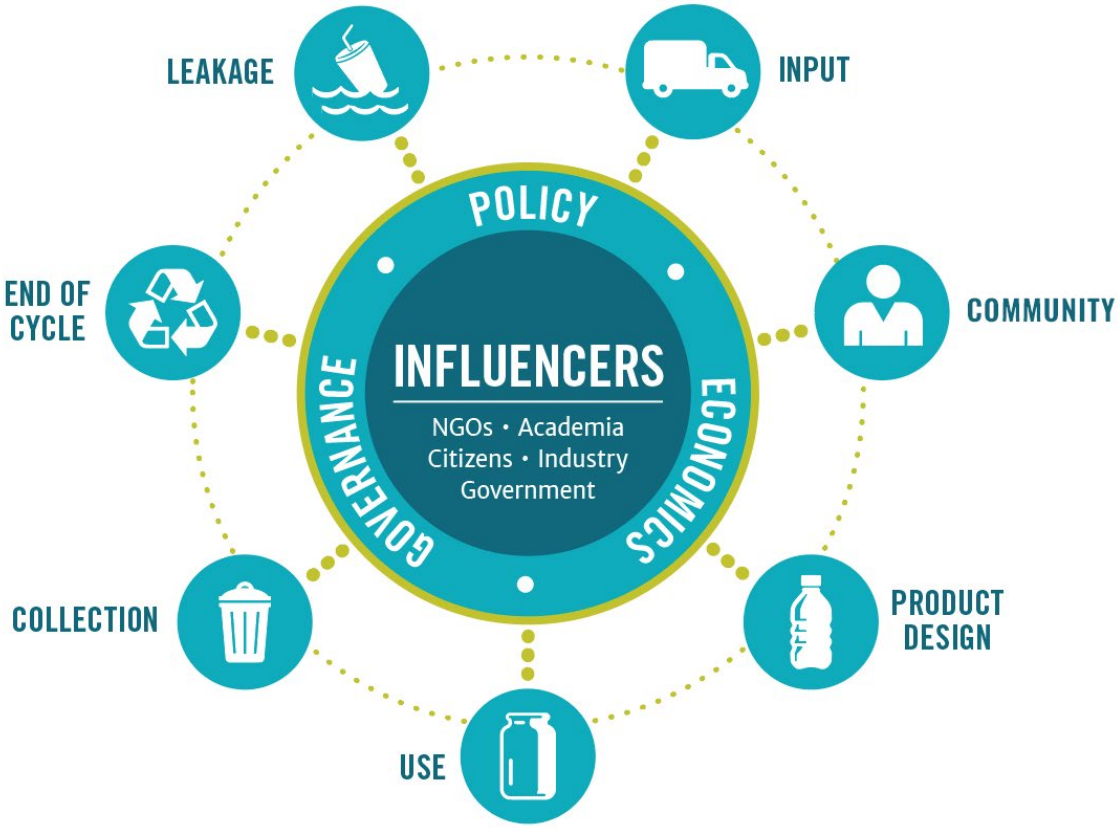
The geographic location, economic drivers, and massive congregations around holidays make Salvador a very important part of analyzing materials' circularity in South America. For instance, it was the convergence of tourism and the cultural activities of Carnival that promoted the creation of the Fundo da Folia (Festival Fund), one of the most popular NGOs in the area who can (and do) physically display the effects of Marine Debris.

The Circularity Informatics Lab (CIL) at the University of Georgia (UGA) developed the Circularity Assessment Protocol (CAP) in 2018, which is a standardized assessment protocol used to collect community-level data to inform decision-makers (Figure 2). 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?

3. Statista. (2024). Number Of Visitors During Carnival Season In Salvador, Brazil In 2020, By Region Of Origin. Accessed on March 21, 2024. https://www.statista.com/statistics/273009/number-of-visitors-at-the-brazilian-carnival-in-salvador-da-bahia/

Figure 2: Circularity Assessment Protocol (CAP) hub-and-spoke model

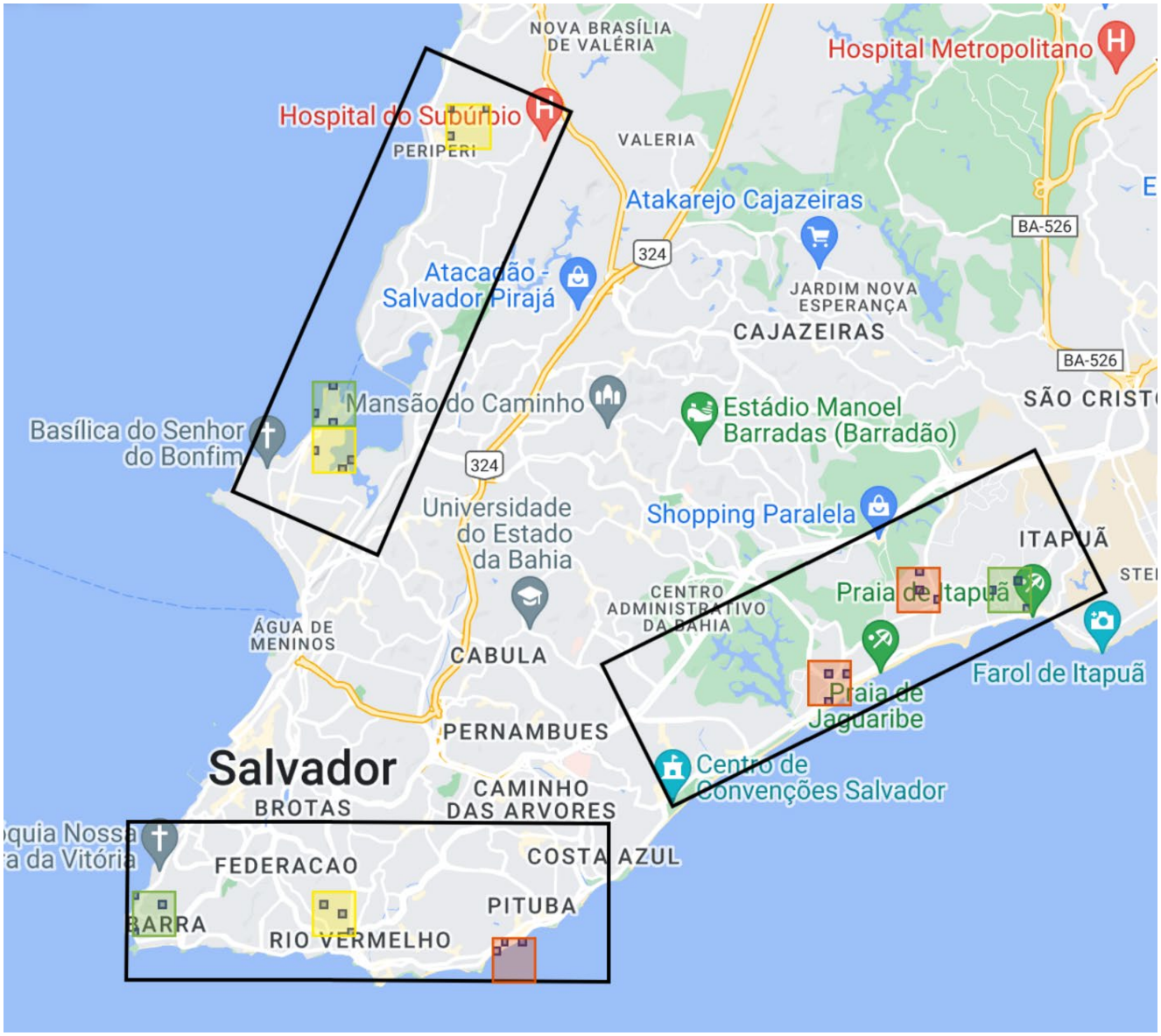


This report documents work conducted by CIL and the local partner SOLOS with support from the Urban Ocean, Resilient Cities Network, and the City of Salvador, Bahia, Brazil. Background information and a literature review were conducted in November 2023. Fieldwork was conducted in October — November 2023. Clarifications and preliminaries for this report were conducted in December 2023 — February 2024. The CAP report is split into the following sections, which include results and discussion of each: Input, Community, Product Design, Use, Collection, End of Cycle, and Leakage, followed by Opportunities. The intent is for the data in this report to inform ongoing stakeholder engagement around solutions to strengthen the circular economy and waste management in Salvador.

Sampling Strategy

In order to randomly sample various locations in the city, the CAP typically identifies a 10 x 10km area over the city (with the center of the city in the center of the area); however, this 100km^2 area's shape can be modified to fit the shape of the city, as is the case for Salvador (Figure 3). In the 100km^2 area, the ambient population is stratified into tertiles (three groups) where random sample locations are identified (Figure 3). Ambient population can be described as "where people go" and "societal activity" — it is not the population density of where people live. These stratified areas typically form sample locations of different land uses, etc.

Figure 3: Population tertiles and survey sites in Salvador



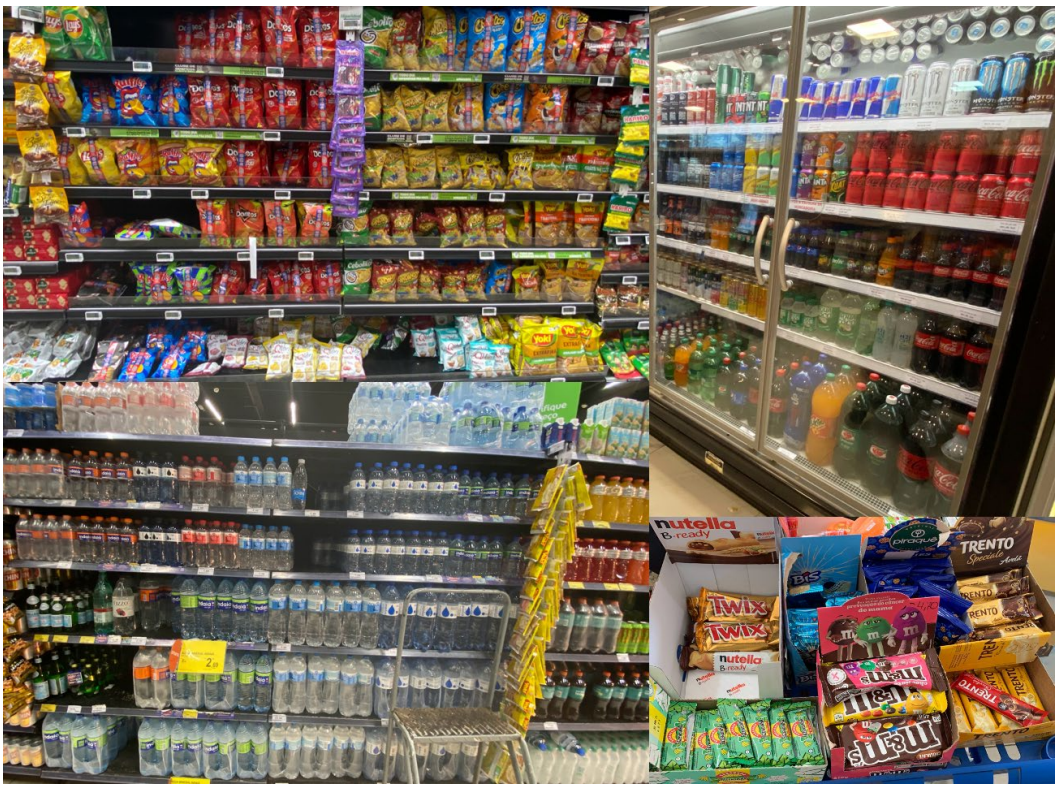
Three 1 x 1km areas for surveying are randomly selected within each population tertile using NOAA's Sampling Design Tool, resulting in a total of nine 1km^2 areas for surveying. In total, 9 sites were surveyed, three in the high population count tertile and three each in both the low and mid population count tertile.

CAP Findings

Input

To get a snapshot of the characterization, scope, and source of common plastic packaged items that are entering Salvador, samples of fast-moving consumer goods (FMCG) in four popular categories were taken within the nine 1 km^2 transects in Salvador. The team selected three convenience or grocery shops to sample within each 1km^2 transect area, where shops were present and open at the time of surveying for a total of 25 stores. In total, 14 unique brands of convenience products were collected and sampled, including 7 candies, 5 chips, and 2 beverages, while a total of 95 unique brands were registered as the most popular in the different stores surveyed (Figure 4). Identical brands were counted and reported when present in multiple stores. Common brands of water beverages were also visually assessed in stores, although samples were not purchased; 11 brands of bottled water are included in the input analysis.

Figure 4: Typical convenience store packaging in Salvador



It was important for the Salvador community that we included alcoholic beverages as part of the CAP study and data analysis. A large part of the reason for including beer and some mixes/mixable spirits is that the aforementioned items appear alongside soft drinks in the majority of stores sampled (Figure 5).

> **"Although it's not the only type of packaging available, offering alcoholic beverages, such as beers, mixed soft drinks and spirits, in disposable packaging is common in convenience stores. And its accessibility can influence consumption patterns and generate debates about regulations to balance commercial practicality with social and environmental responsibility."**
>
> **— Local NGO**

These types of beverages are also available as single serving (under 600ml) to-go options in different materials' packaging including plastic (Figure 5). Additionally, the containers make an appearance again as part of the litter surveys, effectively embedding alcoholic drinks into the holistic circular system.

Figure 5: Alcoholic beverages in the cycle

Top brands of each category, based on a visual assessment of shelf space in a store, conversations with shopkeepers, and repeated occurrence across stores, included the following:

- Beverages: Heineken, Devassa, Coca-Cola
- Candy: Trident, Mentos, Bauducco
- Chips: Cheetos, Doritos, Pringles, OK
- Water: Indaiá, Crystal, Lôa

For each of the top products documented, the team noted the type of packaging (including polymer, if possible), the brand, and the parent company. From there, the team was able to determine 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). Manufacturer and parent company distances (Table 1) are intended to estimate the distance in kilometers between the city and the origin of each product.

Table 1: Distances between Salvador and manufacturer and parent company locations for top FMCG convenience items

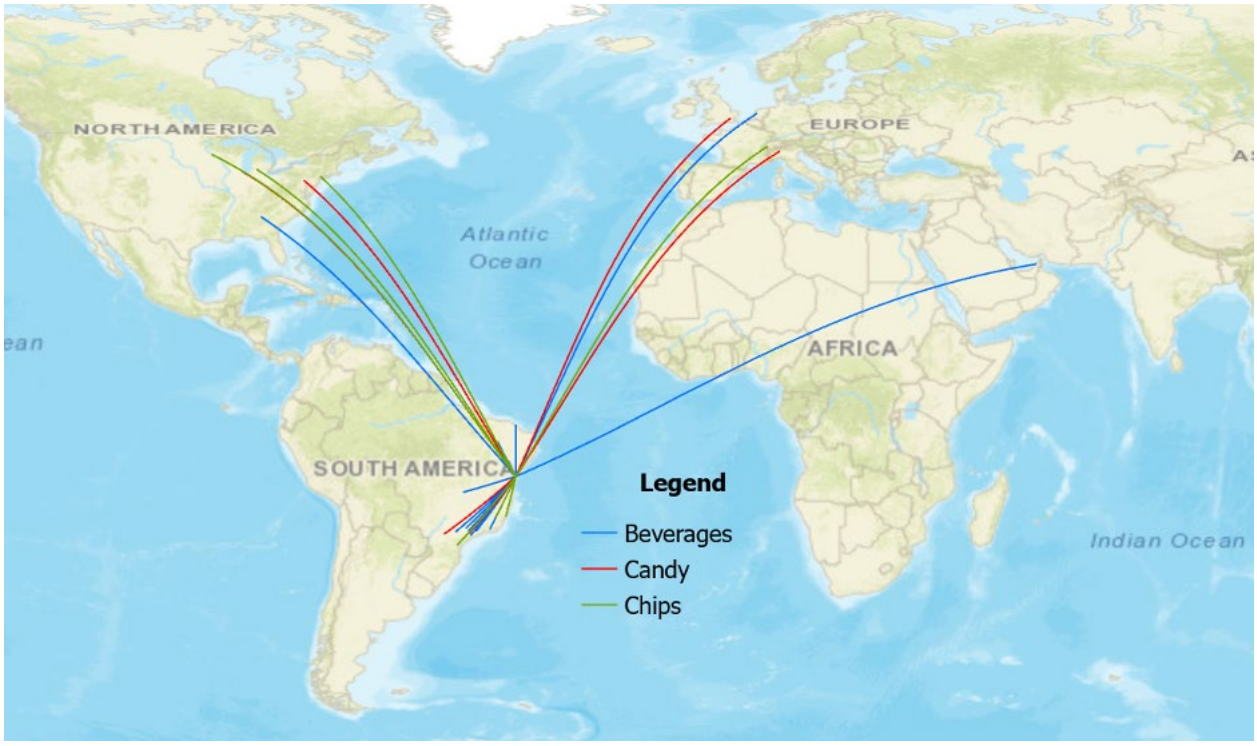
	Distance Store to Parent Company (km)			Distance Store to Manufacturer (km)		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Beverages	45	10998	2143	45	10998	1652
Candy	0	8058	4601	0	7325	1138
Chips	0	8454	4168	0	1915	1124

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

Around 97% of FMCGs (fast-moving consumer goods) surveyed had manufacturing locations within Brazil (Figure 6), which is relatively high compared to other UO cities and there is a high incidence of manufacturing locations in the area around Salvador. Additionally, 63% of FMCG parent companies were based in Brazil (Figure 7) with some Candy and Chip products having manufacturers and parent companies located within Salvador proper (i.e., Vitarella, Piraque, OK Chips). A few of the registered imported products came from manufacturers in Spain, Italy, and the UAE, while parent companies outside Brazil were located mostly in Europe and the United States.

Figure 6: World map displaying manufacturing locations for top convenience items in Salvador

Figure 7: World map displaying parent company locations for top convenience items in Salvador



Considering that a large quantity of FMCG products were found to be manufactured in Salvador, creation and enforcement of EPR regulations, including those in the Federal Law No. 12,305 of 2010, provide an opportunity for reduction in plastic pollution. In some cases, industry stakeholders of the most popular brands may be open to synergistic work and potential solutions that allow them to meet state regulations and accomplish their own sustainability goals. Adequately implementing and enforcing regulations will be important to increase buy-in for EPR measures among corporate stakeholders that have large footprints in the region.

Community

From the hub-and-spoke model, the CAP aims to understand how plastics move in the city through the lens of stakeholders. Their perspective depends on their lived experience and the boundaries within which that experience develops, for which the model includes policy, economics, and governance as the filter for the stakeholder experience. In Salvador, policy allows groups to envision what is and could be possible to achieve in terms of working towards circularity.

Brazil currently has several regulations that apply and could be enforced in Salvador, BA. Mainly, federal Law No. 12,305 of 2010 establishes the National Solid Waste Policy, and highlights in Chapter III, Section II the shared responsibility for products' life cycle. This policy has guidelines for product manufacturing and packaging (mostly the need to steer clear of hazardous waste and design for easy recycling) that adds to the responsibilities of producers and public authorities previously outlined in the law. The law also establishes that sanctions would apply according to Art 56. of the Law 9605 of 1998, which mostly refers to hazardous waste. The 2015 General Packaging Sector Agreement, prepared and managed by Coalizão Embalagens, composed of 14 entities representing around 850 companies, in which companies agreed to a form of EPR that allows them to take back product packaging after source separation and recycling. It also encourages involving the informal recycling sector through incentives for the companies. It is, however, not a law nor a regulation that could be enforced. The 10.936 decree of 2022 works the ambiguity of these two policy elements by reinforcing the importance of shared responsibility and extending the producer responsibility to those companies outside the agreement. It also lists more specific procedures and requirements to navigate solid waste management at different parts of products' life cycle and defines amounts for sanctions for non-compliance. More strictly, it also places the financial responsibility of waste management of hazardous waste onto producers.

Related policies also include the Decree No. 11,044 of 2022 establishes a Recycling Credit Certificate through the Recicla+ Program. Decree No. 11,300 of 2022 establishes the reverse logistics system for glass packaging including manufacturing distances that would make glass returnability a strong opportunity. The presidential Decree No. 5940 of 2006 established a "Solid Waste Selective Collection" in federal buildings and delivery of recovered materials to waste pickers organizations. In the same area, Law 11445 of 2007 allowed for municipal hirings of waste pickers associations and cooperatives directly.

Other programs and initiatives that mostly target single-use plastic have been adopted throughout different Brazilian territories, while in the city of Salvador specifically, Law 7865 of 2010 and Law 4461 of 1991 make selective collection mandatory in shopping centers and schools respectively. Additionally, Law 9699 of 2023 bans plastic bags that have less than 51% renewable materials and Law 9805 of 2024 bans the supply of plastic straws promoting the use of

recyclable, biodegradable, and edible materials for these single-use items. Private sector projects and initiatives also exist in the city of Salvador targeting mostly litter recovery (e.g., Fundo de Folia, River Eco-barriers) and the popular casas SO+MA where people can drop off materials for recycling and even reuse.

Key Stakeholder Interviews

To understand current attitudes and perceptions of plastic waste, semi-structured interviews were conducted with 20 key stakeholders. Among those interviewed, 3 were government officials, 6 were from private waste or recycling companies, 6 were from industry, 2 from academia, and 3 were from non-profit organizations (Table 2).

Table 2: Summary of Stakeholder Interview List

Stakeholder Group	Number of Interviews
Industry	6
Waste Management/Recycling Entity	6
Local NGOs	3
Local Government	3
Academia	2
Total	**20**

In general, stakeholders highlight the ubiquity and importance of plastic to current human practices. However, they do lament the lack of awareness, education, and infrastructure to manage plastics in a more circular way.

> **"Plastic emerged as a great revolution, but unrestrained use needs to be corrected."**
>
> **— Industry Stakeholder**

> **"You see plastic everywhere, but you don't really look at it. About plastic specifically, I think there is still a lack of awareness among the population to reduce the use of plastic and also to make plastic return to their production chain."**
>
> **— NGO Stakeholder**

> **"We need to transition Salvador from a linear economy to a circular one… Unfortunately,**

> **plastic is very flexible; it serves many different purposes. We've gotten used to working with plastic."**
>
> **— Government Official**

There is a need for multi-disciplinary collaboration that is sprouting synergistic groups to solve the issue of plastic pollution in Salvador.

> **"I think all these startups, whether they're from the same state, municipality or whatever, they need to join forces. We need all these actions aimed at a greater good, because it's not just [the cooperatives], but I think we are all actors of transformation. I think this union is very important for us to be able to really take Brazil, which only recycles 4% of waste, to where we expect it to go."**
>
> **— Waste/Recycling Stakeholder**

> **"There are a lot of people doing things, but everyone is scattered. This group is trying to get everyone together, to create a collaborative network so that we can get out of this situation,"**
>
> **— Academia Stakeholder**

> **"It is also a convergent agenda. I think there is no competition on this topic. In Brazil, we are working together with [some] and other competitors. If we find a feasible solution for one, it resolves the issue for all and everyone is happy."**
>
> **— Industry Stakeholder**

> **"They need to understand that waste collection is a shared responsibility. People still think it's the magic of garbage. Individuals and companies believe in the bag's magic, as I call it. Put everything in the pack, leave, and go somewhere."**
>
> **— Waste Entity Stakeholder**

> **"We have a contract with [a cooperative], a partnership contract, waste disposal, governance, and sustainability issues, all formalized between the parties. So, we work in this direction, raising awareness, sensitizing tenants and customers about proper disposal, and aiming for waste reduction. If waste reduction takes longer, we empathize with adequate disposal and reusing of this waste."**
>
> **— Industry Stakeholder**

These types of groups could include a wide variety of stakeholders, bringing targeted ideas for logistics in the waste chain.

> **"Structure the chain so that cooperatives and waste pickers are always included, and solutions that make the recyclability of the waste possible as well."**
>
> **— Industry Stakeholder**

> **"In the case of more affluent condominiums, the person puts the waste at the door. Then, someone goes there, collects it, and takes it away, so perhaps this helps us to have a more organized system in condominiums, for example. But I think there should be coverage throughout the city…"**
>
> **— Public Official**

> **"With regard to waste management, [the contract would require] for us to implement selective collection, and… [w]e tried to implement it in many condominiums."**
>
> **— Waste/Recycling Stakeholder**

Education is a vital point throughout the stakeholder spectrum and needs active participants who can reach and/or interact with the public, either through educational reform or targeted education campaigns.

> **"It's about education, and education is not just about environmental education; it's about global education. People need a minimum level of teaching to understand that you must behave in a certain way in your community to generate a positive effect throughout the whole chain of human survival here."**
>
> **— NGO Stakeholder**

> **"I also think we need to strengthen society through environmental and climate education, the idea of reducing plastic use. It's about making sure that, from an early age, children can understand that they need to keep track of their plastic footprint."**
>
> **— Public Official**

> **"Firstly, it's an awareness campaign for the community. I'll mention something here that might spark some interest. About ten years ago, the cooperative created [an awareness campaign partnered with a market]… So, as a mechanism of interest was created, people started separating materials in their homes and bringing them to the cooperative."**
>
> **— Waste/Recycling Stakeholder**

Another important point on the stakeholders' minds is one of Policy and regulations, usually with clear cut parameters to make compliance and enforcement easier.

> **"I think we should have not only a systemic policy, but actually mechanisms implemented in a systemic way, which involve the entire community, regarding waste segregation and sorting. Often, the lack of these mechanisms causes us to take actions that are often disordered or not so relevant."**
>
> **— Waste/Recycling Stakeholder**

> **"Policies to encourage the production of [plastic alternative] products here, in the city, and the state, as well as a broad awareness of usage and preservation, would significantly improve the situation."**
>
> **— Public Official**

> **"Salvador City Hall, for example, has adopted… the law that will require supermarkets to stop offering plastic bags."**
>
> **— Public Official**

> **"If there was greater compliance with the national policy itself, that federal policy was good and effective… "**
>
> **— Industry Stakeholder**

In terms of establishing selective collection and Extended Producer Responsibilities, current laws at the federal and city level could indeed be very effective. However, it would be helpful to clarify and assign specific agents/structures to inform and promote public awareness of the minutiae of the laws and how to best comply with them. Fortunately, the are some people in Salvador already familiar with the details of selective collection, who are looking for a way to participate in the process.

> **"Today's main goal for all cooperatives, including mine, is for the Municipality to hire us to progress in these door-to-door collections."**
>
> **— Waste/Recycling Stakeholder**

> **"The city needs to understand that they need to hire cooperatives, that's for sure. But let's keep going. One step at a time."**
>
> **— Waste/Recycling Stakeholder**

> **"What is undoubtedly correct is that support is required when the municipality embraces the**

> **idea that cooperatives must be paid for their environmental service. When that happens, the cooperative is more successful and receives more support."**
>
> **— Public Official**

As is the case in most cities, there are certain challenges to such processes.

> **"The waste pickers [want] to be recognized as cleaning agents… but the municipality needs laws, support, and resources to reimburse them."**
>
> **— Public Official**

In terms of support and resources, there is one group of stakeholders identified in the interview process that appears very well suited to offer them.

> **"Industries have understood that waste, in quotes, is energy. It's energy; it's a source of revenue… Large generators are becoming more adept at turning what used to be a problem into revenue."**
>
> **— Public Official**

> **"Companies could invest more in research, development, and innovation to consider other options. Despite being an expensive investment, it pays off in the long run… "**
>
> **— Industry Stakeholder**

> **"Today we have partnerships with four companies. We invest in structural projects… which develops cooperatives and connects them with the recycling industry."**
>
> **— Industry Stakeholder**

With some companies already investing in recycling safe points and recycling machines, expanding these investments and including other companies could address one of the most important worries for stakeholders.

> **"We used to have some places here for depositing recyclable waste that could be reused, but they don't exist anymore. Vandalism played a part; it helped a lot in not having that type of collection anymore."**
>
> **— NGO Stakeholder**

> **"But the first thing for the community is to have a collection point, as the So+ma Project**

already does, but it's not enough, for different applications. Having these points. First, to collect them."

— Academia Stakeholder

"I think it's something feasible. I'd like to see more disposal points spread out in a more mechanized way."

— Industry Stakeholder

"[Investors] got funding to set up, at first, 3 ecopoints at UFBA. These ecopoints will directly benefit the cooperatives, the waste will go straight to the cooperatives, and the citizens will also be able to take their waste to UFBA, not just the academic community."

— Academia Stakeholder

In this analysis, the common themes of intervention points include education, policy/regulations, and infrastructure. For which, collaborative groups of different kinds of actors/stakeholders (including representatives of local government, academia, local NGOs, cooperatives, waste management/recycling entities) can streamline education to promote public awareness. Policy/regulations development and enforcement could offer specific checklists (e.g., what, when, where, how to recycle or to do to support sustainable waste management practices) and logistics to educate the public. Infrastructure support in the form of accessible, safe, and maintained recycling sites and long-term recycling collection programs could increase recycling efficiency. Moreover, it is imperative that stakeholders in these groups approach each other with good disposition and an open mind if true circularity is to be developed.

Product Design

To characterize material types used in common consumer products, samples of common convenience were surveyed as described in the Input section. The local team sampled stores in each of the accessible 1km^2 transects areas for a total of 25 stores. Samples of 15 popular FMCGs were purchased and their brand, material, and weights recorded. Moreover, a list of 52 items provided information on the most common types of material used in FMCGs (Figure 8) and a visual survey provided the most common packaging materials for FMCGs (Figure 9) and Food Staples (Figure 10).

Figure 8: Material breakdown of sampled convenience items in Salvador

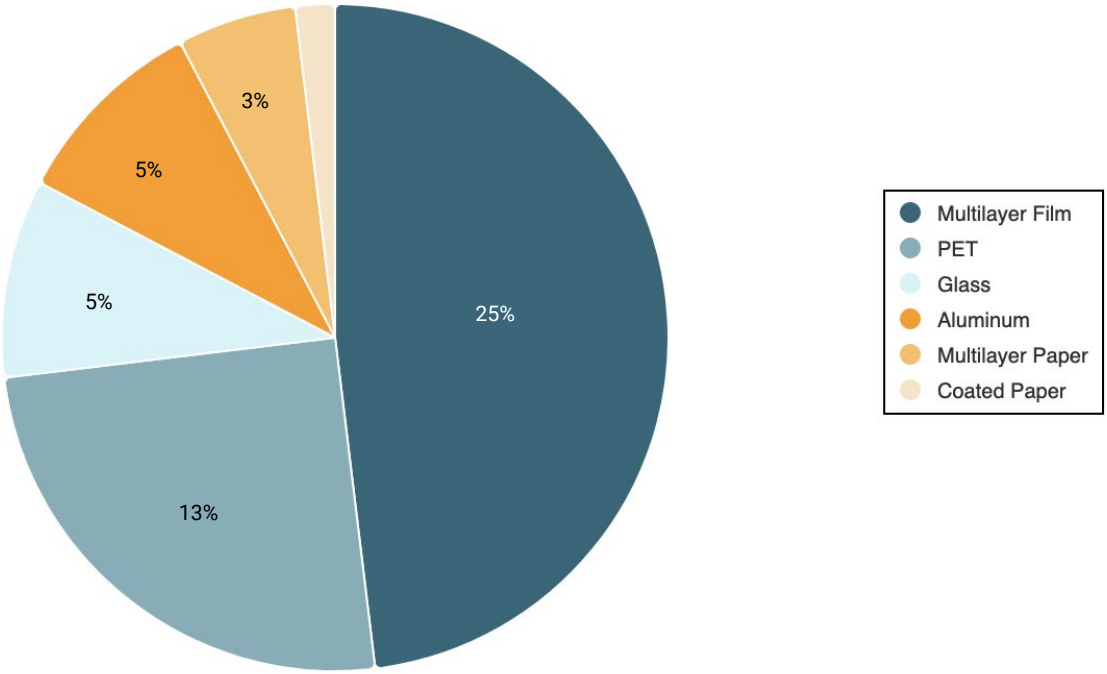


Figure 9: Material breakdown of convenience items materials surveyed in Salvador stores

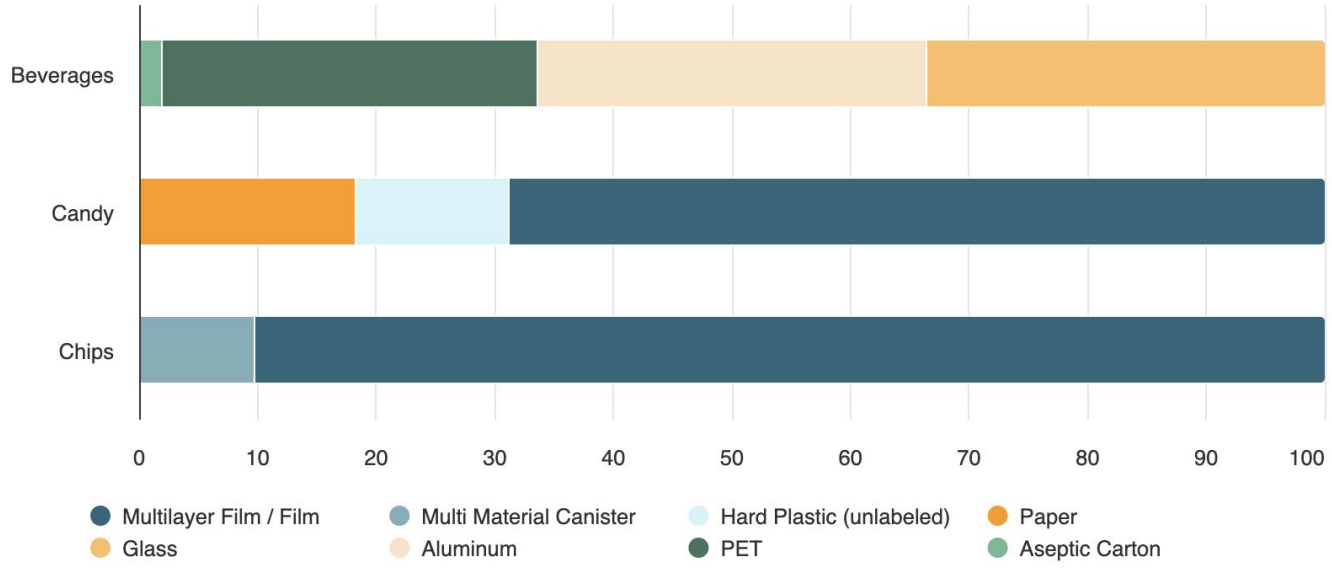
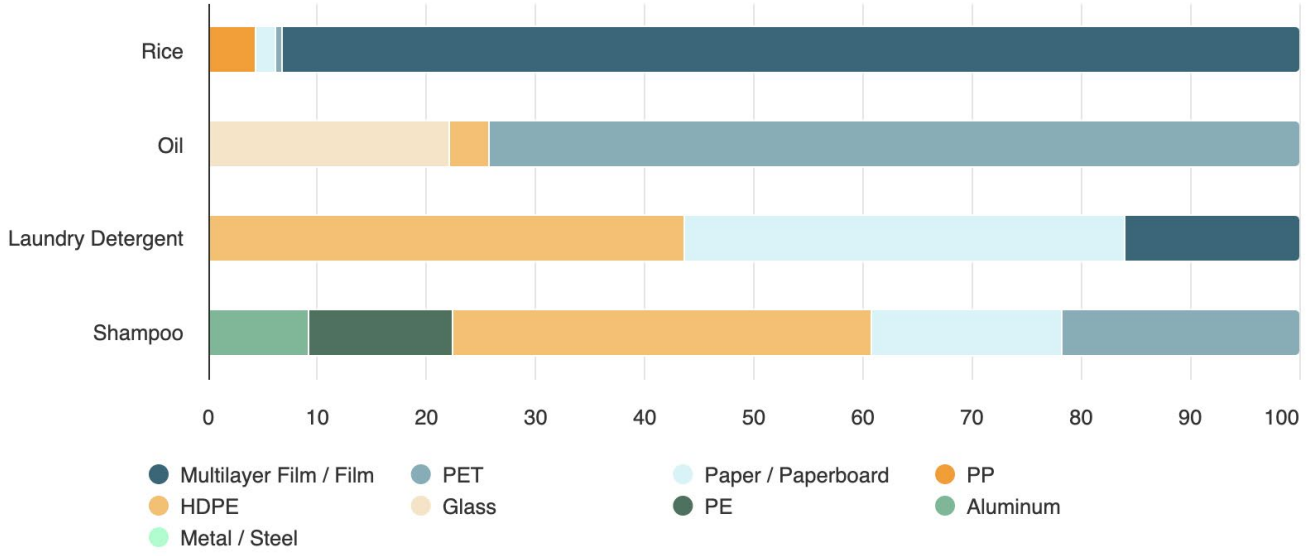


Figure 10: Material breakdown of staple items surveyed in Salvador stores



Plastic is the most popular packaging in convenience items, food staples, and personal care/cleaning products in Salvador. PET bottles and multilayer plastic film account for 73% of all recorded convenience item's packaging, even with the inclusion of alcoholic beverages increasing the percentages of glass and aluminum. Notably, many of the convenience item's and food staple's packaging was either film or multilayer film and the majority of these were labeled clearly and identifiable. This finding is consistent with other sites across the world, and multilayer film is a problematic material type due to the multi-faceted composition presenting challenges with recycling. In convenience items the fraction of this material is 48%, for comparison, in a recent survey in Santiago, Chile 32% of products were in multilayer film.

PET was the second most significant fraction in packaging (25% in recorded convenience items and 70% visually assessed in oil packaging), even present in unexpected grocery staples like Shampoo (22%) and Rice (0.5%) packaging. PET recycling is a more established practice and has widespread interest from stakeholders in Salvador. Aluminum is also popular on recorded convenience items (9.6%), but the informal recycling sector in Salvador seems to take care of this material in a more efficient way than plastics according to stakeholder interviews. At the same percentage (9.6%), glass was tied with aluminum for the third most popular material packaging in recorded convenience items, making it a critical material to address.

From observations, film, PET, and HDPE are the most popular materials on food staples and personal care/cleaning packaging. Film is unsurprisingly the most popular material for on Rice packaging (93.3%) and it's also present in laundry products (16%). HDPE (46.3% Laundry, 38.4% Shampoo) and PET (21.7% Shampoo) dominate the personal care and laundry aisles (Figure 11) with flexible Polyethylene (13.2%) present as sachets usually advertised as "refills."

Figure 11: Laundry aisle materials and presentations of products

Paper/cardboard and related materials were also present in smaller amounts in Candy (16.9%), Rice (1.8%), Laundry (40.4%), and surprisingly on Shampoo (17.4%) items' packaging. Paperboard in the laundry aisle is usually attributable to powder detergents or powder concentrates. However, in the shampoo aisle could be mostly due to extra packaging in shampoo+conditioner combos besides the HDPE of the bottles (Figure 12).

Figure 12: Cardboard packaging on Shampoo

Cigarettes were excluded from sample purchasing, but they are typically a standard size and previous averages have been about 10g of plastic packaging to about 15g of product. This relatively high plastic packaging to product ratio means cigarettes generate larger amounts of plastic waste per unit of product, which is likely driven by the cellulose acetate filters in cigarette butts, which typically weigh about a gram each.

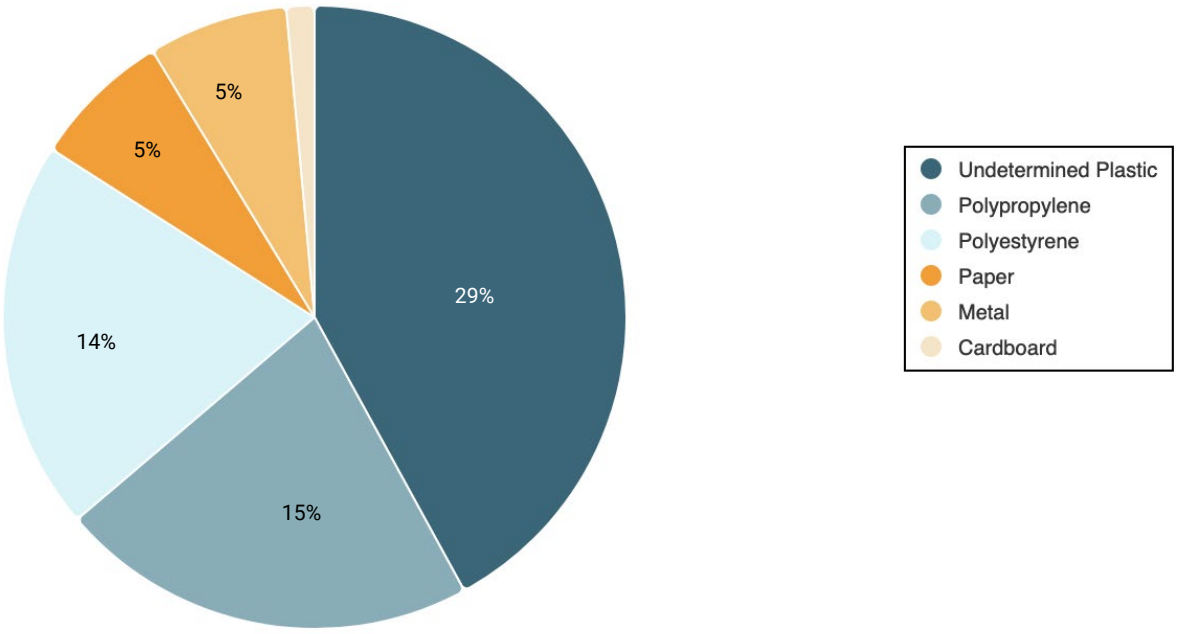
In addition to surveying convenience and grocery stores, the local team surveyed restaurants in each of the accessible 1 km^2 transects areas. Through visual assessments and discussions with restaurant owners, we assessed the material type for to-go food items like containers (including their lids), cups, utensils, and straws. In total, we characterized 70 items in 23 restaurants (Table 3). With few instances of paper and aluminum, the majority of to-go

food items surveyed are plastics or similar fossil-fuel derivatives. In that category, EPS is the most popular material for containers at 12 samples, with its closest second being coated paper with 3 samples. For cups and utensils, undetermined plastic was the definite majority, while straws were mostly registered as PP and undetermined plastic.

Table 3: Products and material types surveyed in restaurants and food vendors

Product	Material	Number of Samples
Bag	Undetermined Plastic	1
Cold	Undetermined Plastic	4
	EPS	2
To-go Container	EPS	12
	Coated Paper	3
	PP	2
	Undetermined Plastic	2
	Aluminum	1
	Cardboard	1
Straw	PP	10
	Undetermined Plastic	8
	Paper	2
	Metal	1
Utensils	Undetermined Plastic	15
	Metal	3
	PP	1

Figure 13: Material breakdown of to-go items surveyed in Salvador



Some restaurants offering sit-down options used reusable tableware, but the majority of restaurants surveyed had no other options than the single-use to-go products for pickup and delivery. Out of the 23 restaurants, one had no information on to-go food items and another used only plastic bags as containers. Every remaining store had straws and only three of them had plastic alternatives. With the new policies in place, however, it will eventually be necessary to go through the, according to stakeholders, challenging yet rewarding process of switching to alternative materials.

> **"We are working on this challenge. In this specific case, the customer is the restaurant and we do not have the power to make them change immediately. We really need to first develop a viable solution for what he sells, for the food he sells, secondly, compare the competitive value with the value of the packaging he uses today, thirdly, connect with the producer of the current packaging so that he starts making this change on a daily basis. If we look at the end customer, it is very well regarded and people are adhering; they order from a specific restaurant because they know that the packaging is not made of plastic or Styrofoam."**
>
> **— Industry stakeholder**

While plastic was a ubiquitous material seen across FMCGs, to-go items in restaurants, and staple packaging grocery stores, the surveys did identify several items — such as HDPE and PET shampoo, laundry, and cooking oil containers — that are readily recyclable and would be ideal for source-separation and resource recovery. It will be valuable in coming months and years to revisit these survey methods to determine the efficacy of interventions, particularly those focused on recycling and recovery, policies around single-use plastic alternatives, and investment in refill and reuse.

Use

Alternatives to raw plastics are making their way in the Soteropolitan community, Sugarcane polymers and bioplastics, for instance are making their way into the city, with factories nearby, products in the supermarket, and government policies, people are making decisions to embrace materials other than raw plastics. There are still a lot of improvements to be made, but there are steps being taken towards exploring more sustainable materials.

> **"We now have a law to ban plastic bags, but the idea is bio-plastic bags, which those of us who work with this know are plastic bags that break down into microplastics even faster. So, it's not a compostable bag but a bag made of oxo-bio plastic, which quickly decomposes when exposed to heat, dirt, and other factors, turning into microplastics just the same."**
>
> **— Waste/Recycling stakeholder**

This stakeholder refers to the previously mentioned Law 9699 of 2023 that requires stores to switch plastic bags to bioplastics options. This law however was not enforced in the majority of the stores surveyed with the most common bags made from plastic. Reusable "Ecobags" were offered for a fee in half of the surveyed stores and there were some plastic packaging alternatives in a little more than half the stores. In the stores, however, the cost of the bioplastics (R$2.49/unit dessert plate) exceeds the cost of its plastic counterparts (R$0.63/unit dessert plate) considerably and the former do not have much information on materials or forms of disposal.

Another alternative to plastic packaging in the stores is glass, which is the main packaging concern for some of the industry stakeholders interviewed. It is also a concern for people in the waste/recycling side of things.

> **"The glass is at the top, everyone has glass. Mainly from who drinks beers now, they aren't returned, so you drink and go accumulating and throwing away and disposing."**
>
> **— Waste/Recycling stakeholder**

The survey team also experienced the ubiquity of glass during the litter transect surveys, finding fragments and whole glass bottles in many areas surveyed (Figure 14).

Figure 14: Glass Bottles found on Transects

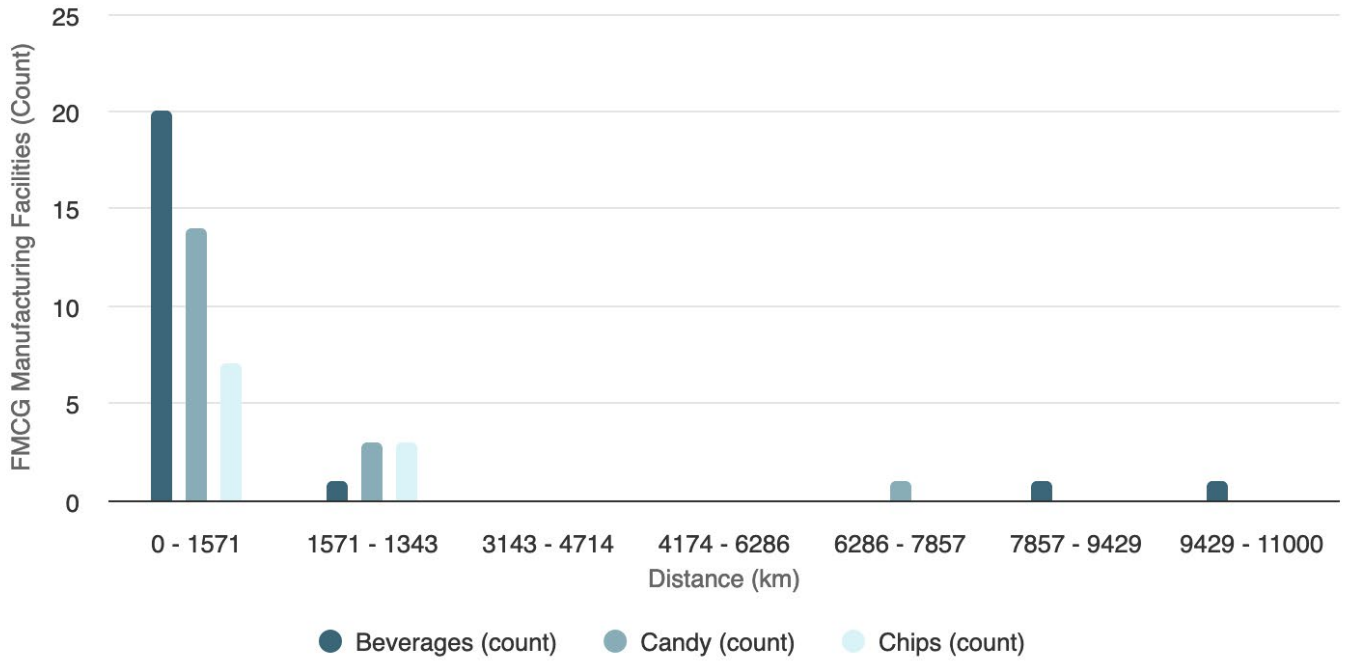
It is noted, however, that stakeholders want to promote recovery of this material, including as part of corporate goals and sustainability commitments.

> **"We have an extensive campaign for returnable packaging, shifting part of the volume to returnable packaging, specifically in RGB and RGT bottles, which are amber, mainly for beers. They are returnable and can survive a 15 to 25-turn or bottle production cycle. It's an extensive cycle. It's a pretty effective cycle in terms of waste production. Creating a consumer mindset to try to return the packaging, offering discounts, making it easy to access the product, and expanding its acceptance in the reverse logistics chain."**
>
> **— Industry stakeholder**

> **"Starting this year, we began using returnable long necks, beginning in the South. Curitiba was the first place we started operating with our returnable long necks. We're starting to work with a type of waste that shouldn't be discarded. It is thicker, it has a slightly different weight, but it can withstand the pressure of refilling, et cetera. We are working more and more to eliminate disposables from our chain."**
>
> **— Industry stakeholder**

From the regulatory side, Chapter 18 of the 11300 decree of 2022 considers the economic viability of glass returnability for companies. Inside that chapter, considerations of transportation, storage, and potential use of the material are discussed, given the fact that the majority of beverage manufacturers surveyed are located within a reasonable distance from Salvador (Figure 15) means that there are strong opportunities for recovery of these items.

Figure 15: Manufacturing locations histogram for Salvador



For other types of glass packaging, according to market reports (MI, 2024), Brazil presents a growth trend in demand for glass packaging, with companies already gearing up to facilitate the recovery process.

> **"O-I Glass will train them to handle glass correctly, and they will invest in infrastructure for the cooperatives."**
>
> **— Academia stakeholder**

Even though transportation and storage would be considered extremely problematic for glass returnability in islands or territories without easy access to trucks, glass is still considered one of the most straightforward and least problematic plastic alternatives. This is notably the case for particular single-use plastic items such as PET beverage bottles, though glass does not serve as a viable alternative for many other types of products, and tradeoffs need to be considered.

Although refill sachets are often thought of as a "less plastic" alternative, the multilayer material of sachets are some of the most problematic packaging. Commonly available in grocery stores, they are offered in smaller quantities than the more recyclable HDPE versions (Figure 16). Smaller product sizes may lead to more frequent, less expensive purchases compared to larger product sizes. However, per quantity, these are often more expensive compared to the price per quantity in larger sizes, in addition to generating more packaging waste per quantity as well.

Figure 16: Refill sachets size examples

The most challenging packaging to recover found in this study, however, is EPS Foam or Polystyrene. Although banned in many places because of their heavy environmental impact, polystyrene is still a popular to-go container material in Salvador. However, even for this often problematic material there are avenues for recovery in the city.

> **"Start Solidarium… created a Styrofoam product that repairs walls and cars. It's called Reparô. [They] want to implement this Styrofoam transformation system in the cooperatives, so that the cooperatives can receive the Styrofoam and transform it into this mass that [they] use. [They] sell it in tubes."**
>
> **— Academia stakeholder**

However, industry stakeholders whose main packaging is plastic are looking at goals to considerably reduce their raw plastic footprint within the next decade.

> **"… we're working on various fronts, from development of the primary chain, as I said, substitution of raw materials, whether with recycled material or actually changing the type of plastic, or at the end of the chain, in reverse logistics."**
>
> **— Industry stakeholder**

Several examples of plastic alternatives were observed in Salvador, which is a promising sign for transitions toward circularity. The city could consider targeting some of the most problematic single-use plastic items and implementing further reuse, refill, and reduction efforts that are locally and culturally tailored in order to ultimately eliminate them from the waste stream and the environment.

Collection

Salvador collection, transportation, and disposal services are carried out through a multi-year bidding process that employs private companies. There are different companies at the helm of collection and landfill management and they each manage their own side of the cycle. According to one of the companies in charge of collection, they collect an average of ten thousand tons of household waste and are in charge of street cleaning at all levels.

> **"[W]e coordinate all the beach cleaning, waste collection and sweeping activities… pruning, garbage collection, household waste collection, beach cleaning, sweeping. What else? Cleaning in areas that are difficult to access. [A specific area of Salvador is our] responsibility… all these neighborhoods, we do all the services."**
>
> **— Waste/Recycling Stakeholder**

With all the collection companies, daily residential collection coverage was 77.34% in 2019 while 21.8% received the service 2-3 times a week. The majority of the city is serviced by compactor trucks. There are areas, however, that require special collection circumstances like motorcycles, body trucks, or fixed dumpsters.

> **"There are places, for example, where trucks don't enter because access is complicated. You know Salvador is entirely irregular. So, there are places where trucks don't pass, for example, because the space is very tight. The City Hall usually puts, for example, motorcycles with a structure… There are neighborhoods where the City Hall, for example, needs to put [places where] people drop the waste in a container."**
>
> **— Public Official**

With this in mind, there are communities who already need to think about taking their trash to static dumpsters out of their way in order to get a waste collection service. Condominiums and wealthy neighborhoods have other options like concierge garbage pickup and the ability to drive to recycling points whenever they have enough materials to accumulate.

> **"But perhaps, in the more affluent neighborhood, the way of dealing with waste is different because, in the more popular neighborhood, the resident has to take their waste and dispose of it themselves. In the case of more affluent condominiums, the person puts the waste at the door. Then, someone goes there, collects it, and takes it away, so perhaps this helps us to have a more organized system in condominiums, for example. But I think there should be coverage throughout the city."**
>
> **— Public Official**

Static dumpsters (as seen in condominiums) for communities without current informal door-to-door waste collection access could offer a recycling option. However, it is important to take into consideration space constraints, potential contamination of recyclables, and the need for regular maintenance of the bins for them to be successful. As source

separation is not something that is widely adopted by residents of Salvador, public outreach and awareness would also be needed.

Most collected waste in Salvador is taken to the landfill, though there is a small percentage that is taken to a transfer station. Households do not directly pay for waste collection since the city manages those payments from funds collected through taxes. There is currently not a formal recycling collection in the city of Salvador, however, there are 14 cooperatives registered to manage recyclable materials, who also have their own accessibility and logistics issues.

One of the most important, widely-mentioned projects related to recycling in the city of Salvador is the So+Ma Vantagens project, in which Casa SOMA recycling structures accept recyclables drop-offs in exchange for points in a rewards system.

> **"Now, there are, for example, projects like Casa So+ma, where people can exchange certain types of reusable products, like cardboard, glass, aluminum, and such. They exchange and accumulate points, so it's another initiative that helps reduce the frequency of this type of waste in public collection. As I mentioned, the City Hall of Salvador does not remunerate the cooperative for the collection of materials, so there is no connection between this action and the City Hall."**
>
> **— Public Official**

> **"Casa Soma is in partnership with the cooperatives, and we can have a cooperative attendant with knowledge in recycling to guide and raise awareness when people bring in materials, encouraging them to bring cleaner materials each day. That's what's been progressing."**
>
> **— Waste/Recycling Stakeholder**

Much of the waste separation in Salvador is done by informal recycling cooperatives who collect, separate, and commercialize materials like cardboard, glass, paper, or metal, as a source of income. They collect approximately 40% Cardboard, 30% PET, 10% White Paper and 20% Other materials. Some of their biggest issues include logistics and the decrease in recycled materials demand, thus, plummeting prices.

> **"The person may have the goodwill to donate the material. Still, when they call the cooperative and say, "I want two bags of materials here," the math doesn't add up when calculating the logistics. What happens? It demotivates these people. But when we earn for these environmental services, these materials will be collected because we've already gone to the field with this paid amount."**
>
> **— Waste/Recycling Stakeholder**

As previously mentioned, without official recycling, this type of collection is currently hindered by cost-effectiveness for cooperatives and informal recycling agents. Trash cans intended for public use, such as those in Figure 17, include those affixed to wood poles, with some rolling bins, and static dumpsters that are often serviced.

Figure 17: Public trash cans and collection bins in Salvador

Collection points have been previously successful for the community and informal recycling sectors if there is safety and maintenance around them.

> **"We used to have some places here for depositing recyclable waste that could be reused, but they don't exist anymore. Vandalism played a part; it helped a lot in not having that type of collection anymore."**
>
> **— NGO Stakeholder**

> **"When the Municipality had the drop-off points (PEV)... They were left in the street without supervision, and people dumped [inappropriate] things in those PEVs. But the challenges are more like these."**
>
> **— Waste/Recycling Stakeholder**

> **"When you deploy with a program like Soma in Salvador, you start engaging people. I think you get to a point where you ask how do you show the population that you have other spaces, but you had-- What I mean is that you had other spaces, with no human interaction. It was your responsibility to dispose of it."**
>
> **— Waste/Recycling Stakeholder**

Also related with selective collection policies, source separation could help collectors streamline resource recovery according to their own specialties.

> **"I think that with selective collection, going back to as many places as we can, to try to complete the cycle, a lot of materials can go back into the recycling cycle. In particular, we should try to reduce the amount we send to landfill sites, which are already overcrowded, and we're adding to the problem we have."**
>
> **— Waste/Recycling Stakeholder**

> **"Let's arrange selective waste collection in all city neighborhoods, and cooperatives participate. In that case, the first thing you'll see is an improvement in the overall quality of life for the population."**
>
> **— Public Official**

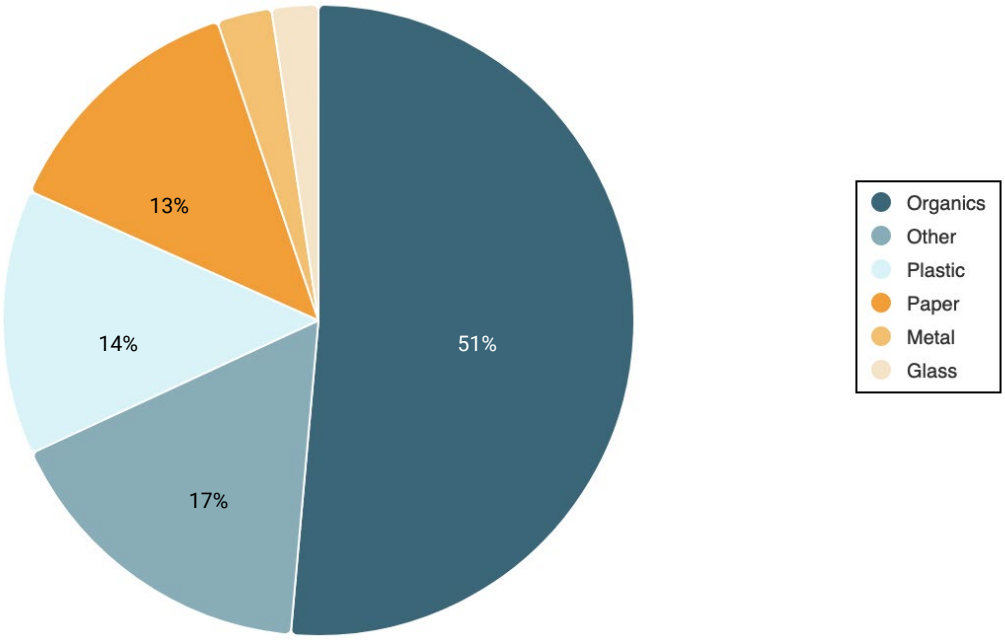
> **"What I do know is that it's a problem, as it is throughout Brazil, with reverse logistics. We have little selective collection, still at a mature level of cooperative development, it isn't yet very expanded as we need it to be, as Brazil needs."**
>
> **— Industry Stakeholder**

While the city of Salvador has high coverage for residential collection, several opportunities were identified around optimizing that system, particularly around increasing collection of recyclables and compostables, rethinking bin placement, and exploring opportunities for source separation of waste.

End of Cycle

In 2020, Salvador sent 979,463.98 tons of MSW to its only landfill, the Aterro Metropolitano Central (AMC), having moved 80% of it through the transfer station. With a generation rate of 0.93 kg/person/day, but a recycling rate of 4% (under national average), it is important to examine ways to divert waste from the landfill. Selective collection and separation at source could potentially increase the collection and quality of humid waste or compost separation for collection and increase cleanliness and processing of recyclables. This process would address the more than 80% of recoverable material in the current MSW composition (Figure 18).

Figure 18: MSW Composition Salvador [4]



With a conservative proportion of organic waste generated in Salvador of 40% (with some sources suggesting closer to 50% and 60%), composting could be extremely beneficial as well as cover the needs of emergent alternative plastics products. Composting companies are currently present in Salvador, although most depend on willingness and investment from the public. The AMC landfill (Figure 19), although property of the city, is managed by a private company. It receives MSW only, with Health Solid Waste and C&D waste having different destinations. The existence of illegal dumps in Salvador is unfortunately still a problem, as it is littering in the city.

4. https://portalresiduossolidos.com/gravimetria-estimada-dos-residuos-solidos-do-municipio-de-salvador-ba/

Figure 19: AMC Landfill Salvador [5]

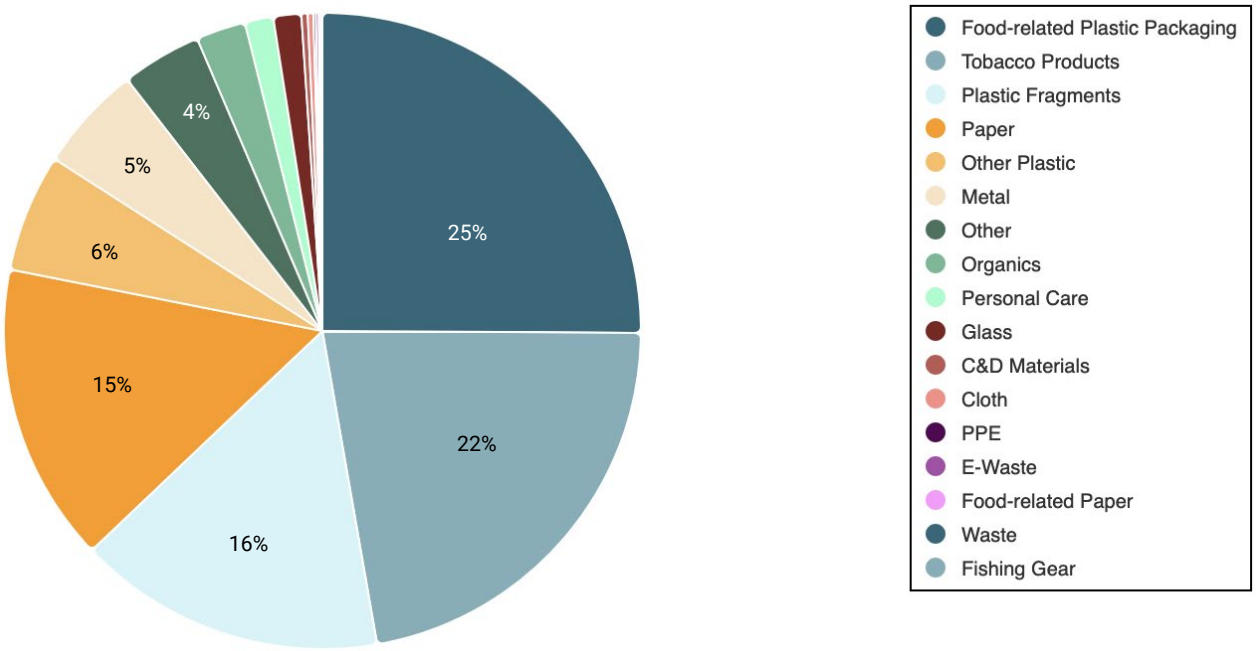
Recyclables are for the most part the domain of the cooperatives, who sell them either as ready to be processed material or, when difficult to find buyers, as processed and built products. However, with the current industry interest and sustainability goals, there is a potential market avenue for recycled PET and glass.

Leakage

In total, 2,830 items were logged in 25 transects (there were logistics issues with two zones) of a 100m^2 except for one for logistical reasons, characterizing nine different square kilometer areas. Transect locations were selected using a stratified random sampling method, in which transects were randomly selected in 10 x 10 kilometers which were distributed across three groups of population count (upper, middle, lower) based on LandScan ambient population data. Litter items were recorded using the open-source Marine Debris Tracker app. A full list of items available in the app and their associated material categories as well as a map of sample sites and their surveyed litter densities can be found in the Appendix. There are significant differences between litter densities even in geographically similar areas (Periperi <1.80/highest and Rio Vermelho >0.63/lowest).

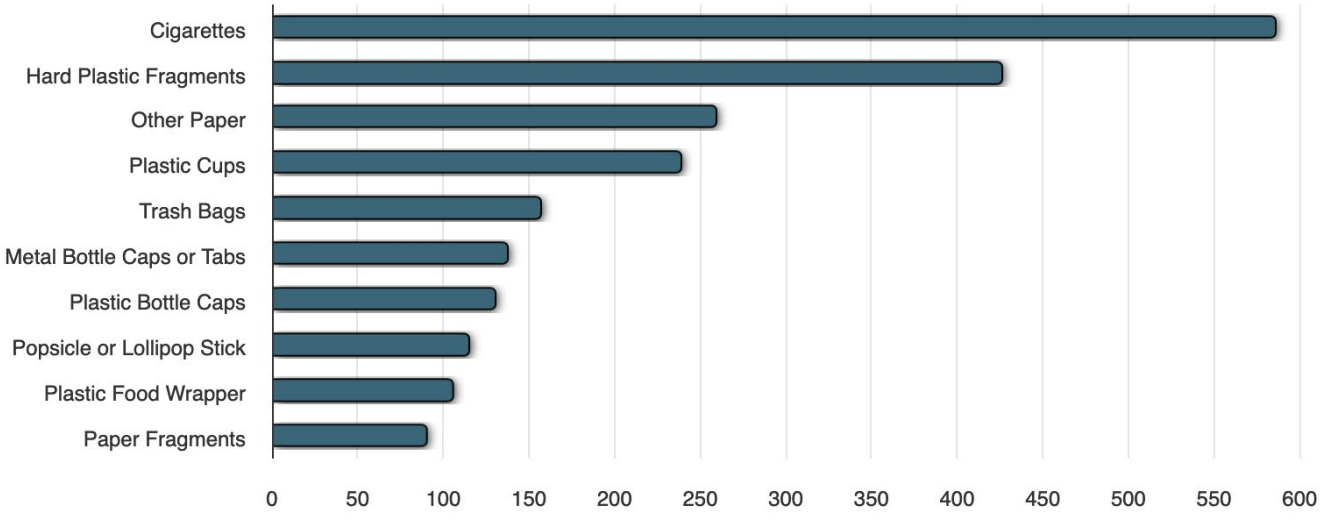
5. Rath JM, Rubenstein RA, Curry LE, Shank SE, Cartwright JC. Cigarette litter: smokers' attitudes and behaviors. Int J Environ Res Public Health. 2012 Jun;9(6):2189-203. doi: 10.3390/ijerph9062189. Epub 2012 Jun 13. PMID: 22829798; PMCID: PMC3397372.

Figure 20: Litter Material Breakdown



The most common materials found in litter are food-related plastic packaging (e.g., plastic cups, plastic food wrappers), tobacco products (predominantly cigarettes), and plastic fragments (hard, film, and foam). Paper was the fourth most common litter material observed. Common plastic items (food plastic, other plastic, PPE, plastic fragments, and personal care items) represented 48% of litter, which is around the average compared to other UO cities.

Figure 21: Count of litter items



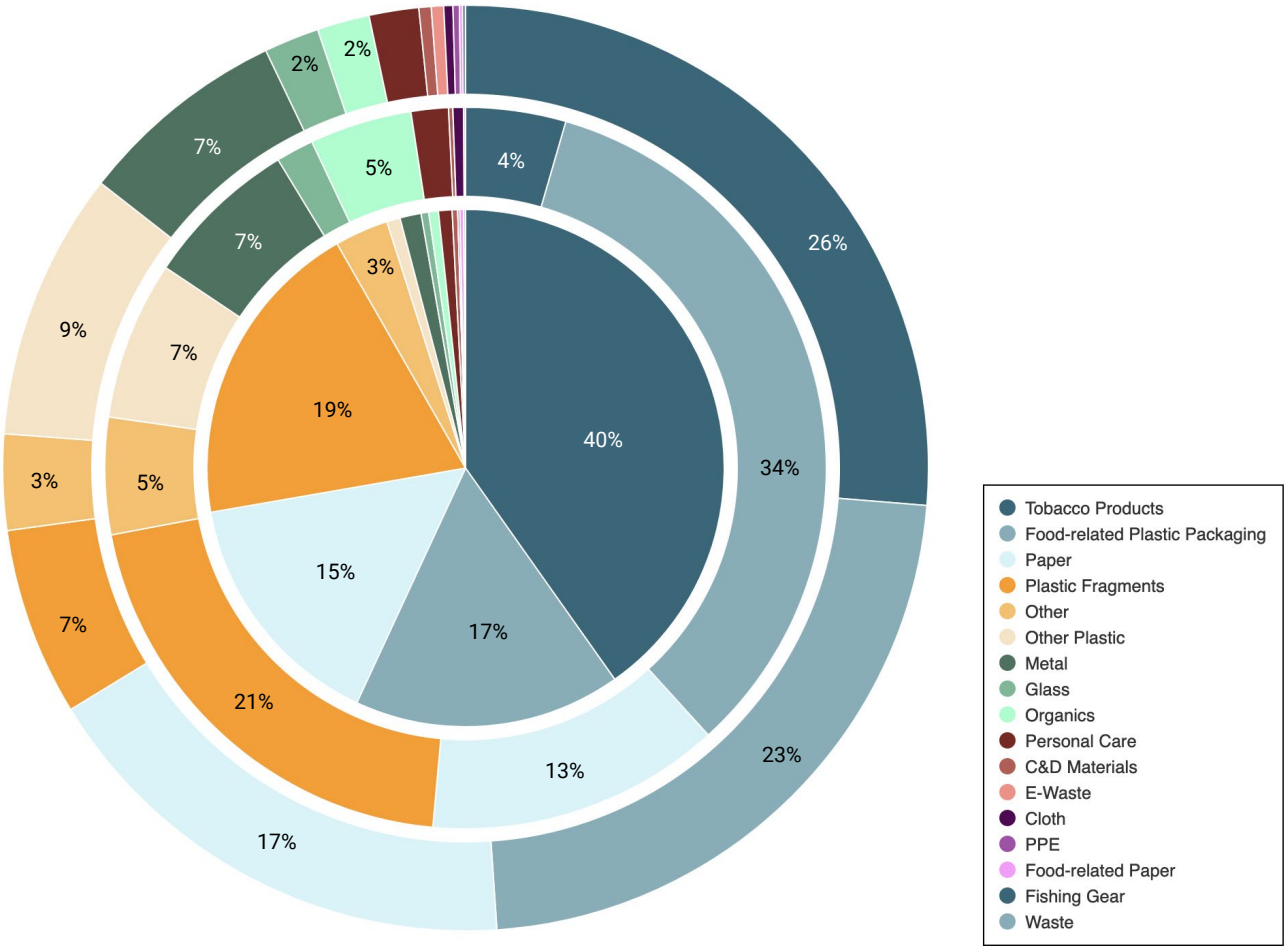
The high proportion of cigarette butts as litter across all population tertiles is notable. Cigarette filters, in addition to leaching contaminants into water systems, are composed of cellulose acetate, a type of plastic, which may not be high in the public awareness. Previous studies have found that successful anti-cigarette litter campaigns should emphasize that these butts are toxic waste and are harmful when disposed of improperly. This is something that outreach campaigns in Salvador may want to incorporate into their messaging.

Although cigarettes are the highest counted items, at close to 600 units, during litter transects, other plastic items are at the most significant counts of over 100 units, paper, metal, and sticks also appear on the hundreds and they are mostly related to convenience on-the-go items (e.g., metal bottle caps or tabs). Food related plastic making its way into the environment (Figure 22), especially waterways, is one of the biggest worries for stakeholders in Salvador.

> **"So, we have this perception that during the rainy season, the trash that comes into the ocean is from various points in the city, not just the coastal trash. Still, when it rains, we notice the movement of the currents, and a lot of stuff comes from other places—tons of tires, computer parts, keyboard remains, mouse, and many other things you can see are not local trash. Its trash brought by the currents and ends up here."**
>
> **— NGO Stakeholder**

Figure 22: Example litter photos

Figure 23: Proportion of most common plastic items in low (inner), mid (middle), and high (outer) population count areas in Salvador



Litter densities were identical in the middle and lower population tertiles, with the upper population tertile having a slightly lower density than both the former. While they were similar in high and low population sites (Table 4). On average, the litter density in Salvador was 1.11 items/m^2, for comparison, three cities sampled along the Mississippi River in the United States had average litter densities of 0.61 items/m^2, 0.69 items/m^2, and 0.28 items/m^2 respectively. The litter densities in Salvador were more similar to results from CAPs conducted in other Urban Ocean cities like Panama City, Panama, which had litter densities of 1.87 items/m^2 in high population count areas, 1.43 items/m^2 in middle population count areas, and 3.04 items/m^2 in lower population count areas as of 2021 (CIL, 2021).

Table 4: Litter Density and Top Litter Items for Each Area of Population Count

Population Tertile	Top 5 Litter Items	Litter Density (count/m²)
Upper (11,929 - 34,739 persons/km²)	1) Cigarettes 2) Other Paper 3) Trash Bags 4) Plastic Cups 5) Metal Bottle Caps or Tabs	1.03
Middle (3,524 - 11,929 persons/km²)	1) Hard Plastic Fragments 2) Plastic Cups 3) Other Paper 4) Trash Bags 5) Plastic Bottle Cap	1.19
Lower (12 - 3,524 persons/km²)	1) Cigarettes 2) Hard Plastic Fragments 3) Other Paper 4) Paper Fragments 5) Plastic Cups	1.19

Hazardous/medical waste is also a concern when disposed of incorrectly (Figure 24). Especially in this case, it appears that medical and other waste is left for the informal recycling sector to sort and correctly dispose of.

Figure 24: Mismanaged medical waste

Street sweeping occurs seasonally in Salvador; vacuum trucks clean sidewalks to prevent dust from May to August, and inherently this practice will also capture some litter. Therefore, not all litter surveyed in this study may be entering the environment. However, these last-chance capture methods do not promote prevention, and leakage is still occurring. In addition to more formal street sweeping practices, an interviewee noted that it is common to sweep outside one's home, which may lead to lower litter in residential areas.

> **"People sweep right in front of their own house, and it's a habit in certain places. It's common sense because people want to live in a clean environment."**
>
> **— Government Official**

The sampling team observed occasional accumulation sites of litter, both single-use plastics on busy street areas, as well as bulkier waste observed nearby. Additionally, several "informal" trash cans were observed, where a bucket, container, or other box was left out and became an accumulation site for waste. Areas with higher litter densities or regular accumulations might represent opportunities for targeted additional waste infrastructure or last-chance capture.

Opportunities

CIL found the following opportunities to expand and enhance circularity in Salvador based on the findings of this report. These opportunities are categorized based on the seven spokes of the CAP model. Stakeholder engagement with the partners of this project should take place to further expand, refine and prioritize these opportunities based on local context, 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

- With a large percentage of products manufactured in Salvador, creation and enforcement of EPR regulations (including those in the Federal Law No. 12,305 of 2010) could lend a significant plastic pollution reduction opportunity.
- Industry stakeholders of the most popular brands are open to collaborative work and potential solutions that allow them to accomplish state regulations and their own sustainability goals (e.g., potential investments on maintenance/safety of recycling sites including in stores locations).

COMMUNITY

- Collaborative groups of different kinds of actors/stakeholders could benefit from having clear checklists on solid waste management (SWM) procedures based on government regulations and input, particularly surrounding any source separation guidelines.
- Collaborative groups of different kinds of actors/stakeholders that operate within Salvador can decide the strongest paths and use of resources from their own perspectives and needs to better educate the public.
- Informal recycling and composting cooperatives and actors could benefit from infrastructure improvements, particularly around accessibility and safety, and long-term contracting investments (including as educational actors).

PRODUCT DESIGN

- Continuous support to the informal recycling community could allow that sector to encourage source separation and recycling, thus acting as education and awareness agents.

- Regulation creation and enforcement could encourage the use of high demand recyclable or even alternative plastics options instead of plastics with low recovery indexes.

USE

- Through emergent research and innovation, groups from waste collection, industry, and academic stakeholders can collaborate to address problematic and challenging materials like expanded polystyrene.
- The use of glass could feasibly be encouraged, promoted, and supported as a plastic alternative, given local context and projected national demands. [6]

COLLECTION

- Ensure that collection points are located in easily maintained safe areas and access is given to recycling co-operatives.
- Creating contracts or other types of formal agreements/partnerships with the recycling community could provide cost-effective recycling coverage.
- Placing static recycling bins beside dumpsters, coupled with public outreach and proper maintenance, could provide a path forward for source separation.

END OF CYCLE

- Support for both recycling and composting cooperatives could divert a large percentage of landfill-bound waste and optimize existing SWM infrastructure.
- Diverting wet/organic/humid waste or compost towards compost stations, farms, or public gardens (depending on source separation) would be beneficial for waste diversion and optimization.
- Separation at the source could include wet/organic waste for compost collection to help make recyclable items cleaner.
- Programs that more effectively engage waste pickers and the informal waste community could be developed to optimize waste processing in the city.

LEAKAGE

- Observe key differences in areas of low litter densities (Rio Vermelho) and high litter densities (Periperi) to understand the nuances and develop systems to help them reach lower leakage levels.
- Outreach and education campaigns and materials related to littering, particularly for problematic and common litter items such as cigarette butts, should be considered for the city and tailored to local needs.
- Recommend that local partners revisit Leakage methods and measure impact of interventions over time, with a particular focus on food plastic and tobacco products.

6. MI Report (2024). Mordor Intelligence. Latin America Glass Packaging Market Size & Share Analysis — Growth Trends & Forecasts (2024 – 2029) https://www.mordorintelligence.com/industry-reports/latin-america-glass-packaging-market Accessed on March 2, 2024.

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Appendix

Table 5: Full List of Debris Tracker Litter Items and Associated Material Categories

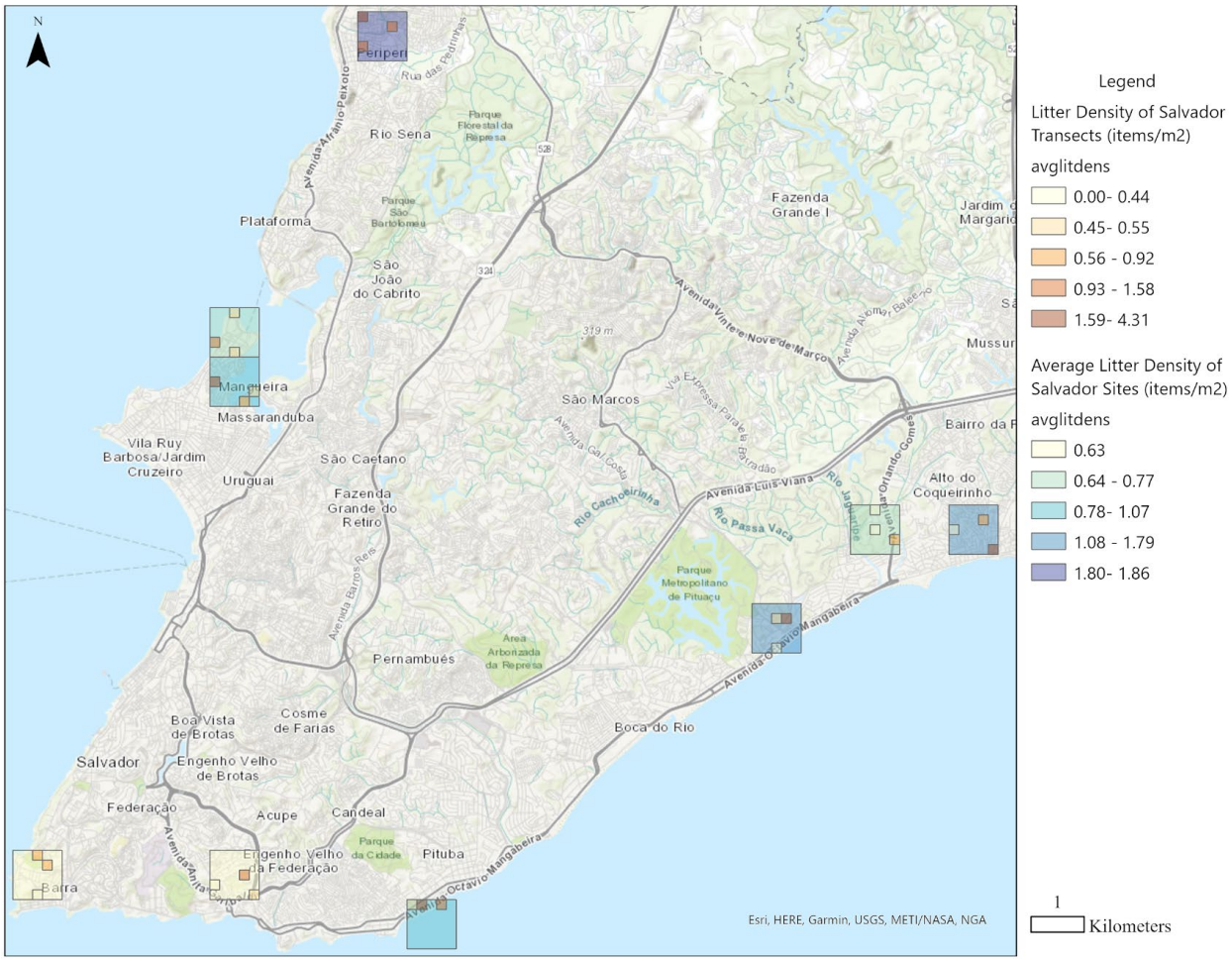
Material	Items
	Aggregate & Brick Bolts, Nails, and Screws Building Materials Lumber Other C&D
	Clothing Towels or rags Fabric Pieces Other Cloth
	Batteries E-Waste Fragments Wire Other E-Waste
	Buoys and Floats Fishing Line Other Fishing Gear Plastic Net or Net Pieces Plastic Rope
	Glass Bottle Glass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

Material	Items
C&D Materials	Aggregate & Brick Bolts, Nails, and Screws Building Materials Lumber Other C&D
Cloth	Clothing Towels or rags Fabric Pieces Other Cloth
E-Waste	Batteries E-Waste Fragments Wire 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 Foil to-go container Metal Bottle Caps or Tabs Metal Fragments Other Metal
Organic Waste	Food Waste Other Organic Waste
Other	Other Popsicle or lollipop Stick
Other Plastic Products	Bulk Bags Flip Flops or shoes Plastic String, Tape, or Packing Straps Rubber Bands Trash bag Tires Balloons Plastic toys or balls Car Parts Hard plastic jugs or containers Other Plastic

Material	Items
Food-Related Paper	Paper cups Paper food box or container Paper plates or bowls Compostable paper cups Paper food wrapper Compostable food box or container Napkins Other Food-Related paper
Paper	Office paper and newspaper Tags, tickets, and receipts Corrugated Cardboard Paper fragments Other Paper
Personal Care Products	Blister Pack or other pill packaging Cotton Buds Ear plugs Personal Care Product Sachet or packet Toothbrushes Toothpaste or Other Product Tube Flossers Feminine products Needles and syringes Other Personal Care Product
Food-related plastic	Foam cups Plastic cups Compostable plastic cups Cup Lids Plastic Bottle Aseptic cartons Mini alcohol bottles Plastic Bottle Cap Plastic Food Wrapper Condiment packet or container Plastic Grocery Bag Sandwich or snack bags Plastic Utensils Straws Foam to-go container or clamshell Plastic to-go container or clamshell Compostable plastic container or clamshell Other Food-Related Plastic

Material	Items
Plastic Fragments	Film Fragments Foam Fragments Hard Plastic Fragments Rubber/ tire fragments Other Fragments
PPE	Disinfectant Wipes Disposable Gloves Face Masks Other PPE
Tobacco Products	Cigarette Packaging Cigarettes Tobacco Sachets or packets E-cigarettes and vaping Plastic cigar/cigarillo tips Lighters Cannabis-related waste Other Tobacco Product

Figure 25: Litter densities in transects and sites surveyed in Salvador



An interactive web map version of this map is available at: https://usg.maps.arcgis.com/apps/mapviewer/index.html?webmap=92d84e3251fa40f2a5a04c041ec718a7

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