CIRCULARITY FROM THE GROUND-UP: CITIES AND SMALL ISLAND DEVELOPING STATES AT THE FOREFRONT OF PLASTIC POLLUTION PREVENTION

by

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(Under the Direction of Jenna Jambeck)

ABSTRACT

Plastic pollution has reached an undeniable level of global impact. The transition towards circular systems that rethink the design and use of plastic products and eliminate plastic waste leakage is critical to protect human health and the environment. Urgency around interventions has reached every level of governance worldwide. However, gaps remain in measuring circularity to inform interventions and evaluating intervention impacts over time in order to adapt accordingly. It is important to collect this data to inform decision-making, particularly in a manner that is comparable across contexts and in a way that the data and methods are accessible and relatable. As the United Nations (UN) negotiations for a legally binding agreement on plastic pollution move towards National Action Plans (NAP) and localized interventions to meet global mandates, it is critical for local stakeholders who know their context best to retain tools for monitoring, evaluation, and decision-making. The objectives of this dissertation are focused on defining circularity through a critical review and application of the Circularity Assessment Protocol (CAP) to holistically quantify circularity for plastic packaging in multiple contexts. These contexts include an analysis of CAP results across six cities in five countries as part of the

Urban Ocean initiative, the application of CAP to set a baseline and develop interventions in a Small Island Developing State (SIDS), and the use of CAP to inform and measure the impact of solutions at the state-level when deployed in several cities in Florida, United States. Findings include the absence of and need for harmonized circularity definitions and metrics that are globally relevant and comparable, the outsized benefits of upstream interventions to optimize local circularity, and the unique challenges and opportunities of cities and small island developing states in preventing plastic pollution. These findings have informed campaigns, policy, infrastructure, and other interventions in the study locations. This research finds that CAP can be an effective, replicable, and scalable tool to quantify circularity for plastic packaging in various contexts and for different use cases globally. It demonstrates the value of, and need for, this work as stakeholders worldwide enter the next era of plastic pollution prevention.

INDEX WORDS: Plastic pollution, Circular economy, Circular materials management, Waste management, Small-island developing states, Urban resilience, Mixed methods

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DEDICATION

This body of work, similar to the CAP itself, cannot necessarily be dedicated or attributed to a single person or entity. It is the product of all who paved the way for it, who supported it, and who will continue to adapt and build it into the future. In that vein, I would like to dedicate this work to those who helped to get me where I am today - my entire family, for supporting my dreams, expanding my world, and showing me that anything is possible; to those who provide me endless support on the journey - my incredible husband, my friends near and far, my pets, my colleagues, my chosen family; and to those who I know will continue this work into the future - the city practitioners, the women in STEM, the next generation of leaders, those working to democratize science and protect what they love around the world. I cannot wait to see what we can build together.

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Glossary

CAP	Circularity Assessment Protocol
CE	Circular Economy
CIL	Circularity Informatics Lab
CREAD	Climate Resilience Execution Agency for Dominica
C&D	Construction and Demolition Material
DOWASCO	The Dominica Water and Sewerage Company Limited
DRS	Deposit Return Scheme
DSWMC	Dominica Solid Waste Management Corporation
DTDC	Door-to-door Collection
EPA	Environmental Protection Agency (US)
EPS	Expanded Polystyrene
EPR	Extended Producer Responsibility
FBA	Florida Beverage Association
FDEP	Florida Department of Environmental Protection
FRF	Florida Retail Federation
FMCG	Fast-Moving Consumer Goods
HDPE	High Density Polyethylene
GDP	Gross Domestic Product
INC	Intergovernmental Negotiating Committee
LAC	Latin America and the Caribbean
LIP	Local Implementing Partner
MDT	Marine Debris Tracker
MLP	Multilayer Plastic
MPs	Microplastics
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management
MT	Metric Tons

MMT	Million Metric Tons
NAP	National Action Plan
NMI	New Materials Institute
NOAA	National Oceanic and Atmospheric Administration (US)
OC	Ocean Conservancy
OECS	Organization of Eastern Caribbean States
PCR	Post-Consumer Recycled
PE	Polyethylene
PET	Polyethylene terephthalate
PP	Polypropylene
PPE	Personal Protective Equipment
PS	Polystyrene
RCN	Resilient Cities Network
rPET	Recycled Polyethylene Terephthalate
SIDS	Small Island Developing State
SUP	Single-Use Plastic
SWM	Solid Waste Management
SWMA	The Solid Waste Management Act (Florida)
TCI	The Circulate Initiative
TPD	Tons Per Day
UGA	University of Georgia
UO	Urban Ocean
WtE	Waste to Energy

Chapter 1: Introduction

1.1 Plastic Pollution and Circular Economy Context

1.1.1 Plastic Pollution - How did we get here?

Humankind has a long history of ingenuity and product design to meet societal needs, but today we have innovated ourselves into a disaster of the disposable. We have designed a complex world, with a range of convenient and affordable items available at our fingertips, which in many parts of the world can be thrown "away" after use and never seen again. The origins of plastics as we know it today can be traced back to the industrial-scale molding of materials such as natural rubber and later cellulose in the mid-1800s (Altman, 2021). The first fully synthetic polymer, Bakelite, was produced in 1907 and was marketed as a fossil fuel-based replacement to natural shellac and ivory. This opened what the Bakelite Foundation called the "fourth kingdom [beyond animal, mineral, and vegetable], whose boundaries are unlimited" (Freinkel, 2011). While many modern materials were designed to reduce the burden on natural resources, market studies suggest that this did not in fact decrease demand for materials such as ivory, and unanticipated burdens at other stages of the life cycle of those products have proven an ongoing challenge (Altman, 2021). After Bakelite came a boom in synthetic materials that led to the development of versatile, malleable, and affordable polymers such as polystyrene, nylon, acrylic, and polypropylene. This also accompanied the development of plasticizers and solvents such as camphor, and concerns around impacts on fenceline communities and worker health can be traced back to the early development of these industries in the 1800s (Altman, 2021). The growth and commercialization of these materials were serendipitously timed with global shortages of resources required for WWII - in 1941, the director of the board responsible for provisioning the American military requested that materials such as aluminum, brass, and other “strategic metals” be replaced with these plastic polymers wherever possible (Freinkel, 2011).

The company DuPont, among others, had foreseen the opportunities for these plastic materials once the military’s monopoly on them ended after the war. By 1943, DuPont had an entire division dedicated to preparing prototypes of plastic housewares and other everyday items. Shortly after the war ended in 1945, DuPont launched a National Plastics Exposition in New York to showcase the products they planned to bring to market (Freinkel, 2011). Within 10 years, the concept of “throwaway living” whereby everything is conveniently disposable, had been popularized by media outlets such as Life Magazine and Business Week (Hellmann et al., 2018). The 1950s were a key inflection point for plastic production, known as the “Great Acceleration,” which saw the confluence of post-war growth of PE and PS production and the development of HDPE and PP, a transition from coal towards crude oil and gas feedstocks, the application of polymer theory, a shift from fresh products in durable packaging to pre-packaged and disposable items (accelerated by the development of the highway system and fast food culture in the US), and more countries getting involved in building bigger plastic plants to reach economies of scale (Altman, 2017; Nelson Rangel-Buitrago, 2023). In 1950, only 2 Mt of plastic were produced annually - by 2019, that number had grown to 460 MT (see Figure 1). More than half of all plastic ever made has been produced since 2002 and production rates are estimated to triple by 2060 (Landrigan et al., 2023).

While production has increased exponentially - with products and polymers that are increasingly complex and difficult to manage/dispose of, made from synthetic polymers that remain cheaper and easier to access than alternatives - the infrastructure and innovation at the end of the plastic life cycle has not been able to keep up (Forrest et al., 2019). The plastics industry promoted the disposability of the product from its inception; in 1956, the editor of Modern Packaging magazine declared, “The future of plastics is in the trash can” and in 1963, he commended the Society of the Plastics Industry for, “filling the trash cans, the rubbish dumps and the incinerators with literally billions of plastic bottles, plastic jugs, plastic tubes, blister and skin packs, plastic bags and films and sheet packages,” concluding that, “the happy day has arrived when nobody any longer considers the plastics package too good to throw away.” (Altman, 2024).

Plastic has revolutionized the fields of transportation, medicine, and food security, but plastic packaging and single-use items are being produced, used, and disposed of at an unsustainable rate. Single-use plastics are those that are designed to be used only once and then discarded. Some of these items, such as plastic shopping bags, are estimated to be used by the consumer for an average of less than 12 minutes before they are discarded, and can last thousands of years in the landfill or environment (Wagner et al., 2017). Single-use items account for the largest and fastest growing subset of plastic manufactured, representing around 35-40% of the market (Landrigan et al., 2023). The mismatch between product design and end-of-life infrastructure was further exacerbated, particularly in the US, when China implemented its “National Sword" policy in 2018 and stopped accepting scrap materials intended for recycling. This policy displaced millions of metric tons of plastic waste and led to economic and environmental challenges felt around the world (Brooks et al., 2018). At that point, the burden of single-use plastics was brought into stark reality.

In 2015, researchers made a first attempt at generating a model to quantify the amount of plastic entering the environment globally, and in turn raised the first major red flag on this issue.

The Jambeck et al. paper that found 275 million metric tons (MT) of plastic waste was generated in 192 coastal countries in 2010 and 4.8-12.7 million MT had the potential to enter the ocean (Jambeck et al., 2015). Further emphasizing the scale of the problem, Geyer et al. in 2017 found that as of 2015, 6,300 Mt of plastic waste had been generated globally, only 9% of which had been recycled, 12% incinerated, and 79% accumulated in landfills or the natural environment, raising the alarm that this could result in a total of 12,000 Mt of plastic waste in landfills or in the natural environment by 2050 (Geyer et al., 2017). This raised concerns across the globe and from a range of stakeholders - “single-use” was even Collins Dictionary’s Word of the Year in 2018 (Kolirin, 2018). According to a World Risk Report on global household waste management in 2024, the most common reported material in household waste globally is plastic (42% of respondents said it was the single most common material type in their household waste), and over 40% of households globally dispose of their waste in an uncontrolled method. The report also highlighted gaps in waste collection and options for environmentally safe waste management between urban and rural areas globally - 39% of households in urban areas had access to waste collection from the government or private companies, compared to 2% of households in rural areas. Similarly, 53% of all households worldwide separate their household waste before disposing, and gaps exist between separation in high-income countries (81%) compared to low-income countries (31%) (LR Foundation, 2024). Different patterns were found between global regions, income levels, and age, and interventions clearly need to be tailored for these contexts.

Recent studies have updated models that quantify how much plastic actually reaches the ocean, which have estimated reduced amounts of 500 kilotons per year (Kaandorp et al., 2023). However, it is important to note that these numbers do not take into consideration the influence of the informal waste sector, do not include top polluting materials such as PET and PVC, and are illustrative of only the waste that makes it to the ocean and therefore excludes other potential deposition sites such as soil, rivers, air, and remote island coastlines. It is indisputable that plastic pollution has deservedly reached the top of political, corporate, and civil society agendas worldwide, and it has become one of the most pressing and ubiquitous environmental, social, and economic challenges of our time.

1.1.2 Current State of Knowledge on Plastic Pollution

Many of the characteristics that make plastic such an attractive and versatile material have also led to a challenge of scale when it comes to the disposal and end-of-life of plastic products. Estimates of plastic waste emissions into the environment reached 19-23 million metric tons in 2016 - the equivalent of 11% of all plastic waste generated that year globally - and are projected to grow to 53 million metric tons by 2030 (Borelle et al., 2021). Plastic particles have been found at the highest point on Earth at Mount Everest, in the deepest part of the ocean at the Marianas Trench, and everywhere in between (Peng et al., 2018; Napper et al., 2020). Documented environmental impacts range from ingestion and entanglement - already documented in nearly 1,000 marine species - colonization by and transportation of invasive and pathogenic species on plastic particles, passage of microplastics (MPs) through the food chain, and resulting negative effects on factors including food consumption, growth, reproduction, and survival in a range of organisms (Cole et al., 2015; Carbery et al., 2018; Foley et al., 2018; Amaral-Zettler et al., 2020; Kühn et al., 2020).

Impacts are not only felt at the environmental level - recent studies have estimated that in 2018 alone, the economic costs of marine plastic as related to marine natural capital ranged between $3,300 and $33,000 per ton of waste, or the equivalent of an economic loss of $6 billion to $19 billion for 87 coastal countries (Beaumont et al., 2019; Deloitte 2020). Other economic impacts of plastic pollution include an estimated $0.5–2.5 trillion resulting from a reduction in global marine ecosystem services as well as a growing body of research on the impacts of plastic pollution which does not reach the ocean, such as soil contamination, air pollution, and degradation of freshwater systems (de Souza Machado et al., 2018; Hurley et al., 2020; Jambeck et al., 2020). This amounts to an annual estimate of damages from plastic production and the current stock of plastic waste in the ocean of around $2.2 trillion (Forrest et al., 2019).

Studies are also increasingly highlighting human health concerns around plastic products and plastic pollution. Synthetic plastic polymers are largely produced from fossil carbon- coal, oil, and gas, with over 16,000 potential chemical additives - only 6% of which are currently subject to international regulation, and over 4,000 of which are already known to be chemicals of concern due to their persistent, toxic, or bioaccumulative nature (Wagner et al., 2024). These toxic additives are incorporated into the production process in order to achieve certain properties such as color, flexibility, water resistance, and flame retardation. These additives include carcinogens, neurotoxicants, and endocrine disruptors, such as phthalates, bisphenols, and per- and poly-fluoroalkyl substances (PFAS) (Landrigan et al., 2023).

Plastic particles are ubiquitous not only in the natural environment, but also in our own bodies - plastics have been found in human blood, human placentas, and human tissue, and known plastic additives have been detected in human breast milk and human urine (Asimakopoulos et al., 2013; Mercogliano et al., 2018; Ragusa et al., 2021; Leslie et al., 2022). There is a growing consensus that the impacts of plastic on human health are more intricate and insidious than previously thought, and many scientists and organizations worldwide are highlighting the need to simultaneously address the persistent organic pollutants (POPs) associated with plastic in an effort to reduce harm (Landrigan et al., 2023). Issues of environmental and social justice are also deeply intertwined with plastic pollution, and it is well documented that the negative impacts of plastic throughout the life cycle disproportionately affect marginalized and disenfranchised communities worldwide (Karasik et al., 2023; UNEP, Apr 2021).

Plastic pollution lies at the heart of what has been termed the 'triple planetary crisis,' the culmination of the climate crisis, the nature crisis, and the pollution crisis, each of which are mutually reinforcing. If current trends persist, by 2050, primary plastic production alone may represent up to 26% of the remaining global carbon budget needed to stay below a 1.5°C or 2°C global average temperature rise (Karali et al., 2024). Transitioning to sustainable waste management systems and more circular economies have been estimated to be able to save around 15-20% of all global GHG emissions (UNEP/ISWA 2015; Zheng et al., 2019; UNEP 2021). The United Nations estimates that $8.1 trillion USD in investment will be needed between now and 2050 to adequately address the triple planetary crisis (UNEP, May 2021). Recent literature has strongly suggested that the most effective long-term solutions to the impacts associated with plastic pollution lie in upstream prevention, and in rethinking the way that we produce, design, distribute, and manage products (Lau et al., 2020; Borelle et al., 2021; Karali et al., 2024). The global transition towards more circular systems is not only critical for plastic pollution, but also for societal sustainability and resilience.

1.1.3 Circularity as a Solution

In the latter part of the 20th century, it was becoming evident that solutions such as recycling and landfilling would not be sufficient or sustainable to deal with our increasing quantity of plastic production and consumption. In looking towards upstream and holistic solutions, a key concept that emerged from that discussion was what has now become the modern concept of the circular economy (CE). The concept can be traced back to the 1800s and has long been embodied in economics, biogeochemical cycling, and industrial metabolism (Murray et al., 2017). The CE with respect to plastic was shaped by several transformational publications and policies that emerged in the early 2000s, including the book "Cradle to Cradle: Remaking the Way We Make Things" published in 2002 by Michael Braungart and William McDonough, the UN Environment Programme (UNEP) report "Circular Economy: An Alternative for Economic Development" released in 2006, and the first ever national-level CE Indicators and CE Promotion Law passed in China in 2008 (McDonough, 2002; UNEP, 2006; Geng et al., 2012). The concept was further operationalized and socialized by the Ellen Macarthur Foundation, which released three reports in 2012, 2013, and 2014 that included CE principles, guidance, and case studies. The EU released its own 'Towards a Circular Economy: A Zero Waste Programme for Europe' in 2014, which paved the way for multiple national policies and plans in Europe and around the world (Murray et al., 2017). CE has since grown across sectors and disciplines worldwide as a solution to plastic pollution and other challenges related to the overconsumption of finite resources.

Despite its growing potential, there is still confusion and disagreement around the operationalization of CE. Some argue that the concept is too vague, is often conflated with waste management and other sustainability ideals, lacks clear definitions and metrics, and risks being used as a greenwashing tool by corporations and other stakeholder groups to tailor to their own interests (Kirchherr et al., 2017; Corona et al. 2019; Mayer et al., 2019; Velenturf et al., 2019). Though research around CE shows growing promise and opportunities, and CE has gathered attention as a potential solution to plastic pollution in global discourse, studies have suggested that only 7.2% of the world's economy is circular and our global consumption continues to grow exponentially (The Circle Economy Foundation, 2024). If governments, corporations, and communities around the world are to operationalize CE and reach their goals around circular materials management and pollution reduction, a comprehensive and collaborative approach is urgently needed to bring about a shared understanding of CE and how it can be measured to inform decision-making.

1.1.4 Research Relevance and Future Directions

A UN Global Agreement to address plastic pollution is under negotiation. However, current government and corporate commitments are insufficient to significantly curb plastic pollution entering the environment (Borelle et al., 2020). Definitions of CE and circularity need to be comparable and a common nomenclature is required if these are to be viable international solutions, but the deeply cultural and local aspects that form the intersection of people, environment, and waste need to be taken into consideration. This has shaped the way that the Circularity Informatics Lab (CIL) has built and continues to scale the Circularity Assessment Protocol (CAP) as a tool worldwide.

The global transition towards circularity is critical for environmental pollution, climate change, and global resilience (Ford et al., 2022). Cities are essential to this process, deciding what works best for them from an environmental, socioeconomic, cultural, and policy perspective. Collaborative, systems-level data like CAP and frameworks that foster threads from science to solutions can help provide the critical support cities need to tackle these interrelated and pressing challenges. Plastic pollution is an anthropogenic challenge that we have designed our way into - with the right tools and knowledge, I am confident we can design our way out of it.

1.2 Research Goals

While the issue of plastic pollution has reached an undeniable level of impact worldwide, and urgency around solutions and interventions towards a more circular economy have reached the global stage through the United Nations Global Plastics Agreement, there is still a great deal of debate on how to quantify those impacts in a holistic manner, use that quantification to inform interventions, and to in turn measure the impact of those interventions over time and adapt accordingly. It will become critical in the coming years to be able to conduct this type of research, particularly in a manner that is comparable across contexts and in a way that makes the data and methods accessible and relatable. As the Global Agreement negotiations move towards National Action Plans, it will also be critical to put that monitoring, evaluation, and decision-making power into the hands of local stakeholders who know their context best.

The goals of this research are focused on the use of a novel methodology, the Circularity Assessment Protocol (CAP), as a tool to holistically quantify circularity with respect to plastic packaging in a range of contexts worldwide. CAP uses a hub-and-spoke model to 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 itself is explained in detail in Chapter 3. In the context of this research, circular economy is defined as a system of circular materials management whereby the concept of waste itself essentially becomes obsolete, as waste production is eliminated as much as possible through systems that rethink the way we produce and consume, and every output into the system has an input back into the system in a way that is safe and sustainable. The overall goals of this dissertation are to:

1. Focus on the application of CAP and adapting the methodology in different contexts and use cases
2. Examine the use of CAP as an effective, replicable, and scalable tool to quantify CE for plastic in various contexts and for different use cases worldwide
3. Support local and global needs around the quantification of CE and the use of that quantification to prioritize interventions

1.3 Research Objectives and Approach

The following objectives and approaches support the overall goals of this research:

Objective 1: Develop and document a comprehensive understanding of the role of CE and circularity with respect to plastic packaging in academic literature within the last five years.

Approach: Conduct a comprehensive review of peer-reviewed literature related to CE and/or circularity and plastic packaging within the last five years (2019-2023). Specific points of investigation and documentation include geographic focus of study, geographic location of the lead author, definition of CE and/or circularity (if any), which industry the study is focused on, does the study view the CE as positive or negative, which point in the lifecycle of plastic pollution does the author portray circularity, whether the study includes any metrics for quantifying CE, whether the study incorporates environmental justice and equity into its research or conclusions, and several others.

Objective 2: Conduct a meta-analysis of CAP in six different cities and contexts as a tool to set a baseline and inform interventions to prevent plastic pollution.

Approach: Use data collected from CAPs in six cities across five countries (India, Indonesia, Malaysia, Panama, and Vietnam) that participated in the first cohort of Urban Ocean (described in detail below) to demonstrate the use and benefit of the tool, identify commonalities between cities, and develop a method for using CAP to prioritize and measure the impact of interventions at the city-level over time.

Objective 3: Deploy CAP in the context of a Small Island Developing State (SIDS) and complement it with supporting marine litter and waste management assessments to create a holistic baseline and identify opportunities for optimizing circular materials management of plastic items for the entire country.

Approach: Implement a country-wide CAP in Dominica, the first country-wide assessment of a Caribbean SIDS, and a complementary assessment of waste management and marine litter and ocean-based sources of plastic pollution (including coastal and marine litter surveys, microplastic analyses of ocean water, and trash traps at river outflows), which can be used to set a national baseline and help develop a National Action Plan for Plastic Pollution and Waste Management in Dominica.

Objective 4: Conduct CAP at the state level across 3 locations in order to identify common trends and opportunities across the locations, share lessons learned and best practices regionally, and drive state-level change in the US.

Approach: Implement CAP in 3 locations in the US state of Florida, including Miami, Orlando, and the FL Keys (Key Largo, Marathon, and Key West), in partnership with Ocean Conservancy's Shores Forward Initiative for the state. Use this data to empower local leaders and organizations and ultimately support policy changes at the local and state level to quantifiably reduce waste generation, divert waste from landfill, increase collection and recycling, and decrease litter.

1.4 Organization of the Dissertation

Following the Introduction, Chapter 2 includes an analytical literature review of CE and circularity with respect to plastic packaging to better understand the historical context and to identify key gaps and needs in the field; Chapter 3 is an analysis of CAP results when deployed across six cities in five countries as part of the Urban Ocean initiative; Chapter 4 applies CAP to set a baseline and inform interventions in a Small Island Developing State (SIDS); and Chapter 5 uses CAP to inform and examine solutions at the state level when deployed in several cities in one state in the United States (US). Chapter 6 serves as an overarching Conclusion which includes Research Objectives and Takeaways, Key Findings, Insights, and Implications, and Future Directions. Together, these sections fit under a larger theme of applying circularity principles to address plastic pollution, and demonstrate the value of, and need for, this work as stakeholders around the globe head into the next era of plastic pollution prevention.

Chapter 2: Circular Economy Analytical Research Review

2.1 Introduction

Circularity as a concept is not a new one. Some definitions of circular economy (CE) date back to the Royal Society of Chemistry in 1848, others are attributed to comparisons between the man-made economy and cyclical ecological systems in the *Spaceship Earth* analogy of 1966, others still date the concept back to the 1980s when it was used to describe a closed system of economy-environment interactions in western academic literature (Murray et al., 2017). It has been related to concepts from physiocrats in economics, biogeochemical cycling in ecology, and industrial metabolism in urban planning and development (Murray et al., 2017). The term 'closed-loop economy' was first used in an article from the European Commission in 1976, explaining the importance of increasing durability in items for maintaining a sustainable economy (Pearce & Turner, 1989).

In the early 2000s, when it was becoming evident that solutions such as recycling and landfilling would not be sufficient or sustainable to deal with our increasing quantity of plastic production and consumption, several key pieces shaped the CE for plastic as we know it today. In 2002, German chemist Michael Braungart and American architect William McDonough published the book "Cradle to Cradle: Remaking the Way We Make Things" which brought together principles of science and design to propose a regenerative model in which everything is a resource for something else and waste itself becomes obsolete (McDonough, 2002). In 2006, the UN Environment Programme (UNEP) published the report "Circular Economy: An Alternative for Economic Development" in which they describe CE as an economy that “balances economic development with environmental and resource protection” and that brings together the concepts of closed-loop economy and “design to re-design” thinking (UNEP, 2006). China was among the first nations to put CE into practice, releasing the first-ever national-level CE Indicators in 2007 and passing the Circular Economy Promotion Law in 2008 (Geng et al., 2012).

To demonstrate the benefits of and how to operationalize CE, the UK-based Ellen MacArthur Foundation released three reports with McKinsey and Company in 2012, 2013, and 2014 that lay out the concepts of CE and provide specific case studies on implementation and benefits in different sectors. The EU then released its own ‘Towards a Circular Economy: A Zero Waste Programme for Europe’ in 2014 (Murray et al., 2017). Since then, CE has gained traction in mainstream media and academia worldwide as a solution to plastic pollution and other challenges related to the overconsumption of finite resources. More than 100 CE articles were published in 2016, compared to only about 30 articles in 2014, and the quantity has grown exponentially since then (Figure 2.1; Geissdoerfer et al., 2017). CE has been referenced as a solution by national governments, bilateral organizations, corporations, academics, and other stakeholders globally, particularly as it relates to the UN Global Plastics Agreement which is currently in negotiation.

Figure 2.1: Google Search for term "circular economy" between 2004-2024

However, the concept of CE has been criticized for being too vague, being a vessel for greenwashing by corporations, and not clearly aligning with sustainability targets (Kirchherr et al., 2017). Some scholars have associated the lack of a consistent definition with a similar lack of coherent approaches and methods to assess and implement CE (Corona et al. 2019; Velenturf et al., 2019). Some have gone further to suggest that the concept of CE can be and has been represented or pursued differently by different stakeholder groups and actors across the value chain to suit their individual interests and values (Mayer et al., 2019). Despite growing attention on CE as a solution in the global discourse, studies have suggested that only 7.2% of the world's economy is circular - a percentage that has seen a 21% drop over the last five years - while our global consumption continues to grow exponentially (The Circle Economy Foundation, 2024).

If we are to truly transition to a CE and operationalize CE in supply chains, a comprehensive and collaborative approach is urgently needed. With the issue of plastic pollution reaching peak attention to date on the global stage, now is a critical time to bring about a shared understanding of CE - particularly around problematic items, supply chains, and sectors, such as plastic packaging - and how it can be quantified and measured to inform solutions going forward.

2.2 Literature Review

Since the release of the Ellen MacArthur Foundation reports and EU CE strategies in the early 2010s, the quantity of peer-reviewed publications related to CE, particularly those in the plastics sector, has also increased. According to publications in Web of Science (previously Web of Knowledge), there was an over 250x increase in article publications that included the search terms “circular economy AND plastics” between 2013 and 2023, growing from just 3 publications in 2013 to over 742 ten years later (Figure 2.2). This growth over time has been noted in other reviews of CE in literature over time (Geissdoerfer et al., 2017; Kircherr et al., 2017). These have included literature reviews that attempt to characterize CE, such as those that explore integration with business models and supply chain across various sectors (Bocken et al., 2014; Schenkel et al., 2015; Lewandowski, 2016), those that draw similarities and differences with sustainable development (Geissdoerfer et al., 2017), those that attempt to capture the breadth and depth of indicators and definitions related to the subject (Iacovidou et al., 2017; Kircherr et al., 2017; Pauliuk, 2018; Corona et al., 2019), and those that demonstrate its implementation, successes, and shortcomings in a global context (Murray at el., 2017; Prieto-Sandoval et al., 2018).

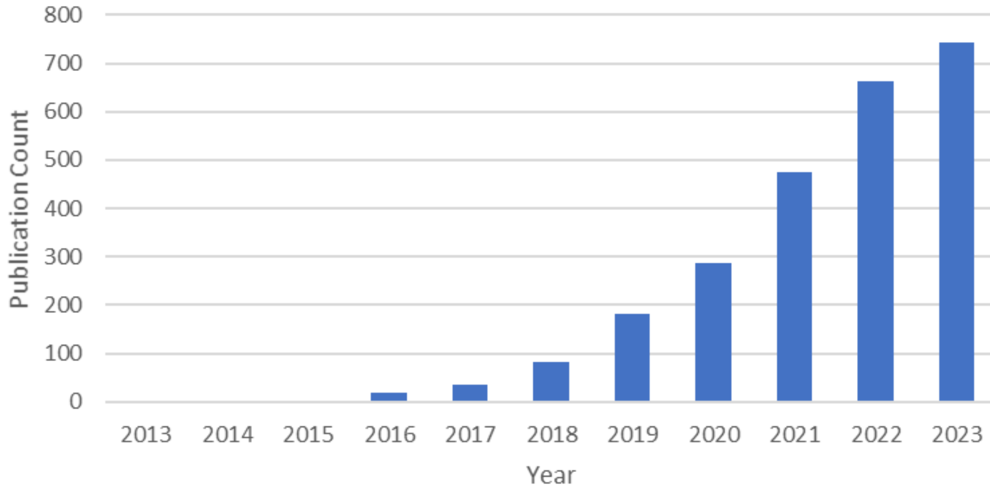

Figure 2.2: Published article count by year in Web of Science containing search terms (circular economy) AND (plastic) between 2013-2023

Previous reviews have identified over 100 definitions of CE in peer-reviewed and gray literature and have found that the majority of articles focus on end-of-life, lack a holistic approach to implementation, under-represent the social aspects of the issue, and are published by developed Western nations (Kircherr et al., 2017; Murray et al., 2017; Johansen et al., 2022); however, no reviews have focused specifically on plastic packaging. This is of particular concern due in part to the pending Global Plastics Agreement, which highlights 'circularity' and 'circular economy' as potential approaches to minimize plastic waste that may require harmonized definitions and metrics. It is also important to understand the trends and directions related to this specific sector of CE. Similarly, few CE reviews have examined the combination of life cycle stage, geographic focuses, sentiments, social justice inclusion or exclusion, and other important factors of CE-related literature over time. Some studies have specifically highlighted the need for more representation of CE in academic literature and across disciplines to effectively communicate these concepts and their relevance to the public and decision-makers (Stahel, 2016).

It was found from literature excluded in this review (other “review” articles related to CE and plastic and packaging) that they were largely reviews of progress in the packaging industry, reviews of implementation of CE policy (especially within the EU), or reviews of advances in technology in this space, particularly waste management techniques and the development of new polymers. None were found to comprehensively review the status of CE and plastic packaging and academic literature from a holistic, interdisciplinary, and global perspective.

CE reports and literature have focused heavily on the plastics sector in recent years. While plastic production has increased exponentially - with products and polymers that are increasingly complex and difficult to manage, made from synthetic polymers that remain cheaper and easier to access than alternatives - the infrastructure and innovation at the end of the plastic life cycle have not been able to keep up (Forrest et al., 2019). Plastic has revolutionized transportation, medicine, and food security, but plastic packaging and single-use items are being produced, used, and disposed of at an unsustainable rate. Single-use products such as packaging account for the largest and fastest-growing subset of plastic manufactured and are among the top litter items identified worldwide (Landrigan et al., 2023). Estimates of plastic waste emissions into the environment reached 19-23 million metric tons in 2016 - the equivalent of 11% of all plastic waste generated that year globally - and are projected to grow to 53 million metric tons by 2030 (Borelle et al., 2020). Beyond environmental concerns, studies increasingly highlight human health and social justice concerns around plastic at every stage of its life cycle (Muncke et al., 2020; Landrigan et al., 2023). It has been suggested that, in the case of circularity and plastics, upstream and international measures are needed for effective implementation and waste management alone will not suffice, making them a prime candidate for an effective CE (Borelle et al., 2020; MacLeod, 2024).

To address this growing issue, in March 2022, the UN Environment Assembly (UNEA) adopted resolution 5/14 requesting the UN Environment Programme (UNEP), which started the process of developing the aforementioned international, legally binding agreement on plastic pollution that is currently in negotiation (UNEP, 2022). Circular economy approaches have been included throughout the draft text as a key aspect of this agreement and its associated interventions (UNEP, 2024). A range of stakeholders and sectors agree that previous efforts to reduce plastic pollution have been insufficient and that the world has reached a point where a unified, global effort is urgently needed to address this crisis and enhance material circularity (Borelle et al., 2020; Simon et al., 2021; WEF, 2023; Eccles, 2024).

Some have suggested that a true CE for plastic will not be possible without a complete re-design of plastic and additives, a severe re-positioning of consumerism and society, or a dramatic decrease in production (Sheldon et al., 2020; Mah, 2021; Bachmann et al., 2023; EMF, 2024; MacLeod, 2024). Indeed, many plastic consumer goods were originally designed to be disposed and not circular, and, unfortunately, this trend has continued in plastic consumer design today, entrenching a “throwaway lifestyle” following the sector’s growth after World War II (Freinkel, 2011; Hellmann et al., 2018). However, current research suggests that plastic can be a part of an effective circular economy, given the right set of circumstances, enabling conditions, and partnerships.

The goal of this paper is to conduct a review of, and examine how, the ‘circular economy’ (CE) for plastic packaging has been portrayed in academic literature, providing insight into the CE topics represented, life cycle stages evaluated, geographic focus, and general sentiments, perspectives, and themes. The aim is to assess the status and identify where there are gaps in literature and research related to the circularity of plastic packaging materials.

Ultimately, these findings could be used by researchers, industry, and decision-makers to inform a global, just, and equitable CE transition.

2.3 Methods

In order to examine the landscape of research in circularity and plastic packaging, an analytical research review was conducted of peer-reviewed literature related to plastic packaging and circularity.

2.3.1 Document Selection

Articles were compiled from the Web of Science database, GoogleScholar database, and ScienceDirect database through the University of Georgia Libraries using the search criteria "(circular economy) OR (circularity) AND (plastic) AND (packaging)" within a publication timeline of January 1, 2019 - December 31, 2023. The time frame was narrowed to within the last 5 years because this is when 87% of all peer-reviewed articles have been published on this topic to date, according to those available through Web of Science.

The search excluded conference proceedings, thesis/dissertations, perspectives, and any articles that have the word "review" in the title or in the abstract, as this often suggests the article is a literature review that would not contribute new research to this landscape analysis. However, these review articles were reviewed for the background and discussion portions of this work. Similar previous CE review articles that were conducted outside of the timeframe, such as Geissdoerfer et al., 2017 and Prieto-Sandoval et al., 2018, were also cross-referenced for context and findings. The intent was to capture current research, innovations, and implementation in the field of CE and plastics. The literature compilation and analysis also excluded gray literature (e.g., reports) though they were reviewed and are included for context and purposes of discussion

Figure 2.3 demonstrates the scoping literature review method employed to identify the final group of articles to be analyzed and coded through MAXQDA.

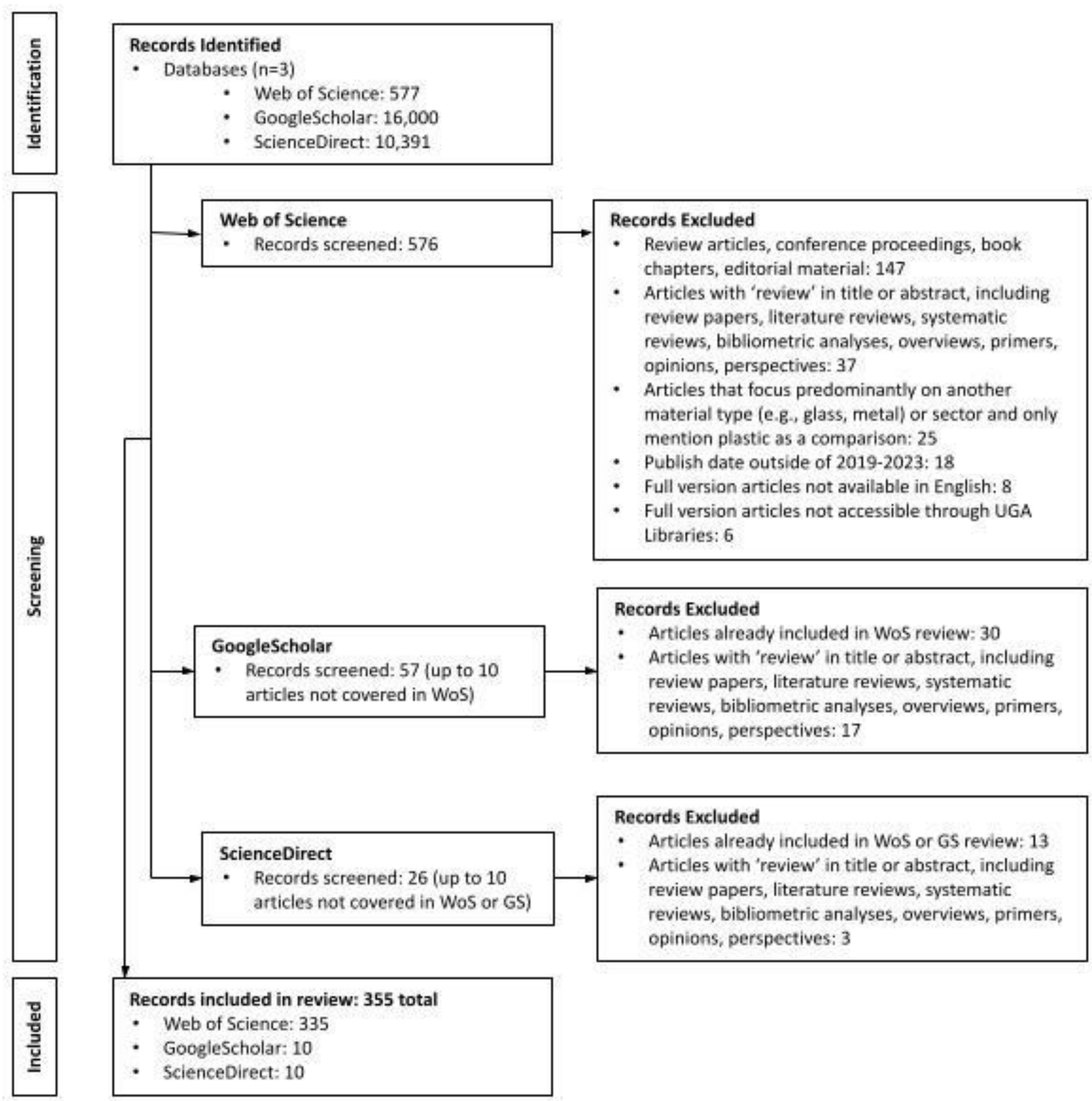

Figure 2.3: Scoping Literature Review Method

Web of Science was the first database fully analyzed with the search criteria outlined in Figure 2.3, based on the assumption that this would be representative of articles found in other databases with the same criteria. In order to validate that assumption and identify a saturation point of articles analyzed, a comparison was conducted with articles identified with the same search criteria in GoogleScholar and ScienceDirect. Among the top 10 most "relevant" (determined by the search engine) articles in GoogleScholar with the same search criteria, 100% overlapped with the articles already analyzed through Web of Science, and 60% of the top 57 most "relevant" articles overlapped, which was the point at which 10 new articles had been found that were not already represented in Web of Science. Among the top 10 most "relevant" (determined by the database) articles in ScienceDirect with the same search criteria, 70% overlapped with the articles already analyzed through Web of Science and GoogleScholar, and 50% of the top 26 most "relevant" articles overlapped, which was the point at which 10 new articles had been found that were not already represented in Web of Science or GoogleScholar. It was therefore determined that the combination of 336 articles from Web of Science, 10 articles from GoogleScholar, and 10 articles from ScienceDirect was representative of the literature.

2.3.2 Document Coding

Once the articles were selected based on the Scoping Literature Review Method (Figure 2.3), manual coding along with the software MAXQDA was used to code for the variables listed in Table 2.1.

Table 2.1: Literature Review Coding Methods

Variable	Description/Code/Search Terms
Database	Manual coding (Web of Science/Web of Knowledge, Google

	Scholar, ScienceDirect)
Title	“TI_Title” autocoding in MAXQDA
Author	Manual coding (first author listed in publication)
Publication Year	“PY_Publication year” autocoding in MAXQDA
Country of the first author's institution / affiliation	Manual coding (based on first author as listed in publication)
Geographic focus of the study	Manual coding (country or region)
Journal	“T2_Title secondary” autocoding in MAXQDA
Keywords	“KEYWORDS” autocoding in MAXQDA
Does the author define 'circular economy'?	MAXQDA search term “circular economy,” manual coding if definition associated (yes or no)
If the author does define ‘circular economy,’ what definition do they use?	MAXQDA search term “circular economy,” manual coding if definition associated
Which sector does the article focus on?	Manual coding (open-ended and re-classified into recycling methods, bio-based plastic & packaging, food & food service packaging, packaging industry general, recycled content, plastic supply chain, consumer awareness & behavior, CE policy, C&D, MSWM general, FMCGs, agriculture, flexible packaging, litter & waste leakage, household MSW, collection methods, reuse systems, fashion & apparel, personal care products, medical, 3D printing plastic waste, repair, civil society, CE in cities)
What is the general sentiment of the article?	Sentiment analysis of “AB_Abstract” autocoded from MAXQDA
Which point in the life cycle do interventions mostly occur in the article?	Manual coding (included input, community, product design, use/reuse, collection, end-of-cycle, leakage, and all phases of the life cycle, determined based on categories adapted from Maddalene et al., 2023 and Jambeck et al., 2024)
From was sector perspective is the article written?	Manual coding (academia, industry, government, consumer, waste industry, or combination therein)
Does the article include metrics on how to quantify / measure CE?	Manual coding (yes or no)
If CE metrics are included, what are they?	Manual coding (methodology listed in publication)
Any non-academic (e.g., govt, community groups) listed as authors?	Manual coding (based on authors and affiliations listed in publication)
Any non-academic groups listed in the Acknowledgements? (beyond financial)	Manual coding (based on Acknowledgements section in publication)
Are human impact and social justice considered in the article?	MAXQDA search terms: equity, equitable, justice (environmental, climate, social), upstream, system [with respect to holistic

	design/thinking], informal waste sector, disproportionate, marginalized, disenfranchised, vulnerable, global south, accessibility, affordability, minority/minoritized, empowered/disempowered, social/society/societal, community, health [human]

To validate the author's manual coding process, two co-authors manually coded a subset (5%) of 10 articles each that the author had already coded. Co-authors answered the following questions: 'In which point of the plastic life cycle do interventions in this paper mostly occur?' and 'From what perspective is this paper written?' The co-author's answers were 85% and 95% in agreement with the author's answers, respectively.

2.4 Results & Discussion

2.4.1 Journal & Geographic Representation

A total of 355 peer-reviewed journal articles were reviewed as part of this analysis. The top five most common journals represented in the literature review included Resources, Conservation, & Recycling (38 articles), Journal of Cleaner Production (38 articles), Sustainability (34 articles), Polymers (24 articles), and Waste Management (20 articles). This list of journals is similar to findings from previous CE literature reviews (Geissdoerfer et al., 2017; Prieto-Sandoval et al., 2018).

Articles were categorized by World Bank geographic region and economic status as outlined in Kaza et al., 2018. Among all articles, three-quarters of first authors were based in Europe & Central Asia (75.6%). The next most common geographic region represented was North America, which comprised less than 10% of articles (7.6%). Similar quantities were observed for papers with first authors from institutions based in East Asia & Pacific (7.3%), and first authors from Latin America & the Caribbean, South Asia, Middle East & North Africa, and Sub-Saharan Africa each represented less than 5%, respectively (Figure 2.4). When considering the regions that are predominantly in The Global North (Europe & Central Asia and North America), 83% of the articles had first authors from The Global North.

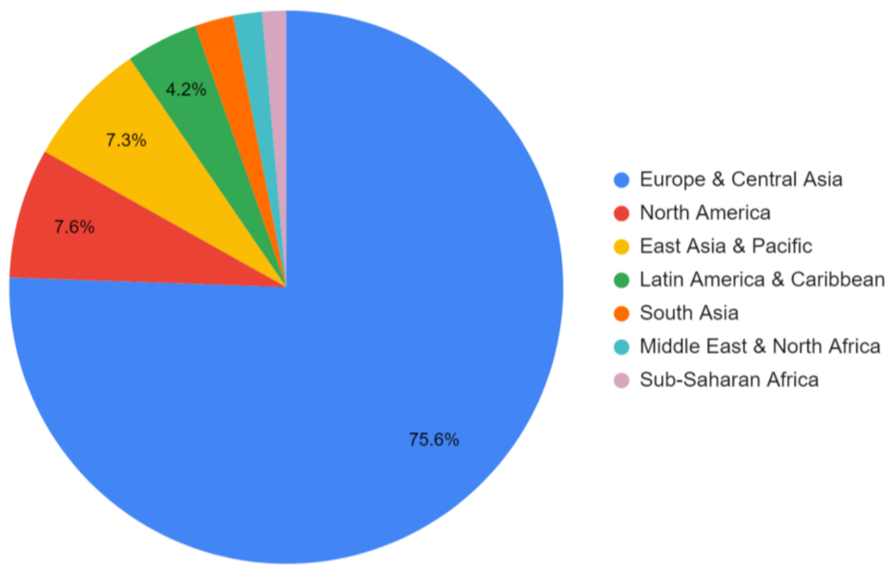

Figure 2.4: Geographic distribution of first authorship among articles reviewed based on World Bank regions

Italy was the most common country for first author affiliations or institutions among the articles reviewed (Figure 2.5). Among the top 10 most common countries of first authorship, all but one was located in Europe. The one exception was the United States ranking 6th in the list with a total of 21 articles.

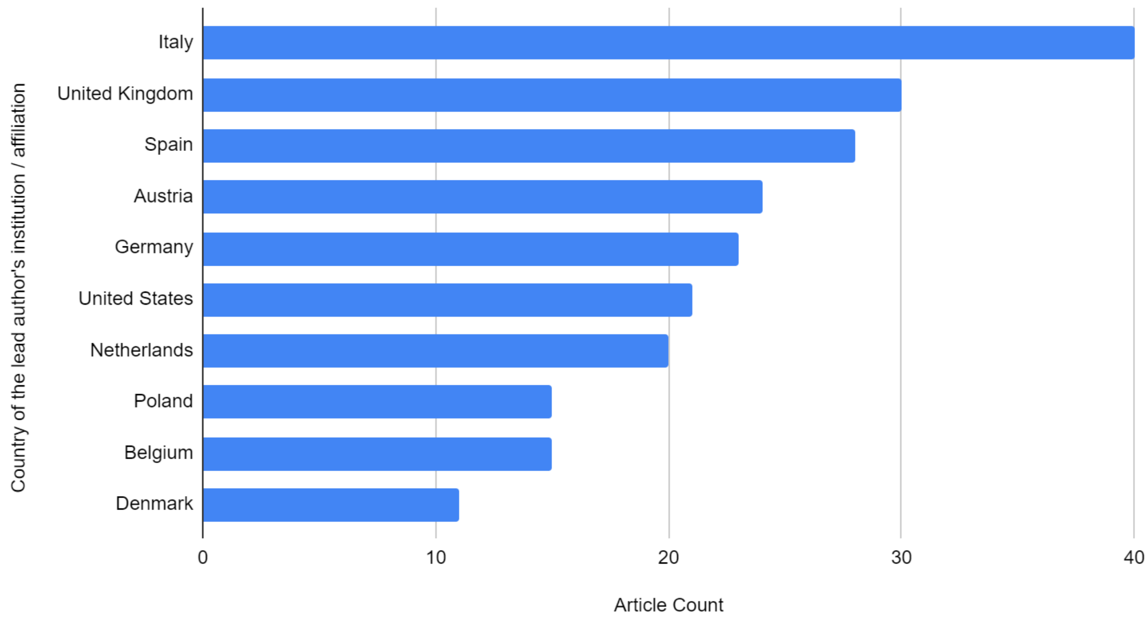

Figure 2.5: Top 10 most common first authorship countries among articles reviewed

The geographic focus of each article was also documented. 61.5% of the articles focused their work on locations in Europe & Central Asia. Outside of articles without a geographic distinction and others with a global focus, the next most frequent geographic focus area was East Asia & Pacific (Figure 2.6). When considering the regions that are predominantly in The Global North (Europe & Central Asia and North America), 67% of the studies focused on The Global North. Other recent CE literature reviews have also presented the majority of authorship locations and research focus has been on The Global North (Comacho-Otero et al., 2018, Haswell et al., 2024).

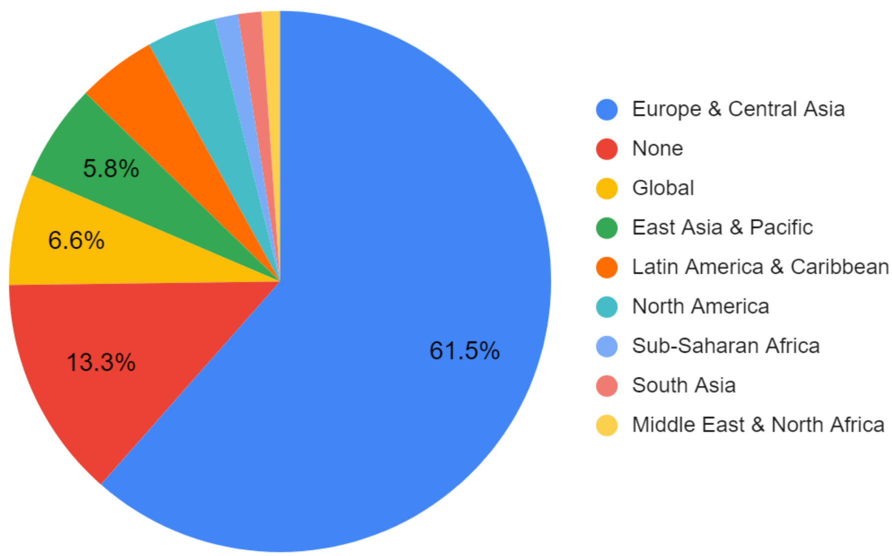

Figure 2.6: Geographic distribution of study area among articles reviewed based on World Bank regions

Among articles that had a geographical focus (80% of articles when excluding those coded as 'global' and 'none'), 93% included a first author from the study focus geography. This demonstrates that there is a high degree of authorship from the region of study. For example, studies focused on The Global South contained researchers from that area, as opposed to first authors from The Global North writing about research being conducted in The Global South. In other recent research, an imbalance between the author regions and location of work has been documented in the fields of sustainability, resilience, and climate change (Rakotonarivo et al., 2023).

The strong presence of Europe in both authorship and study geography shows that the region is proactive and ahead of the rest of the world in publishing CE research, but not necessarily ahead in all aspects of CE. According to World Bank country income classifications, 88% of the articles had first authors from High-Income countries, 8% from Upper Middle-Income countries, 4% from Lower Middle-Income countries, and less than 1% from Lower

Income countries. This is a significant inequity when examining circularity and may mean that circularity is only studied in high-income countries or that high-income countries have more access to circular systems and options. Lower-income countries also have circular practices with lower per capita waste generation rates and are often managing waste from other countries through imported scrap intended for recycling (Kaza et al., 2018). Historically, around 70% of High-Income countries in the Organization for Economic Cooperation have exported plastic waste to lower-income countries in The Global South, which often lack sufficient waste management infrastructure (Brooks et al., 2018; CIEL, 2019). Given the global nature of the plastic life cycle and the proposals for CE in the UN global agreement, it will be important to ensure that potential actions and solutions are tailored not only to high-income countries but also to the Global North.

It is important to highlight the value of incorporating The Global South into CE systems and perspectives. Opportunities as well as voices, perspectives, and unique needs of The Global South have not been well-represented in academic literature on the CE to date (Ashton et al., 2022; Muchangos et al., 2023). Opportunities exist for The Global North to learn from The Global South, for economically developed nations to learn from the developing, and to acknowledge and integrate the unique challenges and learnings of each (Schröder et al., 2019; Hofstetter et al., 2023; Marks et al., 2023; Haswell et al., 2024). Waste generation and consumption have been historically linked to population and economic growth, and there is an opportunity to decouple that relationship to move towards a more sustainable system. It is well documented that the negative impacts of plastic throughout the life cycle disproportionately affect marginalized and disenfranchised communities worldwide, particularly in The Global

South, and that there is a discrepancy between countries exacerbating these challenges and those that bear the burden of the impacts (UNEP, Apr 2021; Karasik et al., 2023).

It should be noted that the global distribution of authorship could be symptomatic of a larger issue, that is, that the Global South isn't represented in academic literature across multiple disciplines (Collyer, 2018). Similarly, only articles written in English or with English translations were included in this analysis. The discrepancy could be due in part to internet access, cost for journal publication, reviewer bias, population density, and size of research institutions. However, if we are to have a truly global approach to plastic pollution and a global agreement that mandates, enables, and/or encourages interventions that are relevant to multiple different contexts, then we need to have globally relevant metrics and definitions. Most existing metrics, indicators, and definitions currently come from gray literature such as reports from the Ellen MacArthur Foundation or UNEP (EMF 2023; UNEP, 2024), but representation in academic publications is critical for application and relevance going forward.

2.4.2 Non-Academic Authorship & Acknowledgements

16% of the articles reviewed included authors that were from outside of academia. The non-academic authors were most frequently from the packaging industry (21 articles), although some had authorship from the waste industry (13 articles) and local or national government (12 articles). Only 8 articles total had some form of authorship from a civil society entity or community organization.

With growing support from industry around the global agreement process, particularly through the Business Coalition in support of the global agreement (Eccles, 2024), it may be promising to see the packaging and waste industries involved in scholarship. However, it is also important to ensure that CE literature includes perspectives from multiple sectors of society, and that conflicts of interests are disclosed so that all sectors are transparent in terms of funding when publishing their work.

A similar trend was observed when characterizing the acknowledgments included in the research articles. Only 18% of articles reviewed included an acknowledgment beyond funding provided for the study (Figure 2.7). Among those that did, the majority (27) acknowledged only the packaging industry for their contribution to the research, highlighting the role that industry has again played in this field.

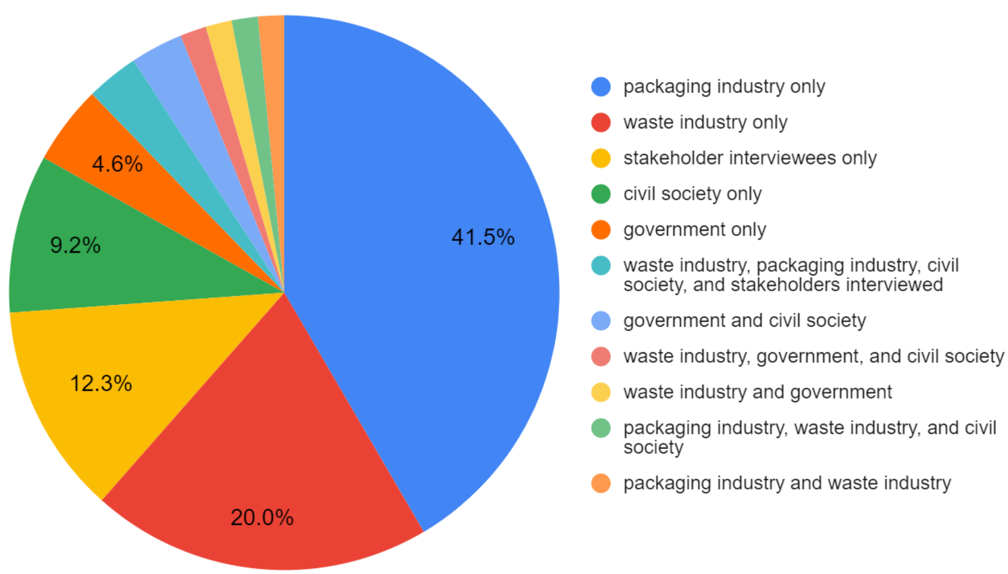

Figure 2.7: Acknowledgements among articles reviewed (for those that did include them)

Few articles (12) acknowledged collaboration with local government and/or civil society. Previous CE studies have emphasized the importance of these sectors in implementing and measuring CE practices worldwide and building support for CE from the ground-up (Maddalene et al., 2023). Similarly, few articles had more than one sector that was represented, consulted, or acknowledged. The importance and value of multi-sector, interdisciplinary, and holistic collaboration in CE has been repeatedly emphasized and is something that should be included in future CE research and scholarship (Hofstetter et al., 2023; Maddalene et al., 2023; Ratsimandresy et al., 2023).

2.4.3 Sentiments, Perspectives and Keywords

According to sentiment analysis in MAXQDA of all 355 article abstracts, 2% of abstracts had a sentiment that was considered ‘positive,’ 69% were ‘slightly positive,’ and 29% were ‘neutral’ in sentiment. While some articles expressed skepticism in the body of the article around CE in terms of its measurability, comparability across contexts, or the impact of past implementation, none appeared to have sentiments that were negative overall, based on the abstract.

A word cloud of article keywords was generated based on coding within MAXQDA (Figure 2.8). The word cloud excluded the names of journals, database search keywords (e.g., plastic packaging, circular economy), and keywords were combined where relevant (e.g., life cycle assessment, life cycle assessment, LCA). LCA was the most common use for quantifying CE and thus was the most abundant keyword overall. There appears to be a heavy emphasis on recycling, waste, management, and end-of-cycle processes in general. Polymers of key attention/concern/opportunity (PET, PE PP, PLA) are also prevalent. Sustainability also has a strong presence among the keywords, though research has cited that CE and sustainability often get conflated (Geissdoerfer et al., 2017).

Figure 2.8: Word cloud (generated by MAXQDA) of the top 50 most common Keywords from articles included in this review

The majority of articles (74%) were written from an academic perspective, as opposed to from the perspective of a waste practitioner, non-profit organization, industry, government, or otherwise. The next most common perspective was that of industry (14%), which included articles that were written by an academic but were intended to be used by industry or had industry as the intended audience. Less than 6% of articles were written from other perspectives such as waste practitioners, consumers, civil society, government/policy, or combinations therein.

It was noted by reviewers/coders that CE was often represented as a ‘need’ or something that was a requirement or inevitable. There appears to be an underlying assumption and consensus across perspectives represented in the academic literature that CE is what we as a society should be moving towards, though the opinions around the methods for achieving CE vary.

2.4.4 Life Cycle Representation

The predominant plastic life cycle stage of the articles was determined based on categories adapted from Maddalene et al., 2023 and Jambeck et al., 2024, and included: input, community, product design, use/reuse, collection, end-of-cycle, leakage, and all phases of the life cycle (Table A1). Those included in the ‘all phases’ category encompassed all seven stages of the lifecycle; otherwise, the most heavily referenced or applied lifecycle stage was coded for each article. While some articles focused on more than one stage in the life cycle, the most prominent one was selected for each unless the full life cycle was the focus of the article.

Over 50% of all articles reviewed focused predominantly on the ‘end-of-cycle’ phase of the plastic life cycle. This was followed by ‘material and product design’ at around 15% of articles and ‘all stages’ also at about 15% of articles. Less than 3% of the articles were about the life cycle stages of reuse, collection, and input, respectively. Waste leakage was the predominant life cycle among just 2% of articles (Figure 2.9). These findings are similar to those of a CE literature review from 2017 that found recycling to be the most common component of nearly 80% of CE definitions identified (Kircherr et al., 2017). This proportion appears to have decreased over the last 5 years and we are seeing more articles that represent the full life cycle. This could suggest that CE literature is trending towards a more holistic approach to building circularity across the life cycle of plastic, not only focusing on recycling, as many recommend is needed to effectively address the plastic crisis (Kircherr et al., 2017; Maddalene et al., 2023; EMF, 2020).

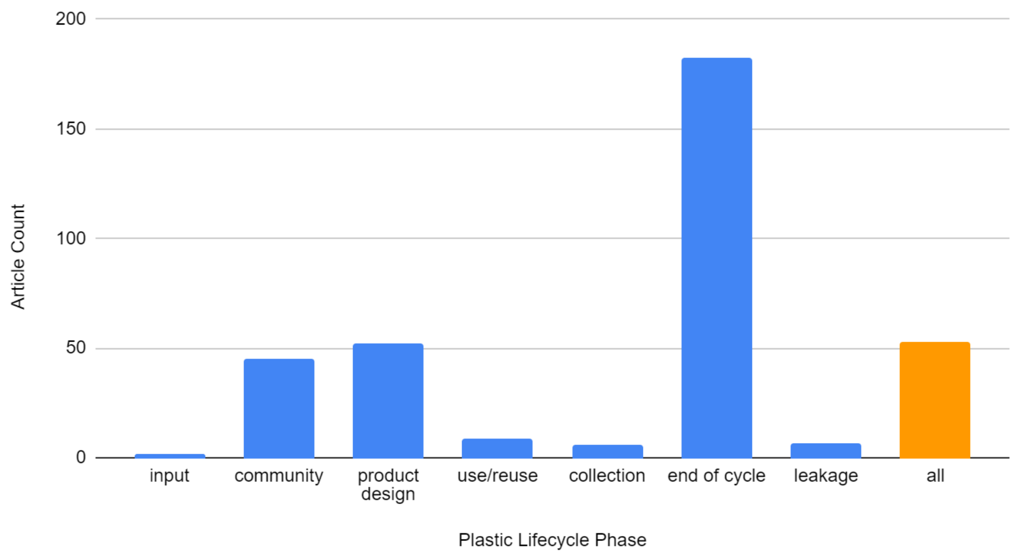

Figure 2.9: Life cycle phases predominantly represented among articles reviewed

While these findings suggest a reliance on material design and end-of-cycle approaches to CE research and implementation, it is also critical for those two aspects, and all life cycle stages, to work together. Studies have demonstrated that when materials are imported and used within a city or community, but do not match the waste management technology or capacity present, this can lead to confusion among consumers and businesses and can increase the potential for waste leakage (Maddalene et al., 2023).

Previous literature reviews related to CE and the plastic value chain have found heavy emphasis on end-of-life processes and a neglect of other life cycle stages in academic literature (Kircherr et al., 2017; Johansen et al., 2022; Gallego-Schmid et al., 2024). Studies have highlighted the lack of a holistic approach in implementation and have identified a need to more effectively link upstream aspects, such as production and design, with end-of-life and waste management approaches (Johansen et al., 2022; Bachmann et al., 2023). The fact that ‘all life cycle stages’ was the second most abundant category represented may indicate a shift towards a more holistic approach to CE research and implementation. Few articles focused on waste leakage and litter, which is to be expected as litter and circularity have not historically been linked, but these articles do demonstrate the benefit of using downstream data on what is escaping the system to inform upstream solutions.

Since anthropogenic mass recently exceeded all living biomass in 2020, researchers have noted that society has historically been focused on production and only considered disposal as an afterthought when we should be looking upstream to solutions that prevent the generation of waste in the first place (Elhacham et al., 2020). Recent literature has strongly suggested that the most effective long-term solutions to the impacts associated with plastic pollution lie in upstream prevention, and in rethinking the way that we use, design, package, distribute, and manage products (Lau et al., 2020; Borelle et al., 2021; Bachmann et al., 2023). The global transition towards more circular systems is not only critical for plastic pollution but also for societal sustainability and resilience.

2.4.5 Sector Focus of Study & Funding

Another aspect investigated in the articles in this review was the sector or area of study that was represented, in terms of industry, theme, or particular area of research or intervention. A wide range of sectors were found, ranging from waste management methods, polymer development, agriculture and farming, policy, and multiple others. The most common sector at 26% was recycling methods, which included articles assessing a specific recycling or upcycling method, such as mechanical recycling or pyrolysis, those that were comparing across methods, and those that were proposing novel methods (Figure 2.10). Among those representing the 'recycling methods' sector, 76% were either focused specifically on chemical recycling or on comparing various different recycling methods.

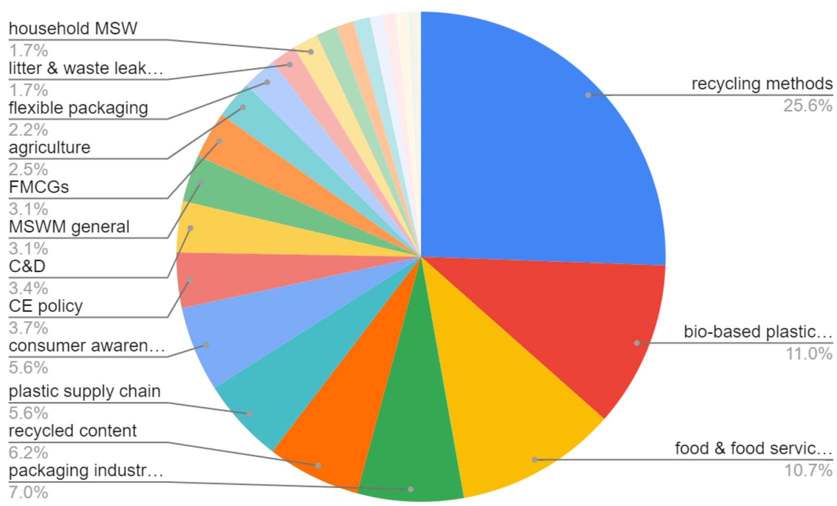

Figure 2.10: Sectors represented among articles reviewed

The next two most common sectors represented, at around 11% of articles each, were 'bio-based plastic and packaging' and 'food & food service packaging.' These data again demonstrate the high proportion of academic literature on CE that is focused on either the end of the cycle (such as recycling) or on material design for packaging, although those two areas do not always operate synergistically.

In terms of other life cycle stages, only 4 articles focused predominantly on implementing reuse systems to support CE and 1 article focused on repair systems. While some articles mentioned the issues of upstream reduction, human health with respect to the use of plastic, and litter removal or abatement, none were categorized as predominantly focusing on those sectors or research areas.

It is a positive sign to see flexible packaging, food packaging, and food service packaging represented highly among the sectors, as research has shown these types of single-use plastic items to be among the most problematic items for production, waste management, and litter (Chiba et al., 2018; Chen et al., 2021; UNEP, 2021; Landrigan et al., 2023). It is also interesting to note the relatively high presence of sectors such as agriculture and C&D, and to see if those sectors and others, such as e-waste, continue to gain momentum and attention in academic literature on CE in the future. Apparel and textiles, medical products and waste, and personal care products were the sectors of focus for less than 2% of the articles, respectively. Studies have suggested that developing a CE for these sectors will be critical to reduce their impact in the future (Kuzmina et al., 2019; Shirvanimoghaddam et al., 2020; Ranjbari et al., 2022)

In parallel with the sector focus of the study, funding sources for the articles were assessed where they were made available. Nearly 50% of studies were funded by government sources alone and 53% of studies had some form of government funding (Figure 2.11). The most common sources of government funding were the European Union, particularly the European Union's Horizon 2020 Research and Innovation Programme, as well as the European Regional Development Fund, the European Commission and the United States Department of Energy. Around 15% did not list their funding source, roughly 12% were funded by research institutes independently, and 10% received no external funding. Industry was the sole funder for around 5% of studies and contributed in some way to around 10% of the studies analyzed.

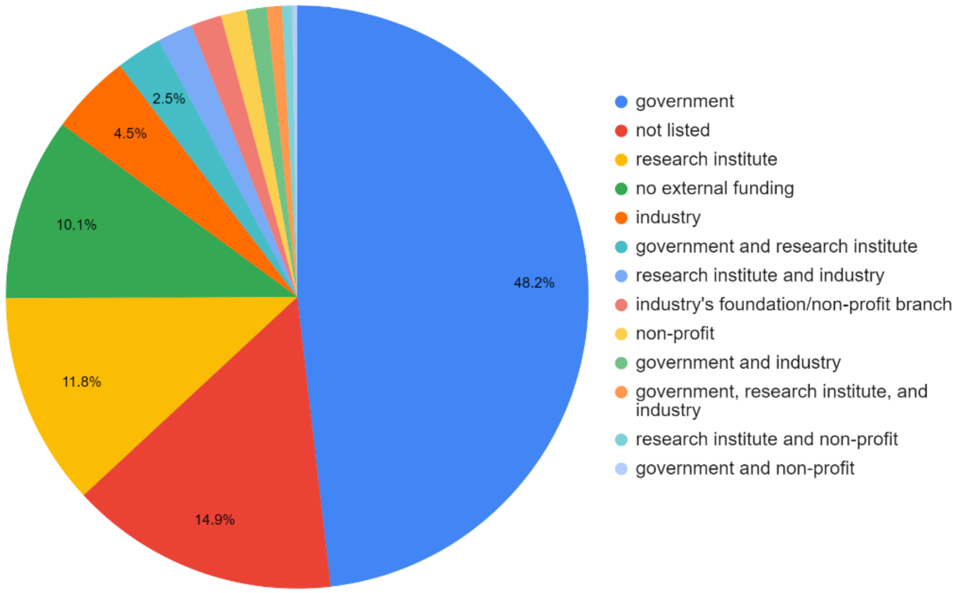

Figure 2.11: Funding sources for articles reviewed

When broken down by sector, the government was also the top funder for all sectors identified in the research studies, with the exception of those that focused on four sectors in particular. Articles with a focus on repair were most often funded by research institutes, those with a focus on fashion & apparel were more often funded independently (no external funding) or by non-profits, those with a focus on civil society were most often funded independently (no external funding), and those focused on circularity at the city-scale were funded by non-profits. 'Recycling methods' was the predominant sector of focus for studies funded by all categories of funders except for two. First, studies funded by a combination of research institutes and non-profits more often focused on consumer awareness & behavior and bio-based plastic & packaging. Second, studies funded only by non-profits were focused on plastic supply chain, food & food service packaging, fashion & apparel, CE policy, or CE in cities. It should also be noted that, while studies funded exclusively by industry did most often focus on the recycling sector, those funded by an industry's foundation/non-profit branch focused most commonly on food & food service packaging. Among articles that focused predominantly on the ‘recycling methods’ sector and were sub-coded to focus specifically on chemical recycling, 59% received some form of government funding (56% were exclusively funded by government) and 27% received some form of industry funding.

2.4.6 Definitions of CE

In total, 63% of all articles reviewed did not include an explicit definition of “circular economy.” Among those that did, 104 unique definitions were identified. The most common definitions included Ellen MacArthur reports (ranging from 2012 - 2019) and publications from the European Commission (ranging from 2013 - 2019).

While the overall breadth of definitions for CE is lower than the 114 definitions identified by Kircherr et al. in 2017, it is still apparent that a single, agreed-upon, globally relevant definition doesn’t exist in academic literature, and that European definitions remain predominant. Other reviews have found a similar lack of cohesion in the past among CE approaches and definitions in literature and have found the concept to be often conflated with sustainability or end-of-life management (Geissdoerfer et al., 2017; Kircherr et al., 2017; Velenturf et al., 2019).

The need for clear, consistent, and harmonized definitions has been highlighted throughout the global agreement negotiation process by multiple stakeholder groups (Simon et al., 2021; Packaging Europe, 2023; WEF, 2024). The revised draft text of the UN international legally binding agreement on plastic pollution that was released at the fourth session of the intergovernmental negotiating committee in April 2024 included explicit references to shared definitions, criteria, and potential targets. Definitions, including for CE and the life cycle of plastic, are to be included as a standalone article, integrated into the provisions of an article, or a combination of the two. “Circular economy approaches” are mentioned several times in the draft text as a potential direction or as a dedicated program of work within the agreement (UNEP/INC, 2024). If this is to be part of a global, legally binding document, there needs to be a degree of consensus on what is included/excluded in CE and how progress will be quantified.

2.4.7 Methodologies to Quantify CE

In total, 34% of all articles reviewed included methods or metrics for how to quantify or measure CE with respect to a system or a product, representing 32 unique methodologies. Across the 120 articles that did include some form of CE methodology or quantification, 50% used life cycle assessment (LCA) and 18% used material flow analyses (MFA). Beyond that, 2.5% or less of articles included other methodologies.

Regarding CE metrics and variables, an analysis of CE indicators from 2019 found that most focused on the preservation of materials through waste management, predominantly through recycling using metrics such as recycling rates (Moraga et al., 2019). There was also a lack of indicators that focused on functions, such as product sharing, and all were focused on the products themselves. Similar to what was found in this study, LCAs and MFAs were the most common methods found in the 2019 analysis, though the authors point out that, while those methods are useful starting points, methodologies need to be developed that take into consideration multiple indicators, incorporate the practical challenges of implementing CE, and include the full scope of the issue and life cycle (Moraga et al., 2019). LCAs have been found to serve as a useful starting point to identify key hotspots and issues, but studies have cautioned that they may offer a skewed or simplified view (Finkbeiner et al., 2014; Hellweg et al., 2014). The cross-sector nature of CE demands interdisciplinary metrics that look holistically across the full life cycle of products (Maddalene et al., 2023). Another key aspect often missing from CE metrics is that of social equity, with studies suggesting that metrics such as quality job creation, poverty reduction, improved health, and the active participation of communities and workers should be included in CE analysis if there are to be meaningful social benefits (Berry et al., 2022). This class of metrics were also mentioned in less than 5% of articles reviewed for this study.

The assessment of CE itself is also crucial, including the development and use of indicators that can assess whether CE strategies and implementation have the desired impacts. An analysis of CE strategies from 2017 found that minimal research had been done in this area, which was also found in this study (Elia et al., 2017). Given the expansion of CE throughout global policy, these types of indicators and assessments will also be critical to ensure that CE methods can be flexible, adaptable, and tailored as needed. The function of sharing lessons learned across countries and context for what does or does not work will be important for CE's relevance and functionality.

2.4.8 Social Justice Across the Life Cycle

There are inextricable links between plastic pollution, circularity, and environmental and social justice that have not been adequately represented in academic literature to date (Murray et al., 2017; Berry et al., 2021; Marks et al., 2023). There has been a general vagueness about the implications for social equity and for gender, racial, and religious equality in CE literature (Murray et al., 2017). Similarly, few studies have explored the dynamics of consumer behavior and consumerism in light of a transition towards a CE, particularly in terms of potential changes to ownership, social acceptance, and cultural aspects of consumption (Camacho-Otero et al., 2018). Some studies have identified rifts between citizen perspectives and policies on CE practices, and have suggested that CE should be more explicitly tied to human development, climate and energy issues, and social topics in order to build public acceptance (Repo et al., 2018; Schröder et al., 2020).

This analysis revealed similar results. Only around 10% of articles surveyed (34 articles total) were found to meaningfully incorporate social justice and equity into their research or findings. This did not include articles that had a minimal reference to the topic, such as those that included 1-2 sentences in the introduction referencing social inequities, that broadly reference human health or social equity factors included in LCAs, or that recommended future research examine these aspects of plastic pollution. Examples of ways that articles meaningfully incorporated social justice and equity included investigations into or engagement with marginalized communities, such as waste pickers; discussions on socioeconomic issues and historical inequalities; recognition of the importance of community participation and empowerment around interventions; and discussions around the challenges of cost prohibition, social norms, and health concerns when developing interventions in this space. However, many of those articles discussed the challenges on a global level, such as the international impacts of the waste trade between The Global North and The Global South, and few captured specific instances and specific interventions to address such challenges.

In line with observations in this review, an analysis in 2022 found that, while “social benefits and impacts” were often referenced in CE literature, they were rarely explained or elaborated upon. The topic is often mentioned in passing or used in a vague context, but the actual benefits or implications are rarely mentioned or cited explicitly (Berry et al., 2022). For example, several articles mention that there are "social" or "societal" benefits to a CE in the Introduction or Conclusion, but that would be the only reference. Several publications that used LCA methods explicitly noted that the "social" aspects were excluded from their analysis, some recommending they be included in future research.

Similar patterns can be found for the incorporation of "equity" and "justice" into CE literature. The term "justice" only appeared in 15 articles in this review and the term "equity" only appeared in 12 articles, though around 50% of those were in the context of "brand equity" and not "social equity." These findings are consistent with an analysis in 2022 that found that literature on CE in the United States largely omitted any reference to equity or justice (Berry et al., 2022). Regarding the impacts on communities from production and upstream processes, the term "fenceline" was not found in any of the articles analyzed, and the term "frontline" was found in two articles but in reference to frontline health care staff and NGOs. The term "disenfranchised" was found in one article, the term "disproportionate" with respect to community impacts and exposures was found in two articles, the term "marginalized" (or "marginalized") was found in four articles, and the term "vulnerable" with respect to populations or communities (as opposed to technologies or markets) was found in six articles. Some studies highlight that, if not properly addressed, CE can perpetuate institutionalized injustices and social inequities and can create new and deeper inequalities among access to societal and ecological co-benefits (Berry et al., 2022; Marks et al., 2023). When looking at patterns of global consumption and waste trade, plastic pollution has also been framed as an issue of colonialism, and it will be critical to ensure that a transition towards a CE does not exacerbate those historic inequities (Liboiron, 2021).

From the articles reviewed for this study, there appears to be a mismatch between solutions being developed in The Global North that don't necessarily take into consideration social, affordability, or accessibility issues that exist in both The Global North and The Global South. Most articles that included a meaningful discussion on social equity and justice implications of CE were among those with study locations in The Global South, often associated with the informal waste sector or overlapping intersectional social issues. This presents a perception in academic literature that waste as an environmental justice or accessibility/affordability issue is only relevant for The Global South, whereas research has shown that inequities exist in exposure to plastic pollution and access to SUP alternatives outside of The Global South (Berry et al., 2022; Youngblood et al., 2022; CIL, 2023). While interventions should be tailored to local contexts, it could present a problem if those interventions portrayed in literature weigh more heavily towards a smaller sector of society.

Another aspect of social justice and equity found in CE literature is that of human health. In total, 110 articles in this review included the phrase "human health" somewhere in the text - often included as part of LCA for EOC (e.g., carcinogens and air quality associated with WM processes), or in material development trying to make something more benign. The impact of plastic on human health throughout the plastic life cycle has historically been overlooked in academic literature and in implementing solutions but is a critical factor that is gaining media and research attention (Muncke et al., 2020; Landrigan et al., 2023; Geueke et al., 2024). Further, the term "cancer" appeared in 22 articles total - often in the context of emissions from WM processed, rarely associated with product design, additives, or use. The term "endocrine" appeared in 9 articles, in reference to endocrine-disrupting chemicals associated with plastic, which have also been gaining attention in plastic pollution and CE dialogues in recent years. The phrase “chemicals of concern,” which is often referenced in the global agreement, is only found in two articles.

While the concept of a “just transition” to CE features throughout the current draft text of the global agreement, there has been conflict over its incorporation and how human rights are reflected in the agreement at large (Dominguez, 2024). This is particularly of concern for party countries where waste pickers play a large role in the waste economy (O’Hare et al., 2024). The phrase “informal” concerning informal waste collection, informal waste management, informal settlements, or the informal waste sector in general appeared in 41 of the articles reviewed. The phrase “waste picker” appeared in 17 articles and the word “scavenger,” with respect to waste and not in the chemical context (e.g., oxygen or ethylene scavengers), appeared in 8 articles. Considering the prevalence of articles that focused on waste management and end-of-cycle life cycle phases, these sectors of society need to be considered and be part of the conversation around interventions. Researchers, practitioners, and decision-makers need to engage and include the informal waste sector and informal settlements, understand how they adapt and create their own economies, and ensure they are active participants in the CE transition. Interventions, metrics, and assessments for CE systems will have to actively include these aspects of social justice and human rights to ensure this just transition globally.

2.5 Conclusion

A literature review was conducted across 355 peer-reviewed articles to investigate how the CE for plastic packaging has been portrayed in academic literature over the past five years. Categories investigated included CE topics represented in the literature, life cycle stages evaluated, geographic focus, and general sentiments, perspectives, and themes. The results show that the majority of first authorship and geographic area of study among publications are based in The Global North and in High-Income countries. Few articles included acknowledgments outside of academia and funders, and even fewer had authors outside of academia. Among those that did, the most common non-academic sector included was industry. Findings also demonstrated a disproportionately high representation of the ‘end-of-cycle’ stage of the plastic life cycle in publications. Recycling, and particularly chemical recycling, was the most common sector represented in research. The findings demonstrate a need for harmonized definitions and metrics for CE that investigate the full product life cycle and that incorporate key socioeconomic components. Findings also highlight a distinct lack of environmental justice and equity topics represented in the CE literature analyzed. The intention is for these findings to be used by researchers, industry, and decision-makers to inform a global, just, and equitable CE transition.

Limitations to this work may include the scientific focus of the databases selected for analysis and the requirement for peer-reviewed literature in the document selection process. This could potentially exclude articles in journals that are not identified through these databases or that have differing qualifications, such as those of non-western science. This study does not include an in-depth investigation into how CE and plastic packaging are represented in grey literature, which may be beneficial to complement this academic-facing work in the future. Similarly, it may be useful to conduct similar investigations into how the CE for plastic packaging is represented in other sectors, such as government/policy documents and industry reports. It would be beneficial to repeat this literature review after implementation of the UN global agreement on plastic pollution to observe any changes.

Future academic research and publications must ensure that CE is not synonymous with solid waste management or sustainability and that CE has a distinct and unique role to play in building resilience. That role must embody a full life cycle approach, taking into consideration human health, environmental justice, and social equity throughout, and aspects of the life cycle must be able to learn from each other. For example, a recyclable material in practice cannot operate in a system that doesn’t have the capacity or technology to recycle it, standard reuse systems may not be viable in locations with major sanitation concerns, and alternative materials may not be scalable solutions if they are not affordable, accessible, and manageable. It will be important for academia to embody this in research and practice and to demonstrate that a full life cycle approach to CE is possible and necessary. Similarly, metrics that are both harmonized and flexible to quantify CE will be critical to ensure that communities, cities, and nations can adapt their CE practices as needed. Researchers and practitioners from The Global South and The Global North should test and adapt metrics across a range of contexts and use cases, document progress via longitudinal studies, and learn from each other in the process. Funders and researchers should incorporate local and non-academic perspectives into CE research and implementation where possible and should support and investigate sectors beyond recycling alone that embody truly circular systems.

With growing global momentum around plastic pollution prevention and CE optimization, now is a critical time to ensure a more inclusive, holistic, and egalitarian approach to CE research and interventions. If we as a global society are to address plastic pollution (e.g., through a legally binding agreement) and drive a more circular economy, we must have a shared understanding of the definitions and principles that underpin those practices. There is no single solution to preventing waste leakage and pollution, and it will require an all-of-society approach to close those loops and optimize CE locally and globally.

Chapter 3 : Circularity in Cities: A Comparative Tool to Inform Prevention of Plastic Pollution

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3.1 Introduction

Plastic pollution is among our time's most pressing and ubiquitous environmental, social, and economic challenges. Plastic waste emissions into the environment were estimated at 19-23 million metric tons in 2016 and may reach 53 million metric tons by 2030 (Borelle et al., 2020). The economic cost of plastic pollution on marine natural capital ranged between $3,300 and $33,000 per ton of waste in 2018 alone, excluding non-marine plastic pollution impacts such as soil contamination, air pollution, and freshwater system degradation (Beaumont et al., 2019; Deloitte, 2020; de Souza Machado et al., 2018; Hurley et al., 2020). Negative impacts of plastic throughout the life cycle are known to disproportionately affect marginalized and disenfranchised communities worldwide (Karasik et al., 2023; UNEP, Apr 2021). Plastic pollution lies at the heart of the 'triple planetary crisis,' the intersection of the climate, biodiversity, and pollution crises, each mutually reinforcing (Passarelli et al., 2021). Effective waste management (WM) and circularity benefits include reducing greenhouse gasses and plastic leakage from extreme weather events (Ford et al., 2022). Literature strongly suggests that the most effective long-term solutions lie in upstream prevention and rethinking how we design, package, distribute, use, and manage products (Lau et al., 2020; Borelle et al., 2020).

While plastic and the circular economy remain important topics in national and global forums, cities are at the forefront of addressing these challenges. By 2050, an estimated two-thirds of the global population will live in cities, consuming 75% of the world's natural resources, producing 50% of global waste and over 60% of greenhouse gas emissions, and nearly 90% of that urban population growth will be in Asia and Africa (UN DESA 2018). Solid waste management (SWM) is often challenging for cities, particularly in developing countries where economic growth correlates with waste generation (Kaza et al., 2018). Cities also face unique obstacles, including burdens on municipal budgets from high WM costs, the need for close communication with local stakeholders, keeping up with changing landscapes of material types imported and used, and understanding the diversity of WM technologies and interconnected systems that enable successful functioning (Guerrero et al. 2013).

The Urban Ocean process includes mapping challenges, risks, vulnerabilities, and opportunities within materials management systems to help develop an integrated approach to circularity-related challenges and opportunities for cities. The Circularity Assessment Protocol (CAP), developed at the Circularity Informatics Lab (CIL) at the University of Georgia, is a standardized methodology used to collect community-level data to inform decision-making (Jambeck et al., 2024), and was chosen as the data collection tool for the first phase of Urban Ocean. As of December 2022, CAP has been conducted or is in progress in 37 cities in ten countries. This paper synthesizes CAP data from six initial cities in the Urban Ocean program (Figure 3.1): Can Tho, Vietnam; Chennai, India; Melaka, Malaysia; Semarang, Indonesia; Pune, India; and Panama City, Panama. The analysis examines commonalities and differences between the cities' CAP results, illustrates how CAP can be used to prioritize and measure the impacts of different interventions, and explores how cities are addressing circularity related to plastic materials.

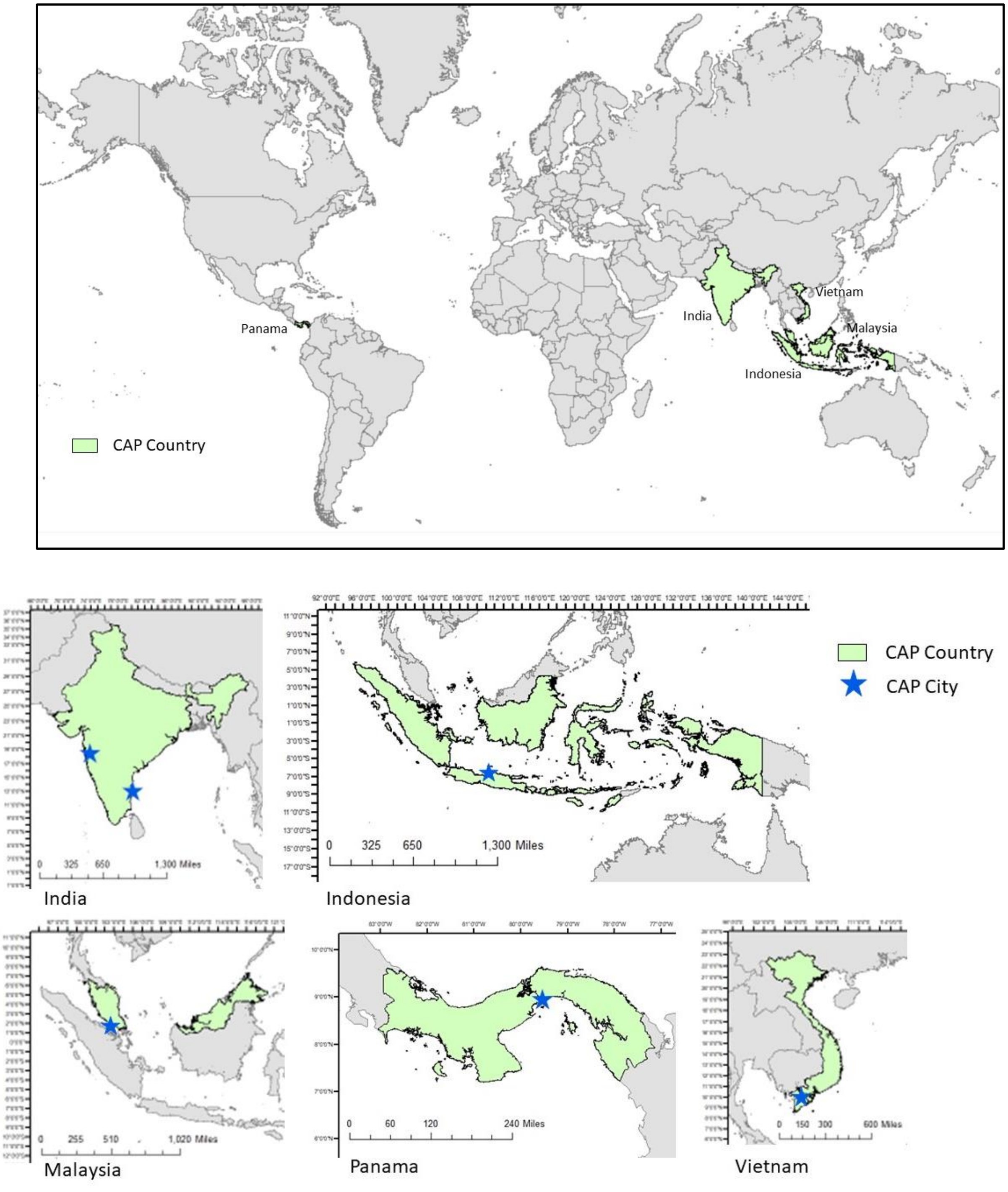


Figure 3.1: CAP Study Site Locations (six initial Urban Ocean cities)

3.2 Materials and Methods

CAP is a mixed methods approach to holistically quantifying circularity through quantitative data collection, qualitative stakeholder engagement, and literature review. This work includes data from six cities in five countries across Asia and South America (Table 3.1). CAP was conducted according to methods outlined in Jambeck et al. (submitted), with minor variations noted below. Research suggests that mixed methods such as this can be valuable for addressing complex challenges in various disciplines (Mertens et al., 2007; Almalki, 2016).

Table 3.1: Socioeconomic statistics for Urban Ocean cities

City, Country	City Population	Region (WB)	Country Economic Status (WB)	Field work Dates
Can Tho, Vietnam	1,246,993	East Asia & Pacific	Lower middle income	Oct - Nov 2020
Melaka, Malaysia	180,671	East Asia & Pacific	Upper middle income	Oct 2020 - Mar 2021
Semarang, Indonesia	1,653,524	East Asia & Pacific	Lower middle income	Oct - Nov 2020
Pune, India	2,935,744	South Asia	Lower middle income	Oct 2020 - Mar 2021
Chennai, India	4,328,063	South Asia	Lower middle income	Sep - Dec 2021
Panama City, Panama	1,937,963	Latin America & Caribbean	Upper middle income	Oct 2020 - Mar 2021

Note: *Population is based on 2022 World Population Review (WPR, 2022) with data from UN World Urbanization Prospects (UN DESA, 2018) (for city centers, not larger metropolitan area) or directly from cities where more current data was available*

Understanding the geographical context of cities is essential for waste and potential environmental impact characterization. Can Tho is in southern Vietnam, the largest city on the Mekong River Delta. Melaka is on the southwestern coast of Malaysia and borders the Malacca Strait. Semarang is the largest city in the Central Java province of Indonesia and borders the Java

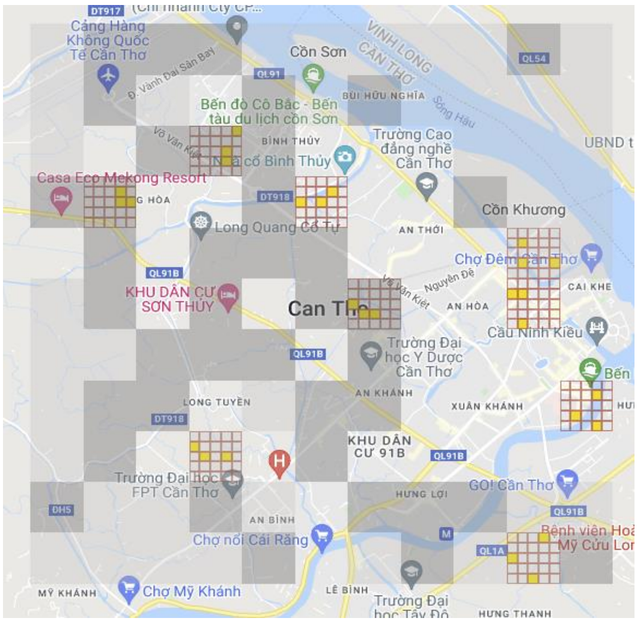
Sea on its northern coast. Panama City is on the Pacific Coast of Panama, with nine rivers passing through it and leading into the Panama Canal. Pune is in the western Indian state of Maharashtra and is traversed by the Mula River. The coastal city of Chennai is the capital of the southern Indian state of Tamil Nadu and is home to three rivers that flow into the Bay of Bengal to the east (Figure 3.1).

International collaboration and partnerships are always key components of the CAP, and especially during the COVID-19 pandemic. Data was collected in collaboration with Urban Ocean Local Implementation Partners (LIPs), following all safety protocols and regulations in each city. LIPs continue to be a part of the Urban Ocean process beyond CAP and include the DRAGON Institute at Can Tho University, Can Tho, Vietnam; Universiti Kebangsaan Malaysia (UKM), Melaka, Malaysia; Initiatives for Regional Development and Environmental Management (IRDEM) at Diponegoro University, Semarang, Indonesia; Centro de Estudios y Acción Social Panameño (CEASPA), Panama City, Panama; Centre for Environment Education (CEE), Pune, India; and Okapi Research & Advisory, Chennai, India.

3.2.1 Site Selection

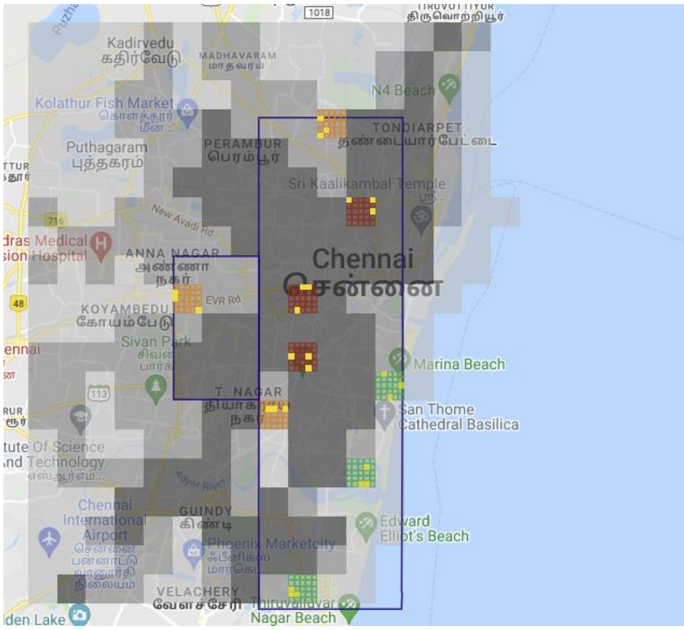
A consultative process identified 100k m^2 areas for each city center in ArcMap. Ambient population was stratified into three tertiles within the area (high, medium, low) using Oak Ridge National Laboratory's 2019 LandScan dataset, which provides the ambient population - a proxy for societal activity - per raster cell at 1km spatial resolution (Rose et al., 2020). Three 1km^2 areas were randomly selected in each 100km^2 area using the National Oceanographic and Atmospheric Administration Sampling Design Tool from each population tertile for a total of nine 1km^2 transect areas. The Sampling Tool then randomly selected three 200m^2 sites in each

1km^2 area as litter transect locations. The only variation from the site selection process outlined in Jambeck et al. (submitted) was for Chennai, where the area included two rectangles instead of a square to reflect the city's area along the coast (see Figures 3.2-3.7 for all sample sites).



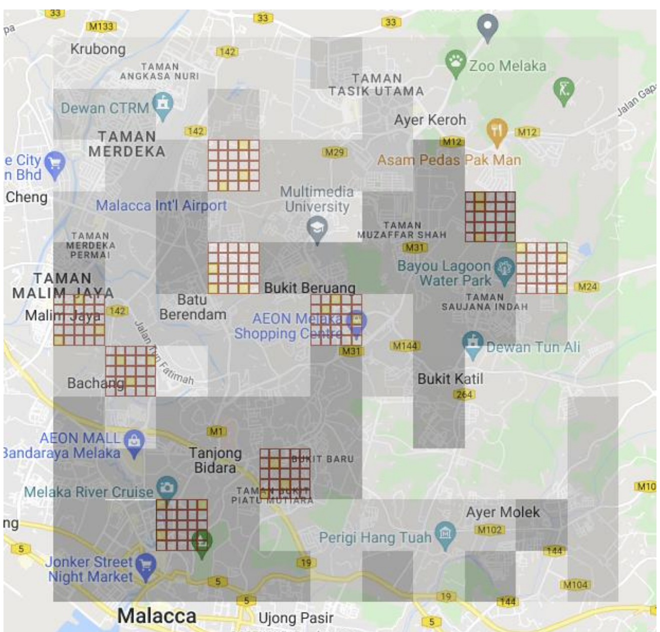
Population tertiles:
Low: 5 - 916 persons/km2
Mid: 916 - 2,225 persons/km2
High: 2,225 - 45,599 persons/km2

Figure 3.2: CAP Fieldwork Location for Can Tho, Vietnam (gray shading represents ambient population, red squares represent 1x1km2 transect areas, yellow squares represent 200x200m2 litter transects)



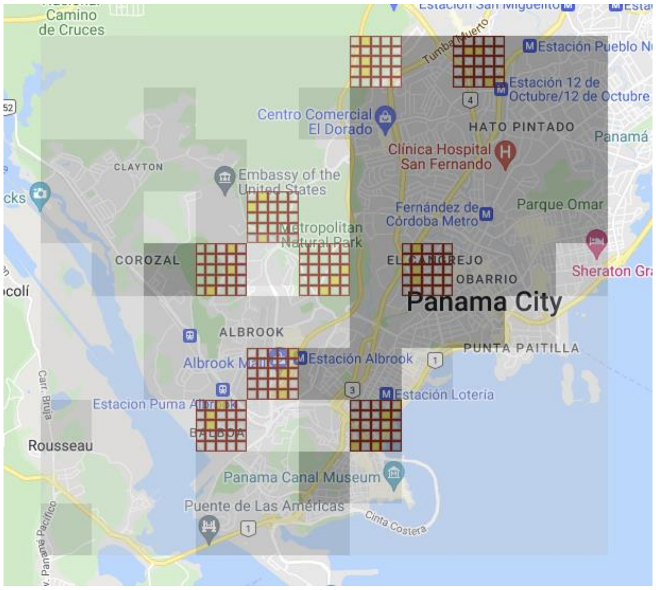
Population tertiles:
Low: 0 - 9,262 persons/km²
Mid: 9,262 - 20,670 persons/km²
High: 20,670 - 85,724 persons/km²

Figure 3.3: CAP Fieldwork Location for Chennai, India



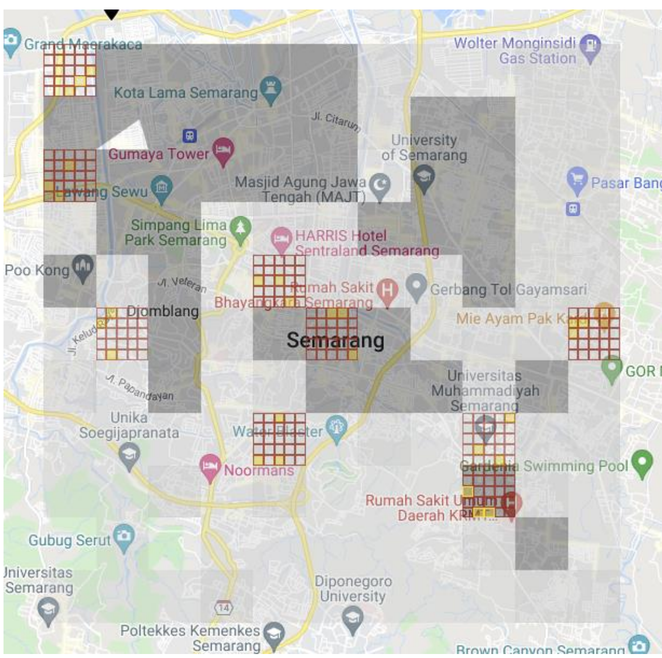
Population tertiles:
Low: 49 - 620 persons/km²
Mid: 621 - 2,608 persons/km²
High: 2,609 - 29,469 persons/km²

Figure 3.4: CAP Fieldwork Location for Melaka, Malaysia



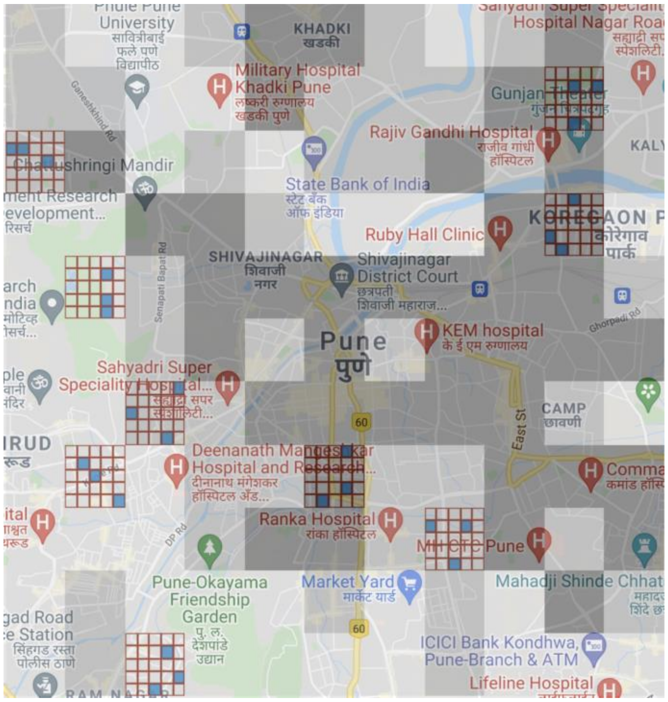
Population tertiles:
Low: 0 - 557 persons/km^2
Mid: 557 - 5,333 persons/km^2
High: 5,333 - 24,081 persons/km^2

Figure 3.5: CAP Fieldwork Location for Panama City, Panama



Population tertiles:
Low: 214 - 5,582 persons/km^2
Mid: 5,582 - 8,122 persons/km^2
High: 8,122 - 15,534 persons/km^2

Figure 3.6: CAP Fieldwork Location for Semarang, Indonesia



Population tertiles:
Low: 5,333 - 24,081 persons/km^2
Mid: 13,910 - 36,568 persons/km^2
High: 36,568 - 77,275 persons/km^2

Figure 3.7: CAP Fieldwork Location for Pune, India

3.2.2 Input

Samples of fast-moving consumer goods (FMCG) items were collected within the nine 1km^2 transect areas to characterize the type and source of common plastic packaged items entering each city (Jambeck et al., 2024). LIPs selected up to three convenience or grocery shops to sample within each 1km^2 transect area unless none were present. For each shop, LIPs collected common brands of candy, chips, beverages, and tobacco products (categories were amended in cities with other popular FMCG items). The "common brands" were determined as the most purchased based on shelf space and/or shopkeeper input. Plastic packaging and product weight were measured for each item using kitchen scales. LIPs noted packaging type (including polymer, if possible), brand, and parent company for each product. Manufacturing and parent company locations were determined from locations listed on packaging or desktop research. Distances between stores and item parent/manufacturing companies were calculated in ArcGIS (Jambeck et al., 2024).

3.2.3 Community

The community section of CAP captures perspectives of relevant "Influencers" in a way that complements and adds context to the quantitative and qualitative data collected in the other CAP spokes. LIPs conducted semi-structured interviews with local stakeholders like Jambeck et al., 2024. Though exact numbers varied for each city, LIPs made best attempts to conduct at least three interviews for each stakeholder group, including convenience/grocery store staff, private waste companies, informal waste sector, food vendors, local government, local NGOs, academia, local plastic industry, and local companies using alternatives to plastic (Table S1). Interviews were recorded and transcribed for coding and thematic analysis.

3.2.4 Product Design and Use

To characterize consumer good materials, LIPs collected samples of FMCG items and documented packaging and product type and weight as described in Input. Within each of the nine 1km^2 transects, the LIPs also visited up to three randomly selected food vendors or restaurants to sample food packaging and utensil types distributed. The weight, material type, and brand (where possible) were documented for each to-go item. Costs were documented for all plastic alternatives available as to-go products or in convenience stores, such as refillable bottles, and compared against single-use items.

3.2.5 Collection and End of Cycle

LIPs and partners documented available data on the city's waste collection and management infrastructure. During litter transects, LIPs documented waste bins and their status (e.g., overflowing) to understand the availability and utility of public waste collection. Literature reviews were conducted in collaboration with LIPs to characterize each city's formal and informal waste collection mechanisms. Stakeholder interviews also informed this section, and LIPs visited WM infrastructure when possible.

3.2.6 Leakage

Litter transects were conducted in the three 200m^2 sites in each of the nine 1km^2 transect areas, similar to Youngblood et al., 2022. Every piece of litter >2.5cm was recorded in a transect 100m long by 1m wide. Transect length was measured using a distance wheel and transect width was measured once and then visually estimated by trained researchers. Transects followed the side of a road or pathway and were continuous but not always linear. Litter type and GPS coordinates of all visible litter items within the transect were recorded using the Site Assessment list on the Marine Debris Tracker mobile application. The list was modified for international use and built upon that used by Youngblood et al., 2022. The complete list of items and material types in the Site Assessment list is available in the Supplemental Material. For uncommon litter items not on the list, researchers tagged the item as "other" and added a description.

3.2.7 Comparative Analysis

The level of impact for each CAP spoke was determined quantitatively, if possible, as described in the Discussion and Results for each case (for example, if the litter comprised a certain percentage of an item, a ban on that item would reduce litter by that percentage). Impacts were categorized as 0%, 25%, 50%, 75%, and 100%, rounded to the nearest point based on quantitative data or estimated qualitatively based on impact. Metrics for level of impact included percentages of parent companies/manufacturers from a product type and/or product distances traveled to point of sale (Input), known perceptions and barriers in communities related to waste and plastic pollution (Community), percentages of material types found among FMCG and to-go items (Product Design), existing or planned schemes for reuse and associated material types included (Use), waste collection coverage, contamination rates, and waste characterizations (Collection), existing and planned WM infrastructure and associated capacity (End of Cycle), and characterization of litter (Leakage). The specific metric used for a given spoke in a given city is noted for each comparative analysis referenced in the Results section.

3.3 Results and Discussion

The CAP for the six cities included documentation of over 27,000 litter items, sampling of 1,300 fast-moving consumer good (FMCG) items (in the categories of beverage, candy, chip, and tobacco) and 470 to-go items from nearly 150 restaurants and food vendors, and interviews with more than 140 stakeholders. Full results and data for each city can be found in the individual city CAP reports at www.circularityinformatics.org (CIL 2022; CIL 2021).

3.3.1 Community

The CAP community data provides context and supporting information for each of the other components detailed below. Table 3.2 includes the number of interviews conducted with each group of stakeholders.

Table 3.2: Overview of Stakeholder Interviewees for CAP

Stakeholder Group	**Description**	**Total Number Interviewed**
Academia	Local academics who collect data related to plastic pollution or waste management or who play an advisory role to the government on these topics	14
Convenience/Grocery Store Staff	Individuals who owned or worked at the stores that were surveyed for convenience products as part of the Product Design section	16
Food Vendors	Individuals who owned or worked at the food vending locations that were surveyed for to-go items as part of the Product Design section	17
Informal Waste Sector	Groups or individuals that operate within the informal waste sector, including individual waste collectors and recycling aggregators	22
Local Alternatives Companies	Companies that produce or are using plastic alternatives, such as bulk stores or refill locations	8
Local Government	Local government departments or individuals that are engaged in municipal waste management or tangential areas	14
Local Plastic Industry	Companies that are based or operate within the city that manufacture plastic or produce plastic products	7
Private Waste Companies	Private waste hauling, landfill, or recycling companies that operate within the city	22
NGOs	Non-profit organizations that operate locally to collect data on plastic pollution, engage in community cleanups, run outreach campaigns, or are otherwise in these issues	14
Other Community Members	Community members who worked in other sectors that use plastic products (i.e., hotels, tourism, etc.)	13

Similar challenges exist across all cities, including gaps between regulations and enforcement, lack of stability and reliability in the recycling market, challenges surrounding behavior change, poor conditions in the informal waste sector, and lack of accessible and affordable alternatives to single-use plastic. Awareness was needed across all cities and sectors, not only among residents on requirements for and presence of household or public waste collection but also for local businesses on the availability of alternatives and the hierarchy of waste disposal for different materials. Most cities had small but enthusiastic groups of citizens that strongly supported refill and reuse, bulk options, and alternative product delivery systems. Several cities had historical precedents for reusable and alternative items, such as tiffin food carriers in Semarang and banana leaf food packaging in Chennai. Another commonality was a demand for programs to engage young, tech-savvy locals in the waste sector, particularly for new technology to support the recycling sector and informal waste workers. Other themes including the need for space, capacity, and infrastructure for adequate waste sorting and management were ubiquitous, though interviewees noted that community engagement and a sense of ownership of interventions must be coupled with any investment in infrastructure or policy to enable long-term success.

3.3.2 Input, Use, and Product Design

The average distance between stores and manufacturers was consistently lower than the distance between stores and parent companies for common FMCGs sampled (beverage, candy, chip/snack, and tobacco products) (Figure 3.8). Identifying manufacturers and parent companies provides an opportunity to discuss Extended Producer Responsibility (EPR), whereby companies share the responsibility of managing their packaging after a product is consumed (Johannes et al., 2021). Shorter distances between production and consumption may allow for cost-efficient and resource-effective EPR schemes, specifically local reuse or refill models that help to eliminate packaging, encourage alternative delivery systems, and increase recapture and recycling by producers. This may also enable more effective packaging design that fits within end-market infrastructure systems available locally. However, it is important to note that this should not exclude larger international brands or foreign products - EPR should apply to producers and importers, targeting the most problematic items and materials. National EPR policies have been proposed or recently amended in Vietnam and India (MOEFCC 2020; Arci & Cao, 2021), and Chennai, Pune, and Can Tho are developing local policies and interventions to support those larger frameworks.

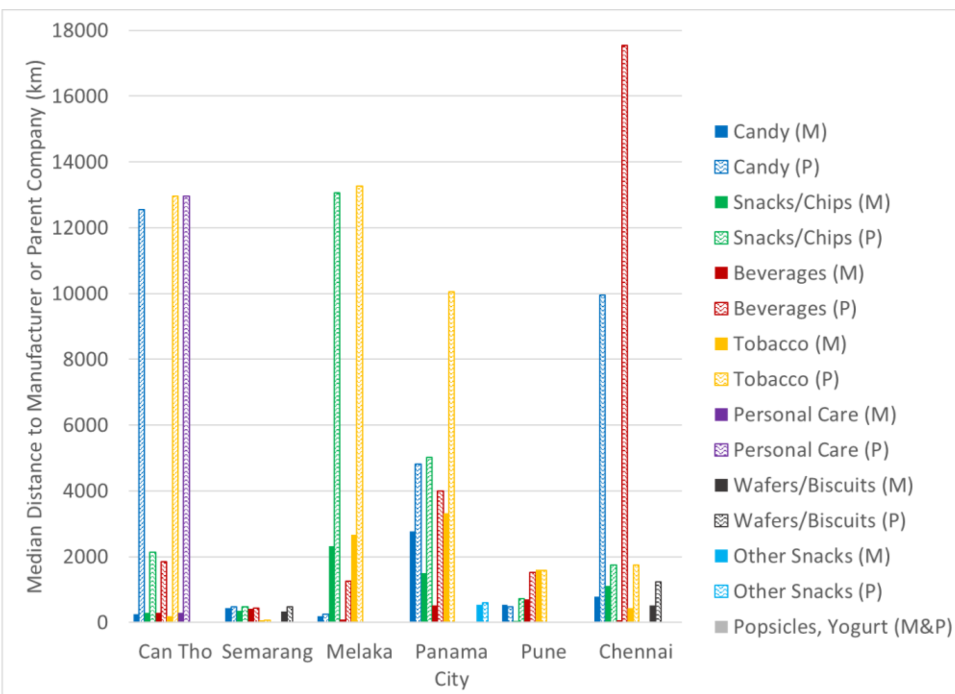


Figure 3.8: Median Distances between Urban Ocean Cities and manufacturers [M] and parent companies [P] by top FMCG items sold in the city

The majority of FMCG items across all cities were packaged in plastic (over 90% of items in some cities), and 53% were packaged in multilayer plastic (MLP) film, the top category of FMCG material type in each city (Figure 3.9a). In Can Tho and Pune, 100% of some product categories, such as candy and chips, were packaged in MLP film. Plastic food wrappers were among the top five most common litter items in all cities (see Leakage). One city did collect MLP for recycling - a local cooperative of informal waste workers in Pune (SWaCH) partnered with ITC Ltd., a major producer of plastic products in India, to collect and recycle low-value plastic items. In 2019, approximately 1,000 SWaCH waste pickers were collecting 130 metric tons of MLP film per month in Pune to be reportedly mechanically recycled (Anantakrishnan 2021).

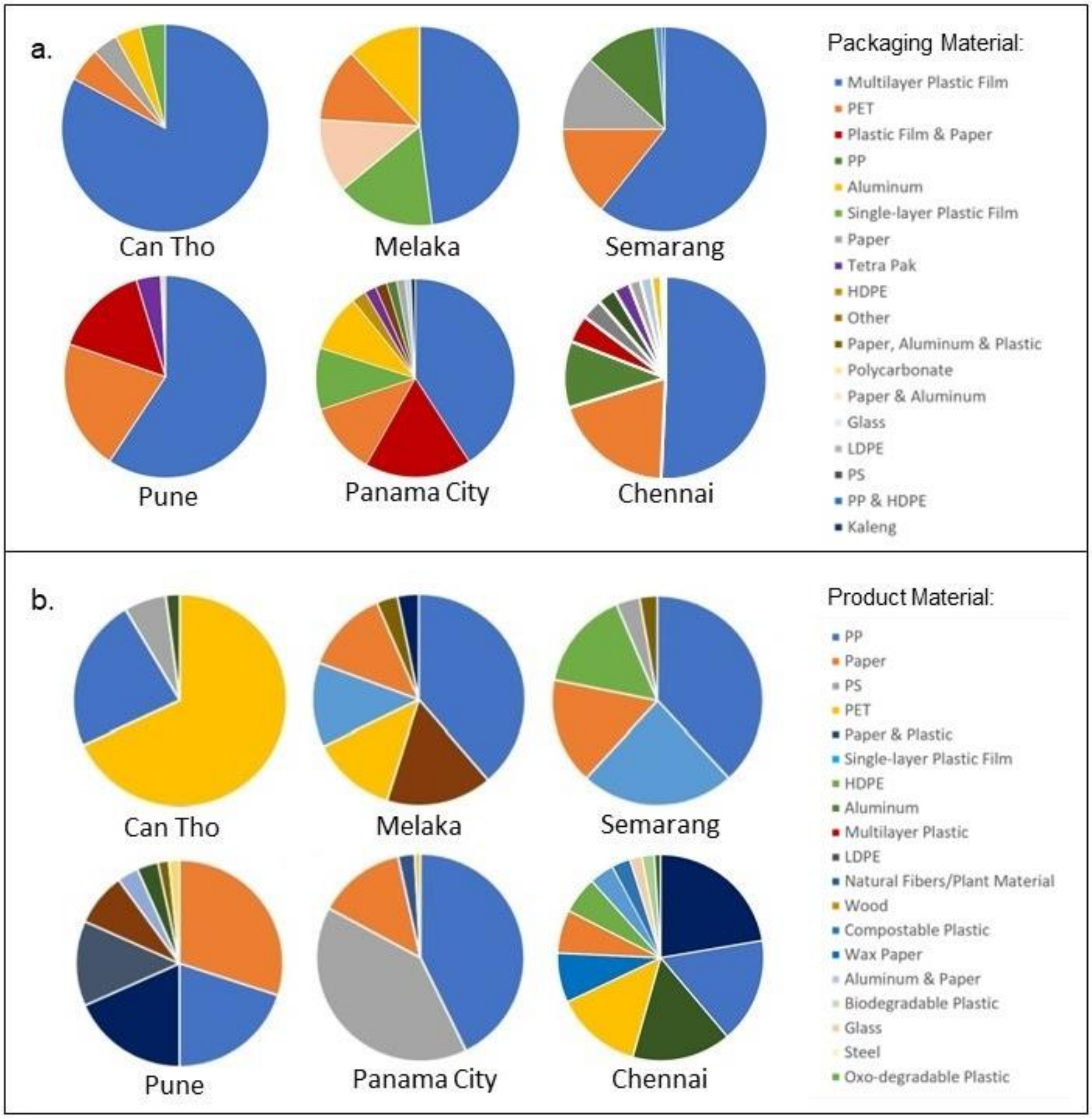


Figure 3.9: Material Breakdown of Packaging Material Type for FMCG Items (a) and of Material Type of To-Go Products (b) for each city

Chennai and Panama City had the widest variety of material types for FMCG packaging. A higher diversity of material types can make recycling more challenging because of economies of scale and added complexities, particularly for segregation, sorting, storage, and public education. Though it has the smallest population among the cities, Melaka averaged 16% non-plastic material types in to-go items, particularly paper. Depending on governance structures and resources, smaller cities may have the ability to be nimble in their transitions and be ideal locations for pilot projects. Indonesia has national and regional regulations to support plastic alternatives; plastic bags and paper alternatives were not among the top litter items in Semarang (though paper comprised 7-9% of litter based on material type), which may indicate a movement towards alternatives that are not leaking out of the system. Plastic grocery bags represented less than 0.87% of litter items found in Semarang, compared to 7.4% of litter items in Can Tho, 2.5% in Melaka, 1.7% in Chennai, 1.2% in Panama City, and 0.27% in Pune. Pune's low leakage of plastic bags may be due to the Pune Municipal Corporation's ban on plastic bags within the city and high door-to-door collection rates (TOI, 2009; MPCB, 2022).

Polypropylene (PP) was the most common material found in to-go items across all cities by count (31%), followed by paper (13%), polystyrene (PS) (12%), polyethylene terephthalate (PET) (11%), and several other materials that represented less than 10% of the whole sample (Figure 3.9b). Less valued plastics, such as PP, PS (including expanded polystyrene (EPS), films, and multi-material items), comprised 60% by count of to-go items sampled, while natural alternative items such as paper and wood comprised 16% of the samples. Around 1% of to-go products across all cities were identified as compostable, biodegradable, or oxo-degradable plastic, but stakeholder interviews highlighted unanimous confusion around the definition of those items, how best to identify them, and how to properly dispose of them. Pune and Chennai had the highest diversity of to-go materials, several of which were plastic alternatives (e.g., natural fibers, paper, glass, aluminum), which could be indicative of these cities' attempts to move away from items anticipated to be nationally banned in 2022 (Parkinson, 2021). Higher-population cities may have expanded opportunities and resources to try circular alternatives.

3.3.3 Leakage

69% of all litter items documented were plastic. Half of all litter items documented across all cities were food packaging plastic (27%), e.g., plastic food wrappers, cups and lids, plastic grocery bags, and straws; or tobacco products (23%), e.g., cigarette butts and multi-material cigarette cartons. The next most common items were paper (11%) and plastic fragments (10%), and the remaining categories represented less than 10% each of all litter items (Figure 3.10). Personal Protective Equipment (PPE) such as face masks and disinfecting wipes comprised around 2% of all litter and ranged from 1-4% of total litter by city, which aligns with other studies that have found increasing amounts of PPE litter during the COVID-19 pandemic (Ammendolia et al., 2021). A full list of items and material categories used for data collection through the Marine Debris Tracker (MDT) app is in the Appendix (Table A1).

City	Top 5 Litter Items
Can Tho	1. Cigarettes 2. Plastic Food Wrapper 3. Plastic Grocery Bag 4. Straws 5. Foam or Plastic Cups or Lids
Chennai	1. Plastic Food Wrapper 2. Cigarettes 3. Film Fragments 4. Plastic Bottle Cap 5. Other Organic Waste
Melaka	1. Cigarettes 2. Plastic Food Wrapper 3. Hard Plastic Fragments 4. Straws 5. Other Fragments
Panama City	1. Film Fragments 2. Foam Fragments 3. Plastic Food Wrapper 4. Cigarettes 5. Plastic Bottles
Pune	1. Tobacco Sachets 2. Paper 3. Glass or Ceramic Fragments 4. Plastic Food Wrapper 5. Cigarettes
Semarang	1. Cigarettes 2. Plastic Food Wrapper 3. Other Organic Waste 4. Straws 5. Other Food-Related Plastic

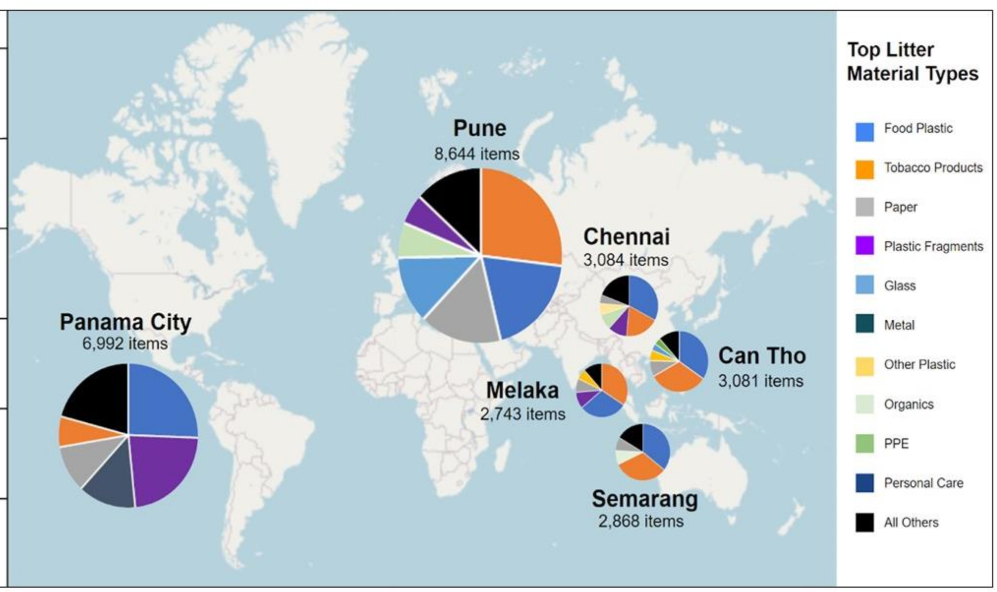
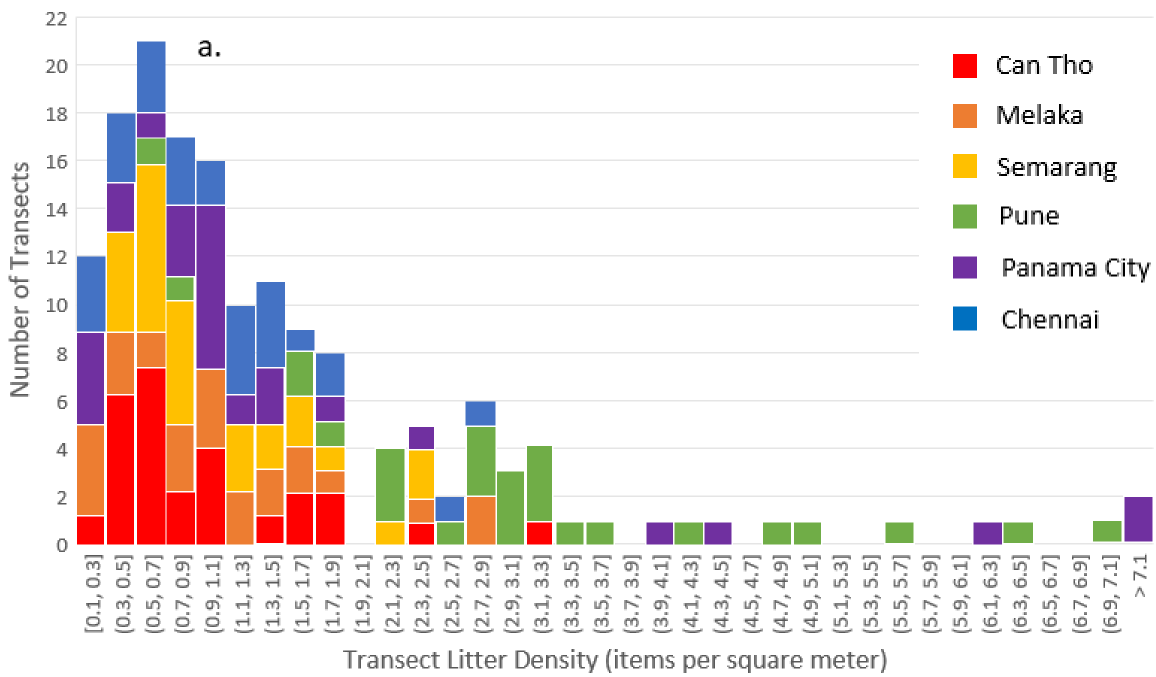


Figure 3.10: Litter counts and material types for all Urban Ocean Cities, where pie chart size indicates amount of litter collected by count ('All Others' includes categories that represented less than 5% of litter collected)

Litter densities and characteristics varied across cities (Figure 3.12a and Figure 3.12b). The positively-skewed histogram is similar to other environmental datasets, such as species distributions and metal concentrations in soil, where there are chronic low levels with areas of higher concentrations in certain contexts (Austin et al., 1987; Austin et al., 2002; Brown & Berthouex, 2002). The mean litter densities were 1.1 items/m^2 for Can Tho, Chennai, Melaka, and Semarang, while the mean was 2.1 items/m^2 in Panama City and 3.2 items/m^2 in Pune. The litter concentrations in Pune and Panama City had a larger range and distribution, although the median of Panama City is close to other cities (indicating the mean is driven by a small number of high values), while the median of Pune is higher than other cities (Figure 3.11 a - b).



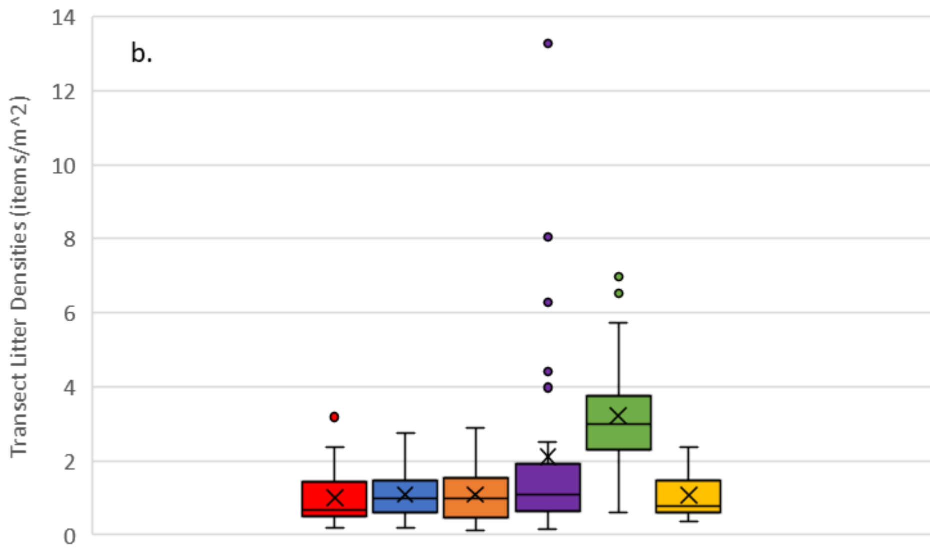


Figure 3.11: Histogram and box-and-whisker plots of litter densities in all transects across all Urban Ocean cities with each city's distribution shown

As shown in Semarang and Chennai, higher ambient population doesn't necessarily correspond with higher litter densities (Figure 3.13). This is similar to findings in the Ganges River Basin and other locations (Schuyler et al., 2021; Youngblood et al., 2022). In Panama City, the highest litter density was found in the lowest ambient population area, potentially influenced by a lack of services or infrastructure in these areas. In Chennai, litter density differed in areas with different waste collection services. When considering standard error, only Panama City and Pune showed statistical differences in litter counts between low, mid, and high societal activity (Figure 3.12).

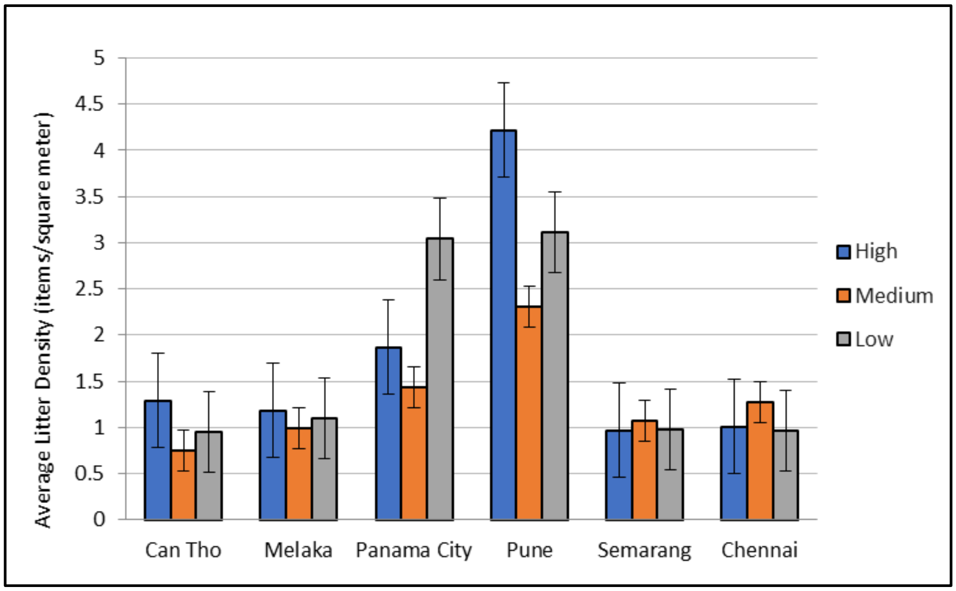


Figure 3.12: Distribution of average litter density for low, medium, and high population count areas across all Urban Ocean Cities, with standard error bars shown

3.3.4 Collection and End of Cycle

The CAP data shows a slight trend of increased litter counts in areas with fewer public waste bins, suggesting that well-managed bins may decrease the abundance of litter while fewer and/or poorly managed bins may lead to higher litter densities than expected (Figure 3.13). Studies have shown that the placement and abundance of waste bins can affect litter densities in public areas (Van Doesum et al., 2021). This data could help encourage expanded waste infrastructure and waste collection capacity, including generating new jobs. Pune has implemented a “Zero Bin" strategy for public waste bins, which reportedly increased household waste segregation and door-to-door waste collection rates (Sohkhlet and Nagargoje, 2020).

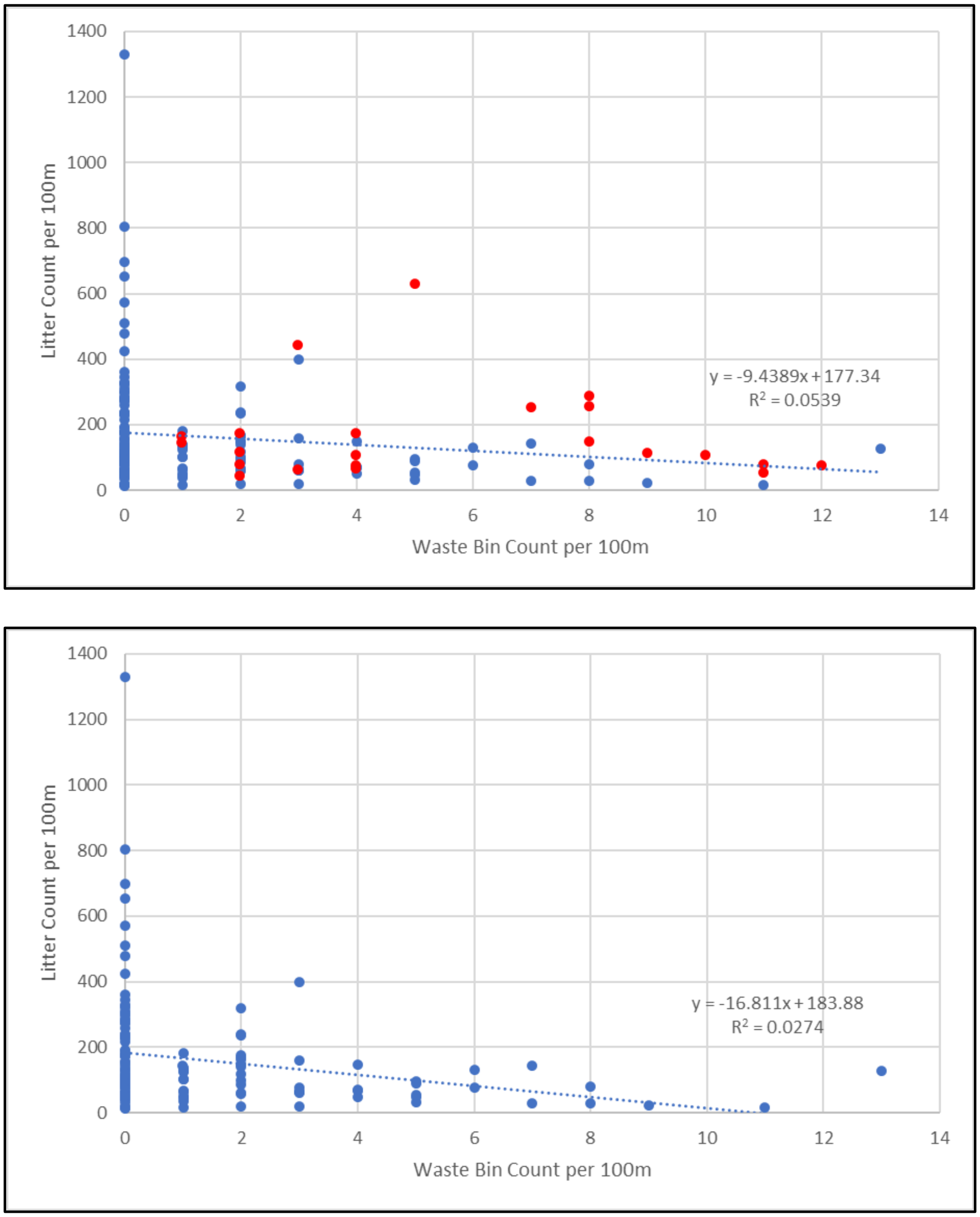


Figure 3.13: Litter Count vs Public Waste Bin Count for all Urban Ocean Cities, shown with and without overflowing bins. Red markers indicate areas where bin(s) were noted as 'overflowing' in that transect (showing steeper slope in trendline when overflowing bins removed).

While Pune had the highest average litter density, it had the lowest percentage of plastic and the lowest percentage of common plastic items (food plastic, other plastic, PPE, plastic fragments, and personal care items) in the litter (Table 3.4); while tobacco sachets were still the top item in Pune, paper and glass were second and third most abundant items found in the environment.

Table 3.3: Litter density and public waste bin data for the six cities

City	Avg Litter Density (items/m^2)	% of litter items that were plastic	% of litter items that were common plastic items*	No. and Avg of Public Waste Bins	% of bins overflowing
Can Tho	1.00	81%	47%	23 (0.85)	No data
Chennai	1.08	73%	56%	43 (1.59)	37.21%
Melaka	1.09	81%	49%	62 (2.48)	54.83%
Panama City	2.11	66%	58%	101 (3.74)	60.39%
Pune	3.22	53%	30%	0 (0)	N/A (no public bins)
Semarang	1.06	79%	42%	76 (2.81)	18.42%

**Common Plastic Items included food plastic, other plastic, PPE, plastic fragments, and personal care items*

The informal waste sector - often characterized as small-scale, labor-intensive, largely unregulated and unregistered individuals, groups, or services related to waste collection and processing (Wilson et al., 2006; Wilson et al., 2012) - provides enormous value to these cities. Systems and mechanisms observed across cities included informal waste collectors who extract recyclable and reusable materials from mixed waste, cooperatives or small enterprises for municipal waste collection, and scrap shops that purchase segregated waste from collectors and sell to recyclers. The Pune Municipal Corporation (PMC) partners with SWaCH, a national cooperative of self-employed waste collectors in India that employs over 3,500 waste collectors in Pune alone (SWaCH 2021). This collaboration has likely contributed to the highest door-to-door waste collection rate of all the cities. As observed in other locations, there is a correlation between packaging material types, material value in the informal sector, and litter (Youngblood et al., 2022). While the informal sector is critical for collection, sorting, and recycling, the communities are often marginalized, with negative public perceptions and poor living and working conditions (Wilson et al., 2006; Wilson et al., 2012). Increased access to and engagement in decision-making spaces could provide the informal sector with opportunities to address solutions to these conditions, on their own terms.

WM infrastructure should meet the city's needs and reflect the materials used there. For example, many landfills observed were at or nearing capacity in cities where 90% or more of the waste is landfilled, and compostable alternatives existed in cities where industrial composting infrastructure is lacking or non-existent. These cases represent a mismatch between waste and infrastructure that could lead to increased mismanaged waste. Similarly, labeling around oxo-degradable, compostable, and biodegradable alternatives can be confusing to consumers. If clarified labeling is introduced, it is critical that both infrastructure and public awareness around proper management of these items also improve.

3.3.5 Impact Analysis

For this analysis, a given intervention's impact for each CAP spoke was categorized as 25%, 50%, and 75% impact (with 100% [the center in Figure 3.14a] denoting a completely circular process achieved from the baseline [outer rim in Figure 3.14a]). Impact percentages are based on quantitative data as described in Materials and Methods or estimated qualitatively based on known impact (Figure 3.14a). Semarang could reduce overall litter by 29% (by item count) if it eliminated cigarette litter and by 32% if the city eliminated litter of all tobacco products. The collected waste composition in Semarang is ~60% organic material, and 79% of litter was plastic, including 50% FMCG products such as plastic food wrappers, tobacco packaging, bottles, and caps. Stakeholder interviews indicated that source separation of waste, which increases the value of recycling and results in more effective WM (Matter et al., 2013; Gangwani et al., 2019), is a challenge, and the local landfill is rapidly reaching capacity. Moving up the life cycle from leakage to collection, implementing and enforcing source separation could encourage the reuse of durable products, maximize collection, and increase the efficiency of the waste system. Further upstream, EPR measures in Semarang could affect all of the CAP spokes - 97% of manufacturers and 85% of parent companies for popular FMCG items in Semarang were domestic, and 89% of those products were in plastic packaging. The majority of common FMCG packaging was material that is difficult to capture and recycle, has little value in the informal waste sector, and is likely to end up as litter (69% MLP film, 13% PP film, 2% combination film PP and high-density polyethylene [HDPE]). Measures that put responsibility on producers and brands to work with communities to rethink product packaging, redesign product delivery systems to minimize waste, and implement schemes to recapture packaging could have a transformative impact on the local circular economy for plastic products in Semarang (Figure 3.14b).

a) How to interpret

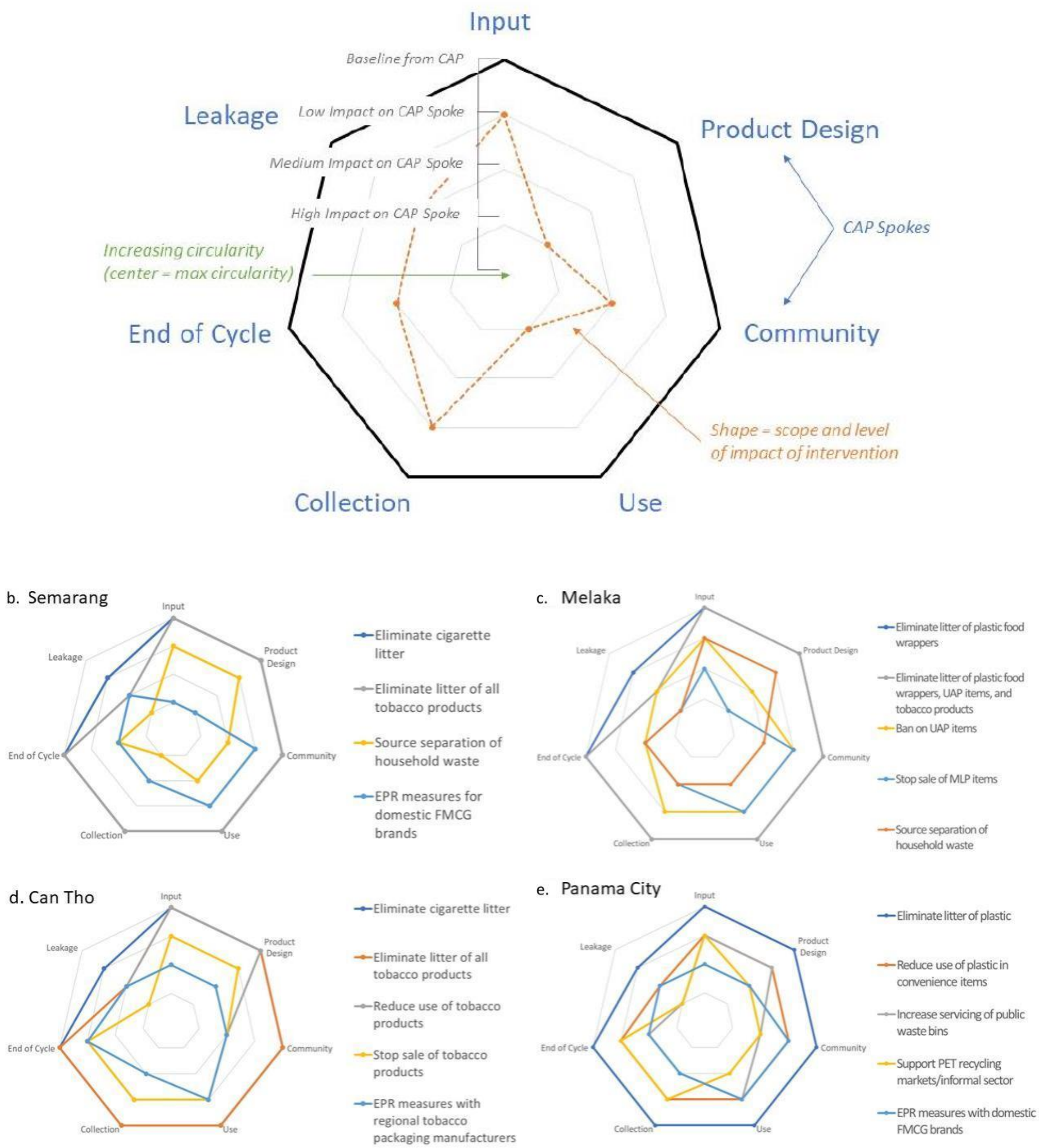


Figure 3.14: Potential Impact of Interventions Based on CAP data

Melaka could reduce litter by 8% if it eliminated litter of all Unnecessary, Avoidable, and Problematic (UAP) Plastic (US Plastics Pact, 2022), by 11% if it eliminated litter of plastic food wrappers, by 32% if it eliminated litter of cigarettes, and by 34% if it eliminated litter of cigarettes and all other tobacco products. Chennai reported similar percentages for potential litter reduction. However, those interventions would mainly impact the leakage spoke of the CAP. An intervention such as source separation of waste could immediately impact collection, end of cycle, and leakage but indirectly impact other spokes such as input and product design. Litter prevention coupled with upstream interventions, such as replacing UAP items with a city-wide reuse system or halting sales of MLP items, could impact other CAP spokes through reduced input of UAP items into the city, incentives for innovations in product design, increased reuse by the community, less recycling contamination, and increased efficiency of WM (Figure 3.14c).

Can Tho could reduce overall litter by 29% if it eliminated cigarette litter and by 33% if it eliminated all tobacco litter. If the city were to implement a behavior change campaign or policy to reduce the use of tobacco products, this would likely improve community health, enhance collection, and improve WM with less multi-material packaging ending up in the waste stream. In Can Tho, rethinking design and delivery of tobacco products could impact every CAP spoke, e.g., 20% of MLP film documented among FMCG products came from tobacco products, and top tobacco products had the lowest average and median distance between stores and manufacturing plants, suggesting that local EPR could reduce plastic packaging and incentivize recapture and redesign (Figure 3.14d).

Panama City was the only city with plastic bottles among the top five litter items, where the informal waste sector is reportedly smaller and overall recycling rates are lower (Banco Interamericano de Desarrollo 2015). The main landfill that services Panama City is anticipated to reach capacity in 2022 and poses human and environmental health threats (Torente-Velásquez et al., 2019). Increasing PET recycling may help decrease litter and increase collection and management by diverting from landfills. CAP could help measure the effectiveness of programs such as Basura Cero, a public-private partnership that placed recycling drop-off locations throughout Panama City (Alcaldía de Panamá 2018-b; ANCON 2019). The highest density of public waste bins and the highest percentage of overflow (60%) were observed in Panama City, suggesting that enhancing maintenance of public waste bins could impact collection, WM, and litter in the city. Looking upstream to EPR, 22% of manufacturers and 17% of parent companies for FMCG products in Panama City were based within Panama. Most FMCG packaging (68%, including 98% of snack products) was some form of plastic film, a top litter item in Panama City. CAP data suggested that domestic products are more popular among local consumers, which could allow for increased circularity within Panama and opportunities for EPR (Figure 3.14e).

As other studies have found, no "one size fits all" solution exists for SWM in cities, and unique characteristics and strengths must be considered (Wilson et al., 2012). While each Urban Ocean city has a unique context, commonalities across all cities include an abundance of MLP film in FMCG items and litter, a lack of convenient and affordable alternatives to single-use plastic for consumers and business owners, and a need for increased space, capacity, technology, and workforce for WM systems. Common strengths include high amounts of domestic manufacturing and parent companies, unique innovations to maximize collection, high amounts of organic waste and opportunities for waste segregation, existing regional or national policy frameworks, and an energized, environment-conscious younger generation. Differences between cities often exist in waste collection structure, incentives, and specific problematic consumer and litter items based on cultural context (e.g., cigarettes vs. tobacco sachets).

As part of Urban Ocean, each city participates in an Opportunity Assessment to identify interventions based on CAP findings. Can Tho proposed an initiative to enhance the city's SWM and recycling facilities through river-based trash traps, enhanced source separation, and improved waste treatment facilities. Melaka plans to create a clean river and coastal area by enhancing recycling infrastructure, building upon governance frameworks and policies, and increasing education, with a focus on single-use and MLP. Panama City intends to increase the recovery of recyclables, starting with innovative processing technology for waste traps in local rivers. Pune aims to holistically approach waste segregation, collection, and management, building upon its existing cooperative model with waste pickers to ensure effective processes for each waste stream. Semarang proposed an integrated SWM model that leverages community-based management and waste banks to increase collection and equitable economic growth. Chennai is taking a multi-faceted approach and has planned pilot programs around strengthening EPR, formalizing and empowering the informal waste sector, public campaigns and incentives for source separation, Near Zero Neighborhoods, and Clean Waterscape waste traps.

3.4. Conclusion

A UN global agreement to reduce plastic pollution is under negotiation. However, current government and corporate commitments are insufficient to significantly curb plastic pollution entering the environment (Borelle et al., 2020). The global transition towards circularity is critical for environmental pollution, climate change, and global resilience (Ford et al., 2022). The results presented here support previous work illustrating a systems change approach that includes pre- and post-consumption interventions that achieve the highest impact (Lau et al., 2020). Cities are essential to this process, deciding what works best for them from an environmental, socioeconomic, cultural, and policy perspective. Urban Ocean facilitates knowledge exchange whereby cities can learn from each other: what works/what doesn't in different cultures and economies. When fostering a truly circular materials management system, no solution works in a vacuum. In a functioning circular economy, all pieces are connected and constantly communicate, learning from each other to optimize the system. Collaborative, systems-level data like CAP and frameworks that foster threads from science to solutions can help provide the critical support cities need to tackle these interrelated challenges.

Chapter 4 : CAP and SIDS: Deep Dive in Dominica

4.1 Introduction

The Caribbean Sea and the sovereign states and dependent territories within it have long been known worldwide for their natural beauty. The area is considered a biodiversity hotspot, covering 4 million km^2 of sea, 230,000 km^2 of land area, and over 7,000 islands, islets, reefs and cays that are home to thousands of endemic species, many of which are threatened or endangered (Figure 4.1) (CANARI, 2019). As of 2016, the region has a permanent population of 638 million people (Kaza et al., 2018). It is also one of the most frequented tourism hotspots worldwide, attracting over 27 million visitors annually and bringing in $57 billion/year in gross revenues from marine and coastal tourism, an estimated 15% of the region's GDP. Fisheries and ocean-going transportation are estimated to contribute an additional several billion USD (Diez et al., 2019).

Unfortunately, the combination of heavy tourism, coastal development, rising ocean temperatures, increased hurricane activity, and overfishing in the region in recent years has led to a decline in the natural environment of the Caribbean (Weatherdon, 2016; IUCN, 2017; CANARI, 2019). The region is particularly vulnerable to these impacts, especially that of marine pollution, and it is estimated that the cost of inaction to address marine pollution will have a disproportionately high impact on Caribbean nations that are heavily dependent on tourism and fisheries (Lachmann, 2017; Mittempergher et al., 2022; Raes et al., 2022). Some Caribbean countries have estimated annual direct costs of mismanaged waste, including revenue loss from fisheries and clean-up costs alone, of up to $15 million USD/year (Mittemergher et al., 2022).

Plastic pollution in particular is a key area of concern for the Caribbean - some reports have found an average of over 2,000 litter items/km in select Caribbean countries compared to a global average of 573 items/km, and up to 80% of marine litter on the coasts and 12% of the waste stream is comprised of plastic (Diez et al., 2019).

Caribbean SIDS have historically faced unique challenges with solid waste management, including lack of waste management infrastructure, lack of capacity and finance to implement and enforce regulations, wide geographic spreads making logistics and economies of scale difficult, and a need for harmonized data collection and monitoring (Busch, 2022). In recent years, Caribbean nations and territories have made major strides towards combating plastic pollution. Over 20 Caribbean countries have currently implemented some form of national plastic policy and several more are in negotiation, including 46 policies and regulations implemented as of 2020. The majority of SIDS have also ratified, signed or acceded to a global and regional instrument, protocol, or convention related to marine debris (Busch, 2022). SIDS have been organizing and playing an active role in the UN Global Plastics Agreement negotiations (IUCN, 2023). Studies have demonstrated that there is a high amount of transportation of marine litter within the Caribbean Sea, further emphasizing the need for collaborative regional action in order to tackle the issue (Courtene-Jones et al., 2021). The CAP is one of many tools that could support such regional action through shared definitions, methods, data, and nomenclature across geographies.

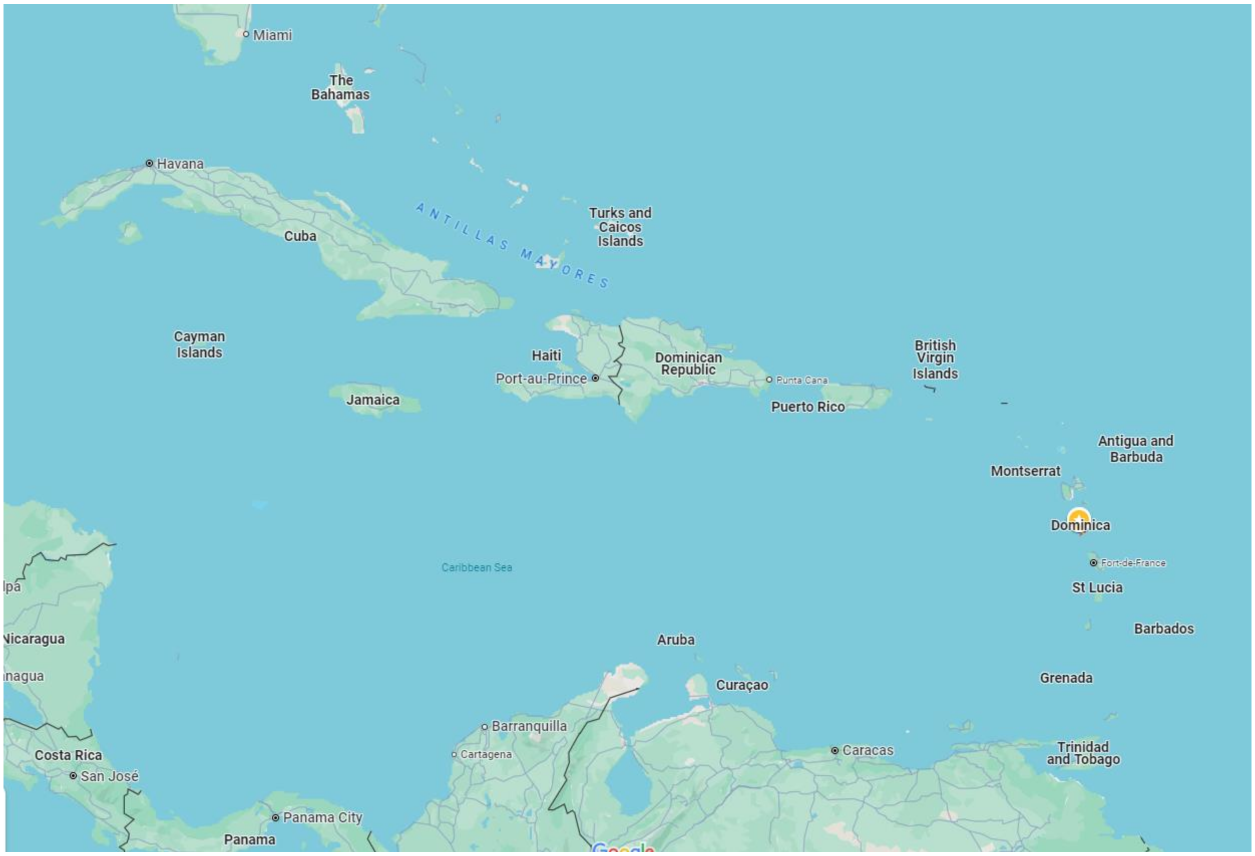


Figure 4.1: Sovereign States and Dependent Territories of the Caribbean (GoogleMaps)

Known commonly as “The Nature Isle” or “The Nature Island,” Dominica is home to an abundance of natural beauty and natural resources. Located in the Lesser Antilles in the southern Caribbean, Dominica has a land area of 751 km^2, including nearly 150 km of coastline, and a population of 74,600. The country’s government operates as a parliamentary republic and is politically divided into ten parishes. The economy of Dominica is dependent on agriculture and fisheries but also has strong and emerging sectors in ecotourism, education, and communication (CIA World Factbook, 2023). Some of the key drivers of ecotourism in Dominica are beaches, abundant freshwater pools, scuba diving locations, and a resident population of sperm whales, all of which have the potential to be strongly negatively impacted by plastic pollution.

Following the devastating impacts of hurricanes Maria and Irma in 2017, Dominica invested heavily in resilience and disaster preparedness. In 2018, Dominica passed the Climate Resilience Act, which mandated the Climate Resilience Execution Agency for Dominica (CREAD) and led to the development of the Dominica Climate Resilience and Recovery Plan of 2020. The Plan lists ongoing and planned initiatives in Dominica that are addressing climate resilience, including a section on Waste and Recycling which outlines objectives to divert waste from landfills, reduce waste generation, decrease littering, and increase public awareness. Specific proposed activities to be completed between 2020-2025 include legislation and incentives to reduce the volume of waste going to landfills, promoting reuse and recycling, construction of a MRF, developing a bulky waste collection system, and running a public awareness campaign (CREAD, 2020). The plan also notes Dominica's existing Single-Use Plastic (SUP) Ban implemented in 2019 - which bans the import of several problematic plastic items such as expanded polystyrene, utensils, plates, and straws (Skerrit, 2018) - and states:

> ***"Ban on single use plastics – notably following a disaster, the proliferation of plastic waste, especially when the waste collection system is overwhelmed, causes significant damage to the environment, clogs sewerage systems and small waterways, increasing the risk of flooding in certain areas, as well as damages the marine environment with long-term effects"***

Members of Dominica's Ministry of Environment and the Dominica Solid Waste Management Corporation (DSWMC) have participated in the negotiations for the UN Global Plastics Agreement and want to ensure that Caribbean Small Island Developing States (SIDS) have a strong voice in the final agreement language. Dominica has set the goal of becoming the world's first Climate Resilient nation, and it is clear that the future of solid waste management and of climate resilience in Dominica are intrinsically linked (CREAD, 2020). In 2023, Dominica was named one of two Caribbean countries, along with Grenada, for a pilot by the Organization of Eastern Caribbean States (OECS) called Recycle OECS. The country has made great strides in recent years to move towards a more sustainable future, but leaders there are also open about the need for data to justify interventions, bring in additional funding and capacity, and measure the success of their growing body of work in this space over time.

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 4.2). 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?

In addition to the standard seven spokes of the CAP fieldwork, two additional components were investigated to better understand ties between land-based and marine litter in and around Dominica and to better characterize the extent to which marine debris poses a threat to the natural environment and marine life of Dominica:

8. **Environment** - What is the status of plastic pollution in the coastal habitats and offshore of the study area? What are the most harmful/prevalent litter items and where are they likely coming from?
9. **Impacts** - Are there correlations between the types of polymers (>50-micron samples) that end up on the land/coast as litter and those found on reefs and in the surrounding water? What are some of the documents and/or anticipated impacts on the coastal environment, particularly on the sperm whale population?

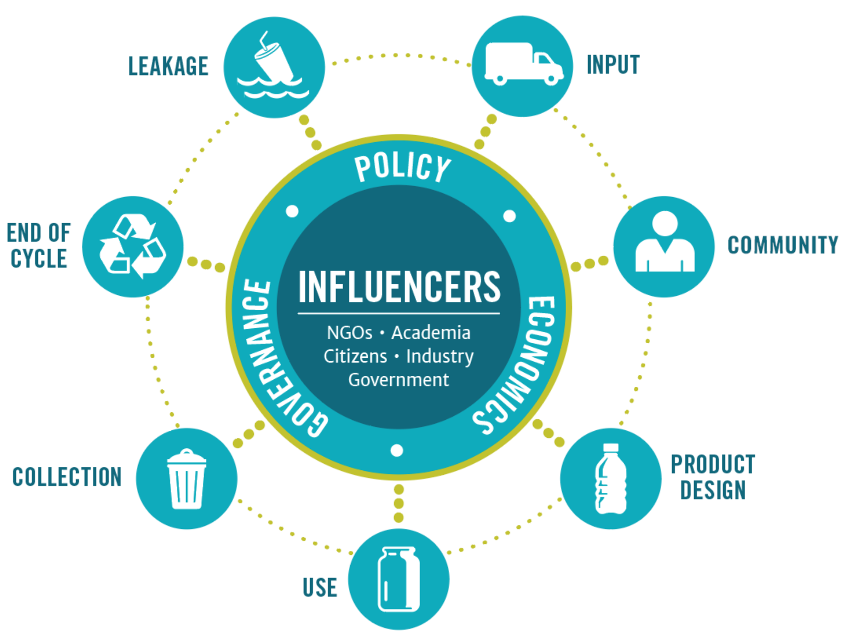


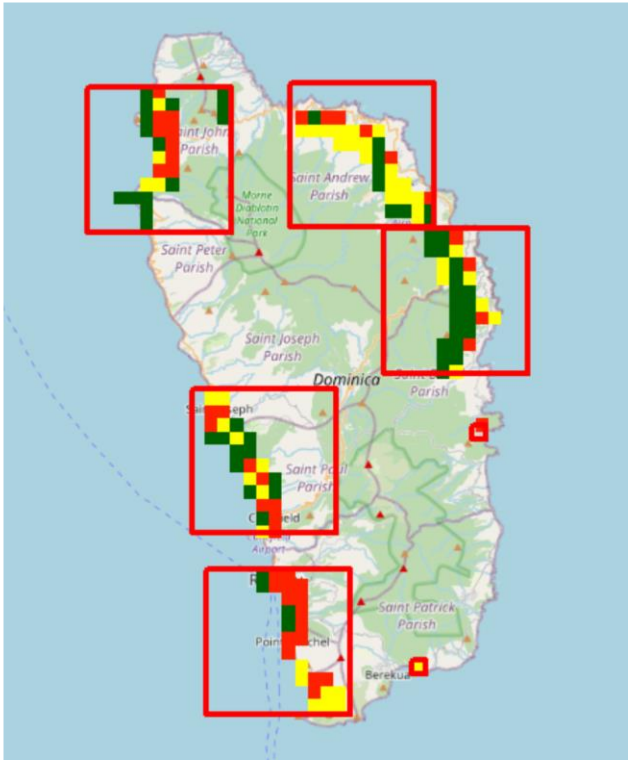
Figure 4.2: Circularity Assessment Protocol (CAP) hub-and-spoke model

The CAP in Dominica serves as a holistic approach to characterize the state of plastic pollution and marine debris on the island and to inform the most effective upstream solutions to stop it at the source. CAP fieldwork was conducted in Dominica in April and October 2023 with guidance from the Dominica Solid Waste Management Corporation (DSWMC), funding from Dynamic Planet, and volunteer support from the Dominica State College. 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. Given its size, the Dominica CAP encompasses the whole island with a focus on the leeward side of the island (Caribbean side) where there are local populations of sperm whales, vessel traffic, and the capital city.

With the current national momentum to address sustainability, resilience, and conservation in Dominica, there is a clear opportunity for positive action toward litter prevention and circular materials management. A critical first step in that process is to understand the existing context in terms of sources, sinks, and pathways. CAP data can be used by local partners in Dominica to prioritize interventions, justify key proposals, inform local campaigns and messaging, engage the private sector and identify potential new jobs, and ultimately put knowledge in the hands of decision-makers. The CAP methods are conducted in collaboration with local partners to build capacity for harmonized evaluation and monitoring across departments and organizations on-island. This work also has the potential to position Dominica as a model for other islands in the Lesser Antilles and broader Caribbean that are also interested in increasing their circularity. This is the first time that a study like this has been completed in Dominica and will be critical for the local community and region. With support and leadership across Dominica's Solid Waste Management Corporation, government, businesses, and citizens, and with funding and additional support from Dynamic Planet, the ‘Nature Island’, will be healthy, clean, and resilient for local residents and visitors alike for generations to come.

4.2 Sampling Strategy

In order to randomly sample various locations in a city, the CAP typically identifies a 10 x 10 km area over the city of interest (Maddalene et al., 2023; Jambeck et al., 2024). In the case of Dominica, the aim was to randomly sample across the entire island and country. As such, ambient population was examined across the whole country using LandScan 2021 data from Oak Ridge Laboratory. As the majority of population density in Dominica is concentrated within 2km of the coastline, a perimeter of 2 km inland from the coastline was cast across the island. Within this area, the ambient population was sectioned into tertiles (three groups) (Figure 4.3). Ambient population count can be described as “where people go” and “societal activity” and is measured by the quantity of people that pass through a given area over a 24-hour period — it is not population density of where people live. These three areas typically form samples of different land uses and activities. To further specify the sample area, five 10x10 km square areas and two 1x1 km square areas were identified collaboratively with DSWMC and Dynamic Planet that provided representative areas of development and societal activity across the island (outlined in red in Figure 4.3).



Ambient Population Density

High (n=29)
94 - 6,885 people/km^2

Medium (n=10)
25 - 94 people/km^2

Low (n=11)
1 - 25 people/km^2

Figure 4.3: Population tertiles identified within potential sampling area in Dominica

Within each larger 10x10km sampling area, three 1 x 1 km areas for surveying were randomly selected (one within each population tertile) using NOAA's Sampling Design Tool (Figure 4.4). Additional 1 x 1 km areas were selected within the smaller sampling areas near Rosalie and Stowe. In total, 17 1 km^2 sites were surveyed for store product samples and restaurant product samples. Within each 1 x 1 km square, three 200 x 200 m squares were also randomly selected using NOAA's Sampling Design Tool to conduct 100 m litter surveys. Some locations had to be adapted in situ to accommodate for accessibility and safety and best efforts were made to sample areas immediately adjacent or similar in setting to those identified in GIS. This resulted in 50 litter transects across the island.

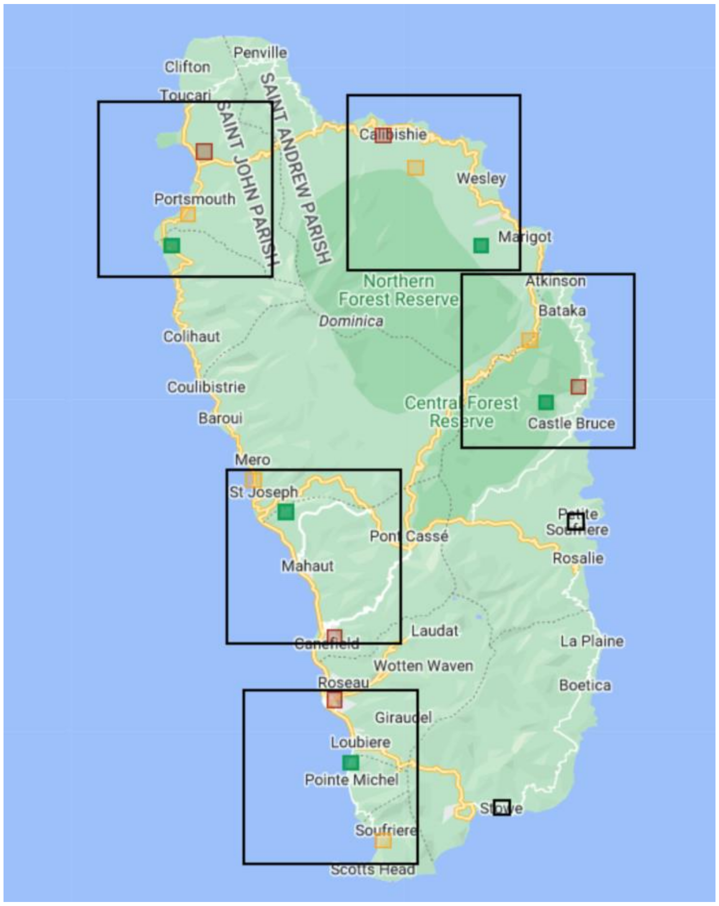


Figure 4.4: Final CAP Sampling Sites identified through GIS in Dominica

In addition to the standard CAP methodology, litter surveys were also conducted at 10 randomly selected coastal and beach areas and a 20 km stretch just offshore along the west coast of the island. Microplastic analysis was also conducted from existing filtered water samples from offshore locations collected by the National Geographic Pristine Seas team around Dominica in December 2022 (NGS, 2024). This holistic data will allow connections to be made between land-based and ocean-based sources of pollution in Dominica and can most effectively inform methods for prevention.

4.3 Input

To get a snapshot of the characterization, scope, and source of common plastic packaged items that are entering Dominica, samples of fast-moving consumer goods (FMCG) in five popular categories were taken within the 17 1 km^2 transects across the country. The sampling 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. In total, 225 unique brands of convenience products were collected and sampled, including 110 candies, 24 chips, 54 beverages, 22 tobacco products, and 15 biscuits/wafers (Figure 4.5). Samples of identical brands were not collected multiple times, even when present in multiple stores. Common brands of tobacco products were also visually assessed in stores, although samples were not purchased.

Figure 4.5: Typical convenience store packaging in Dominica

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 4.1) are intended to estimate the distance in kilometers between the city and the origin of each product.

Table 4.1: Distances between Dominica and manufacturer and parent company locations for top FMCG convenience items

	Length Store to Parent Company (km)				Length Store to Manufacturer (km)			
	Minimum	*Maximum*	*Median*	*Average*	*Minimum*	*Maximum*	*Median*	*Average*
Beverages	1	14,087	1,679	2,790	1	2,1950	664	2,641
Biscuits & Wafers	310	8,980	515	2,222	0	9,892	632	2.571
Candy	0	15,694	3,140	4,076	0	23,855	3,779	5,363
Chips	0	4,087	1,099	1,839	0	9,213	1,675	2,668
Tobacco Products	0	13,936	3,285	4,536	0	7,687	3,460	3,152

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

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**: Coca-Cola, Busta, Quenchi, Trois Pitons

- **Biscuits/Wafers**: Shirley, Domino, Tea Time, Bermudez

- Candy: Mints & Ginger Mints (Fitzroy & Pereira), M&M, Cadbury, Xtime

- **Chips**: Holiday, Cutters, Bermudez, Lays

- **Tobacco Products**: Dunhill, Hillsborough, Special, Marlboro

Among all of the five FMCG categories, each had at least one example of a manufacturer that was located domestically in Dominica, and all categories except for Biscuits/Wafers had at least one parent company located in Dominica (Table 4.2, Figure 4.6, Figure 4.7). On average, candy products and tobacco products had manufacturing and parent companies located farthest from Dominica.

Table 4.2: Top Manufacturing/Import Locations for top FMCGs in Dominica

FMCG Category	**Top Three Manufacturing/Import Locations**
Beverages	1. Trinidad & Tobago (30%) 2. United States (17%) 3. Dominica (9%)
Biscuits & Wafers	1. Trinidad & Tobago (53%) 2. Colombia (13%) 3. Turkey (13%)
Candy	1. United States (47%) 2. Trinidad & Tobago (14%) 3. China (7%)
Chips	1. United States (33%) 2. Jamaica (33%) 3. Trinidad & Tobago and Dominica both had 12.5%
Tobacco Products	1. United States (33%) 2. Dominica (33%) 3. Peru and UK both had 17%

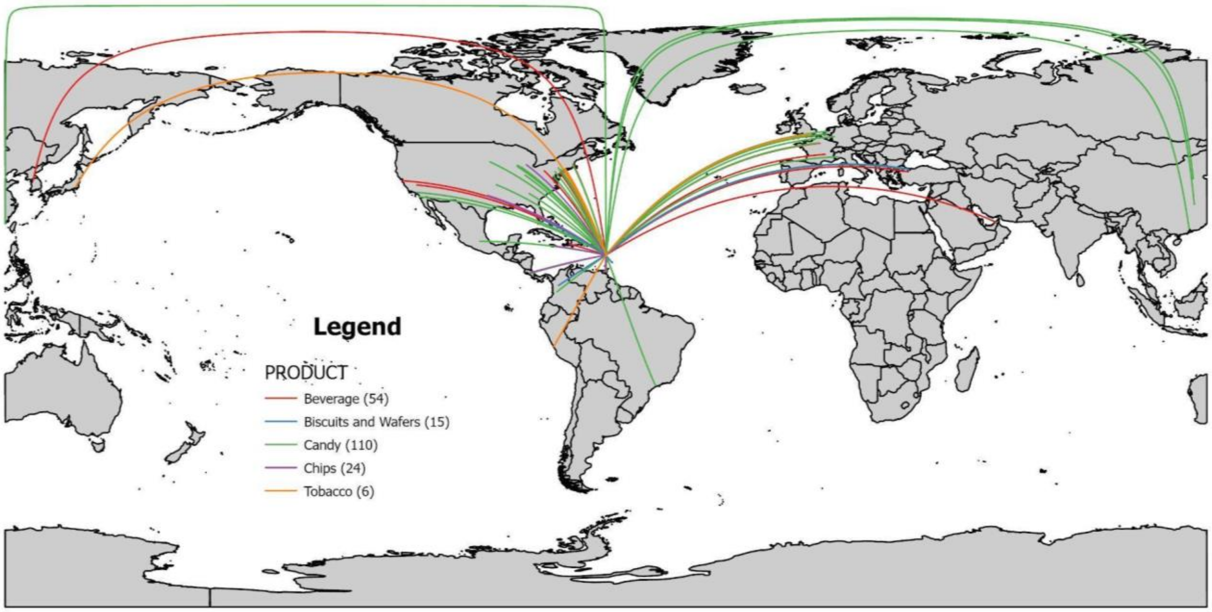


Figure 4.6: World Map displaying parent company locations for top convenience items in Dominica

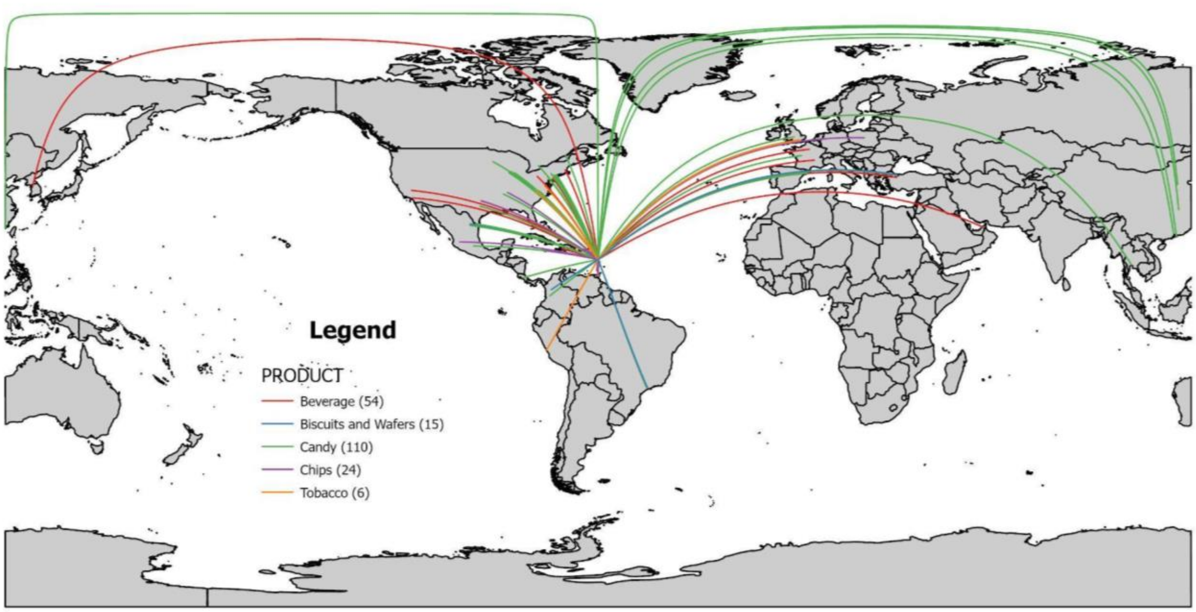


Figure 4.7: World Map displaying manufacturing locations for top convenience items in Dominica

All categories had large amounts of products imported from other Caribbean countries, mainly Trinidad & Tobago and Jamaica, as well as from the United States (US). Trinidad & Tobago was among the top three importing locations for all FMCG categories except for Tobacco Products and the US was among the top three importing locations for all FMCG categories except for Biscuits/Wafers (Figure 4.8).

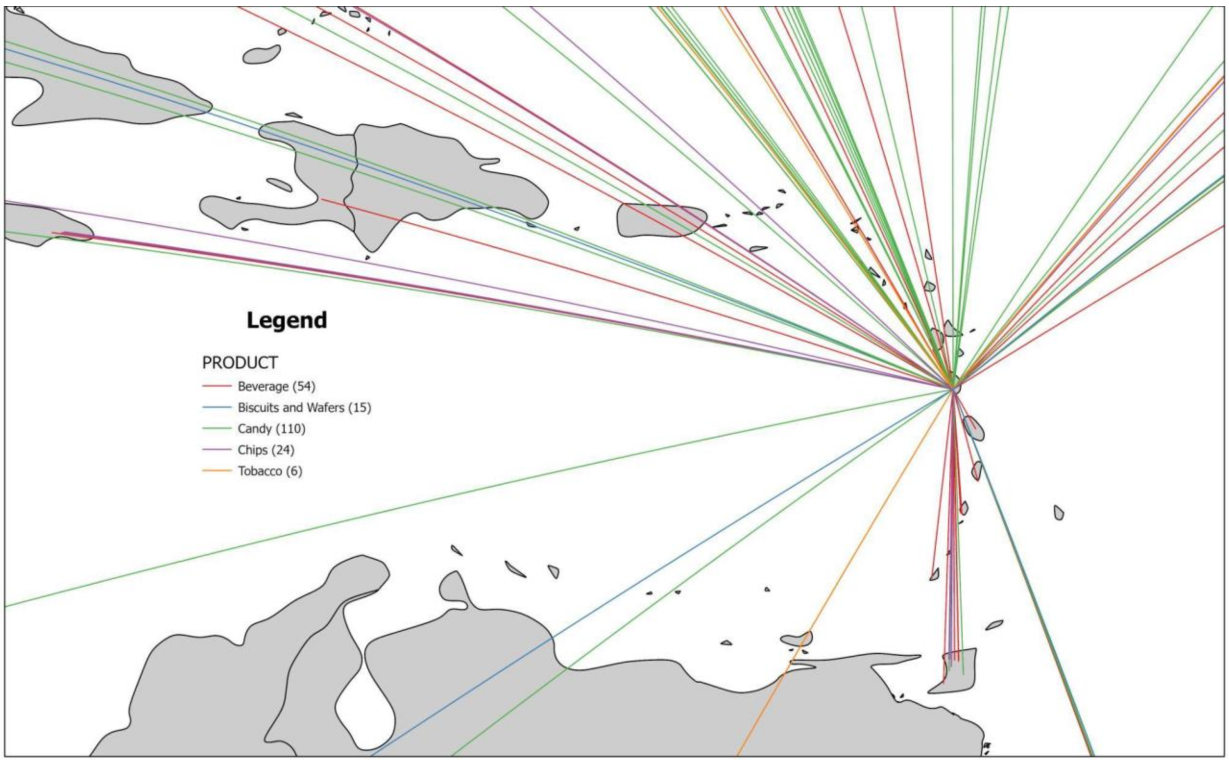


Figure 4.8: Zoom in on map of the Caribbean displaying manufacturing locations for top convenience items in Dominica

Across all FMCG categories, 94% of products are manufactured outside of and imported into Dominica (Figure 4.9). Similar quantities were found among parent companies of convenience products (Figure 4.10). Compared to other island nations, a recent CAP in Aruba found over 99% of FMCGs originated internationally and a CAP in the Maldives found 95% of FMCGs originated internationally (CIL, December 2024; CIL, October 2024). While Dominica is still among the top three locations for both manufacturers and parent companies of FMCGs overall, there are ample opportunities for increasing domestic operations for common consumer products, as well as for enhancing buy-back and extended producer responsibility (EPR) schemes. Particularly for beverages, there could be opportunities to also explore overlaps with health initiatives related to sugar-sweetened beverages that are imported internationally. The Latin America/Caribbean region is among the top consumers of such beverages, and using tools such as import taxes, marketing, and labeling could potentially help with human health as well as pollution reduction (Lara-Castor et al., 2023). One local company in Dominica reportedly pays 3% on all imported goods as part of the local Environmental Tax, but it is unclear what the final use of those funds is and whether there are options for those funds to go towards waste management circularity initiatives.

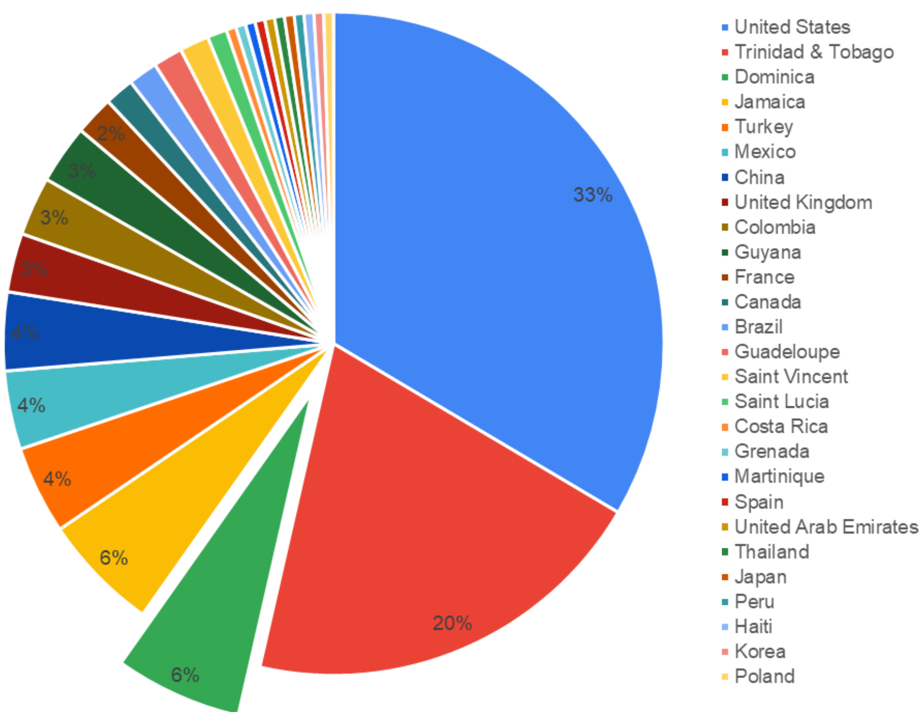


Figure 4.9: Manufacturing Locations for Commonly Found Convenience Items in Dominica

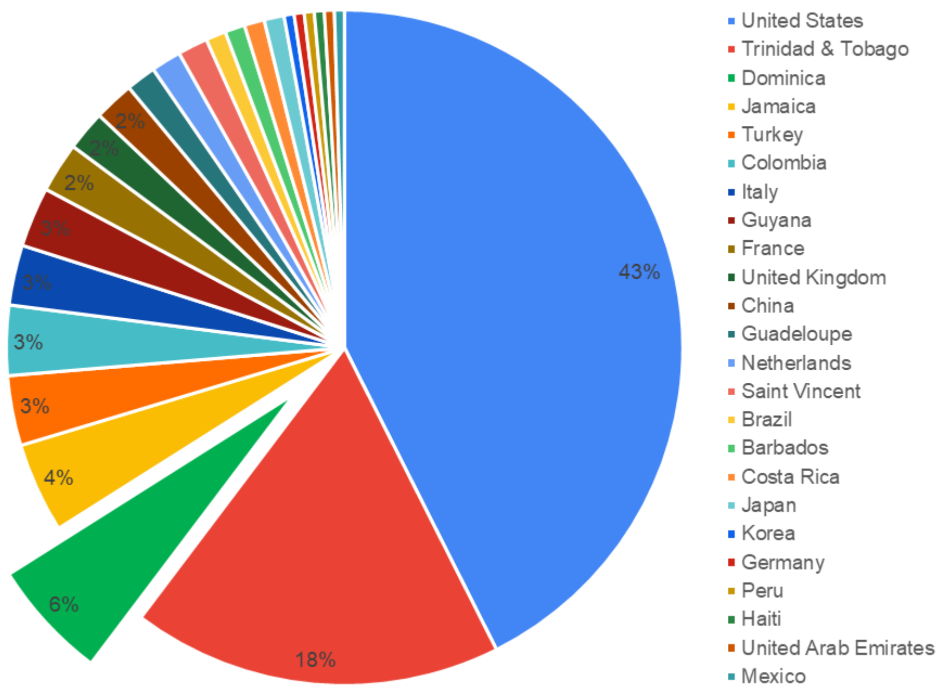


Figure 4.10: Parent Company Locations for Commonly Found Convenience Items in Dominica

It is also important to note that among the beverages surveyed, 10 bottled water brands (all of which were bottled in clear PET) were manufactured outside Dominica and imported to the island. It would be worth exploring opportunities to bottle local fresh water or increase production from local operations such as Trois Pitons, as opposed to importing bottled water from other parts of the Caribbean. There was reportedly another bottling operation on the island that produced and distributed local spring water, but it was destroyed in Hurricane Maria and has not been rebuilt, in part due to the lack of buildable land and access to water that has not been contaminated by agriculture - though it is worth noting that the government is encouraging shifts to local organic fertilizer and upgrading pesticide legislation. Trois Pitons bottles are filled locally with purified municipal water. Currently, Josephine Gabriel & Co. distributes Coca-Cola beverages, Trois Piton water, and Quenchi beverages in Dominica in various sizes. The Coca-Cola beverage and PET bottles are imported together from Saint Lucia while the Trois Piton and Quenchi products are bottled at the plant in Canefield using PET bottles imported from Barbados. All of these products were traditionally bottled in glass, but they switched to PET in 2010 because of the high cost of the glass supply chains, coming largely from Costa Rica and Mexico. Josephine Gabriel & Co. have conducted temporary promotions related to extended producer responsibility in the past, such as encouraging consumers to bring back their bottle caps for prizes. This had not been tried with the PET bottles due to contamination concerns. However, consumers increasingly want to win prizes on their phones or via social media instead of physically bringing in items, and the promotions have not happened for a while. Josephine Gabriel & Co. wants to support and invest in recycling infrastructure for PET in Dominica, but this will likely require investment from Coca-Cola. They are also working with a recycling broker to identify local markets, as Coca-Cola's 'every bottle back' campaign does not include Dominica. Coca-Cola is reportedly working on developing biodegradable bottles, which the subsidiary is also interested in.

> **"In an ideal world, whatever we produce can be properly collected, sorted, recycled, and then sent back out into the community." - Private Company**

In addition to domestic opportunities, the Input data also reveals a strong FMCG market within the Caribbean. Top importing Caribbean Island nations include Trinidad & Tobago, Jamaica, Guadeloupe, Saint Vincent, Grenada, and Martinique. Other key importers within Latin America include Colombia, Guyana, Peru, Costa Rica, and Mexico. A small amount of Trois

Pitons and Quenchi bottles are exported from Dominica to other Caribbean islands, including Guadeloupe, Martinique, Sint Maarten, and the British Virgin Islands. These countries should be prioritized for collaborations around regional-level EPR schemes to minimize waste and enhance local economies.

4.4 Community

To understand current attitudes and perceptions of plastic waste, semi-structured interviews were conducted with 28 key stakeholders. Among those interviewed, 11 were government officials, 6 were students from the local university, 3 were from private companies (including tourism operators), 2 were community leaders, 2 were from non-profit organizations, 2 were private store owners, and 2 were private restaurant owners (Table 4.3). In addition, a social media analysis was conducted for plastic pollution in the Caribbean in collaboration with SEE Suite (Social Media Engagement & Evaluation Suite) at the Department of Advertising and Public Relations at the University of Georgia, which is described in Section 4.4.2.

Table 4.3: Summary of Stakeholder Interview List

Stakeholder Group	Number of Interviews
Local Government	11
Students	6
Private Companies	3
Community Leaders	2
Non-profit Organizations (NGOs)	2

Store Owners	2
Restaurant Owners	2

4.4.1 Community: Stakeholder Interviews

While studies have noted that the human dimension of plastic pollution in SIDS has been historically understudied, those studies have also found that, when the topic is investigated, there is general awareness of the issue, concern around associated environmental and human health, willingness to participate in solutions (such as waste separation), and multiple entry points for different types of policies to affect society (Raes et al., 2022; Kanhai et al., 2024). The need for increased and consistent public engagement, education, awareness, and buy-in for SUP alternatives in Dominica was a common theme across interviews (examples in Figure 4.11). When it comes to waste sorting, using alternative materials, or bringing your own reusable items, messaging in Dominica needs to be relevant and consistent. Several interviewees noted the value of engaging Dominicans at specific venues where they are already present and engaged, such as entertainment events, cultural festivals, church gatherings, youth clubs, workplaces, and grocery stores, as opposed to creating new spaces or tools for communicating. Interviewees also mentioned the importance of using platforms that Dominicans already engage with, such as radio and social media, to reach people with key messaging and embed that messaging in popular content. The challenge, as was mentioned several times, is moving from communication and messaging to engagement and consumer action.

“There's a difference between informing people and engaging people - the challenge always lies in actually getting people to take action, shop with a reusable bag, get engaged” - NGO

The importance of making changes affordable and convenient was also heavily emphasized in stakeholder interviews. When it comes to reuse, several interviewees cited concerns around hygiene and convenience generally, which should be targeted for messaging if reuse initiatives are implemented in Dominica to assuage and address community skepticism. Messaging and incentives need to be able to reach all consumers, not only those who care strongly about the environment or nature.

“Some people are very willing to pay 50 cents for a bag instead of purchasing a reusable one for 5 dollars - you need to make it easy for people to make those changes.” - NGO

Figure 4.11: Examples of education and outreach posters from DSWMC

Incentives were often touted as a success when it comes to waste collection and recycling for specific items in Dominica. Specifically, some local breweries will provide money off for beer purchasing if consumers bring back their original glass bottles. Interviewees emphasized that Dominicans need to see an incentive for separating out their waste and for reusing, returning, and recycling certain items and that those incentives need to be effectively enforced.

> **“People respond to incentives. If you can incentivize a project it's going to be successful…We collect more beer bottles than we sell, and our margins on drinks are so minimal, it offsets our purchasing. Incentivizing recyclables works.” - Private Business**

Some interviewees also felt that there may be opportunities for effective science communication, particularly around the ties between plastics and human health, in order to make topics relevant to individual people and families. They also felt this would be useful to demonstrate that certain habits can have a negative impact on both their wallet and their health. Dominica’s identification and reputation as the “Nature Island " also came up often in interviews, and several interviewees suggested that national messaging around waste and pollution should be centered around the pride of place that comes with that designation. Some mentioned that Dominica wants to be set apart from other SIDS that are often portrayed as ‘dumping grounds’ and they want to ensure that there is a circular process for everything that enters the island.

"The good news is that people here take pride in being the 'nature island.' People are proud of the national trail. This [Dominica] is the hidden gem. It's not a stretch to tie it [pollution prevention] into that national pride of the environment here." - Private Business

"People need to understand the meaning of the Nature Island. They know the mountains, the rivers, the sea, but they don't take action to properly take care of it." - Local Government

However, some also highlighted the challenges of tying nature and the environment to topics of waste and pollution. Some government officials cited concerns around the triple planetary threat of climate change, biodiversity loss, and pollution - which is evident through Dominica's efforts to become a climate-resilient island - but it was noted that leaders don't readily make the connection that waste management is a key tool for addressing pollution and that those aspects are all linked.

"As a region, we tend to focus more on the environment, and we don't look at solid waste." - Local Government

Interviewees also had varying responses to the single-use plastic ban in Dominica. Local manufacturers and distributors in particular had a difficult time with implementation, as they have traditionally relied heavily on plastic packaging and had difficulty affording the often more expensive alternatives. Some mentioned that they felt disenfranchised because supermarkets were still able to import products that were packaged in the same plastic material that they couldn't import for manufacturing (e.g., individually wrapped biscuits). Government officials mentioned that they had to allow extra time for businesses to find and afford suitable alternatives, particularly to EPS products that had to be lightweight and waterproof. A great deal of public education and outreach was conducted in advance of the implementation of the ban, including handing out 60,000 reusable bags to the public, hosting local pop-up stands at grocery stores, working with local supermarkets and restaurants to offer discounts for customers that brought their own reusable items on certain days, and others. DSWMC also held a community consultation after the ban went into effect and realized that businesses were still struggling with affording alternatives, and the government ended up temporarily removing the import tax on plastic alternatives such as paper products. For consumers, confusion still remains around conventional vs. biodegradable vs. compostable plastics. Often the products that are now able to be imported cannot biodegrade properly in the environment, require industrial composting, or are mislabeled traditional fossil-based plastics. Enforcement is an ongoing challenge, particularly around litter tickets that are handed out under the Litter Act of 1990.

> **"[Our agency] has been trying to message to the public that "litter is litter" so that people don't think it's alright to leave certain trash items in the environment." - Local Government**

> **"Enforcement is an area I'd like to see us improve on. Litter tickets are not well respected. There is a reluctance to prosecute or fine people, which could be revenue for the government." - Local Government**

Another social and administrative challenge is the topic of implementing waste separation for the public in Dominica. This has been a key topic for DSWMC in recent months. A key question is how to incentivize separating household waste at the source, whether that should take place through upfront charges, penalties for incorrect separation, or otherwise. Similarly, the issue of open dumping is an ongoing challenge. As is common in other island contexts and in locations with active rivers and streams, the hydrology of Dominica often lends itself to a method of waste management in and of itself, whereby the waste that is accumulated in storm drains, along rivers, on beaches, and elsewhere is flushed into the ocean with heavy rainfall. This also remains a challenge for Public Works and for The Dominica Water and Sewerage Company Limited (DOWASCO).

> **"It [litter and waste] stays there [in the environment] until the next big storm, then it is washed out." - Private Company**

> **"A few weeks ago, I was hiking segment 9, where you have to cross 11 tributaries. I saw lots of litter where people are stopping to cross upstream … At [storm drain] intakes, sometimes we will find plastic bottles that are 25 years old, from brands that are not sold here anymore. They could have been higher up on the mountain and for a long time and got washed down." - Local Government**

"'The sea will swallow everything,' that is still the stigma, especially in country [rural] areas. People dump trash at rivers or burn it even if they know better … It comes down to convenience." - Local Government

The value of regional collaboration was cited as a key opportunity for exchanging lessons learned on outreach, messaging, waste management techniques, and capacity sharing. A WhatsApp group exists for waste managers across islands in the Caribbean and OECS where they can regularly connect, share ideas, and problem-solve. There has been interest from DSWMC in formalizing that group via in-person meetings, digital platforms, and otherwise to ensure that waste management capacities are shared and maximized across the region. For example, one interviewee noted that Saint Lucia is working on a RePlast program to repurpose their plastic waste, and Saint Vincent has developed a private network of recyclers that is subsidized by the local government. Dominica has been playing an active role in the UN Global Plastics Agreement negotiations and there are also opportunities for knowledge sharing, collaborative advocacy, and potentially for Dominica to become a model not only for a climate-resilient island but also a fully circular one.

4.4.2 Community: Social Media Analysis

In order to gain perspectives from a broader group, CIL also conducted an analysis of conversations about plastic pollution in the Caribbean occurring on social media platforms in partnership with SEE Suite (Social media Engagement & Evaluation Suite) at the Department of Advertising and Public Relations at the University of Georgia. The data collection period was January 2022 through August 2023. SEE Suite analyzed content from Twitter, Facebook, and Instagram over that time period.

On Twitter, over 800K mentions related to plastic pollution in the Caribbean were observed for the time period. The majority (75%) had a neutral sentiment. A negative sentiment was observed in 19% of posts, largely related to impacts on the environment and on marine animals, and 6% had a positive sentiment, largely related to actions that companies were taking, bans on SUP, bottle deposits and recycling opportunities, individual actions, and an appreciation for litter-free natural environments. Dominica's focused efforts to reduce plastic production and usage were demonstrated through 5,292 posts (0.65% of the total dataset). Content includes highlights on the issue of plastic pollution within the Caribbean but also demonstrates the diverse efforts and discussions shaping the region's response. Spikes in Twitter activity on this topic were observed around launches of key campaigns like #LetTheEarthBreathe in April 2022, Earth Day in late April 2022, viral videos and content from regular users around littering and environmental impacts (e.g., Jan 2023), meetings related to the UN Global Plastic Agreement (e.g., May 2023), and World Environment Day in June 2023. Among Twitter mentions on the topic, 8 major themes were found associated:

1. **Tourism:** Tourists' environmental consciousness in the Caribbean is rising. Noteworthy efforts include @WetTribe's Mangrove installations combating Ocean Acidification, supported by retweets from influencers like @Petchary. Major organizations, including IUCN and UN Jamaica, amplify awareness through retweets. Trinidad and Tobago's CESaRE NGO contributes significantly, addressing plastic's impact on the Caribbean environment.
2. **Ocean Cleanup:** #BeatPlasticPollution drives neutral sentiment, focusing on preventing plastics from becoming historical relics. @USAToday highlights 'The Ocean Clean Up',

removing 77 tonnes of ocean trash. @CarbonCredit's innovation in using ocean plastics for car tires gains substantial attention, reflecting a shift toward sustainable practices.

3. **Individual Action:** Individuals are pivotal in the fight against plastic pollution. @jamentrust's widely retweeted post outlines actionable steps. Conversations revolve around proper plastic disposal methods and home-based reduction strategies. Jamaica's EcoKids Project emphasizes children's education, emphasizing their crucial role in this environmental process.
4. **Wildlife:** Global movements like #PlasticFreeJuly gain momentum, aiming to protect marine life. @SuzieBird4's tweet, showcasing plastic harm to Caribbean seabirds, echoes concerns. Discussions emphasize plastics' detrimental impact on both oceans and the wildlife dependent on them.
5. **Waste Management:** Proper waste management is imperative, focusing on negative impacts: Health, Sea, and Human. @JamaicaGleaner sheds light on the struggle of developing nations like Jamaica, particularly in recycling solid waste. @Rainmaker1973 highlights successful waste management projects, preventing significant trash from entering the Caribbean Sea.
6. **Fossil Fuel:** Neutral posts comparing plastic and fossil fuel usage resonate in Caribbean islands. These discussions emphasize the interconnection, stressing the need for fossil fuels in plastic production. Individuals in islands like Puerto Rico, Jamaica, and the Dominican Republic actively engage in these conversations.
7. **Single-Use Plastics:** Conversations starkly outline single-use plastics' ocean impact. Both private users and influential entities like @UN stress the crucial necessity of keeping single-use plastics out of the ocean, reflecting a collective call to action.

8. **Microplastics:** User @voserahlaura's impactful tweet, advocating against littering, gains significant traction in the Caribbean. It resonates widely, urging others neutrally to follow suit. Additionally, numerous tweets highlight the pervasive presence of microplastics in our environment, underscoring their impact on both humans and the planet.

Top influencers for the topic in Dominica on Twitter included Dominica CBIU (@SominicaCBIU), Zaimis Olmos (@zaimis), and Invest Dominica (@Invest_Dominica) (Figure 4.12).

Figure 4.12: Example Twitter post from Zaimis Olmos on a cleanup in Dominica

On Facebook, 5,537 relevant posts were identified during the timeframe with a reach of over 24 million people (Figure 4.13). Similar distributions were observed for the sentiment analysis, with around ¾ neutral. For posts related to Dominica specifically, comprising 6.8% of the total dataset from Facebook, positive discussions focused on litter collection, clean beach initiatives, and waste disposal management efforts, while negative mentions include efforts to reduce waste during national emergencies, and neutral sentiments related to cultural and personal aspects of Dominica. Similar themes were observed within the Facebook posts.

1. **Overall Conversations:** Much of the content centers around environmental reports, especially from organizations like Jamaica Gleaner. Informational content includes news reports, petitions, and efforts by organizations like NEPA and 242 News Bahamas in cleanup initiatives.
2. **Tourism:** Posts cover a range of Caribbean vacations, primarily advertised by American Holidays and Cayman Airways. There is discussion about the impact of climate change on vacationing, as well as advocacy for Earth Day cleanups by the Minister of Tourism in the Cayman Islands.
3. **Waste Management:** Positive sentiment revolves around congratulating successful waste management initiatives by organizations like The Copper Foundation and the IDB of Trinidad and Tobago. Negative sentiment arises from reports like Plastic News on a methane explosion in the Dominican Republic and discussions about large corporations contributing to pollution.
4. **Large Corporations:** Neutral posts discuss the role of big corporations in plastic pollution, while positive posts highlight instances of beneficial corporate social responsibility. Negative sentiment focuses on blaming big businesses for widespread plastic pollution.
5. **Individual Action:** Neutral posts stress the importance of individual actions in preventing plastic pollution. Positive posts celebrate cleanup efforts and innovative

pollution prevention methods, while negative posts highlight the detrimental effects of pollution.

6. **Single-Use Plastics and Microplastics:** Neutral sentiment discusses efforts to reduce single-use plastic, while negative posts emphasize the adverse effects of plastic pollution. Positive posts celebrate progress in plastic-free initiatives.

Dominica Water and Sewerage Company Limited
Jun 27, 2023 02:44:29 PM

DOWASCO has partnered with the Dominica Solid Waste Management Corporation to spread the message about ending plastic pollution. This DSWMC anti littering educational program in collaboration with its partners and with proceeds from the Norwegian Government is a collective responsibility to keep the nature island litter-free. Be the Solution, End Plastic Pollution Now! https://www.facebook.com/857584989498733/videos/227649780099778

Organisation of Eastern Caribbean States
Aug 09, 2022 04:08:46 PM

Residents of the Kalinago Territory in Dominica are taking the lead in advancing the concept of ZERO WASTE. This initiative aims to drastically reduce marine pollution and the amount of litter being taken to local landfills. As we will hear in this report, the proposal in Dominica is within a broader OECS project promoting the blue economy. #oecsblueeconomy #onecaribbeansea #natureisle Government of Dominica Discover Dominica https://www.facebook.com/596647145839126/videos/596588961862436

Dominica Solid Waste Management Corporation
Apr 25, 2023 06:25:25 PM

Final day of assessment, was an excellent experience for all. Proper garbage/waste disposal management continues to be top on the agenda. Photos from Dominica Solid Waste Management Corporation's post https://www.facebook.com/610503834453465/posts/614108357426346

Figure 4.13: Examples of Facebook posts related to Dominica that had positive sentiments and high amounts of likes, comments, and total reach

Spikes in Facebook conversation on the topic were related to events such as Earth Day and local cultural festivals, local news stories related to the impacts of plastic pollution in the marine environment, and actions related to key social media campaigns such as #plasticpollutes, #beatplasticpollution, and #breakfreefromplastic (Figure 4.14). Key Facebook influencers identified included DSWMC, Plastic Pollution Coalition, Global Alliance for Incinerator Alternatives, Plastic Free Cayman, Jamaica Gleaner, and the Jamaica Observer.

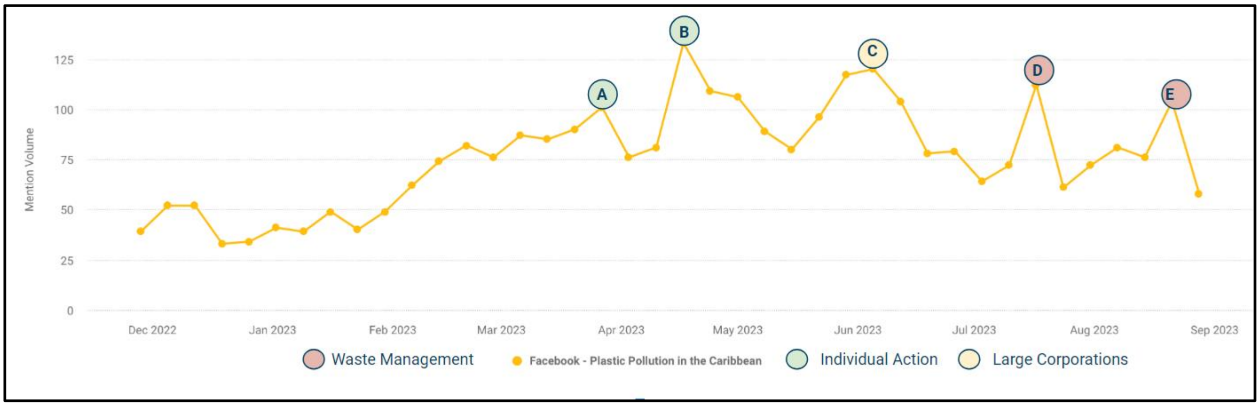


Figure 4.14: Example spike analysis from Facebook on plastic pollution in the Caribbean December 2022 - September 2023

Key posts and events also demonstrated spikes in related content and activity on Facebook in Dominica specifically (Figure 4.15).

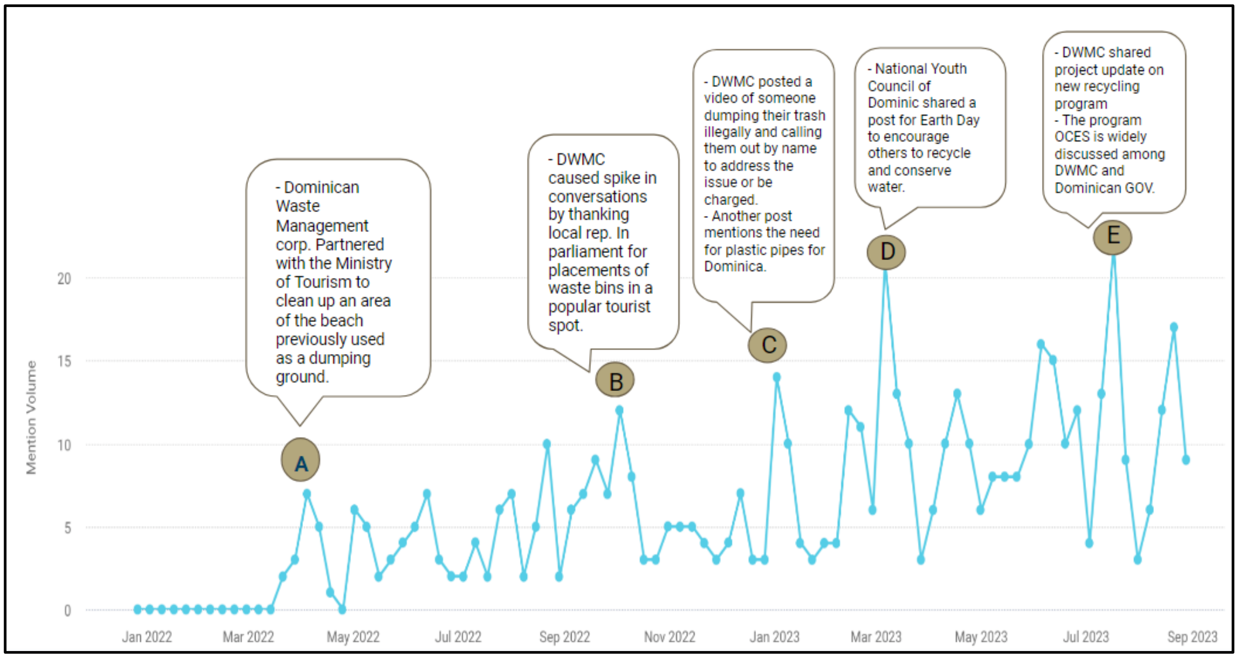


Figure 4.15: Example spike analysis from Facebook in Dominica specifically

On Instagram, 15.57K relevant results were found with a reach of over 26.3M viewers within the timeframe. Similar themes were observed as those associated with the Twitter and Facebook posts, particularly around tourism, wildlife, and waste management. Top influencing accounts among global organizations posting about plastic pollution in the Caribbean included @4ocean, @parley.tv, and @plasticpollutes. Much of the conversation on Dominica on Instagram, around 3.5% of the total dataset, was related to tourism in the area. There was also a large portion of the conversation that covered the sperm whale species in the area that is adversely affected by pollution. Some of the other points of conversation were related to efforts that Dominica is making to improve their sustainability, such as the OECS recycling initiative. One particular post by photographer Paul Nicklen that emphasized the importance of protecting wildlife in Dominica had a 770K total reach, 38K likes, and 297 comments (Figure 4.16).

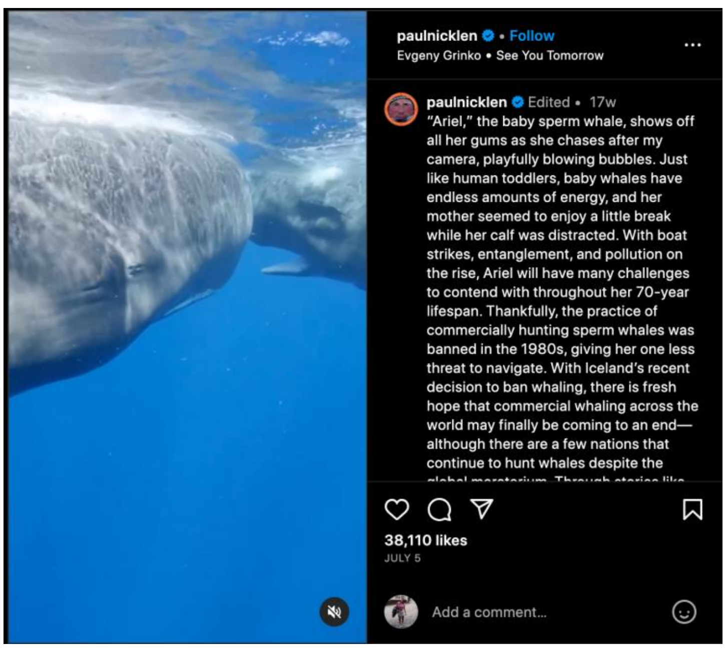


Figure 4.16: Post by Paul Nicklen using #Dominica featuring local sperm whales and plastic pollution

There are ample opportunities to engage the public and targeted audiences on plastic pollution prevention and waste management through social media, particularly through platforms and accounts that are already popular in Dominica and the Caribbean. Notably, most of the conversations about plastic pollution in the Caribbean are occurring outside of the Caribbean instead of within the region, presenting an opportunity for local voices to become more engaged in shaping the messaging and perspectives both within the region and worldwide. Dominica could be a key leader in this space and should capitalize on key moments, such as progress with the UN Global Plastics Agreement and local cultural festivals, to highlight positive efforts happening on-island via social media.

4.5 Product Design

The purpose of the Product Design section is to characterize the materials and formats found in products, particularly packaging. Data was collected among three types of stores across Dominica: convenience stores (including gas stations, roadside stands, and standard convenience stores that do not sell fresh food), restaurants and food vendors, and large grocery stores.

4.5.1 Product Design: Convenience Products

To characterize material types used in common consumer products, samples of common convenience items were obtained as described in the Input section. The CIL team sampled convenience stores in each of the $1km^2$ transects areas. In total, 225 unique forms and brands were purchased to obtain packaging weights. The average weight of both the packaging and the product itself was collected for all samples (Table 4.4).

Table 4.4: Average weight of products and their plastic packaging for common convenience items

Product Type	Number of Samples	Average Weight of Plastic Packaging (g)	Average Quantity of Product (g or mL)
Beverage	54	23	448
Biscuits/Wafers	15	1	38
Candy	110	4	31
Chips	24	4	42

Cigarettes were excluded from purchasing of samples in this case, but they are typically a standard size and we have previously found an average of about 10 g of plastic packaging to about 15 g 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.

For each convenience item surveyed, the CIL team documented the polymer type and/or material of the packaging (Figure 4.17).

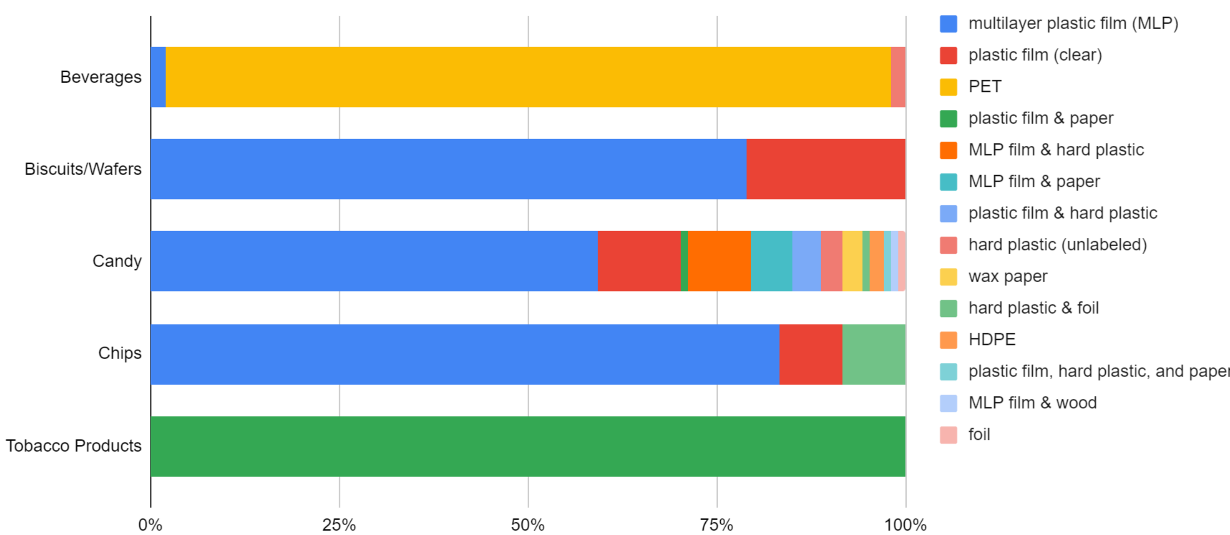


Figure 4.17: Material breakdown of top convenience items in Dominica

Among beverage products sampled, 91% were packaged in PET bottles. The majority (87%) were packaged in clear PET - among the most readily recyclable and highest-value recycled plastic polymers - while 1.2% were packaged in black PET, 1.2% were packaged in green PET, and 1.2% were labeled as packaged in recycled PET (rPET). The remaining non-PET packaged beverages included those packaged in HDPE (4%), multilayer plastic (MLP) (1.2%), and #7 Other Plastic (1.2%).

Candy products had the highest diversity of packaging material types. The majority (60%) were packaged in MLP film, followed by those packaged in single-layer, clear plastic film (11%), a combination of MLP film and hard plastic (8%), and a combination of MLP film and paper (6%). The remaining material categories, each of which represented <5% of the samples, included plastic film & hard plastic, hard plastic, wax paper, MLP film & wood, plastic film & paper, foil, hard plastic & foil, and a combination of plastic film, hard plastic & paper. The majority of packaging was some types of multi-material combination, which are difficult to recycle and typically have little to no value in recovered waste streams.

Among biscuit/wafer products sampled, the majority (73%) were packaged in multilayer plastic (MLP) film, while the remaining 27% were packaged in single-layer, clear plastic film. Similarly, the vast majority (83%) of chip products sampled were packaged in MLP film, followed by single-layer, clear plastic film (9%), hard plastic & foil (4%), and a combination of hard plastic, foil & paper (4%). All of the 22 tobacco products that were sampled were packaged in a combination of coated paperboard and single-layer, clear plastic film. Multilayer and multi-material packaging can present a challenge to waste management systems and should be targeted for redesign or extended producer responsibility to prevent those items from ending up in the landfill or in the environment. With a large proportion of candy, chip, and tobacco products coming from Domestic and other parts of the Caribbean (particularly from Dominica, Trinidad & Tobago, and Jamaica), there may be opportunities for regional collaboration around product re-design and recapture for the most problematic packaging types.

4.5.2 Product Design: Restaurants and Food Vendors

In addition to surveying convenience stores, the CIL team surveyed restaurants and free-standing food vendors in each of the 1 km^2 transects areas. Through visual assessments and discussions with restaurant owners, the team assessed the material type for to-go food items like containers (including plates and lids, where applicable), cups, utensils, and straws. In total, the team characterized 108 items in 40 restaurants (Figure 4.18). This included 37 food containers, 17 straws, 17 cups/beverages, 15 utensils, 16 bags, 3 cup lids, and 3 plates.

Figure 4.18: Example to-go materials surveyed in Dominica

Across all to-go items sampled, the highest proportion (36%) were made of polylactic acid (PLA), which is an alternative to fossil-fuel-based plastic that can be industrially composted (Figure 4.19). However, PLA cannot break down or biodegrade naturally in the environment without the high temperatures required for industrial composting. This is likely also the case with to-go items that are labeled as made of cornstarch unless otherwise specified by the manufacturer. The next most common material types among to-go containers were fiber and non-coated paper, which should be backyard compostable if the product labels are accurate. Among the remaining categories of material types, coated paper, other plastic, and polystyrene (PS) will likely need to be disposed of in landfill, while aluminum, PP, and PET are potential candidates for recycling.

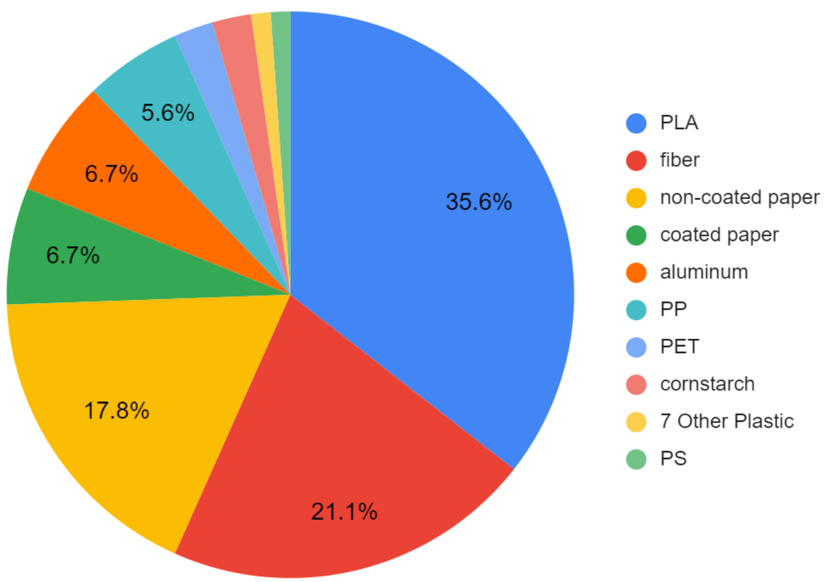


Figure 4.19: Material breakdown of all to-go items surveyed from restaurants and food vendors in Dominica

When material types are broken down based on the individual to-go item, it is clear that fiber containers are most favorable for food to-go containers and PLA is most favorable for items such as cups, lids, and utensils (Table 4.5). It's also noticeable where traditional fossil-based plastic, such as PP and PET, are still found among specific to-go items such as straws, utensils, and cup lids.

Table 4.5: Products and material types surveyed in restaurants and food vendors

Product	Material Type	Number of Observations
To-Go Food Containers (including lids, if applicable)	fiber	19
	aluminum	6
	coated paper	4
	non-coated paper	4
	PLA	3
	7 Other Plastic	1
Cups	PLA	12
	coated paper	2
	paper	1
	PET	1
Cup Lids	PLA	1
	PET	1
	PS	1
Plates	paper	3
Straws	paper	9
	PLA	5
	PP	3
Utensils	PLA	11
	cornstarch	2
	PP	2

This information is also represented visually in Figure 4.20.

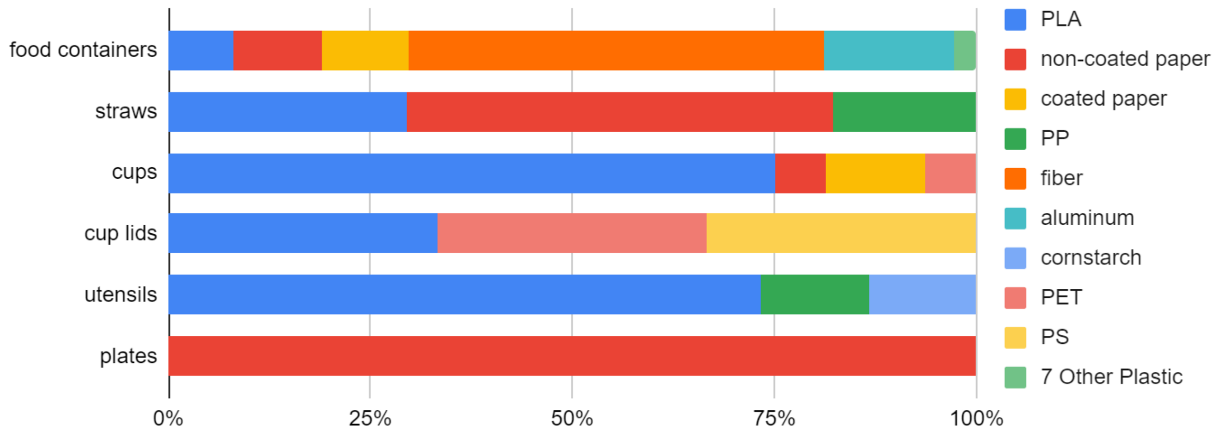


Figure 4.20: Material breakdown of to-go items surveyed from restaurants and food vendors in Dominica broken down by item type

It can be difficult to identify the manufacturer and country of origin of to-go items without seeing their original packaging; however, several brands (40% of all samples) were clearly shown on the items and the information was available. Of those that could be identified, the largest proportion (18%) were manufactured in and imported from the United States (Figure 4.21). The second highest proportion among those identifiable were from Dominica, most commonly from the company 100% Green. It should be noted that not all of the products from that company are manufactured themselves in Dominica, and some are still imported from manufacturers elsewhere. Other importing countries for to-go items included the Dominican Republic, China, and the United Kingdom. Several items listed on the product that they were manufactured in China but did not specify a brand or parent company.

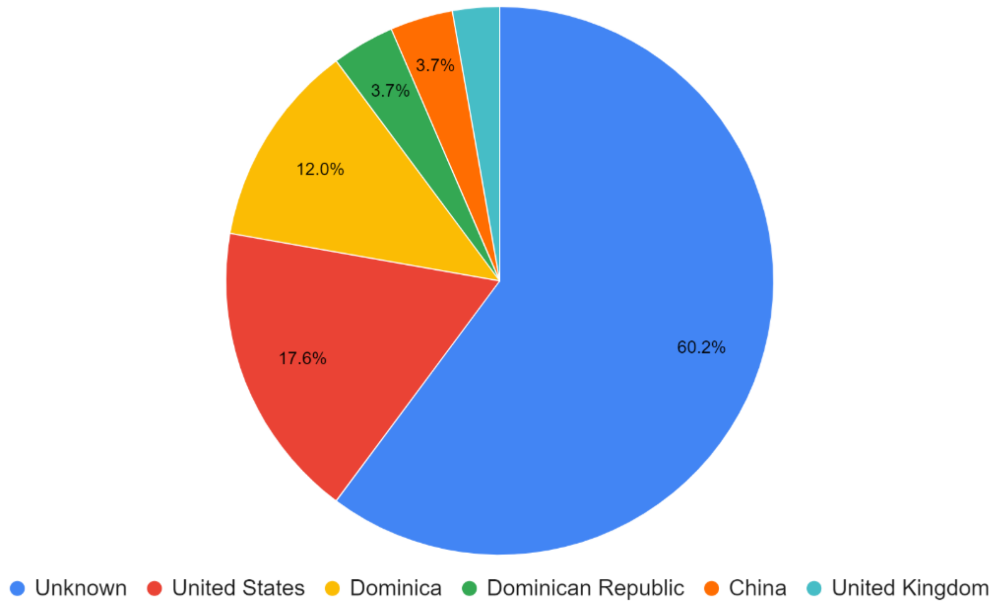


Figure 4.21: Sources of Plastic Alternative Brands in Food Vendor and Restaurant To-Go Items

The top 10 most common brands that were found for plastic-alternative products among food vendors and restaurants in Dominica, as well as their manufacturing location according to what was listed on the packaging or available online, were as follows (from most to least common):

1. 100% Green (based in Dominica)
2. Prime Ware (based in the United States)
3. Asta (based in Dominica)
4. World Centric (based in the United States)
5. NoTree (based in the United States)
6. Bionature (based in the Dominican Republic)
7. Vegware (based in the United Kingdom)
8. Ingeo (based in the United States)

9. Greenware (based in the United States)
10. Alfreds (location unknown)

The most common brands, among those that were readily identifiable, were also broken down based on the product types in the following Table 4.6.

Table 4.6: Common plastic-alternative brands among restaurant food vendor to-go items

To-Go Item from Restaurants & Food Vendors	Most Common Brands (among those identifiable)
Food Containers	Asta, BioNature, NoTree, Vegware, 100% Green
Cups	WorldCentric, Ingeo, 100% Green, Greenware, PrimeWare, Vegware, NoTree
Straws	PrimeWare, 100% Green, Asta, WorldCentric
Utensils	100% Green, Asta, Vegware, World Centric

In 2019, Dominica implemented a Single-Use Plastic (SUP) Ban which bans the import of several problematic plastic items such as expanded polystyrene, utensils, plates, and straws. The ban specifically targeted foodware and food-related single-use plastic items as a starting point for legislative action. The policy was formally announced in the National Budget Address in 2018 by Hon. Roosevelt Skerrit, Prime Minister and Minister of Finance, where he stated:

> **"Therefore, Madam Speaker, consistent with the Government's vision to create the world's first climate resilient nation, our designation as "The Nature Isle" and our commitment to protect Mother Earth, effective 1st January 2019, a number of items**

considered to be inimical to the environment will be banned. (Government of Dominica, 2018)"

The process started in December 2018 with a 0% duty on the importation of authenticated biodegradable products (including lids, cups, single-use containers, cutlery, and drinking straws) and on the importation of reusable shopping bags. In January 2019, the ban went into effect on the importation of non-biodegradable single-use plastics from all ports of entry in Dominica (Clayton et al., 2021). Education information was posted across departments and venues (Figure 4.22) and reusable shopping bags were provided to residents.

Figure 4.22: poster with information on the Single-Use Plastic Ban

Progress since the implementation of the ban is evident, particularly in the small quantity of fossil-based single-use plastic, such as PP, PET, and PS, that was observed among to-go items (less than 6% of the sample respectively for each material type). However, stakeholder interviewees noted that the language on the single-use plastic import ban is based on the product labeling and not on the product polymer itself. This was observed in some to-go items and grocery bags that were labeled as PET or LDPE that are biodegradable, which are likely actually fossil-based and not biodegradable or are oxo-degradable and will simply break up into microplastics over time. There are opportunities to improve upon the existing legislation and specific policy language to ensure that the single-use plastic ban is enforced as it was intended and that undesirable products such as this do not continue to make their way through importation.

4.5.3 Product Design: Grocery Stores

In addition to surveying material types from common items found in convenience stores and among to-go items in restaurants and food vendors, the CIL team surveyed 9 Large Grocery Stores across the island and looked at the material type of packaging of several key household items. This included: Cooking Oil, Eggs, Greens, Laundry Detergent, Milk, Rice, and Sugar (Figure 4.23).

Figure 4.23: Example of grocery store items surveyed in Dominica

Among all household items surveyed in grocery stores, the most common packaging material type was single-layer plastic bags (Figure 4.24). These items are most likely to end up in landfill or in the environment as they are often lightweight and low-value for recycling. The following two most common material types among household items (both comprising 15% respectively of the sample) were PET and HDPE, which are typically among the highest-value plastic polymers for recycling.

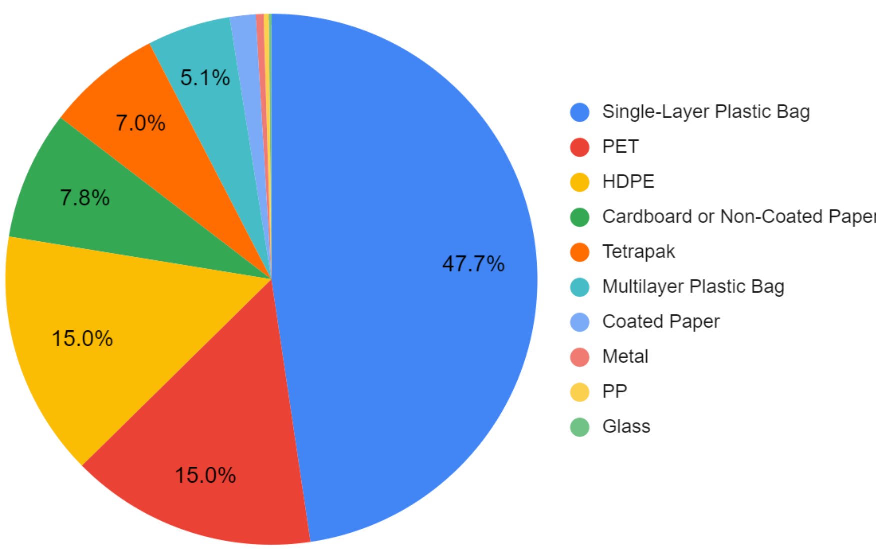


Figure 4.24: Material breakdown of staple item packaging surveyed from grocery stores in Dominica

When investigated by item type, laundry detergent products had the highest diversity of material types in their packaging (~40% HDPE, 36% MLP bag, 22% PET, 2% PP) (Figure 4.25). Cooking oil also had a high diversity of material types, though less evenly distributed than those found in laundry detergent (~82% PET, 13% HDPE, 4% metal, 1% glass). All of the vegetable greens surveyed were packaged in single-layer plastic bags, as were the majority of rice products (97%) and sugar products (86%). Eggs were nearly evenly split (50%/50%) between those packaged in single-layer plastic bags and those packaged in cardboard containers. Similarly, milk was nearly evenly split (50%/50%) between being packaged in HDPE bottles and Tetrapak.

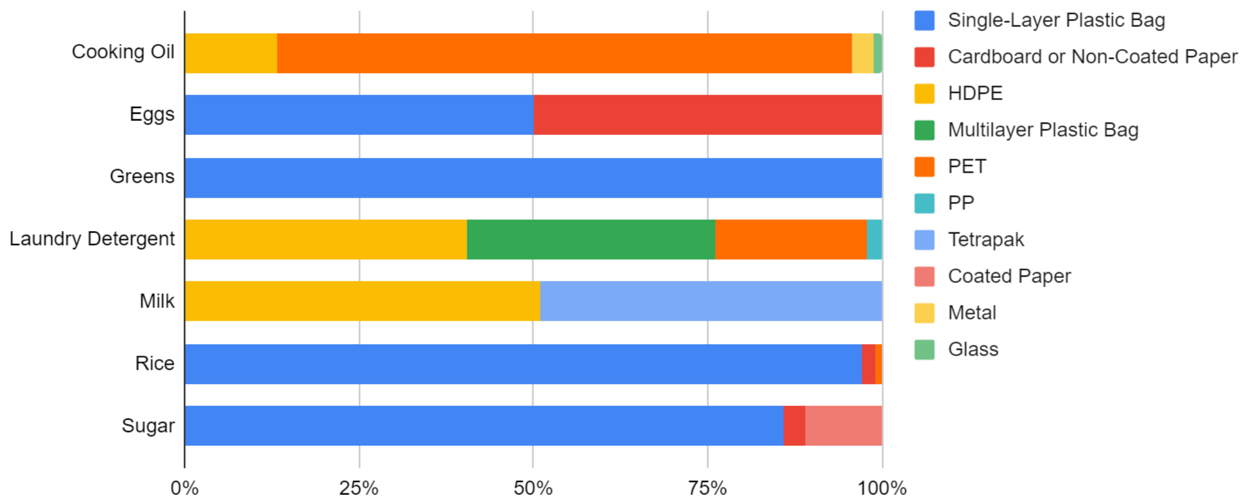


Figure 4.25: Material breakdown of staple item packaging surveyed from grocery stores in Dominica based on item

4.6 Use

The intention of the Use section of the CAP is to characterize trends around use and reuse of products within the community, as well as identify alternatives and their cost comparisons with traditional single-use items. Among the 9 large grocery stores that were sampled as outlined in the Product Design section, 107 individual SUP and plastic alternative items were identified and surveyed. This consisted of 44 sandwich bags, 22 cups, 13 food containers, 12 plates, 9 utensils, 5 straws, and 2 shopping bags (Figure 4.26).

Figure 4.26: Example of single-use plastic options available in grocery stores (left) and alternative options available in grocery stores (right)

Among all SUP and alternative items, 14 different material types were identified. Among the alternatives, five different labels/nomenclatures were identified to distinguish the materials, including compostable, biodegradable, bio-disposable, environmentally friendly, and reusable (Figure 4.27).

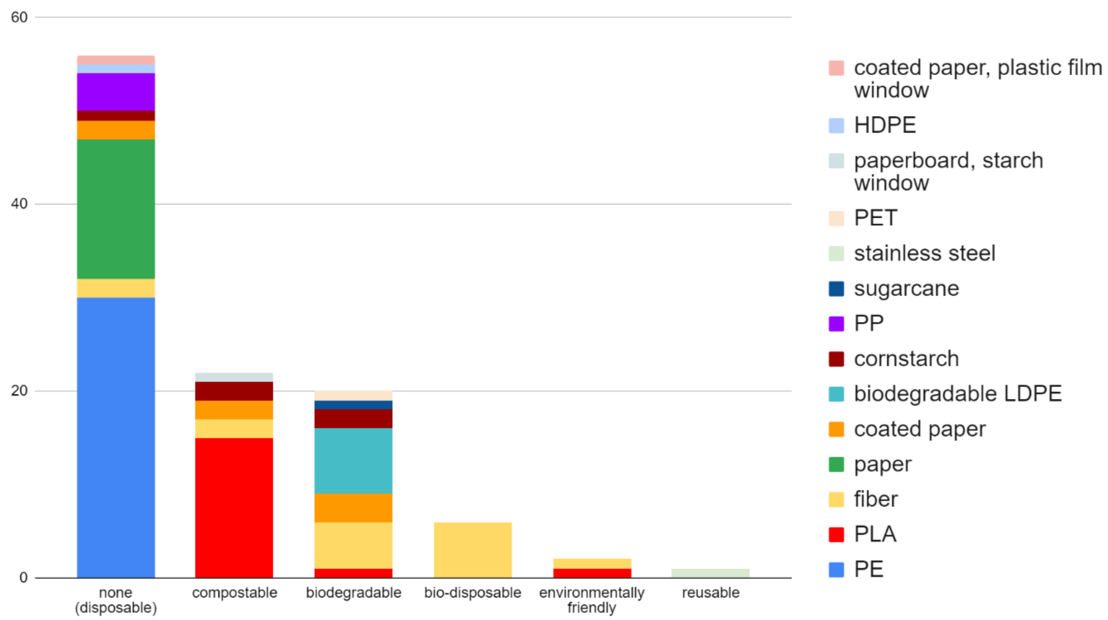


Figure 4.27: Material of Plastic & Alternatives Items in Grocery Stores, separated by Use Type

The current SUP ban in Dominica applies only to foodware and does not include household items that are sold in grocery stores. As such, there were still many single-use and disposable plastic items still available in grocery stores in Dominica, particularly among sandwich bags and cups. The majority (54%) of those single-use items were made of polyethylene (PE), as well as paper (27%), PP (7%), and several others. The vast majority (68%) of household items in grocery stores that were labeled as compostable were made of PLA, but compostable items were also found in the form of fiber, coated paper, cornstarch, and a combination of paperboard and starch. PLA items were also found labeled as biodegradable and environmentally friendly. All items labeled as bio-disposable were made of fiber and only one reusable option was found in the form of a stainless-steel container. The largest proportion of items labeled as biodegradable (35%) were made of biodegradable LDPE, which is most likely oxo-degradable and does not fully biodegrade in the environment. The wide variety of materials and labels can be confusing to consumers and an updated labeling process should be considered.

Among SUP alternatives identified in the grocery store surveys, those labeled as biodegradable or a form of organic material (e.g., natural fiber or wood) were on average 1.13 times more expensive than the standard SUP options (Table 4.7). Those labeled as compostable plastic were 2.06 times more expensive than SUP and those labeled as reusable or refillable were nearly 67 times more expensive.

Table 4.7: Cost comparison of alternatives and single-use plastic options in grocery stores

Plastic Alternative Label Designation	**Average Cost per Unit of Single-Use Plastic item (e.g., straw, utensil, sandwich bag)**	**Average Cost per Unit of Alternative**	**Cost Difference for Alternative**
Biodegradable or Organic Material	$0.45	$0.51	1.13 x
Compostable Plastic	$0.45	$0.93	2.06 x
Reusable/Refillable	$0.45	$30.00	66.67 x

Similar to the findings from the Input and Product Design sections, it is important for stakeholders in Dominica to understand which countries and brands are most heavily importing alternative products, particularly in light of the SUP Ban and potential similar bans in the future. Among brands that were identifiable, the largest proportion (around 36%) of alternative items came from the US. Importantly, around 15% came from Dominica, highlighting further opportunities for domestic business models around alternatives that support policies and bolster the local economy (Figure 4.28).

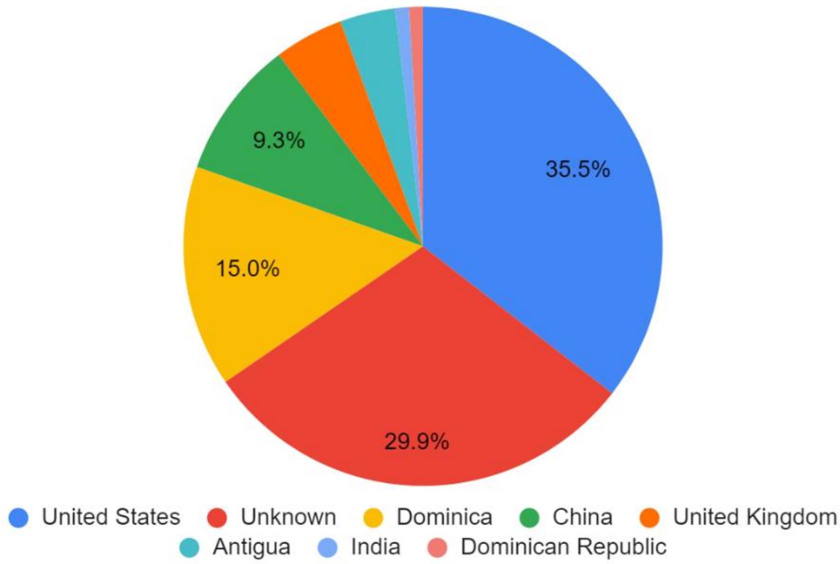


Figure 4.28: Sources of all Plastic Alternative Brands found in Grocery Stores

When observed by use type/labeling, opportunities and potential monopolies are apparently for different regions. For example, while they comprise a small number of samples, it's clear that nearby Caribbean nations such as the Dominican Republic and Antigua are potential markets for compostable alternatives (Figure 4.29). The data also shows that most of the SUP household items sampled that are still entering grocery stores in Dominica are coming from the United States, China, and Unknown or Unlabeled brands/locations. It is worth mentioning that a small amount of those SUP items is also coming from Dominican companies, which could potentially present EPR or sustainable business opportunities for those brands.

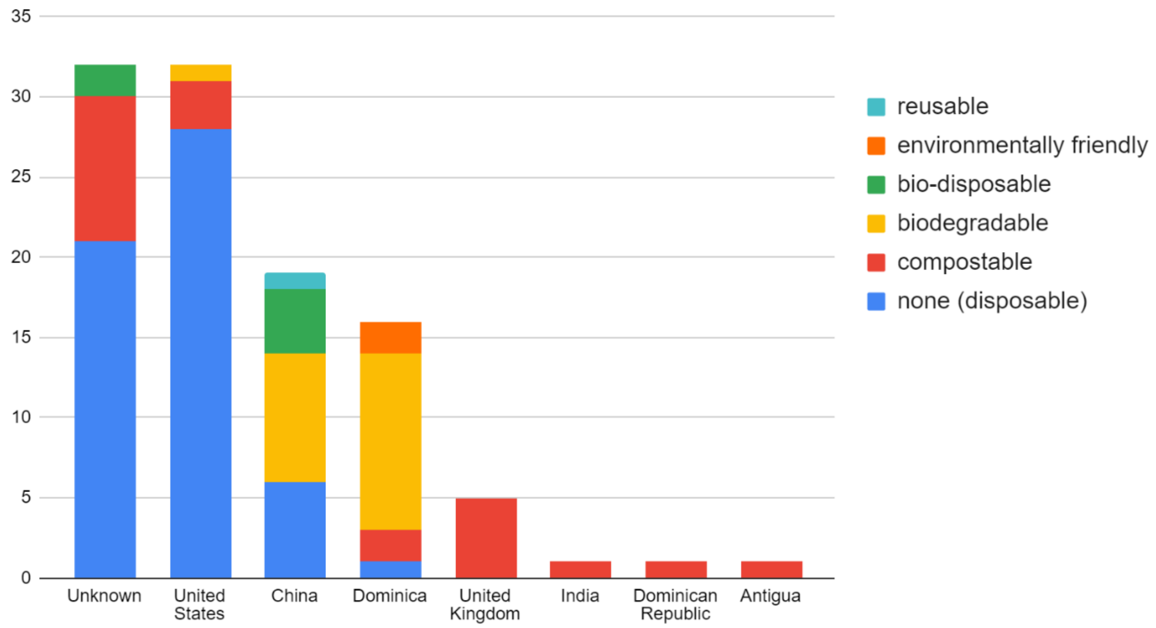


Figure 4.29: Sources of Plastic & Alternative Brands in Grocery Stores, separated by Use Type

All Brands of Alternatives available in Grocery Stores (identifiable):

1. Fresh Market
2. Asta
3. Vegware
4. China Town Resources Ltd
5. Essential Everyday
6. World Centric
7. Best Choice
8. 100% Green
9. Umite Chef
10. Shoppers Value
11. Party World
12. NoTree
13. Home Smart
14. Greenware
15. Diamond
16. BioNature
17. All Best Inc.

Only one of the large grocery stores sampled offered a bulk purchasing option (Figure 4.30), though customers were required to use the single-use plastic bags provided. Refillable options or bring-your-own-container options were not identified in any of the stores, and several stakeholders mentioned that reuse and refill are not commonly practiced in Dominica, in part due to health concerns. Some interviewees noted that in the past, Dominica had a local manufacturer of jams, jellies, juices, and other household items that were packaged in glass and that offered a deposit/return scheme that worked well, but that has since closed and all items have largely been transitioned to plastic packaging and import. In some stores, larger sizes of products are available in bulk, but most are re-packaged into smaller plastic bags for distribution. Many roadside vendors also re-package items into smaller plastic bags.

Figure 4.30: Example of a bulk purchasing option at a grocery store in Dominica

From all convenience stores, grocery stores, and restaurants/food vendors sampled as outlined in the Product Design section, 22 distributed single-use to-go bags (Figure 4.31).

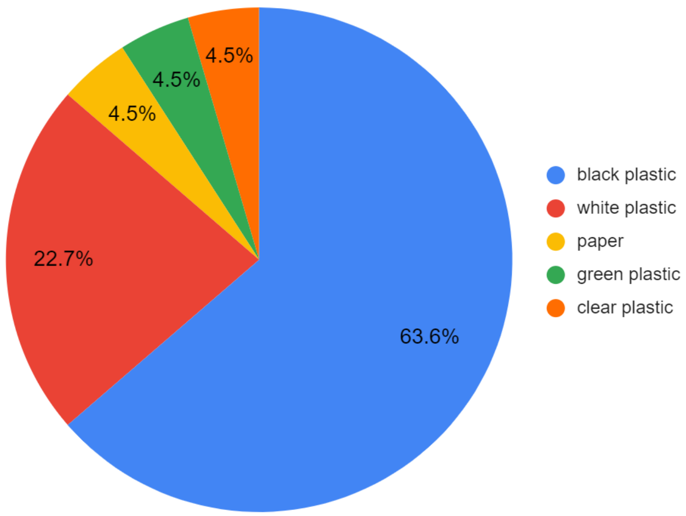


Figure 4.31: Material breakdown of single-use to-go shopping bags distributed in convenience stores, grocery stores, and restaurants/food vendors in Dominica

Among locations that handed out to-go bags, the majority (64%) used predominantly black plastic bags, often labeled as biodegradable LDPE, though they are likely oxo-degradable (Figure 4.32).

Figure 4.32: Example of black plastic to-go shopping bags available at stores in Dominica, labeled "biodegradable HDPE"

Only around 5% of locations predominantly distributed to-go bags that were not plastic (paper), though several did offer smaller items, such as individual candies, in paper bags in addition to the SUP bags. Around 33% of to-go bags were made of HDPE, the majority of which were made of a white plastic polymer, but green and clear HDPE was also observed. One of the grocery stores sampled charged customers an additional $1 if they opted to take a plastic to-go bag, and 1 grocery store offered reusable bags at checkout for an additional $3 each. It is clear that, despite the import ban, plastic bags are still a waste and environmental challenge in Dominica, as 178 plastic bags were found in the litter surveys (discussed further in the Leakage section).

The current SUP ban in Dominica includes foodware items, such as cups, forks, plates etc., but does not specifically include SUP shopping bags. This could present an opportunity to strengthen plastic policies domestically. Among the 20+ Caribbean countries that have implemented some form of national SUP policy, most include plastic bag bans. A significant decrease in the number of plastic bags that end up as litter in those countries has been observed since the policy implementation, particularly in Antigua, Aruba, and Panama (Courtene-Jones et al., 2021). This suggests that the policies are working and Caribbean SIDS are taking the right initial steps, though more work is needed. Several other countries, including Antigua and Barbuda, Belize, and Saint Vincent and the Grenadines have policies that target problematic litter items such as expanded polystyrene (EPS) (Brooks et al., 2020).

Another potential opportunity for reduction and reuse in Dominica lies in local juices. Currently, local juices are bottles and distributed in clear PET bottles with attached PP caps that are opened by pulling off a small plastic tab (Figure 4.33). This is a popular consumer good that you can find in convenience stores, roadside stalls, and most food vendors and restaurants. In addition to a high abundance of plastic PET bottles found in the litter surveys, many bottle caps, plastic cap tabs, and hard plastic fragments that may have originated from these or similar products were found littered across the island. However, while the disposable plastic tab that keeps the lid closed was readily identified in the litter, entire bottle caps were more commonly identified in the litter from other brands and not from these local juices. The design of the attached PP caps demonstrates the capacity of a local entity to make design choices that are different from multinational corporations that could be beneficial to the environment and to recycling. Further, there may be local business opportunities for collecting back these local juice bottles, using a different material, washing and reusing the bottles, or otherwise to reduce the likelihood of the bottles or caps ending up in the environment.

Figure 4.33: Example of local juice bottle

Beyond SUP shopping bags and bottles, there are other national policy interventions that could minimize the use and disposal of problematic plastic items in Dominica. For example, there are currently no EPR or packaging legislations in Dominica, whereby consumers would be able to see a direct benefit of returning commodities to the parent companies and potentially receiving incentives such as coupons, rebates, or otherwise. Similarly, there are no existing policies that aim to reduce the amount of plastic that is produced and manufactured upstream, beyond encouraging reuse of existing plastic items. Several studies have emphasized the need to reduce plastic usage and waste generation as a primary method of addressing plastic pollution in Caribbean SIDS, and policies should be enacted to reinforce that prioritization (Busch, 2022; IUCN, 2024; Kanhai et al., 2024).

One of the challenges with the existing national plastic policy is related to the HS Import Codes. Historically, it has reportedly been difficult for the government to differentiate between the import of standard plastic versus compostable or biodegradable plastic, and companies that were trying to import alternatives after the ban would have to send a sample to the Dominican Board of Review for approval. However, the process is difficult to follow and certain items have been able to slip through due to their labeling strategies, such as items labeled as biodegradable LDPE that may in fact be oxo-degradable. One way to address this might be focusing the import ban on the polymer type or resin code instead of the product label, though this would require stricter monitoring and enforcement. This is something that the Bureau of Standards could potentially support. Enforcement of policies also poses a challenge in Dominica. A Waste Control Bill was introduced in 2019 to provide enforcement and compliance support for the SUP ban, but as of December 2023 that still has not passed. There have reportedly been legislative delays in the Caribbean and the COVID pandemic was a higher priority for several years. It would be beneficial to bring local leaders together in Dominica to revisit this bill and re-prioritize passing it in the coming year.

4.7 Collection

Investigation into the waste collection methods of Dominica was conducted through stakeholder interviews, site visits to waste collection sites, and reviews of existing waste characterization and literature on the topic.

The Latin America/Caribbean (LAC) region generated an estimated 231 million tons of waste in 2016 alone, representing 11% of global waste generation, and has the third highest per capita waste generation rate (0.99 kg/person/day) after North America and Europe/Central Asia (Kaza et al., 2018). While the waste collection coverage for LAC is relatively high at 84% on average - about 50% of which ends up in a sanitary landfill and less than 5% recycled - the average coverage for rural areas drops to 30%, and over 320,000 tons of plastic is estimated to go uncollected every year across the Caribbean (Kaza et al., 2018; Diez et al., 2019). Studies have also highlighted gender inequities and higher impacts of plastic pollution on women in Caribbean SIDS, particularly through discrepancies in access to personal protective equipment in the informal waste sector, in disproportionate exposure to the health hazards of plastic through domestic care work, in the unique roles that women play in fisheries, and in a general lack of female perspective when it comes to design, implementation, and evaluation of policies (Arnould et al., 2023). In 2019, it was found that among the top thirty global polluters per capita, ten were from the Caribbean region, and this led to global media attention on the role of the Caribbean in the plastic pollution crisis (Ewing-Chow, 2019).

Per capita waste generation rates in Dominica in 2018 were around 0.5 kg/person/day, lower than the global average at the time of 0.74 kg/person/day and the LAC regional average of 0.99 kg/person/day (Kaza et al., 2018). Dominica also has among the lowest per capita waste generation rates for Caribbean nations and territories, which average around 1.6 kg/person/day and reach highs of 4.46 kg/person/day in the U.S. Virgin Islands, 3.75 kg/person/day in the British Virgin Islands, 3.43 kg/person/day in the Cayman Islands, 3.28 kg/person/day in Puerto Rico, and 2.91 kg/person/day in Aruba (Kaza et al., 2018). In 2018, it was estimated that Dominica had a higher percentage of plastic in the waste stream at 16%, compared to the global and LAC average at that time of ~12% and the Caribbean average of ~14% (Kaza et al., 2018; Brooks et al., 2020). A more recent waste characterization at the landfill in Dominica found that plastic comprised around 24% of all solid waste collected in the country (Figure 4.34; Seureca Veolia & Unite Caribbean, 2023). It's estimated that around 2,200 metric tons of waste was generated in Dominica alone in 2020, and it's been reported that Dominica has the lowest percentage of waste collected in the Eastern Caribbean (UNEP/OCHA, 2017; Kaza et al., 2018).

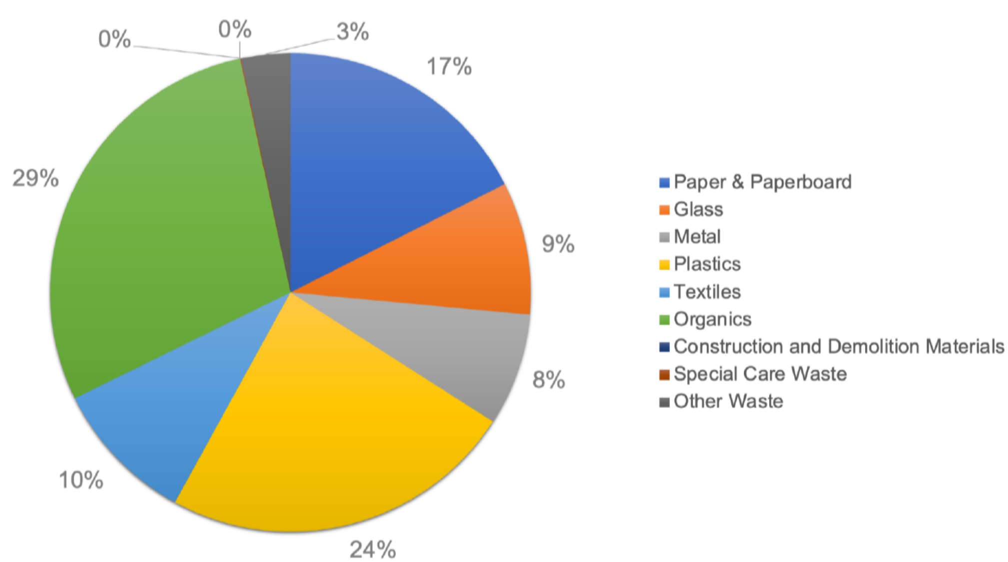


Figure 4.34: Dominica solid waste composition July 2023 (Data Source: Seureca Veolia & Unite Caribbean, 2023)

Household municipal solid waste (MSW) collection in Dominica is conducted by DSWMC across the entire island. There are around 75 staff at DSWMC and the majority are conducting waste collection. DSWMC reportedly has two collection trucks provided by Japan and one recycling truck with separate compartments provided by Switzerland, which are responsible for servicing the whole country. Reportedly 100% of Dominica residents have access to curbside MSW collection and DSWMC collects all household waste as well as recyclables (including glass, plastic, cans, and paper) Monday through Friday. There is currently no mandate for bins used for household waste collection, and DSWMC will collect waste from any receptacle provided (most households use blue barrels, Figure 4.35, left). Some neighborhoods have public waste collection centers (Figure 4.35, right) where residents can deposit their trash in a centralized location for collection by DSWMC, as opposed to having individual household containers. Some stakeholders mentioned that put-out for curbside recycling is generally very low.

Figure 4.35: Community and residential waste collection center recently emptied (left) and community waste collection center that is full (right)

DSWMC also handles public waste bins in the larger cities across the island. These are predominantly standard green bins along sidewalks (Figure 4.36, left) and larger trash and recycling bins in public areas like beaches and parks (Figure 4.36, middle). However, DSWMC is in the process of replacing many of those bins with segregated waste bins that have been donated by OECS and are being shipped from China to enhance source segregation, composting, and recycling (Figure 4.36, right). As of December 2023, several of these bins could be seen at the airport and at public events in Roseau.

Figure 4.36: Public trash cans and collection bins in Dominica

DSWMC also faces the challenge of stray dogs or people getting into trash bins and ultimately spreading litter around the vicinity (Figure 4.37).

Figure 4.37: Collection bin in Roseau that had been rummaged through

In addition to DSWMC household collection, there are two private hauling companies in Dominica that collect commercial and industrial waste across the island, as well as a small number of informal, independent waste workers that collect items such as white products, bulk items, and others. Some stakeholders reported that they had witnessed some waste haulers dumping waste on the side of the road or down one of the many large ravines in the inland portion of the island. There is only one landfill on the island and it can be a long distance for some haulers to travel, which may incentivize disposing of the waste elsewhere.

For beverages that were sampled in Dominica as described in the Product Design section, it was also documented whether the labels and/or bottle components themselves contained any instructions related to waste collection or disposal (Figure 4.38). The most common labeling (25% of beverages) was the chasing arrows symbol, though not always accompanied by resin number or location-specific recycling instructions. The second most common (20% of beverages) had no labeling for disposal. Labeling was also analyzed based on the manufacturer and parent company locations of the beverage products. Among those from Dominican manufacturers, only one sample had a label with disposal instructions, and it was the Throw In Bin symbol. The Chasing Arrows and the Throw In Bin symbols were the most internationally used, particularly those from Trinidad & Tobago. The circular arrow Recirculate symbol was observed only in beverages from French countries. Money-back offers were only observed in beverages from Jamaican manufacturers. Manufacturers from the US had the highest diversity of label type (seven total, including ‘none'), and Saint Vincent and Jamaica had the second highest diversity of label type (five total, including ‘none’). Around 5% of beverages noted on the label that they were made of post-consumer recycled (PCR) content, which was only observed in US and UK manufacturers.

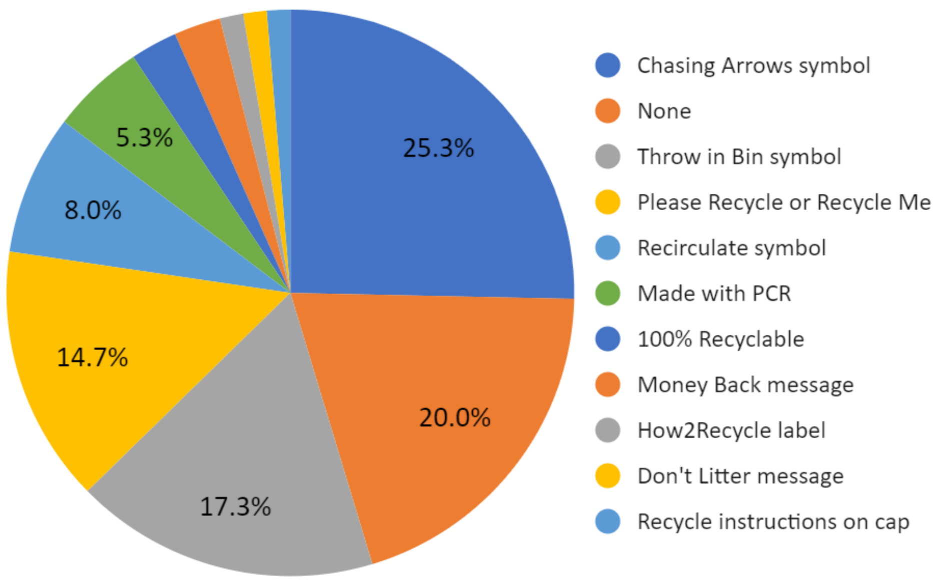


Figure 4.38: End-of-life instructions observed on labels and caps of Beverage brands in Dominica

Several stakeholders mentioned that public awareness and education are vital for the success of future waste management initiatives such as separating at source, increasing recycling, and using SUP alternatives. As part of that process, it may be beneficial to look into standardizing labeling, language, and instructions around what types of materials should be disposed of in which manners in Dominica, based on the local waste management infrastructure, capacity, and markets.

4.8 End of Cycle

The waste management infrastructure of Dominica has changed over time as the local economy, materials, and management methods have evolved. Dominica was largely an agricultural economy through the 1960s and 1970s, so MSW was mostly organic and the import of consumer goods from other countries was relatively low. During that time, open landfills and illegal dumping were reportedly the predominant waste management methods. When Hurricane David struck the island in 1979, plastic packaging started arriving in Dominica from AID groups, and around that time single-use plastic was being heavily marketed and advertised globally as synonymous with modernism, convenience, wealth, and status. As Dominica was rebuilding and modernizing after Hurricane David, it relied more and more heavily on imported plastic products. While the banana agriculture economy was booming in the 1970s and 1980s, more money coming to the island resulted in higher consumerism, which meant more packaging and products, but still a general lack of adequate SWM infrastructure to handle those materials. After Dominica gained independence in 1978, the banana industry started to falter, as the UK sought out other islands in the Caribbean for sourcing. The island however remained heavily dependent on imported plastic consumer items, which were becoming more plentiful and cheaper on the global market over time with the boom of the plastics industry.

In 1999, the Dominica government commissioned the Fond Cole scientific landfill for household waste in order to move away from open dumping and address increasing waste management needs. At the time, a Material Recovery Facility (MRF) was proposed to accompany the landfill to handle recyclables, but the MRF didn’t end up being developed, reportedly due to procurement issues. This meant that there was no waste diversion put into place when the landfill was built, as was originally intended.

Following the devastating impacts of hurricanes Maria and Irma in 2017, Dominica invested heavily in resilience and disaster preparedness. The Solid Waste Management Act of 2002 was one of few pieces of national legislation at the time that specified the requirement of disaster preparedness response plans by licensees. Much of the solid waste management infrastructure on the island, including a compactor funded by the Caribbean Development Bank, a PET shredder funded by the Pan American Health Organization, a small PET-dedicated truck funded by the Swiss Government, a biodiesel facility financed by the Global Environment Facility and the United Nations Development Programme, and the structure of the Fond Cole landfill itself, sustained initial damage in tropical storm Erika in 2015 and were further damaged by the 2017 storms. Some also require maintenance or parts that are not available on-island and have since fallen into disrepair. While the landfill was originally intended to reach capacity around 2022, the surplus of waste from Hurricane Maria essentially saturated it in 2017, and there are no other viable locations for a landfill on the island (UNEP/OCHA, 2017).

With the landfill already exceeding its expected fill date and having little to no increased land area into which to expand, DSWMC is dedicated to pursuing waste diversion activities such as waste separation, recycling, composting, and others. There is a strong need for a long-term, sustainable vision and plan for domestic solid waste management in Dominica, with an emphasis on reduction and reuse.

4.8.1 End of Cycle: Landfill

The Fond Cole landfill, the only scientific landfill in Dominica, was originally built with funding support from the Norwegian Ministry of Foreign Affairs under the "Tackling Ocean Pollution from Turf to Surf" initiative (Figure 4.39). While it was initially commissioned in 1999, operations officially opened at the landfill in 2005. It covers an area of roughly 18 acres just north of the capital on the west coast and accepts waste from across the island, including industrial waste, green waste, commercial waste, household and institutional waste, and hazardous healthcare waste (DSWMC, 2023).

Figure 4.39: Weighing station at the entrance to the Fond Cole landfill

The landfill was originally estimated to reach capacity in 2022. Phase 1 and Phase 2 cells of the landfill are completely full and DSWMC is planning to expand to a Phase 3 cell that is currently housing a large amount of metal scrap (Figure 4.40). That new cell is expected to extend the life of the landfill by an additional 15 years if waste production rates remain stable; however, there is limited land nearby for expansion and strict permitting requirements that prevent new landfill space from being developed.

Figure 4.40: Area of the Fond Cole landfill currently planned to become Phase 3 expansion

The Fond Cole landfill is lined and properly covered using soil that is excavated on-site. The leachate is collected in a pond on site but it is not treated. Landfill gas is regularly vented from the landfill but is not formally collected. There is some privately owned equipment at the landfill that DSWMC and the Government of Dominica are trying to purchase, such as backhoes and crushers for cars, and some equipment is borrowed from OECS, such as trucks and balers (Figure 4.41).

Figure 4.41: Photos from the Fond Cole landfill

The COVID-19 Pandemic put significant stress on the waste management systems of Dominica, including the landfill. Residential waste quantities remained the same, if not increased, but DSWMC was also responsible for collecting and managing the biomedical waste from all of the formal and pop-up health centers across the island. Stakeholders reported a significant increase in personal protective equipment (PPE) littered on the ground during that time.

The landfill does not currently accept construction and demolition (C&D) waste, which presents a challenge for open and informal dumping in Dominica. It would be beneficial for the landfill to develop a separate waste stream or collection point for C&D materials, or potentially arrange regional collaborations for the disposal, reuse, and recycling of such materials. Another challenge in Dominica is derelict automobiles that are often left on the side of the road. There are disposal options at the landfill, but there is little space and people are not always able to transport the automotive waste to the landfill. This is another waste stream that should be targeted for diversion, recycling, and repurposing in the future.

4.8.2 End of Cycle: Recycling

While some infrastructure exists to support recycling in Dominica, it does not match the current need and demand, and the local recycling economy is feeling the pressures of the changing global recycling market. There is one baler at the Fond Cole landfill, which was provided by the European Union. There is also one PET shredding machine that was provided by Venezuela, but it is not currently in use because recycled PET is not currently being exported. Dominica previously sent its recycled plastic content to the US and Indonesia, but operations have stopped. The landfill currently houses over 2 dozen 4x4 ft bales of PET and a growing pile of unsorted plastic recycling, likely over 40 ft tall, which has been accumulating since 2015 (Figure 4.42). This has mostly come from local MSW. At the moment, DSWMC and the Dominican government are unable to export that content for recycling, citing that it is too costly of a process and does not make financial sense with the current global recycling market. In the past, metal scrap from Dominica was sent to recycling markets in Trinidad and parts of Asia, and plastic had gone to the US and Indonesia, but those operations have halted. Stakeholders familiar with the local waste management and recycling industry noted that the War in Ukraine has also had an impact on their plastic recycling markets and has increased fuel prices, which can be detrimental to economies of SIDS that rely on long-distance transport for goods and trade.

Figure 4.42: Field photos from the Fond Cole landfill, showing baled PET bottles and those waiting to be baled

Plastic recycling is not the only market that has faced challenges in Dominica. In the past, Dominica sent recyclable heavy metals to Asia, but that operation has also ceased due to the high cost of fuel and low returns for sold material. E-waste and batteries are the only recyclables that Dominica is currently exporting, which are currently being sold to a US-based company through a recycling broker in St. Maarten. There is also a domestic recycling process in place for used oil on the island, largely in partnership with tropical shipping organizations, which has been reportedly working well.

Stakeholders reported that some of the most abundant imports to Dominica are PET bottles of water, juice packaged in Tetra Pak and PET, and household goods in HDPE containers. This was also reflected in the store surveys conducted for the CAP as well as the most recent waste characterization conducted at the landfill, which found 24% of collected solid waste to be plastic, around a quarter of which was PET (Figure 4.42). It would therefore be beneficial for Dominica to prioritize the repurposing and reusing of plastic waste into benefits and commodities.

> **"Dominica needs to start repurposing its plastic waste into a commodity. Dominica imports a lot of plastic, even durable things like park benches, that they could potentially be making on-island with their plastic waste, instead of exporting it for recycling. I would rather it turn into a physical commodity that the island can use directly and offset some plastic imports." - Local Government**

A recent solid waste composition study in Dominica found that around 24% of all plastic collected is clear PET containers and around 8% is HDPE containers, both of which are readily recyclable and are among the strongest and most cost-effective recycling markets (Figure 4.43). The study also found that over half (53%) of the plastic waste collected is film plastic, which is among the most difficult and least cost-effective plastics for recycling. While polymers such as PET and HDPE could be prioritized for recycling, difficult-to-recycle plastics such as films should be prioritized for product redesign, EPR, or other interventions focused on reduction and alternatives.

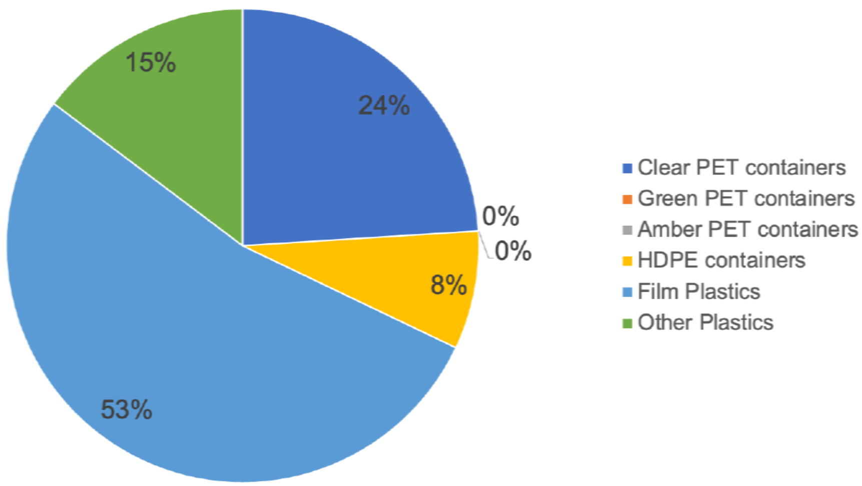


Figure 4.43: Dominica's Plastic Waste Stream Composition July 2023 (from Seureca Veolia & Unite Caribbean, 2023)

Similarly, the waste characterization also found that PET items in the municipal waste stream in Dominica represent a higher proportion of the recyclable waste by ton, particularly when compared to film and other plastics. This further emphasizes the opportunity to target the >90 tons per year of recyclable PET and HDPE collected in Dominica for effective recycling markets. If source separation of waste were implemented, then the further >400 tons per year of PET and HDPE in municipal solid waste that is not currently deemed recyclable could also be recovered. The study also found that film plastics, which are most difficult to manage and recycle, comprise the highest quantity by tonnage of plastic in the municipal waste stream (50.73%), despite their lightweight format (Table 4.8).

Table 4.8: Dominica's Plastic Waste Composition in tons per year based on 2022 quantities (adapted from Seureca Veolia & Unite Caribbean, 2023)

Material Type	Tons Per Year Municipal Waste	Tons Per Year Recyclable Waste	Total Tons Per Year	Percentage of Waste Stream
Clear PET Containers	385.2	65.3	450.5	26.10

Green PET Containers	0.0	1.2	1.2	0.07
Blue PET Containers	0.0	0.0	0.0	0.00
Total PET Containers	385.2	66.5	451.7	26.17
HDPE Containers	128.4	26.6	155.0	8.98
PP Plastics	0.0	0.0	0.0	0.0
Polystyrene	0.0	0.0	0.0	0.0
Film Plastics	850.7	25.4	876.1	50.73
Other Plastics	240.8	2.4	243.2	14.08
Total	**1605.0**	**121.0**	**1726.0**	**100**

Another beneficial finding of the 2023 waste characterization in Dominica was that the most commonly found clear PET containers in the recycling stream were from local companies, predominantly Trois Pitons and Quenchi (Figure 4.44). As these items were also readily identified in both the store and litter surveys from the CAP, this highlights the opportunity to engage with local distributors and manufacturers to encourage source separation of waste, collection, recycling, and potentially reuse and redesign of products so that they are less likely to end up in the environment and more likely to remain in the economy.

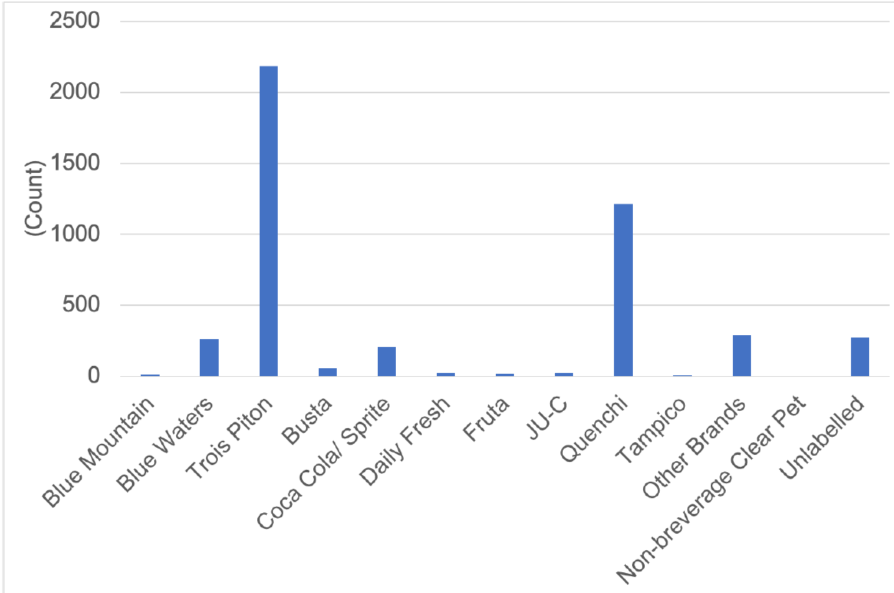


Figure 4.44: Dominica's composition of clear PET containers within recycling stream (from Seureca Veolia & Unite Caribbean, 2023)

In recent years, DSWMC proposed a $1M concept for a material recovery facility (MRF) to be designed at the landfill. The original intention was to have the MRF work in conjunction with the Fond Cole landfill when it was originally built. The proposal received high reviews in the process of government review, but funding was not awarded. Coca-Cola also invested in a baling and shredding machine for the landfill in the past, but interviewees recounted that it arrived with a missing part and was never repaired, and it is currently not functional. Having proper recycling infrastructure - as well as skills and knowledge for upkeep and repairs of that infrastructure - coupled with continued support, incentives, and outreach for source separation of household waste, could dramatically increase the quality and quantity of plastic recycling in Dominica and could help drive local and regional recycling markets.

In July 2023, Dominica and Grenada joined a pilot project Recycle OECS whereby DSWMC and Grenada Solid Waste Management Authority are developing Model

Demonstrations for reducing plastic waste on their respective islands. To date, DSWMC has supported a waste characterization study at the landfill, held several meetings and convenings to engage local businesses in recycling practices, and is rolling out a Zero Waste Schools program and other education, outreach, and messaging around sorting at source and supporting recycling. This is part of a larger EU Zero Waste Initiative for the Eastern Caribbean that is being implemented by the OECS Commission in partnership with Agence Française de Développement (AFD). The pilot runs through December 2024.

There is an opportunity for DSWMC and the government in Dominica to be a leader for circular economy efforts in the Caribbean. Several other analyses and initiatives have identified the benefits of regional recycling and cooperation in the Caribbean to build a circular economy, including reports from Saint Lucia, Grenada, and Antigua & Barbuda, the IUCN Plastic Waste Free Islands Initiative, and the AICS Closing the Caribbean Plastic Tap project (Mittempergher et al, 2022; Raes et al., 2022, IUCN 2024). It will be critical to identify economies of scale and strategic regional collaborations going forward to maximize waste diversion and processing and move towards a system that reduces the generation of waste upfront.

4.8.3 End of Cycle: Composting

As was evident in the store and restaurant surveys across the island, there has been an influx of compostable materials into Dominica in recent years, in part due to the import ban for single-use plastics. However, the waste management infrastructure does not currently match the supply of compostable materials that consumers are using. For example, many hotels and local restaurants have switched to PLA instead of single-use fossil-based plastic for their cups, but that material requires specific conditions for industrial composting and proper management and cannot break down or biodegrade in the natural environment. Many of those items were also observed in litter surveys, meaning that those items are still ending up in the environment. If they are properly discarded, then they end up in the landfill, where they could potentially be contributing more heavily to GHG emissions than standard plastics, and where they are adding to the dwindling capacity of the landfill (Roberts, 2021).

Anecdotally, many consumers and business owners alike were not aware that compostable plastic such as PLA required industrial composting, or that it needs to be processed any differently than organic material that will eventually break down in the environment or in the landfill. If not addressed, increased litter of food items made from compostable plastic and increased GHG emissions from the landfill could potentially become an unintended consequence of the single-use plastic import ban. As such, it would be worth exploring opportunities for industrial composting infrastructure in Dominica, in addition to prioritizing reduction and reuse instead of switching to alternative materials as much as possible. This further emphasizes the importance of enforcing the import ban as it was intended and ensuring that mislabeled polymers and products are not entering Dominica and potentially causing damage to existing waste management systems. Another potential option for Dominica would be the construction of an anaerobic digestion system that could biodegrade industrially compostable plastics, which could be beneficial in managing waste, contributing biogas back into the energy grid, and generating fertilizer byproducts.

Efforts for standard backyard composting have started to take hold in some areas of Dominica, particularly through the Kalinago Zero Waste pilot. Some hotels and tourism operations have reportedly made attempts to compost food waste, but not at scale. Interviewees noted the importance of regular collection and proper containers for this type of waste, as the tropical climate can rapidly attract pests and cause odor. These are factors that should be taken into consideration if backyard composting is scaled across the island.

4.8.4 End of Cycle: Zero-Waste Pilot

In 2022, DSWMC, in collaboration with OECS and the Norwegian Ministry of Foreign Affairs, started a flagship Zero Waste pilot project with the Kalinago indigenous community in the northwestern portion of Dominica. An initial Situational Analysis was conducted to assess the state of waste management and provide recommendations for fostering a zero-waste system. These recommendations included expanding upon and institutionalizing source separation of waste, creating collection infrastructure to avoid littering via stray dogs and other animals, and streamlining compostable refuse to increase quality and quantity (EnviroPlus 2022).

The goal of the pilot project was to create a system to enable proper waste sorting and processing and to simultaneously provide jobs and livelihood support to the indigenous Kalinago population. The intention was to provide every household in the territory with a residential garbage bin, a blue bin for recycling, and a 5-gallon bin for composting. Collection trucks originally came once per week to collect the household bins, but several months into the pilot the trucks were reduced to coming every two weeks because there was significantly less general garbage to collect. Another goal is to use compost for agriculture so that it can be profitable. This is something that has long been practiced among the Kalinago, such as using grass cuttings from NEP cleanups for organic farming. Interviewees also noted that the Kalinago have been using the local Calabash plant to create bowls and baskets and that the community is moving towards reusing and repurposing wherever possible.

"In the past, when the Kalinago went to Roseau, they would come back with plastic [shopping] bags. Now they are trying to use reusable bags … The Zero Waste Initiative is making reusable fabric bags out of jeans and other clothing." - Community leader

These efforts have been coupled with strong education and outreach around how to use the new infrastructure, the value of sorting at source, and the benefits of a zero-waste system both environmentally and economically. Interviewees attributed the success of the pilot project to its bottom-up nature and the thought and planning that took place upfront, including data collection through the situational analysis, many community meetings, and outreach and education. As one interviewee described it, the process was not forced onto the community, and instead, they let the community decide how they wanted the project to take place.

In the long term, DSWMC is hoping to have an organic waste and composting plant in the Kalinago territory. They are working closely with the Kalinago Council on drafting a design for the plant and its location. DSWMC hopes to create two additional regional organic composting plants across the island, as organic waste comprises around 40% of municipal solid waste in Dominica and around 64% of household waste in the Kalinago territory (EnviroPlus 2022; Seureca Veolia & Unite Caribbean, 2023). To date, the pilot has had many successes in diverting waste from landfill, and the hope is to expand upon and replicate this pilot initiative in coming years.

4.8.5 End of Cycle: Tourism and Business

Tourism and local businesses have an important role to play in solid waste management in Dominica. The Tourism Ministry of Dominica indicated in a press release that as of April

2023, Dominica received 190 cruise calls and 236,288 passengers for the 2022-2023 cruise season, representing a roughly 30% increase from the 2019-2020 season and the beginning of the COVID-19 pandemic. The ministry projected an additional 15-20% increase in cruise calls and passenger numbers for the 2023-2024 cruise season (Dominica News Online 2023). In addition to daily cruise passengers, the number of stayover visitors to the island exceeded 60,000 in 2022, representing an over 300% increase from 2021 and nearly approaching pre-pandemic numbers (Dominica Update 2023). While still lower than other popular Caribbean destinations, tourism in Dominica is certainly growing and now is a critical time to ensure that practices and policies remain sustainable for the local environment and economy.

According to interviewees, cruise ships are given the option to deposit their solid waste on Dominica when they come into port and they are permitted to leave plastic, glass, aluminum, and cardboard that is already processed and baled. Cruise ships are not currently permitted to deposit organic waste. Hotels often have their own waste management systems. DSWMC has reached out to hotels on the island to attempt recycling separation and processing, particularly PET bottles, but that has not happened at scale yet. Many of the higher-end hotels on the island were able to afford to switch to compostable plastic for to-go ware when the import ban went into place; however, those items are still destined for the landfill as industrial composting does not currently take place at hotels. Some hotels are also moving towards lower waste options such as refillable shampoo bottles and water refill stations, but this is not universal.

Anecdotally, several interviewees felt that the general litter found on the island comes largely from residents and not from tourists or visitors, but the sheer number of visitors can put a burden on an already near-capacity waste management system. There are key opportunities to collaborate with this sector to ensure it is contributing to circular and zero-waste systems on the island and not providing additional challenges or barriers. Messaging and practices among tourism operators could also be streamlined and mandated. Many tourism operators already provide water refill options to their guests, low-waste snacks such as fruit, and other options to minimize their impact, and there may be opportunities to expand upon those actions and make them mandatory through permitting or otherwise. With respect to the cruise ship sector, it may also be worth exploring whether cruise ships that typically deposit waste on the island could transport recyclables or other waste either back to their main ports in the United States where there is enhanced solid waste management infrastructure or to other islands that have facilities to handle those materials based on a regional economy of scale.

As is the case with many solid waste operations worldwide, DSWMC often struggles with not having enough funding to complete all of the work that the department wants and needs to do. Some portion of the visitor levy is currently allocated to DSWMC to supplement their annual budget, which interviewees noted has comprised around 30-40% of the total budget when fully operational. However, hurricanes and the COVID-19 pandemic in recent years heavily limited that influx of funds. As tourism begins to rebound, it will be important for the Customs Department, the Treasury Department, and DSWMC to work closely to ensure those funds are allocated as intended. DSWMC also receives a small amount of funding directly from IATA for flights that come into the island, which could potentially also be revisited as tourism rebounds. There may be other creative solutions to supplement those funds, such as additional zero-waste, circular economy, or sustainability taxes for incoming visitors or tourism operators such as cruise lines. The funds that private companies pay for importing goods as part of the Environmental Tax in Dominica could also be allocated towards waste management and circularity initiatives.

In general, local businesses should be engaged in conversations with DSWMC about the Global Plastics Agreement, goals, implications, and opportunities to ensure alignment moving forward.

4.8.6 End of Cycle: Disaster Preparedness

Waste management is intrinsically linked to Dominica's efforts to become a climate-resilient island and to enhance disaster preparedness. When a major hurricane hits Dominica, the cleanup of debris and waste is largely the responsibility of the Public Works department and now DSWMC, but the DSWMC landfill is often used as a holding location for the collected items. Interviewees mentioned that Hurricane Maria demonstrated the need for a dedicated landfill for hurricane and other natural disaster cleanup. The landfill is already nearing capacity, and the input from the hurricane was reportedly too much for the island to handle. In addition, littering and mismanaged waste can exacerbate flooding and decrease the effectiveness of stormwater management and drainage systems that the island is continuously developing. It would be beneficial for waste management to be taken into consideration for any further disaster relief and climate resilience planning in Dominica.

4.9 Leakage

To better understand the quantities, types, and sources of litter in Dominica, systematic litter surveys were conducted for different environments and contexts across the island. This included land-based surveys, coastal beach surveys along the west coast of the island, nearshore floating debris surveys, and microplastic surveys from ocean samples around the island. Dominica has a Litter Act that was put in place in 1990 and further amended in 1997 (UNEP LEAP 2024), which includes language around fines for littering, though interviewees noted that the law is not well enforced and that fine quantities may need to be adjusted. As an island nation with 365 rivers, is it critical for Dominica to enact litter prevention measures throughout the island to prevent waste from ultimately entering the ocean, particularly during major rain events.

4.9.1 Leakage: Land-Based Litter

In total, 4,023 items were logged in 50 land-based transects (each approximately 100m^2) characterizing 4.36 square kilometers across the island (Figure 4.45). Transect locations were selected using a stratified random sampling method, in which transects were randomly selected in ten square 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 can be found in the Appendix (Table A1).

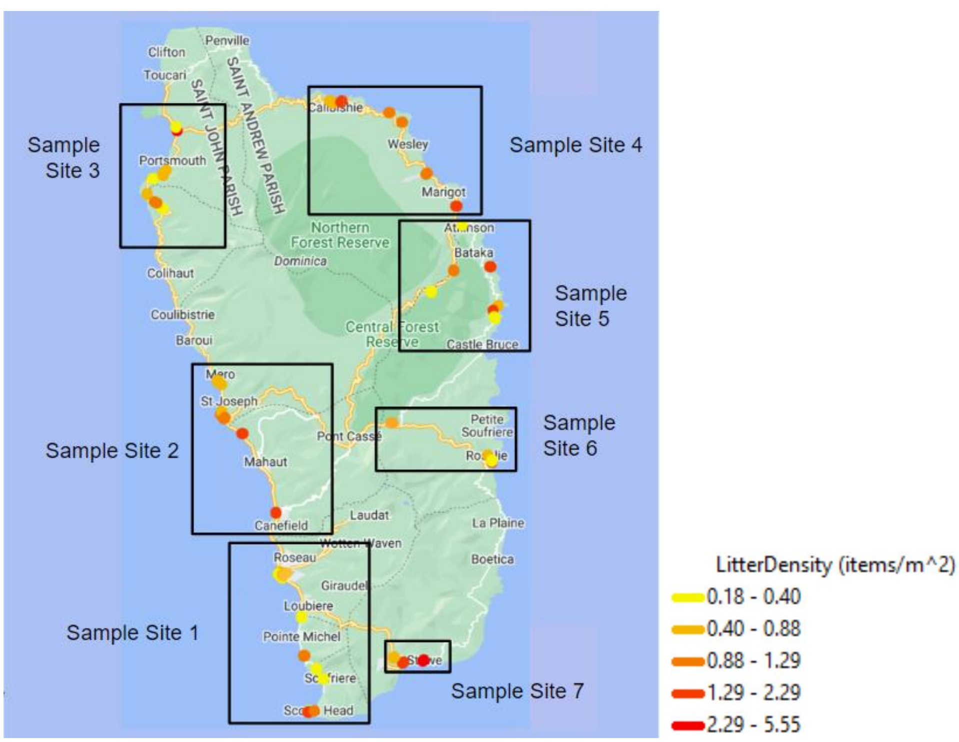


Figure 4.45: Average litter densities observed across sample sites in Dominica

The vast majority of littered items surveyed were plastic items (~70% of all items). The most common material type of land-based litter surveyed was food plastic (41% of items), followed by plastic fragments, metal, glass, and paper. Other material types, such as tobacco products and other plastics, comprised less than 5% of litter items respectively (Figure 4.46). Popular common plastic items (including food plastic, plastic fragments, PPE, personal care items, and other plastic) comprised 63% of all litter items surveyed. This is higher than other similar locations, such as 55% observed in Miami, 39% in Aruba, 48% in Hilo, and 37% in the Maldives.

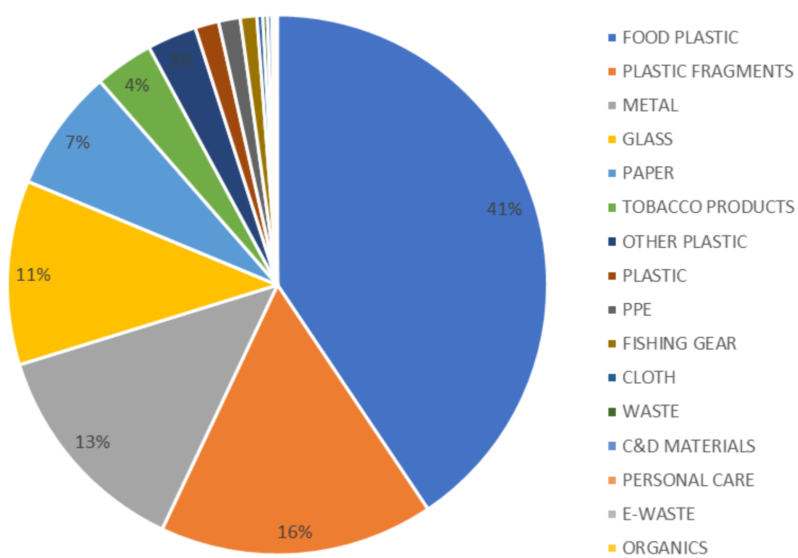


Figure 4.46: Material Breakdown for Land-Based Litter in Dominica

Across all land-based litter surveys, the top five most common items were 1) hard plastic fragments, 2) plastic food wrappers, 3) plastic bottles, 4) plastic bottle caps, and 5) metal bottle caps or tabs. However, it is worth noting the high abundance of hard plastic fragments that were found at Site 6, on Rosalie Beach on the east coast, which may have skewed the data (Figure 4.47). This Site had the highest litter density among the land-based sites and over 50% of the litter observed there was hard plastic fragments. The high density of small, brittle, hard plastic fragments along the windward and Atlantic side of the island is likely indicative of marine debris and litter that originated elsewhere and was transported to the coast, as has been observed in other parts of the Caribbean (Courtene-Jones et al., 2021).

Figure 4.47: Density of hard plastic fragments found at Site 6 on Rosalie Beach

If the data from Site 6 is removed, then plastic fragments become the third most abundant material type overall instead of the most abundant, and the top five most common litter items become: 1) plastic food wrappers (12% of items), 2) plastic bottles (11% of items), 3) hard plastic fragments (9% of items), 4) plastic bottle caps (8% of items), 5) metal bottle caps or tabs (7% of items) (Figure 4.48). Importantly, many of those top items, particularly plastic bottles and caps, are readily recyclable. Other non-recyclable litter items, such as plastic films from small bags of candy and ice pops, should be targeted for redesign, reuse, or collection to reduce instances of litter.

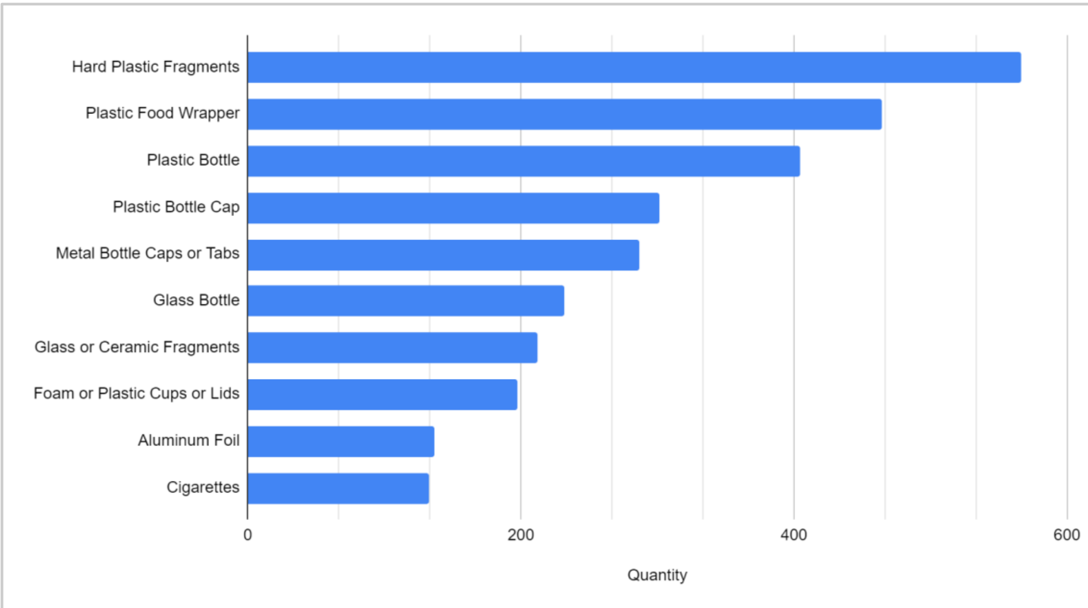


Figure 4.48: Quantity of the top ten litter items observed in Dominica

Other scientific studies have shown that common marine litter items in Latin America and the Caribbean (LAC) include plastic bottles, plastic food packaging, and abandoned, lost, or otherwise discarded fishing gear (ALDFG), and land-based litter items are dominated by tobacco products, plastic fragments, and food plastic, specifically plastic bottles, cigarette butts, and plastic bottle caps (Diez et al., 2019; Brooks et al., 2020; Courtene-Jones et al., 2021). Dominica follows a similar trend, but there was a lower abundance of tobacco products and a higher quantity of recyclable items such as plastic bottles found in the litter surveys.

Other island locations, such as Hawaii and Aruba, have established bans on SUP grocery bags and on foam to-go ware products. Aruba is implementing bans on additional SUP products as part of their Plastic Ordinance, such as cups, straws, and stirrers. There is a higher density of littered plastic grocery bags observed in Dominica and other locations without existing policies such as the Maldives when compared to locations with plastic bag bans (Table 4.9). The Maldives, however, is planning a plastic bag policy for 2025. The density of plastic bottles in Dominica is comparable to that of Aruba, though lower than the Maldives and higher than Hilo, Hawaii. This could be due to differences in access to curbside recycling and PET recycling markets on-island. Dominica has a comparatively low density of plastic and foam container litter, which could be in part due to the transition towards fiber and biodegradable food containers as part of their SUP policy. However, Dominica has a comparatively high density of plastic cups and lids, which could represent the compostable alternatives such as PLA that were often found in the store and restaurant surveys. Precautions and policies should be put in place to ensure that those items still do not end up littered in the environment, as they will not break down naturally and could still pose a threat to the natural environment, flooding risks, and human health.

Table 4.9: Comparative litter densities in island contexts

Item	Average items per transect in Maldives (items/100 m^2)	Average items per transect in Hilo, HI (items/100 m^2)	Average items per transect in Aruba (items/100 m^2)	Average items per transect in Dominica (items/100 m^2)
Plastic grocery bags	4.48	0.03	0.67	1.42
Plastic and foam cups or lids	1.78	0.42	1.71	3.94
Plastic utensils	1.81	0.22	0.85	0.90
Straws	1.07	0.19	1.63	0.34
Plastic and foam containers	1.85	0.33	0.22	0.16
Plastic beverage bottles	17.26	0.44	8.74	8.08

Importantly, litter was also often co-located with storm drains, canals, open dumping areas, or other natural areas of accumulation for litter and waste (Figure 4.49). This can pose a challenge to infrastructure and resilience and can also be difficult to clean in certain locations, such as cliff-side dumping spots.

Figure 4.49: Example litter photos from canals (left), open areas (right), and along cliff sides (right)

When compared across ambient population density, differences can be observed in the most common material types for litter (Figure 4.50). For example, lower ambient population areas had the highest proportion of food plastic items, whereas middle ambient population areas had the highest proportion of plastic fragments. Relatively similar proportions were observed for non-plastic litter items such as glass and paper. These differences could suggest discrepancies in access to waste management, messaging and outreach, or collection infrastructure available in those locations.

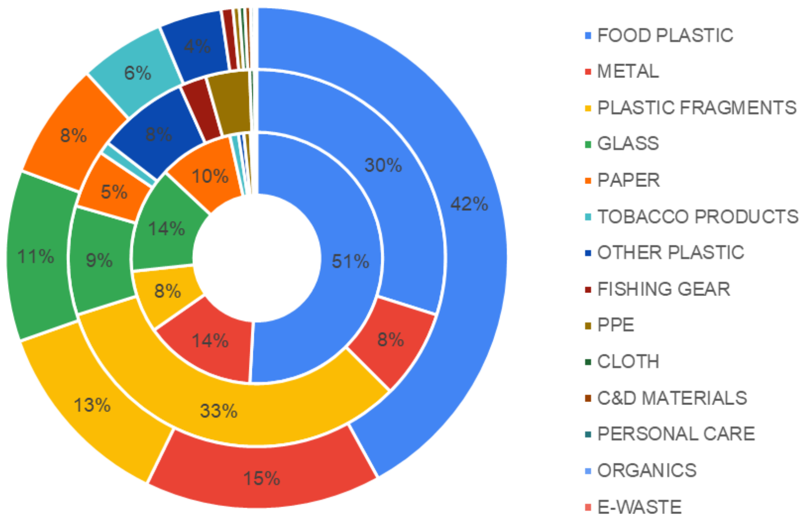


Figure 4.50: Proportion of most common plastic items in low (inner), mid (middle), and high (outer) population count areas in Dominica

Different material types can also be observed based on physical geography (Figure 4.51). For example, food plastic was the most common litter item by material type on average in all sampling locations except for Site 6 near Rosalie Beach. Fishing gear and miscellaneous plastic items were more often found in fishing communities, such as Stowe in the south. Metal items were also often found in areas with higher societal activity, such as car parts and metal fragments in residential and busy areas. Tobacco products were also more readily found in areas such as Roseau where there were more people during the day and more activity in the evenings. Understanding the most problematic litter items in different locations can help target interventions and messaging to prevent those items from entering the environment.

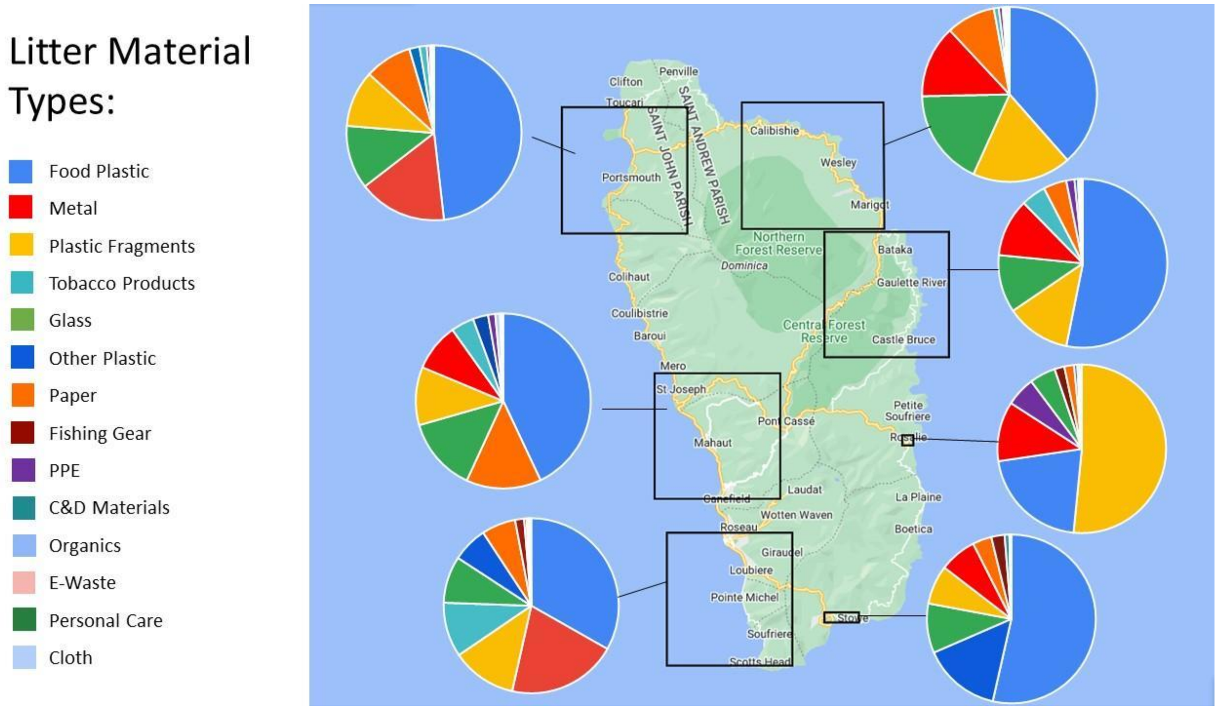


Figure 4.51: Litter material types observed by sample site

Litter density can also be observed based on ambient population density (Table 4.11). In Dominica, the highest average litter density was observed in areas with middle ambient population, followed by areas of high ambient population, and the lowest litter density was observed in areas of low ambient population. This could be a positive indication that more rural areas still have access to waste collection and are using those services, or it could be a matter of less litter in areas where people often do not visit or live in the inner parts of the island. Average land-based litter density in Dominica, at around 0.92 litter items/m^2, is relatively similar or low compared to other locations, such as 2.52 items/m^2 in Aruba, 2.58 items/m^2 in Miami, 1.12 items/m^2 in the Florida Keys, 2.92 items/m^2 in the Maldives, and 0.27 items/m^2 in Hilo.

Table 4.10: Litter Density and Top Litter Items for Each Area of Population Count

Population Tertile	Top 5 Litter Items	Litter Density (count/m2)
High (n=29) 94 - 6,885 people/km^2	1) Plastic Food Wrapper 2) Hard Plastic Fragments 3) Plastic Bottle 4) Metal Bottle Caps or Tabs 5) Plastic Bottle Cap	0.95 items/m^2
Medium (n=10) 25 - 94 people/km^2	1) Hard Plastic Fragments 2) Plastic Bottle Cap 3) Plastic Bottle 4) Glass or Ceramic Fragments 5) Bottle or Container Caps	2.04 items/m^2
Low (n=11) 1-25 people/km^2	1) Plastic Food Wrapper 2) Plastic Bottle 3) Glass Bottle 4) Aluminum Foil 5) Plastic Bottle Cap	0.77 items/m^2

Differences in land-based litter density, common materials, and common items can also be seen across physical geographies (Table 4.12). Observed litter densities were on average highest at Site 6, where a large quantity of hard plastic fragments was found on the windward and Atlantic side of the island. Litter densities were also high at Site 7 in the south and Site 4 in the northeast. The lowest litter density was observed at Site 1 in the southwest. Hard plastic fragments and food wrappers were among the top five most common litter items in all geographic areas. Most also had a high amount of plastic bottle caps, metal bottle caps or tabs, and plastic bottles. Plastic bottles were the most common litter item found at Site 3 in the northwest and at Site 7 in the south.

Table 4.11: Top Litter Material Types, Items, and Density for Land-Based Surveys in Dominica

Sample Site Area	Top 3 Litter Materials	Top 5 Litter Items	Average Litter Density
Site 1 (n=12)	1) Food Plastic, 2) Metal, 3) Plastic Fragments	1) Metal Bottle Caps or Tabs, 2) Hard Plastic Fragments, 3) Cigarettes, 4) Plastic Food Wrapper, 5) Plastic Bottle Cap	0.65 items/m^2
Site 2 (n=7)	1) Food Plastic, 2) Paper, 3) Glass	1) Plastic Food Wrapper, 2) Plastic Bottle, 3) Hard Plastic Fragments, 4) Glass Bottle, 5) Other Paper	1.07 items/m^2
Site 3 (n=8)	1) Food Plastic, 2) Metal, 3) Glass	1) Plastic Bottle, 2) Plastic Food Wrapper, 3) Plastic Bottle Cap, 4) Hard Plastic Fragments, 5) Foam or Plastic Cups or Lids	0.87 items/m^2
Site 4 (n=7)	1) Food Plastic, 2) Plastic Fragments, 3) Glass	1) Plastic Food Wrapper, 2) Hard Plastic Fragments, 3) Glass or Ceramic Fragments, 4) Glass Bottle, 5) Plastic Bottle	1.18 items/m^2
Site 5 (n=7)	1) Food Plastic, 2) Plastic Fragments, 3) Metal	1) Plastic Food Wrapper, 2) Hard Plastic Fragments, 3) Plastic Bottle, 4) Glass Bottle, 5) Metal Bottle Caps or Tabs	0.93 items/m^2
Site 6 (n=6)	1) Plastic Fragments, 2) Food Plastic, 3) Metal	1) Hard Plastic Fragments, 2) Plastic Food Wrapper, 3) Plastic Bottle Cap, 4) Hair nets, 5) Aluminum Foil	2.24 items/m^2
Site 7 (n=3)	1) Food Plastic, 2) Other Plastic, 3) Glass	1) Plastic Bottle, 2) Plastic Bottle Cap, 3) Bottle or Container Caps, 4) Plastic Food Wrapper, 5) Foam or Plastic Cups or Lids	1.92 items/m^2

For some litter items, the team was able to also identify the brands present (Figure 4.52). For plastic cups, the most common brand identified was from KFC fast food, most commonly plastic-lined paper cups, and around 40% of all plastic cups identified in the litter surveys were made of PLA, a compostable plastic that required industrial composting. Among plastic bottles, the most common brands identified were Trois Pitons, Coca-Cola, Busta, Sprite, and Quenchi - over half of which come from a domestic distributor. The most common brands identified among glass bottle litter were Carib, Kubuli, and Heineken, which may highlight opportunities to improve upon or expand glass bottle return programs. Anecdotally, interviewees felt they saw less glass bottle litter from local brands that offered return/deposit after that program went into place. Among plastic food wrappers, which was the second most common litter item found across all land-based surveys, the most popular brands identified were Candy Mints, Holiday chips, chewing gum, Bermudez, and Xtime. Several of those brands are also manufactured and distributed within the Caribbean and may present opportunities for regional extended producer responsibility and product redesign.

Figure 4.52: Examples of top brands found in litter items

Dominica has a National Employment Program (NAP) that assists in roadway cleanups across the island. There is a group of NEP workers in each community who are hired by the government to clean roadways twice a month. They have set collection days for litter that they collect with DSWMC to ensure it is properly disposed of. From anecdotal observation, it is clear that areas with a strong NEP presence have less litter and are overall well-maintained and clean (Figure 4.53). This is a strong and effective program that should be continued and supported throughout Dominica.

Figure 4.53: Examples of roadside areas maintained by NEP

4.9.2 Leakage: West Coast Beach Litter

In addition to the randomized land-based litter sampling, ten coastal and beach areas along the west coast of Dominica were selected for litter surveys. These were selected based on locations where DSWMC had previously conducted litter surveys and was planning to do ongoing research (Figure 4.54). In total, 1,692 litter items were logged across the ten coastal sites, covering a roughly 1,200m^2 area. The average litter density observed in these areas was 1.36 items/m^2, which is slightly higher than the land-based litter densities observed. Over half of these sampling locations were associated with a storm drain, canal output, or informal open dumping site.

Figure 4.54: Coastline and Beach Litter Sampling Locations in Dominica

The material breakdown of coastal litter items was similar to that of the land-based survey, with the highest proportions of litter being plastic fragments (44%) and food plastic (30%) (Figure 4.55). These two categories comprised nearly 3⁄4 of all litter surveyed along the coast. Glass was observed at a slightly lower percentage, but metal and paper items were observed less on average in coastal locations compared to land-based surveys. Not surprisingly, fishing gear comprised a higher proportion of waste found on coastal surveys than land-based surveys.

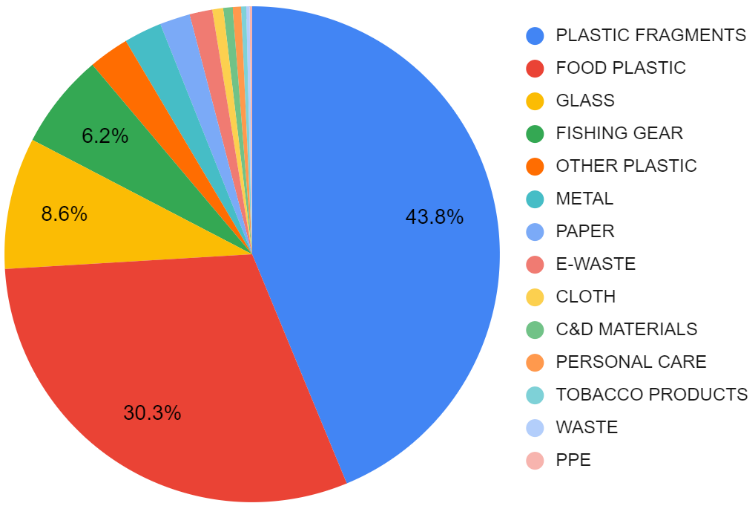


Figure 4.55: Material Breakdown for Coastline and Beach Litter in Dominica

The top ten most common litter items found in the coastal litter surveys included: 1) hard plastic fragments, 2) foam fragments, 3) plastic bottles, 4) glass or ceramic fragments, 5) plastic bottle caps, 6) other fishing gear, 7) film fragments, 8) plastic food wrappers, 9) plastic string/tape/or packing straps, and 10) plastic utensils (Figure 4.56). It is worth noting that some of the plastic utensils identified may have been compostable plastic, but it is difficult to make the distinction when the item has been in the environment and is not well marked.

Figure 4.56: Example of beach litter on the west coast of Dominica near a storm drain outlet (left) and resulting from dislodged trash bins (right)

Geographical differences were observed in litter materials, items, and densities across the coastal survey locations (Table 4.13). The highest litter density was observed at Boy Boy Beach, which had a higher litter density than any of the land-based litter transects. Observed litter densities were also higher than that of the land-based litter transects at Donkey Beach, Rockaway Beach, Soufriere Beach, and both the Caribbean and Atlantic sides of Scotts Head Beach. The lowest litter density was observed at Champagne Beach, which is an area that is relatively maintained and regularly cleaned as it is a popular spot for tourism. All types of plastic fragments were found across the sample sites and plastic bottles remained a common litter item.

Table 4.12: Top Litter Material Types, Items, and Density for Coastal and Beach Surveys in Dominica

Transect Area	Top 3 Litter Materials	Top 5 Litter Items	Average Litter Density
Belle Hall Beach	1) Plastic Fragments, 2) Glass, 3) Tobacco Products	1) Hard Plastic Fragments, 2) Paper Cups, 3) Glass or Ceramic Fragments, 4) Cigarettes, 5) Glass Bottles	0.28 items/m^2
Purple Turtle Beach	1) Food Plastic, 2) Plastic Fragments, 3) Glass	1) Glass or Ceramic Fragments, 2) Hard Plastic Fragments, 3) Compostable plastic container or clamshell, 4) Compostable cups, 5) Plastic Bottle Cap	0.55 items/m^2
Mero Beach	1) Plastic Fragments, 2) Food Plastic, 3) Metal	1) Hard Plastic Fragments, 2) Plastic Utensils, 3) Plastic Bottle Cap, 4) Film Fragments, 5) Plastic Bottle	0.89 items/m^2
Donkey Beach	1) Plastic Fragments, 2) Food Plastic, 3) Paper	1) Foam Fragments, 2) Hard Plastic Fragments, 3) Plastic Bottle, 4) Plastic Bottle Cap, 5) Plastic Food Wrapper	1.87 items/m^2

Rockaway Beach	1) Plastic Fragments, 2) Food Plastic, 3) Paper	1) Foam Fragments, 2) Plastic Bottle, 3) Hard Plastic Fragments, 4) Film Fragments, 5) Paper fragments	1.59 items/m^2
Boy Boy Beach	1) Plastic Fragments, 2) Food Plastic, 3) Glass	1) Plastic Bottle, 2) Foam Fragments, 3) Hard Plastic Fragments, 4) Film Fragments, 5) Plastic Bottle Cap	3.57 items/m^2
Champagne Beach	1) Plastic Fragments, 2) Food Plastic, 3) Paper	1) Hard Plastic Fragments, 2) Foam Fragments, 3) Plastic Bottle, 4) Compostable plastic container or clamshell, 5) Film Fragments	0.19 items/m^2
Soufriere Beach	1) Glass, 2) Plastic Fragments, 3) Food Plastic	1) Glass or Ceramic Fragments, 2) Hard Plastic Fragments, 3) Plastic Food Wrapper, 4) Plastic String/ Tape/ or Packing Straps, 5) Plastic Bottle	1.91 items/m^2
Scotts Head Beach (Caribbean)	1) Plastic Fragments, 2) Food Plastic, 3) Fishing Gear	1) Hard Plastic Fragments, 2) Plastic Bottle Cap, 3) Foam Fragments, 4) Film Fragments, 5) Fishing Line	1.49 items/m^2
Scotts Head Beach (Atlantic)	1) Food Plastic, 2) Plastic Fragments, 3) E-Waste	1) Hard Plastic Fragments, 2) Plastic Bottle, 3) Plastic Bottle Cap, 4) Film Fragments, 5) Plastic Grocery Bag	1.22 items/m^2

Anecdotally, several interviewees mentioned that they believed most of the coastal litter in Dominica originated from land-based sources and was not from human activity taking place on the beaches themselves. In some locations, such as Purple Turtle, Mero, and Champagne beaches, the higher presence of compostable foodware may be indicative of direct dumping from patrons of local food vendors or people that are bringing food to the beach for recreation. As noted earlier, most of those compostable items, particularly the compostable plastic, will not break down naturally in the environment and will behave similarly to standard fossil-based plastic if not properly disposed of. Most of the beaches, however, did demonstrate an abundance of items such as food wrappers and bottles that appeared to have been transported there by nearby storm drains or waterways. Any item of litter that ends up in a coastal area is likely to end up in the ocean, and interventions should be focused on mitigating key sources such as drains, canals, rivers, and local recreation.

4.9.3 Leakage: Nearshore Ocean Litter

A 20 km stretch of nearshore area was also sampled for floating litter via boat (Figure 4.57). In total, 125 litter items were logged. There were intrinsic challenges associated with this type of sampling due to visual reach, rough seas, and the inability to see subsurface or bobbing litter, and data should not be considered an exhaustive sampling of litter in this area.

Figure 4.57: Nearshore Litter Sampling Locations in Dominica

Floating bottles were among the top items identified in the nearshore litter survey; however, it was not always clear which were used as markers or flotation for fishing gear and were intended to be semi-permanent as opposed to those that were floating as litter (Figure 4.58). DSWMC has collaborated in the past with fishermen on waste management, but it would be beneficial for a more formal relationship or set of messaging to be developed around best practices for the disposal of fishing gear, particularly nets, traps, oil, and empty ice bags.

Figure 4.58: Example of floating nearshore marine litter in Dominica

All of the floating litter that was identified in the nearshore surveys was either fishing gear (~70% of items) or food plastic (~30% of items), by material type (Figure 4.59). The top five most common litter items observed were other fishing gear (largely floating bottle markers for fish traps), plastic bottles, plastic bottle caps, plastic food wrappers, and plastic grocery bags.

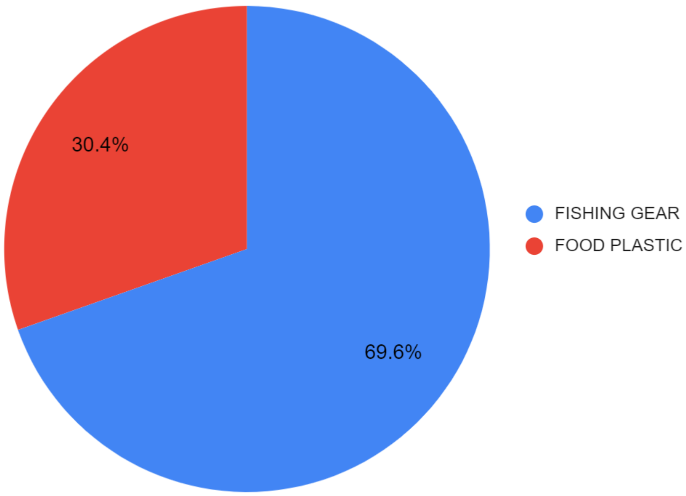


Figure 4.59: Material Breakdown for Offshore Litter in Dominica

It was evident in the nearshore survey that drainage from canals and storm drains, open dumping immediately along the coast, and output from freshwater streams and rivers contributed heavily to the litter that was entering the marine environment around Dominica (Figure 4.60).

Figure 4.60: Sources of floating macroplastic and litter entering the nearshore marine environment - storm drains (left), coastal open dumping (middle), and freshwater streams and rivers (right)

Different solutions may be appropriate in the context of coastal litter and nearshore marine debris in Dominica. These may include storm drain nets, river booms, or other interception devices. A river boom was attempted during fieldwork in Dominica in Canefield using a 10-ft plastic bottle boom from Elastec (Figure 4.61). The boom was able to trap a fiber food container, a plastic glove, a paper cup from KFC, two plastic bottles, and three food wrappers over the course of five days, but the flow of the river was very heavy and it is estimated that not all floating litter items were effectively trapped.

Figure 4.61: River boom that was piloted in Canefield in April 2023

It may be useful to explore something more permanent and sturdier that could perhaps be maintained by local school groups, youth groups, or otherwise. It is clear that the hydrology of the island plays a key role in contributing to marine litter and the many rivers, streams, and drain outlets across the island should be prioritized for interventions. This is also critical to Dominica's endeavor for climate resilience, as eliminating waste along drains and canals can alleviate flooding and reduce risks during major weather events.

The west coast of Dominica is also a critical habitat for the local population of sperm whales. While individuals are known to move between Dominica, Martinique, and Guadeloupe, over half of the individuals from that regional unit are regularly identified on the leeward side of Dominica and there is a large resident population (Rinaldi et al., 2020). Many studies recognize that this population has been in decline in recent years - in part due to increased occurrences of water pollution, entanglement in fishing gear, and ingestion of marine debris - with estimated annual decline rates of 4.5% - 6.2%. (Gero et al., 2016; Rinaldi et al., 2020; Vachon et al., 2020). The Dominica Sperm Whale Project and Project CETI are among the groups that have been monitoring this population. Dominica remains a tourism hub for vessel-based whale watching in the Lesser Antilles and was one of the first and only islands to also offer swim-with-whale opportunities for tourists. As such, sperm whales contribute heavily to the local economy through tourism and play a key role in the local marine ecosystem, but these same activities need to be regulated to minimize the impact on the whales themselves and their habitat. It is important to ensure that steps are taken to minimize local impacts on sperm whales, particularly through mitigating marine debris and other point-source pollution, to protect this unique population for generations to come.

It has been well-documented that plastic fishing line, plastic bags, and other plastic marine debris pose a serious threat to sperm whales and other marine megafauna. Sperm whales are among several cetacean species worldwide that have been readily observed actively interacting with plastic marine debris (Rodriguez et al., 2023). One popular story in 2019 documented a baby sperm whale named Digit off Dominica that had fishing line entangled in his fluke for three years (Welch, 2019). Necropsies worldwide have shown cases of gastric rupture, starvation from gastric blockage, and physical entanglement as causes of death for sperm whales.

This is not only caused by common marine debris such as plastic bags and fishing line, but examples have also found pieces of candy wrappers, clothing hangers, bottles, mattresses, appliances, rope, coffee capsules, pipe, and other land-based and household plastic items in the stomachs of stranded sperm whales (Jacobsen et al., 2010; de Stephanis et al., 2013; Unger et al., 2016; Tonay et al., 2021). Studies have also suggested that these items were ingested by sperm whales at the surface as debris, instead of perhaps bitten off from operational or active fishing gear in the water column (Jacobsen et al., 2010). Understanding the sources of these fatal types of marine debris is critical for upstream prevention to ensure that these items are not entering the terrestrial environment, and ultimately reaching the ocean, in the first place.

4.9.4 Leakage: Offshore Microplastics

As part of the National Geographic Pristine Seas expedition to Dominica in 2022, water samples were collected from surface water and analyzed for microplastic concentrations and characteristics (Figure 4.62). Grab samples of water were collected from the surface layer using 1,183 mL stainless steel bottles, which were triple-rinsed with seawater near the collection site prior to collection. The water samples were filtered through cellulose acetate filters with a 10-micron pore size, and the filters were stored in aluminum pans covered in aluminum foil. Precautions were taken by researchers to avoid contamination of microplastics both onboard for the filtration and for the analysis for microplastics conducted. A random selection of 11 of 28 sample filters were then analyzed with spectrum microscopy methods for the presence of microplastic particles. Samples were opened and analyzed in a class 10,000 clean room at the New Materials Institute at the University of Georgia. A high-throughput Raman microscope was used to survey the spectrum of many thousands of microparticles down to about 30 µm (n =

8,304 spectra) and blank controls were used to evaluate microplastic concentrations from samples.

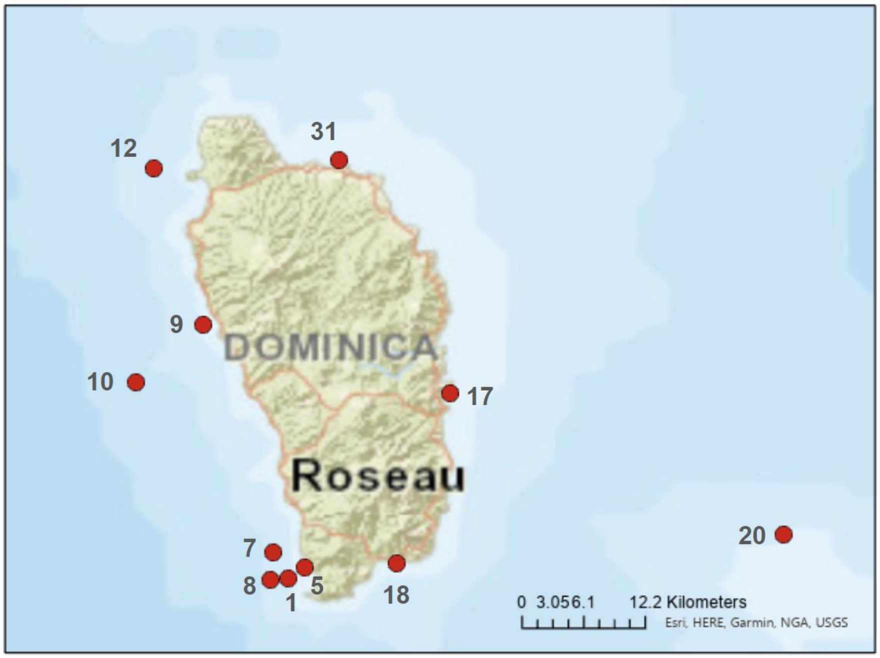


Figure 4.62: Locations of ocean microplastic sampling by the National Geographic Pristine Seas Team

Out of the 11 water samples that were randomly selected for analysis, five contained microplastics. A total of nine particles were detected across all samples analyzed. Polymers identified included PE, HDPE/LDPE, PS, and PET. The most common polymer identified from the surface water samples was PET.

While the quantities of microplastics appear low, they are significant due to the low volume of water sampled (Table 4.14). In 2021, a Caribbean-wide study of microplastics found an average of 1.17 microplastic particles per m^3 (or 1,000 L) of surface water sampled via manta trawling. Quantities ranged from zero microplastics detected in some locations in Aruba and Colombia to a maximum of 5.09 particles/m^3 detected in the San Blas Islands in Panama. Types of polymers also differed significantly between locations (Courtene-Jones et al., 2021). Comparatively, the highest quantity of microplastics observed in the Dominica surface water samples was 3 particles (from sample DMA_MP_08). As this was from a 1.18 L water sample, this would extrapolate to 2,535 particles/m^3, which is magnitudes higher than that observed in Courtene-Jones et al. However, further analysis using higher water concentrations and more comprehensive area coverage would be required to provide an accurate estimate of that extrapolated microplastic quantity.

Table 4.13: Microplastic quantities and characterization from surface ocean water samples in Dominica

Sample ID	**PE**	**PP**	**PS**	**PET**	**PVC**	**HDPE / LDPE**	**Nylon-6,6**
DMA_MP_01	0	0	0	1	0	0	0
DMA_MP_05	0	0	0	0	0	0	0
DMA_MP_07	0	0	0	0	0	0	0
DMA_MP_08	0	0	0	3	0	0	0
DMA_MP_09	0	0	1	0	0	1	0
DMA_MP_10	0	0	0	0	0	0	0
DMA_MP_12	0	0	0	0	0	0	0
DMA_MP_17	0	0	0	0	0	0	0
DMA_MP_18	0	0	1	0	0	0	0
DMA_MP_20	1	0	0	1	0	0	0
DMA_MP_31	0	0	0	0	0	0	0
Total Sample Microplastics	**1**	**0**	**2**	**5**	**0**	**1**	**0**

The fact that five of the nine found microplastic particles in Dominica were PET is also important to highlight. These smaller particles of PET appear to be fibrous fragments and are likely found at the surface waters due to their small size. Such PET fibers may have come from land-based sources (e.g., laundering of PET-based clothing), although a more comprehensive survey would be required to confirm the source of these microplastics. PET was also among the top littered items found in Dominica and the material, in the form of beverage bottles, is regularly used as a marker and flotation device for nearshore fishing gear, which would also contribute to marine PET microplastics (Figure 4.63). As PET has a density greater than that of sea water, coupled with the high quantity of PET found in litter surveys in Dominica, this may suggest that a higher concentration of PET microplastics could be found in subsurface waters or sediments in Dominica, as has been found on other locations in the Caribbean (Courtene-Jones et al., 2021). There are opportunities for further investigation and ongoing monitoring of these factors in Dominica through the local university, DSWMC, and the local Bureau of Standards.

Figure 4.63: Example of PET bottles used for fishing gear markers and buoys

The presence of microplastics in ocean water also raises concerns about concentrations in local fish species, particularly species that are regularly ingested by humans. Fish protein comprises a large proportion of the local diet in the Caribbean. Instances of food-borne diseases and toxins have been well documented in Caribbean fish species and remain a concern for local food sources (Tester et al., 2010; Hull-Jackson et al., 2019). Recent studies have also found microplastics in commercial fish species across the Caribbean, though impacts on human health among populations that depend on those species for food in the region is not as well documented (Aranda et al., 2022; Garcés-Ordóñez et al., 2022; Orona-Návar et al., 2022). Studies have, however, demonstrated clear linkages between microplastics and negative impacts on human health, such as occurrences of asthma, cancer, cardiovascular disease, pulmonary disease, decreased fertility, and others (Landrigan et al., 2023). Further research should be conducted to investigate the prevalence, characteristics, and sources of microplastics in the waters surrounding Dominica and the associated potential ecosystem and human health impacts.

4.10 Key Findings and Opportunities

CIL found the following opportunities to expand and enhance circularity in Dominica 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 could 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	**Findings:** In total, 225 unique brands of convenience products were collected and sampled from 37 convenience stores across Dominica. Among all of the five convenience product categories (beverages, candy, chips, tobacco, and biscuits/wafers), each had at least one manufacturer that was located domestically in Dominica. The United States, Trinidad & Tobago, and Jamaica were among the top importing countries for convenience products. Across all product categories, Dominica-based operations represented around 6% of the market both among manufacturers and parent companies. Opportunities exist to enhance local manufacturing and business opportunities and to mobilize regional partnerships for extended producer responsibility (EPR), product redesign, and takeback schemes. **Opportunities:** ● Adjust Dominica's SUP import ban and policy to be based on the type of polymer or resin code instead of the product labeling to ensure non-biodegradable or non-compostable items are not being imported; support enforcement mechanisms and polymer testing infrastructure ● Target key importing countries for FMCGs, such as the United States, Trinidad & Tobago, and Jamaica, for potential extended producer responsibility or collaborative waste collection and recycling options, particularly for the most problematic plastic items such as films ● Explore opportunities to bottle local spring water, including revisiting infrastructure proposals from pre-Hurricane Marina, or increase production from local operations such as Trois Pitons to reduce bottled water importation from other parts of the Caribbean
COMMUNITY	**Findings:** Semi-structured interviews were conducted with 28 key stakeholders, including local government officials, students from the local university, private companies (including tourism operators), community leaders, non-profit organizations, private store owners, and private restaurant owners. Interviewees expressed general support for the single-use plastic (SUP) ban in Dominica and for increased opportunities around recycling. There was a unanimous need to increase education, outreach, and consistent messaging to the public and to businesses around waste separation, particularly at key events (e.g., music and cultural festivals) and through existing popular channels (e.g., radio shows and social media). Interviewees expressed the importance of making changes affordable and convenient and stressed that messaging and incentives need to be able to reach all consumers, not only those who care strongly about the environment or nature. **Opportunities:** ● Strengthen existing solid waste and SUP policies and legislation within Dominica, including but not limited to Utility Fees and the Litter Act and associated fin structures - complement this with learning exchanges with other Caribbean nations that have implemented SUP bans, such as Saint Kitts & Nevis and Antigua & Barbuda ● DSWMC could host a formal national campaign around sorting household waste at source, taking learnings from the Kalinago Zero Waste pilot ● Bolster public education and awareness (including school programs, cleanups, regular radio shows, cultural events, billboards) particularly around littering and environmental preservation, with ties to messaging around protecting the Nature Island, and ensure this is extended to visitors and tourists ● Develop clear messaging around the disposal of compostable plastics that can be targeted for restaurants, the general public, and tourism operators/tourists

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Provide additional support, budget, and staff for marketing, education, and outreach around solid waste management through DSWMC
Consider hosting a Caribbean-wide convening to share SWM best practices, network across groups, and identify shared goals for INC; this could be conducted through OECS, CARICOM, or other existing networks
Incorporate data around ties to litter, pollution, and human health into public communication, potentially in collaboration with the Ministry of Health

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<td>PRODUCT DESIGN</td>
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Findings: In addition to the 225 convenience items, 108 to-go foodware items were sampled from 40 restaurants and food vendors across Dominica. Convenience product packaging was dominated by multilayer plastic film and PET plastic bottles. The largest proportion of material for to-go foodware was PLA, an industrially compostable plastic, followed by fiber and non-coated paper, reflecting the influence of the SUP import ban. In addition, 9 large grocery stores across the island were surveyed for the material type of packaging of several key household items: Cooking Oil, Eggs, Greens, Laundry Detergent, Milk, Rice, and Sugar. Nearly 50% of all household items sampled were packaged in single-layer plastic bags, followed by those packaged in PET and HDPE. Difficult-to-recycle products such as plastic film could be targeted for product redesign, EPR, bulk/reuse options, or elimination, while recyclable items could be targeted for collection and effective end-markets. Compostable plastic also needs to be handled appropriately, as it will not break down naturally in the environment.

Opportunities:

Consider an updated labeling process, particularly for different types of plastic items, to reduce confusion among consumers and reduce contamination of sorted waste streams - this includes guidance on the packaging related to disposal (e.g., chasing arrows symbol vs. recirculate symbol), which may also require regional discussions and collaborations with manufacturers and importers to ensure harmonization and consistency
Develop incentives and opportunities for expansion of local businesses in SUP alternatives, particularly for foodware, to reduce the reliance on imported goods to meet the needs of the SUP ban
As the most abundant material type among FMCGs, PET bottles and multilayer plastic film could be targeted for product redesign, reuse, or recycling opportunities
Capitalize on lessons learned from other Caribbean and island nations on product design and disposal innovation that has been successful

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USE	**Findings:** Among the 9 large grocery stores that were surveyed, 107 individual SUP and plastic alternative items were identified in the categories of sandwich bags, cups, food containers, plates, utensils, straws, and shopping bags. The most common single-use grocery bag distributed was black plastic labeled “biodegradable LDPE,” which is likely in fact oxo-degradable. Alternative (biodegradable, compostable, alternative material, reusable) household items were unanimously more expensive than single-use plastic options. Many of the alternative brands that were identifiable were imported from the United States, China, the United Kingdom, though there is also a market within Dominica that could be expanded upon. Several countries, including the United States and China, were also found to continue importing standard single-use plastic options. Opportunities exist to strengthen the SUP import ban and other policies and legislation to provide viable and affordable SUP alternatives, grow the local economy, decrease dependence on foreign imports, and increase waste diversion from landfill. Local efforts around the circular economy could also bolster jobs and skilled workers on-island. **Opportunities:** ● Expand upon technology and social media rewards, similar to the WePlanet model, to encourage consumers to bring reusable items - this should be adopted and encouraged by local manufacturers, grocery stores, convenience stores, and food vendors ● Foster business opportunities domestically around reuse models and alternative materials, as well as investment and local capital to support those initiatives - this could include washing/reuse services, development of new SUP-free materials, bottle collection and deposit schemes, government subsidies, or local collaborations for on-island bottling, or otherwise ● Explore opportunities for reusable alternatives or increase the collection and recycling for local juices ● Expand the current SUP import ban to fossil-based plastic grocery bags based on polymer and not based on labeling ● Develop messaging to address community concerns around reuse and refill models, potentially in collaboration with the Ministry of Health, and ensure operations are hygienic, safe, and sustainable
COLLECTION	**Findings:** Investigation into waste collection methods was conducted through stakeholder interviews, site visits to waste collection sites, and reviews of existing waste characterization and related literature. While Dominica has a relatively low per capita waste generation rate compared to other parts of Latin America and the Caribbean, it has a comparatively higher percentage of plastic in the waste stream, presenting challenges for waste diversion and recycling. Coverage for household waste collection across the island is high, but more infrastructure may be needed to ensure waste is properly transported and disposed of after pickup. Household waste sorting and providing source separation waste bins will be important for maximizing diversion from the landfill. **Opportunities:** ● Incentivize and develop clear infrastructure (e.g., marked or colored bins) to support household separation of waste that can maximize recycling, composting, and landfill diversion ● Ensure strategic and segregated collection infrastructure for key events on-island, such as local holidays, cultural events, festivals, and others ● Explore funding options to obtain new collection infrastructure, such as additional collection trucks and potentially transfer stations across the island to decrease the likelihood of trucks dumping waste inland and in ravines ● Take lessons learned from other Caribbean nations (such as case studies from Aruba) on ways to address C&D waste, potentially by developing a dedicated

	landfill or collection area for that type of waste on the island, creating local business opportunities around recycling and repurposing of that waste, or others; similar solutions could be explored for addressing derelict automobile waste in Dominica ● Where possible and appropriate, expand upon the household collection model used in the Kalinago Zero Waste pilot to maximize source separation and diversion ● Explore the possibility of engaging the cruise ship sector and potentially other trade sectors in transporting recyclable waste either back to mainland ports with enhanced solid waste management infrastructure or to other islands with complementary infrastructure in attempts to reach regional economies of scale
END OF CYCLE	**Findings:** The one landfill in Dominica, Fond Cole, is rapidly reaching capacity and only has around 15 years of capacity left if the current expansion is completed. Efforts should be focused on waste diversion away from landfill and optimizing reduction, reuse, recycling, and composting options. Key infrastructure is needed locally, such as a material recovery facility, along with end-markets for waste that could be shared regionally to reach economies of scale. The Kalinago Zero Waste pilot has provided a strong example for household source separation, messaging and outreach, and incentives that can help reduce the amount of waste sent to landfill. There are also key opportunities to align solid waste management (SWM) with local business, tourism, disaster preparedness, and climate resilience. **Opportunities:** ● Develop a National Action Plan to strategize around and prioritize interventions for waste reduction, waste management infrastructure, community outreach and education, alternative materials, business opportunities, and other actions to increase Dominica's circular economy ● Explore funding opportunities for priority SWM infrastructure needs that would contribute significantly to waste diversion, such as industrial composting and/or anaerobic digestion, material recovery facilities, crushers and balers, and others ● Focus funding and resources towards opportunities for waste diversion away from the landfill and away from methods or technologies that may create additional waste or unintended environmental or health consequences, including continuing with and expanding upon the Recycle OECS pilot ● Engage with other Caribbean countries on opportunities for shared recycling markets, shared waste processing infrastructure (e.g., tire shredders, glass crushers, etc.) and economies of scale - this could be started with other countries that have conducted similar analyses and/or are going through similar recycling pilots, such as Grenada, Saint Lucia, and Antigua & Barbuda ● PET bottles could be a key focus for the increase of collection and recycling and may require investment in infrastructure, EPR, community awareness campaigns, and identification of end-markets - it would also be useful to collaborate regionally to ensure economies of scale for proper management of PET ● Ministries could include waste management explicitly in any further disaster preparedness, disaster relief, and climate resilience planning in Dominica, and ensure alignment across departments, agencies, and offices within the government ● Identify creative solutions to supplement funding for government-led solid waste management, such as additional zero-waste, circular economy, or sustainability taxes for incoming visitors or tourism operators such as cruise lines - similarly, a portion of the funds that private companies pay for importing goods as part of the Environmental Tax in Dominica could also be allocated towards waste management and circularity initiatives ● DSWMC has collaborated in the past with fishermen on waste management, but it would be beneficial for a more formal relationship or set of messaging to be

	developed around best practices for disposal of fishing gear, particularly nets, traps, oil, empty ice bags, and other problematic items
LEAKAGE	**Findings:** Litter surveys were conducted across 50 1x1 km^2 land-based transects across the island, 10 coastal and beach locations on the west coast, and along a 20 km stretch of nearshore ocean on the west coast. In addition, 11 1L water samples around the island were surveyed for microplastic concentrations and characterization. The majority of land-based litter (~70%) was plastic. Common items included hard plastic fragments, plastic food wrappers (including small plastic bags from candies and ice pops), plastic bottles, and plastic bottle caps. Slightly lighter litter densities were observed on beach and coastal areas. Open dumping, particularly along the coast and for C&D waste, also presents a key challenge. Interventions should be targeted at preventing land-based litter from entering the ocean via key pathways, such as rivers, canals, and storm drains. **Opportunities:** ● DSWMC could explore collaborations with the Bureau of Standards and local schools to increase litter and microplastic monitoring across Dominica to further research major sources, sinks, and potential health concerns ● Trash intervention mechanisms could be placed along rivers, canals, storm drains, coastlines, and other major land-based sources of marine debris across the island; this could be done in collaboration with DOWASCO ● Conduct further research into the prevalence and potential health impacts of microplastics in key commercial fish species in Dominica ● Engage local tourism operators in documenting and removing litter and debris, particularly from the marine environment (such as dive operators, whale watching trips, and others) ● Work with local school groups, clubs, and businesses to include cleanups as part of regular events, particularly beach cleanups, and continue initiatives such as the annual Clean A Mile and International Coastal Cleanup ● Encourage the use of technology like the Debris Tracker App or others to collect litter data in a standardized format across the island that can be used to track changes over time ● NEP efforts could continue to be funded and supported across the island; where possible, conduct monitoring in those areas to continue demonstrating their positive impact on road cleanliness ● Provide support for enforcement of Litter Act fines, potentially through additional Litter Wardens in rural areas of Dominica

4.11 Conclusion

This study offers the first-ever island-wide CAP to investigate the CE of plastic within the context of Caribbean SIDS. The CAP findings demonstrate opportunities for domestic and regional cooperation around EPR and DRS, particularly for PET beverage bottles, which were a high proportion of land-based litter, coastal/beach litter, nearshore marine debris, and the predominant polymer found in offshore microplastic sampling. Findings highlighted local business opportunities around manufacturing SUP alternatives, reuse models, and product delivery systems that could reduce waste and reliance on imported products. MLP presents a significant challenge on the island, as imported goods are often packaged in this material, but it is likely to end up littered in the environment. The current SUP import ban was found to be effective for preventing the use and littering of problematic items such as EPS, but it was also found that gaps in the policy have led to the import of mislabeled items (such as black plastic bags labeled 'biodegradable LDPE'), and have also led to confusion around how to properly manage the alternatives that are being imported and used. Findings suggest that household waste sorting coupled with increased collection and infrastructure for recycling and composting could be beneficial for waste diversion from the landfill, which is rapidly nearing capacity. This has already been demonstrated through pilot projects, such as the Kalinago Zero Waste Initiative. Litter data and the hydrological profile of the island also highlighted the need for litter capture in waterways, along streams, and at storm drain outputs, particularly to protect the local sperm whale population and coral reef ecosystem on the west coast of the island.

Given the current national, regional, and international efforts around plastic pollution, it would be beneficial to replicate the CAP in Dominica in several years to measure the impact of policies, campaigns, and the National Action Plan. There is also a need for duplication of the CAP in other Caribbean SIDS to help refine opportunities for a regional approach to build economies of scale, particularly around recycling. Conducting other CAPs in the region would also be beneficial given the interconnected nature of plastic pollution in the Caribbean; for example, on the east coast of Dominica near critical leatherback sea turtle nesting grounds, litter surveys demonstrated high quantities of plastic fragment litter which likely originated from elsewhere and was transported to the Dominican coast over time. A high proportion of convenience products also originated from other Caribbean SIDS and countries, further demonstrating the need for regional collaboration. There is also a need for ongoing monitoring of plastic pollution in Dominica. The CAP presents findings for a single snapshot in time, and there may be a benefit to replicating in the rainy and dry seasons, before and after hurricane season, before and after major festivals like Carnival, and other influential events to better identify needs and opportunities.

Islands provide unique opportunities and testing grounds to foster circular systems, and the concept of circularity is particularly important for islands due to a general lack of land space for landfill, an economic reliance on external imports of products often packaged in plastic waste, high quantities of tourism and transient populations, and the presence of natural ecosystems that are often important from a societal, environmental, and economic perspective. Waste reduction and diversion will be critical for Dominica in the coming years to meet the growing demands for SWM and pollution prevention. In many ways, plastic pollution prevention is synonymous with resilience in Dominica. If the island is to become the first climate-resilient nation, per its national strategy, then waste management and pollution prevention must be incorporated into planning across the government, private sector, and communities on the island. The CAP findings are already being used in proposals for SWM infrastructure in Dominica, such as a new MRF at the landfill, in outreach and education campaigns around sorting at source, in school programs and competitions across the island and the Lesser Antilles, and importantly they have been used to inform a National Action Plan on Solid Waste Management and Plastic Pollution Prevention for Dominica. With their role in the region as well as in the UN global plastic agreement negotiations, Dominica has the opportunity to be a leader in developing a circular and resilient island nation.

Chapter 5 : CAP Regional Approach: State of Florida

5.1 Introduction

5.1.1 Plastic Pollution and Waste Management in the United States

The United States (US) is a major contributor to global plastic pollution. Despite being home to only 4.3% of the world's population, the US was the top generator of plastic waste and total waste in 2016. Per capita municipal solid waste (MSW) generation in the US (2.04-2.72 kg/person/day) is among the highest in the world, around 2-8 times the waste generation rates of other countries, and has been increasing since 1960 (NASEM, 2021). While waste collection rates are nearly 100% for North America, over half of all waste collected - of which 12% is plastic - is destined for landfill (Kaza et al., 2018). It has been estimated that 1.13–2.24 MMT of leaked plastic waste entered the environment from the US in 2016 alone, resulting in around 0.84 MMT of plastic litter across the country (Law et al., 2020). The US also plays a strong role in plastic exports and imports, which have increased over the last three decades (NASEM, 2021).

The US Commission on Ocean Policy made marine debris a national ocean priority in 2004 when it called for increased mitigation efforts through the National Oceanic and Atmospheric Administration (NOAA). This eventually led to the Marine Debris Act of 2006, which has since been amended several times and was recently reauthorized through the Save Our Seas 2.0 Act in 2018. Despite its presence on the national agenda, meaningful progress towards combating plastic pollution at the source has largely happened in the US through state and local legislation, including bans on certain products, extended producer responsibility (EPR) policies, and increased waste management capacity (NASEM, 2021). Local and state-level action is critical to addressing plastic pollution and waste management in the US and curbing its significant contribution to plastic leakage.

5.1.2 The Role of Florida

With the second-largest coastline of all US States and an economy highly dependent on tourism, Florida has been at the forefront of national conversations around ocean conservation and marine pollution in the US, and plastic pollution is no exception. In many ways, Florida is advanced in its practices, research, and monitoring for solid waste management. The state is home to the Hinkley Center for Solid and Hazardous Waste (hereafter the Hinkley Center), which is the only state-funded solid waste research center in the US, as well as several state university programs that receive funding for solid waste management research. The Florida Department of Environmental Protection (FDEP) has an extensive solid waste monitoring program and requires annual county-level reporting on solid waste collection, processing, recycling rates, waste composition, and several other metrics. Florida also has an active Marine Debris Reduction Plan since 2017 that is regularly updated and evaluated. The Marine Debris Reporting and Removal program in Florida was created as a partnership between the Florida Department of Environmental Protection (DEP), the Florida Fish and Wildlife Conservation Commission, and Palm Beach County Reef Rescue in 2008 - that same year, Florida became the first US state to pre-empt plastic bans through The Energy, Climate Change, and Economic Security Act of 2008 (House Bill 7135), preventing local action on "auxiliary containers, wrappings, or disposable plastic bags," and current policies are hotly contested (Florida State Legislature, 2011; Bohnsack et al., 2012; Townsend et al, 2021). Other bans on single-use items were still allowed at that time.

There is promising progress being made toward waste reduction and building a circular economy (CE) at the city level in Florida. To date, city ordinances that ban or tax single-use plastic (SUP) products, including items such as polystyrene containers, bottles, and utensils, have been implemented in over a dozen local governments in Florida, and more are using voluntary measures (FDEP, 2021). Studies have suggested that local residents, activists, businesses, and decision-makers are also largely inclined toward these changes (FDEP, 2021). With growing action and momentum at the city level, and ongoing state-level initiatives by NGOs to support local governments in gathering data to inform solutions (see more on Shores Forward below), now is an ideal time to use CAP to build a base of local knowledge and capacity to drive regional change around plastic pollution and waste management in Florida.

5.1.3 Current State of Policy in Florida

5.1.3.1 State-Level Policy

The Solid Waste Management Act (SWMA) of 1988 from the Florida Legislature set a goal of recycling 30% of MSW in all counties across the state by 1994, with a list of "minimum four" materials (aluminum cans, glass bottles, newspaper, and plastic bottles) to reach a goal of 50% recycling rates, which included plastic bottles. That 30% overall MSW recycling goal was amended in 1993 to only apply to counties with populations over 50,000 and a fifth material, steel cans, was added to the 50% recycling rate goal. In 1996, the goal was adjusted to become a 30% MSW reduction goal that only applied to counties with populations over 75,000. In 2002, three more items were added to the material list (cardboard, office paper, and yard trash) for the original 50% recycling goal and the scope for the 30% MSW reduction goal was further reduced to only apply to countries with populations over 100,000. As part of these state-level goals, since

1988, all Florida counties have been mandated to report solid waste and recycling information to FDEP, and FDEP has been mandated to report the information to the Legislature and Governor, though the regularity and requirements around that reporting for FDEP were reduced in 2002 from "annually" to "periodically."

In 2008, the Energy, Climate Change and Economic Security Act (Florida Statute 403.7033/HB 7135) led the Florida Legislature to increase the statewide recycling goal to 75% of the waste stream by 2020 (FDEP, 2010). This goal was explicitly aspirational in nature and cities and counties were not mandated to reach it. As part of that Act, interim goals for recycling rates were set in 2010 for counties to reach 40% by 2012, 50% by 2014, 60% by 2016, and 70% by 2018. According to FDEP, Florida reached the interim goal for 2012 with a statewide recycling rate of 46%, but did not meet the 2014, 2016, or 2018 goals. The latest available statewide Solid Waste Management Report from 2023 reported a recycling rate of 41%, excluding recycling credits for renewable energy and yard trash beneficially using landfill gas (FDEP, 2023). Though this is higher than the national US average recycling rate of 32%, it still falls short of the Florida State Legislature's 75% goal.

In accordance with the Energy, Climate Change, and Economic Security Act, that same year Florida became the first state to pre-empt local-level regulations on plastic bags and wrapping. The statute requests an analysis by FDEP on SUP regulations, and states that, "Until such time that the Legislature adopts the recommendations of the department, no local government, local governmental agency, or state government agency may enact any rule, regulation, or ordinance regarding use, disposition, sale, prohibition, restriction, or tax of such auxiliary containers, wrappings, or disposable plastic bags [used by consumers to carry products from retail establishments] (Florida State Legislature, 2011)." This banned the creation of any new policies related to such items at the time and retroactively made several existing local policies on plastic bags and SUP containers such as polystyrene to-go food containers illegal across the state. Florida is one of 12 US states that have existing or proposed state laws preempting local single-use plastic bag bans or exactions, eight of which, including Florida, also have statewide waste diversion or recycling goals (Harris, 2019).

The preemption has been hotly contested since it went into effect and several pieces of legislation have been introduced to try to allow for flexibility. In 2014, SB 830 was proposed to create statewide standards for reusable bags and recyclable paper bags for relevant municipalities, but the bill died in the Environmental Preservation and Conservation Subcommittee (Florida State Legislature, 2014). Similarly, in 2015, SB 306/HB 661 was proposed to authorize small coastal municipalities to regulate or ban disposable plastic bags, but the bill died in the Agriculture and Natural Resources Subcommittee (Harris, 2019). There has also been strong pushback against these efforts, particularly large lobbying groups. In 2017, the Florida Retail Federation (FRF) sued the city of Coral Gables and prevented the city from enforcing a plastic bag and polystyrene ordinance due to state-level pre-emptions. This case set a legal precedent across the state and resulted in several other local governments repealing their ordinances out of threat of lawsuit by the FRF (Watts, 2022).

Several attempts have been made to overturn the preemption outright. As recently as 2023, a Florida Senator from the city of Orlando proposed SB 498 to remove the preemption for recyclable and polystyrene materials, but this bill also died in Committee (Florida State Legislature, 2024). The Bill was assigned to three Senate Committees but never had a hearing nor a House companion bill (Russon, 2024). Others have attempted to double down on the law. In 2024, SB 1126 and HB 1641 were introduced to expand the statewide preemption to include auxiliary containers of various material types, not only plastic. The bill proposed the following definition:

"Auxiliary container means a reusable or single-use bag, cup, bottle, or other packaging that meets both of the following requirements: a) is made of cloth; paper; plastic; including, but not limited to flames plastic, expanded plastic, or polystyrene; cardboard; molded fiber; corrugated material; aluminum; glass; postconsumer recycled material; or similar material or substrates, including coated, laminated, or multilayer substrates, and b) is designed for transporting, consuming, or protecting merchandise, food, or beverages from or at a public food service establishment as defined in s. 509.013(5), a food establishment as defined in s. 500.03(1), or a retailer as defined in s. 212.02(13)."

The bill would have prevented any local bans on the included containers per the bill's definition and any state agency regulation of food packaging and would have made existing SUP regulations from nearly 20 municipalities retroactively illegal (Florida State Legislature, 2024; Beyond Plastic, 2024; Russon, 2024). SB 1126 did not advance out of Committee in either chamber and HB 1641 did not get called to a committee hearing, though it's clear that arguments on either side persist (Russon, 2024).

As requested in the original statute, FDEP prepared a Retail Bags Report in 2010 to assess SUP regulatory options and then produced an update to the analysis in 2021 as part of an amendment to Florida Statute 403.7033 (SB 694). Both reports covered the use of plastic bags in Florida, environmental impacts from improper disposal, and examples of plastic bag reduction efforts in other geographies. The 2021 report also included interviews with local government, retailers, residents, and recycling facility stakeholders in Florida, the majority of which responded that regulation on SUP carry-out packaging would be effective in the state. As it stands now, the Florida State Legislature has yet to adopt recommendations from the latest FDEP report from 2021 (Townsend et al., 2021).

Interestingly, some types of SUP have gained more traction in state-level policy. In 2019, Florida Governor Ron DeSantis vetoed a proposed bill that would have put a moratorium on local regulation of SUP straws until 2024 (Meszaros, 2024). In 2022, The Florida Legislature passed SB 224/HB 105, also known as the Florida Clean Air Act, allowing local governments to restrict smoking on public Florida beaches and parks, partially in an effort to reduce the litter of cigarette butts (Florida State Legislature, 2022; NBC 6, 2022).

5.1.3.2 Local-Level Policy in Florida

The balance of power between state and local governments varies across the country. Florida has adopted the Home Rule approach, which is codified in the Florida constitution, stating "Municipalities shall have government, corporate and proprietary powers to enable them to conduct municipal government, perform municipal functions and render municipal services, and may exercise any power for municipal purposes except otherwise provided by law (Florida State Legislature, 1968)." Eleven out of twelve of the other US states with preemption laws also operate under the Home Rule, as opposed to the Dillon's Rule where local governments only have powers explicitly granted to them by the state (Harris, 2019; Watts, 2022)

According to the NGO 'Plastic Free Florida,' at one point as many as 50 municipalities in Florida had passed SUP and/or polystyrene ordinances at the local level (Plastic Free Florida, 2022). Several have since been repealed due to the preemption, but 19 still remain as of 2024 (Beyond Plastic, 2024). Those that still remain often target SUP items not specified in the preemption, such as plastic straws, or restrict the use of SUP items specifically on government property or at government events per vendor contracts and local ordinances. Examples include plastic straw bans in Sanibel, Surfside, Ft. Myers Beach, Key West, and Miami Beach (Meszaros, 2024). Some cities, as Orlando did in 2019, have passed ordinances that ban the use of plastic bags, polystyrene, and plastic straws on public property, and Leon County and Seminole County are considering enacting similar legislation (Surfrider Foundation, 2019; City of Orlando, 2024). The cities of Gainesville, Palm Beach, and St. Augustine all passed local ordinances banning polystyrene and plastic bags in 2019 (Surfrider Foundation, 2019). In 2023, the City Commission of Key West directed the City Manager to implement a "Plastic Free Key West" program, including a voluntary certification program with local businesses, and urged the Florida Legislature to, "adopt legislation that would allow local governments to regulate the use of auxiliary containers, wrappings, or disposable plastic bags used by consumers to carry products from retail establishments in the city of Key West" (City of Key West, 2023).

Beyond SUP policies, the handling and jurisdiction over solid waste is also fragmented across the state. According to Florida State Statutes, all counties oversee their own solid waste disposal facilities, and local governments cannot develop their own plans for disposal unless approved by the county (Florida State Legislature, 2023). This further pull between county and city oversight has created tension in some locations in Florida (CIL, March 2024). In order to address this, some local ordinances do exist to try to enhance this autonomy and strengthen enforcement, such as Orlando's Recycling Ordinance from 2023 which requires all multi-family homes and commercial properties to have recycling and hauling services (CIL, March 2024).

Several Florida cities and countries are also including solid waste management (SWM) and plastic pollution into broader strategic plans, such as Miami's Greenhouse Gas Reduction Plan, Orlando's Office of Sustainability Zero Waste Plan, the Key West Forward plan, and the

Miami 305 Business Engagement Plan (CIL, August 2021; CIL, February 2024; CIL, March 2024).

5.1.4 Research Objectives

The research objectives for this work are:

1. To conduct a Circularity Assessment Protocol (CAP) in multiple cities in Florida to reach a critical mass of data statewide, share lessons learned and best practices regionally, and evaluate the potential for state-level change in a US State.
2. Create a snapshot of circularity and plastic pollution and identify common challenges and opportunities that may be applicable statewide for three different locations within the state: a large metropolitan area on the eastern coast, a large inland city with high tourism, and a series of smaller cities on the islands in the south of the state.
3. This is the first US State-level assessment conducted with multiple CAPs and Florida is in a prime position to use this information to inform decision-making in the coming years.

5.2 Methods

5.2.1 CAP Methods

With support from Ocean Conservancy, CAP has been conducted in three locations in Florida since 2021. CAPs were conducted based on the methods outlined in Maddalene et al., 2023 and Jambeck et al., 2024. Fieldwork for the City of Miami CAP was conducted in May 2021. The final report was produced in English, Spanish, and French Creole, and the Shores Forward initiative created summary documents and flyers with key findings and opportunities in all three languages as well. CIL also participated in stakeholder workshops (August 2022) that were organized by Shores Forward in Miami to disseminate CAP findings and collectively determine initiatives that the community may want to move forward with. Fieldwork for the Florida Keys CAP, which included Key Largo, Marathon, and Key West, was conducted in September 2022, and fieldwork for the Orlando CAP was conducted in May 2023 (CIL, August 2021; CIL, February 2024; CIL, March 2024)

5.2.2 Comparative and Analytical Methods

Data from all the Florida CAPs were compiled and analyzed across each CAP spoke: input, community, product design, use, collection, end of cycle, and leakage (CIL, August 2021; CIL, February 2024; CIL, March 2024). The comparative analysis across cities was conducted in a similar manner to Maddalene et al., 2023. Common challenges and opportunities were compiled based on individual city data and publicly available statewide data on infrastructure and waste management. Additional desktop research on state and local level policies was conducted to complement the CAP findings and to help identify opportunities for each CAP spoke and each product type outlined in Section 5.4 and Section 5.5.

5.3 Results

5.3.1 Input

On average, all categories of fast-moving consumer goods (FMCG) sampled across all CAP locations in Florida had at least one brand that had a manufacturer or parent company located within or near Florida. Across all FMCG sampled in Florida, approximately 78% of the manufacturing locations were located within the US, and around 10% of all FMCG manufacturers were located within Florida. In some cities, such as those in the Florida Keys, over 90% of FMCG had domestic manufacturers. Other common countries for manufacturing locations included China, Mexico, Brazil, Venezuela, and South Korea (Figure 5.1). Around 75% of all FMCG had parent companies located within the US. Other common countries for parent company locations included Italy, Switzerland, South Korea, and Japan (Figure 5.2).

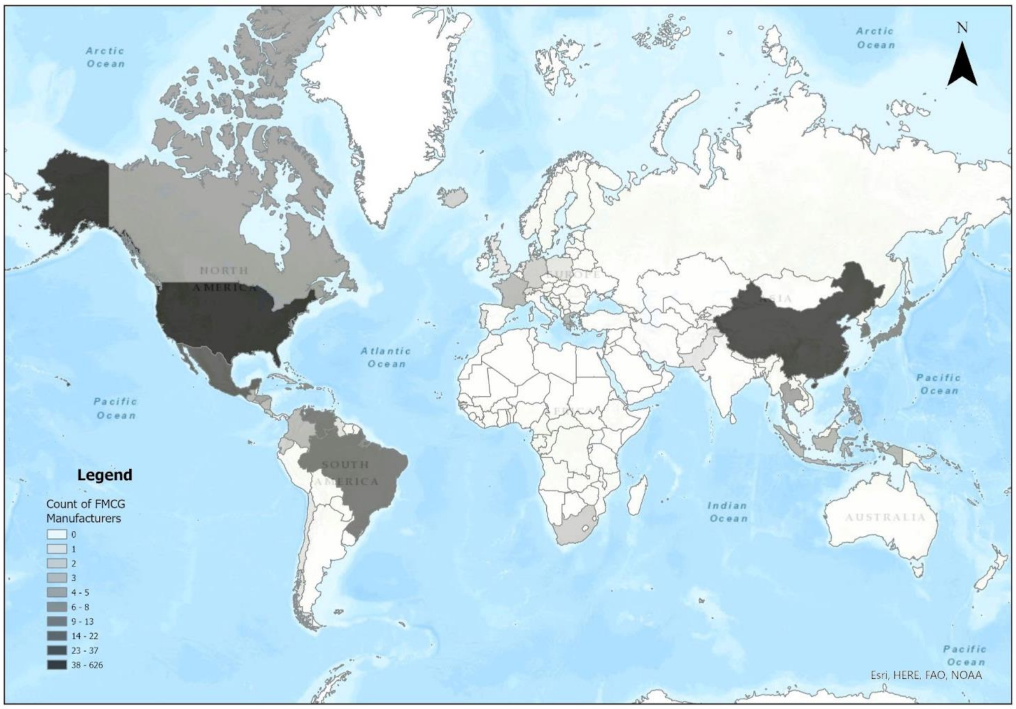

Figure 5.1: Locations of Manufacturers for top FMCGs found in Florida

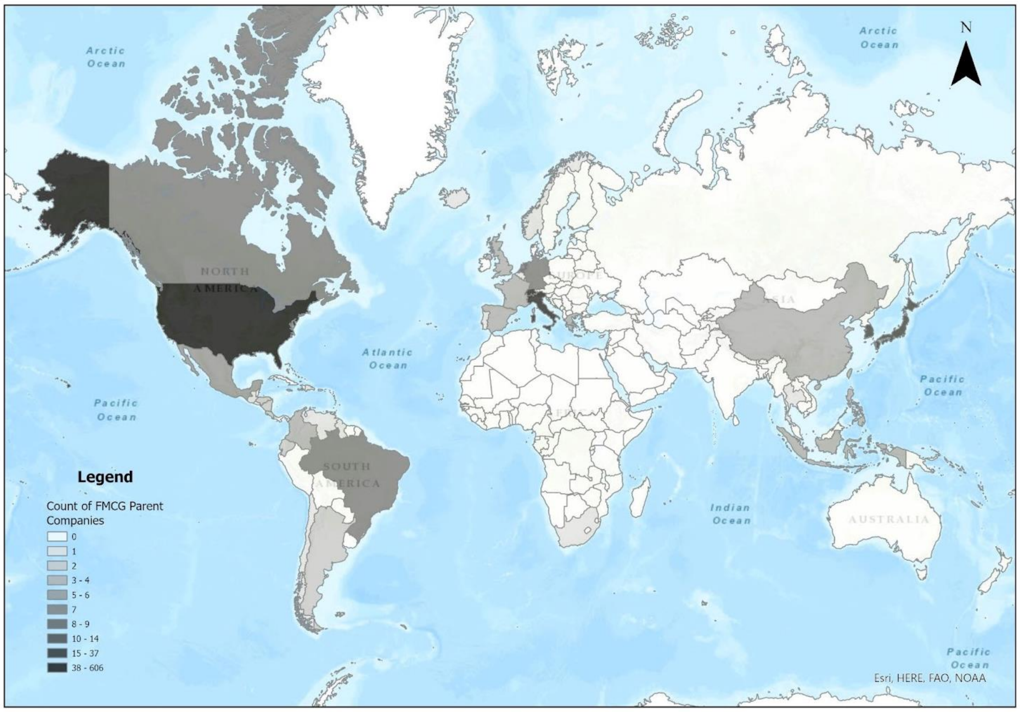

Figure 5.2: Locations of Parent Companies for top FMCGs found in Florida

Top brands that were identified in the store surveys for FMCG across Florida included Nestle, PepsiCo, Mars, Mondelez, Frito-Lay, The Hershey Company, Barberi International, ITG Brands, The Coca-Cola Company, Keurig Dr. Pepper, and the Ferrero Group. Most of these brands have joined the Business Coalition for a Global Plastics Treaty and are actively advocating for measures such as extended producer responsibility (EPR) and a legally binding UN treaty to address plastic pollution and increase the circularity of plastics.

Florida is also home to manufacturing, bottling, and distribution locations for some of the largest beverage companies in the US and globally, including PepsiCo, Coca-Cola, Niagara, Sunshine Bottling, Tropical Bottling Corp, and Anheuser-Busch. Beyond beverages, Florida also houses manufacturing locations for key food and convenience brands including Nestle, General Mills, Kraft Heinz, Kellogg, Conagra, Mondelez, Mars, and Tyson Foods. The Florida Beverage Association also supports the American Beverage Association's Every Bottle Back initiative, which aims to collect back as many PET bottles sold in Florida as possible for bottle-to-bottle recycling (FBA, 2024).

5.3.2 Community

To understand current attitudes and perceptions of plastic waste, semi-structured interviews were conducted with 48 key stakeholders across all three CAP locations in Florida (Table 5.1). Stakeholders were identified in collaboration with the local government and project partners in each location and best efforts were made to get representation across the sectors of local government, non-profits, businesses, waste companies and operators, academia, and other sectors that may be relevant to the location such as tourism.

Table 5.1: Stakeholder interviewees across all Florida CAP locations

Stakeholder Group	Interview Count
Local Government	20
Non-profit	12
Local Business	6
Private Waste Company	5
Sustainability Specialist/Consultant	3
Academia	2

Across the CAP locations in Florida, interviewees noted differing perspectives on whether plastic pollution is a problem and disagreements on where it comes from and who is responsible for fixing it. This particularly came through in light of Florida being a coastal state with strong ties to the ocean and inland waterways. Some cited that as a benefit to awareness, while some cited it as a challenge.

"People do not understand the relationships between trash on land and trash in the ocean." -NGO/Activist

"You think it [plastic pollution] is a coastal problem but it's really not." -Government Official

"This [South Florida] was a swamp, we literally dried it up to live here; the stormwater system and canal system means that everything gets carried into the bay." -Government Official

"People are aware in the sense that it directly affects their little bubble or community, but they are not aware of how it impacts the wider city or state. There is a 'if it doesn't directly impact me then I'm not concerned with it' attitude." -Government Official

"The general level of awareness in the public is kind of split. The districts that are bay facing are very aware, but when you start to get westward (areas where there isn't a view of the bay) and even those on the river are not as aware." -Government Official

“Obviously, in Florida, everything washes into our waterways, making that connection with people, and they're like, "Oh, I didn't realize it goes all the way to the ocean." That helps. That definitely gives them a better reason not to litter.” – Government Official

A key characteristic of many communities in Florida is diversity. According to the 2020 Census, Florida had a population of around 21 million (the third most populous state in the US) and had a diversity index of 64%, ranking it the 8th highest in the country. Compared to other US states, Florida also had a high ratio of metropolitan areas where non-white race-ethic groups are highly represented (Frey, 2021; US Census, 2021). This can lead to geographically fragmented populations, differing levels of awareness, and variations in capacity and infrastructure for things like SWM. Many interviewees noted that even waste looks different in various communities in Florida, including what is considered recycling versus garbage and how items are disposed of.

“In [an area with a largely Spanish-speaking population], the penalty signs for illegal dumping are in English.” -NGO

“[Florida city] has so much diversity and so many people coming and going, it’s a cultural thing.” -Private Waste Company

“Contamination in [affluent community] is shipping envelopes and packaging; in [lower-income community] it’s organic and construction materials.” -Government Official

Unfortunately, the disparity of resources and challenges with communication can lead to mistrust among minority groups that makes reuse and natural resource management difficult. This can be seen, for example, in risk perception and bottled water drinking choices among populations in Florida (Graydon et al., 2019). Florida, along with many parts of the southeast, has a long history of environmental justice and environmental racism issues, particularly related to hazardous and toxic waste disposal, incineration infrastructure, brownfield sites, and superfund sites (Pollock et al., 1995; Stretesky, 1997; Stretesky et al., 1998; Vaz et al., 2015; Pittman, 2023). While Florida statutes do have some language around ‘Consideration of Environmental Justice in Land Use,’ particularly for brownfield remediation, environmental justice is not incorporated into many agency or legislative processes or procedures in the state, such as permitting, enforcement, or agency missions (EJC, 2024).

In 1994, Florida established an Environmental Equity and Justice Commission (now defunct) to, “examine and determine the possible concentration of environmental hazards in people of color and low-income communities and to assess related inequities and risk.” (EJC, 2024). The Commission found in its final 1996 report, as is still accurate today, that the environmental, economic, and social impacts of these waste management practices are still disproportionately felt among minorities, immigrant populations, and people of color in Florida (Gipson, 2022; Pittman, 2023). As an example, in 2023, a region of one of the CAP cities in Florida that has a predominantly immigrant population gained media attention for being overwhelmed with litter, despite frequent attempts to get the city to increase street sweeping, increase the frequency of trash collection, fine people for littering or open dumping, and increase the frequency of stormwater basin clean-out. As one resident described, there is a perception that "the city doesn't care." (Aguirre, 2023). Similarly, there is an ongoing dispute as of September 2024 as to the placement of a new trash incineration plant in Miami-Dade County, which some have claimed is, "almost a form of racism, because the places these incinerators end up are not white, middle-class neighborhoods, they're where people of color live, and you just have to look at the higher levels of cancer and illnesses they have there." (Luscombe, 2024). These types of stories speak to ongoing challenges around equity and justice when it comes to waste management in FL. However, it is important to note that there are a number of groups actively working to identify sustainable, equitable, and just solutions for all Floridians (Earth Justice, 2024).

> **"The level of collection and waste management is different for certain communities. The more you are taxed the more access you have [to resources]. In lower-income places, people are often working many jobs and don't have time to call the public works office or solid waste management if they miss a pickup." -Government Official**

> **"When you look at the litter on the road, you see more trash in certain neighborhoods...There is unequal awareness in layers of society." -Local Business**

Florida is also a very popular location for tourism and seasonal residencies. In 2023, Florida welcomed over 140.6 million visitors (an all-time high for the state) including 129.1 million domestic visitors, 8.3 million overseas visitors, and 3.2 million Canadian visitors (Florida Gov, 2024). Many interviewees noted that tourists and other transient populations can also present a challenge for SWM, as they have likely come from a local with differing rules on waste disposal and recycling, they may not be made aware of local policies, and they are often visiting with a tourism mindset that may not lend itself to environmental stewardship. Interviewees also noted that tourists and visitors seem less likely to bring their own bags or containers or buy-in to local reduction and reuse opportunities, potentially because they have not brought those items on vacation with them or they are unaware that those programs exist. This could present opportunities for a sharing economy around these items locally if visitors are not able to bring their own.

“When people come down here for vacation the last thing they’re thinking of is ‘how do I recycle’ - they don’t want structure and rules.” -Government Official

“If you look at tourists’ shopping carts, one whole cart will be bottled water. They are going to the beach and on boats and won’t bring their own refillable bottle.” -Government Official

“Vacationers don’t recycle, plus they are super transient.” -Private Waste Company

[Said from the perspective of a tourist] "'I'm on vacation, so I'm entitled to do whatever I want to because I'm paying to be here so someone else pick it up.' That's a mentality as well" –Government Official

"Locals reuse cups and bags, but tourists don't. They buy everything and don't bring their own cups or totes on vacation." -Government Official

Many stakeholders referenced a "recycling problem" in Florida. This includes difficulties around infrastructure and recycling markets, a general lack of trust in the waste collection and processing system among the public, skepticism around whether waste actually gets recycled, high amounts of "wish-cycling" and contamination in recycling streams, and low or ineffective enforcement mechanisms. It was mentioned several times in interviews that "no one knows where their trash goes after it enters the bin," and "everyone thinks that their responsibility ends when they put waste in the bin."

"There's a perception that all collected recycling gets trashed anyway. Everyone has bins and separates recycling, but there is a 'why bother' mentality." -Local Business

"Lots of people feel reluctant to make recycling mandatory for businesses - because it's costly -- the perception is that it's more expensive to recycle, there isn't enough space, and there is no time. We have more bars per capita than any city in Florida. They don't have time to take the lemon out of the cup and recycle it." -Sustainability Specialist

“The recycling is always contaminated - there’s a perception that ‘only 30% actually gets recycled’ - some of this is due to ignorance and some is because people just don’t care.” -Local Business

“What does disposing of waste ‘properly’ even mean? There is an attitude of ‘my job is done when I put it in the trash.’ The public perception is ‘my job is to just get it in the bin.’ In terms of education, no one knows where their trash goes after they put it in the bin.” -NGO/Activist

“What mostly drives wish-cycling is that people see the recycling arrows on everything and it all goes in [the recycling bin]. Anything that looks remotely like plastic [goes in].” -Government Official

“The city could take it [the mixed plastic from single-stream recycling collection] to the burner [WtE plant] for less than it costs me to process at the MRF.” -Private Waste Company

“We don’t dare send our clean paper abroad anymore...because of the risk that it could get sent back [due to high contamination].” -Private Waste Company

“For corporate businesses, it’s “the law to do recycling” but they don’t really follow through. No one would know if I wasn’t recycling. [The waste management company] charges me a contamination fee for my recycling container - I’m trying to do a good thing, but then if we don’t do it properly I get charged, and I’m already paying more to have a recycling bin. And no one even cares that I do… when I get charged a fee it’s like why do I even bother doing this? It's a hassle - even if you’re trying your best, you’re probably still getting it wrong.” -Local Business Owner

In addition, several interviewees noted a general lack of SWM infrastructure in their city. This included everything from hauling trucks, to staff and space, to complex WM technologies.

“We are still waiting on the garbage truck we ordered in June 2021. We’re now looking at getting it next year. We usually order a new truck every year, now we are 2 years behind. All trucks are about 10 years old, and we change out for a new one every year.” -Private Waste Company

“That's part of the problem that we have as a city and as a solid waste division, and as one component in a region-wide effort to divert waste, is we don't have the wherewithal financially, legally, all those aspects on how to approach actual Zero Waste, whether or not that's doable, or if we have the infrastructure in place to accommodate that.” -Sustainability Specialist

According to a Florida State Statute, all counties oversee their own solid waste disposal facilities, not the cities in which they operate or service. Local municipalities therefore cannot develop their own plans for disposal unless they are first approved by the county (Florida State Legislature, 2023). With this in mind, several city government SWM operations noted that they do not have the power to pursue development or plans in SWM without the approval of their respective county office. Some cities have included exclusive franchises over all front-load garbage services in their city code.

> **“That means anything collected in the front and load dumpsters, it's mandated that they use city services. It's an essential working monopoly. It's a common government structure to fund and supplement other types of services. They usually do this with solid waste or water reclamation so that you're able to provide that service for residents and then also supplement things that don't make money, like potholes and road maintenance and things like that, stormwater maintenance, things that. Stormwater is an enterprise but other things like that, lake enhancement, lake quality, those things that don't really generate revenue.” – Government Official**

> **“The problem is that we don't have any autonomy, or we don't own our own transfer station, we're not a real stakeholder in that sphere. We used to have a MRF, and we used to have an anaerobic digestion facility at our disposal… We don't have either of those now... We're severely limited on our infrastructure which does dictate sometimes that our recycling goes to the landfill.” –Government Official**

“...we're pretty much at the hostage of private hauling. If they wanted to go much higher, which I believe they are going to, much higher than $65, we have no other way to recycle besides that, unless we start getting a lot more creative or start taking a lot more ownership over that infrastructure which doesn't exist in our area. We really have no options.” –Government Official

The growing popularity of compostable products has put further strain on an already stressed SWM system. Stakeholders noted that, despite generally positive sentiments around moving away from disposable SUP, there have been challenges with awareness, affordability, and disposal associated with these compostable alternatives.

“There is a lack of awareness among the public on how to dispose of compostable plastic alternatives. The city wants to get a composting facility, but the cost and staff are resource barriers...As a city we need to make composting more available or increase awareness among the public on those products.” -Government Official

“We’re just replacing one single-use item with another...We have to stop using plastic. There is no other option.” -NGO/Activist

“Promotion of biodegradable and compostable is null and void down here, there is no way to process it for hundreds of miles around.” -Government Official

“There’s no reasonable alternative for coffee cups; there are “compostable” ones but that's kind of greenwashing because you need an industrial composting facility and it needs to be sorted and collected… consumers think that they can drop it in their backyard and it'll break down. Even if we did collect [compostable] cups there is nowhere to send them.” -Local Business Owner

“Price is the biggest barrier…Lean Orb [compostable] products are probably twice the cost of Sysco [plastic products].” -Local Business Owner

While there were many examples of positive change and community support at the local level, stakeholders across the Florida CAP locations unanimously noted the challenges of political will and policy at the state level. The highly fragmented nature of policy in Florida and the state level preemptions have made it particularly difficult to implement change at the local level.

“[Waste management] is an issue of political will, not practicality.” -Sustainability Specialist

“The mayor had a huge desire to look at glass crushing. People were behind it and looked into technology for it, but there just wasn’t enough political will and it fell through.” -Sustainability Specialist

“The will isn’t there and there is so much resistance to change.” -Local Business

“Bans get preempted in Tallahassee -- it’s all about capitalism.” -NGO

“Lots of places here have no concept of ‘waste.’ Especially grocery stores. It’s all about profit, less about environmental consciousness” -NGO

“Florida is tough, we have lots of policies banning bans.” -Government Official

“In Miami you have the headache of local, municipal, state etc. regulations that are all conflicting and unclear.” -Academia

“Three years ago, there was a regulation [in a Florida city] on plastic bags and as soon as people started to make changes based on that regulation to comply, the city lost its appeal in court in Tallahassee against the retail industry lobby. The ban was banned.” -NGO

“Even when the [plastic bag] ban was in place, you could go across the street and be in [the neighboring municipality] and be able to get plastic bags.” -NGO

“We have established citywide policies that can be reflected and applied throughout the city. The problem is a lot of that just is pre-empted. The good news is we have

that model waiting. The bad news is that sometimes, we can't implement it because of state-level regulations." -City Sustainability

Given the diversity, transient nature, and varying perspectives of the population across Florida, there is a need for tailored, local, meaningful education and outreach, particularly around SWM. Stakeholders noted that it is important to meet people where they are, build a sense of pride in place, and work to rebuild a sense of trust in the SWM system in FL. Interviewees in every CAP city in Florida noted the importance of education and outreach in order to drive awareness and sustainable behavior change around SWM, littering, open dumping, and general environmental stewardship.

"Communities need knowledge that is not pointing fingers and passing blame." -Government Official

"Communication about waste and plastic is nonexistent." -NGO/Activist

"Even though it's very transient and visitor-oriented, really [Florida city] is a series of small towns, and the people that live there are small town people in a very good way - they care about their communities and they aren't always huge fans of outsiders. Educating and bringing awareness needs to happen in a way that resonates and makes sense to a community, especially one that is low income or high diversity. You can't just say 'this needs to change' when they have limited means and limited options." (NGO)

“In terms of circularity in [Florida city], it's very important to 1) make sure everyone understands and has trust in the recycling system and 2) get businesses on the sustainability train. Many people in south Florida have lost faith in our ability to recycle for different reasons, but educating the public through creative ways would go a long way.” -Sustainability Specialist

Despite these shared challenges, stakeholders across all CAP cities in Florida also highlighted that solutions to plastic pollution and circularity do exist, especially at the local level. These solutions need to be accessible, affordable, and feasible for all sectors of society. We know that there is demand among local populations in Florida - A survey by the Florida Department of Environmental Protection (FDEP) in 2021 showed that 97% of local government and 93% of residents “believe regulation is necessary for containers, wrappings, and disposable plastic bags,” and 90% and 82% respectively expressed willingness to “support additional waste reduction, reuse and recycling through increased fees” (FDEP, 2021). Meaningful interventions can happen through community awareness, public/private partnerships, mobilizing local businesses, economic incentive structures, policy and regulation, and many other avenues. Lessons should also be shared across cities and sectors in Florida on what has worked and hasn’t worked in this area. Building circular systems also comes with tremendous job opportunities, particularly in a location like Florida which is home to several of the largest domestic and international beverage bottlers and food companies (KFW, 2024).

“Convenient and affordable solutions need to exist for this to be feasible.” - Government Official

“Small businesses can still be reached. There's an opportunity to change the mindset there, they can be more flexible. Even if it’s small changes (e.g., straw bans) it's important for people to see that it's possible and profitable.” -NGO

“The community is open to change, but it needs to be easy and accessible. Someone needs to figure out money and availability - people will pay more but not much.” - Government Official

“We need financial incentives for businesses - tax breaks, willingness to pay surveys, etc., and a certification/list of environmentally friendly companies…Economic incentives would work really well in [Florida city].” -NGO

“We need to build a critical mass around the hospitality and food & beverage industries, and put those people in touch with vendors who are ‘sustainable’ or ‘ethical’ who sell products that are less wasteful or have alternatives.” -Local Business Owner

“There need to be incentives for bringing your own bags, containers, takeout, etc.” - NGO

Particularly in the context of Florida, it is important to tie plastic pollution and circularity to issues of climate, resilience, and equity. Waste leakage can increase flooding, spread disease, and exacerbate other impacts related to climate change. It is also important to take into consideration economic aspects, such as access to alternatives and resilience of supply chains, when designing circular systems. Florida is among the most vulnerable areas of the US to the impacts of climate change and associated social justice and inequity issues. Florida ranks 3rd among US states for highest CO2 emissions, 1/3 of Florida's land is in jeopardy from 27 inches of sea level rise, rates of persistent flooding as well as heat-related deaths are on the rise, and at least 2 million Floridians face a shortage of local, fresh, and healthy food due to food deserts (EDF, 2020; USF, 2021) - all of which have a disproportionately high impact on low-income communities and communities of color in the state (CAP, 2021). These environmental, biological, and socio-economic systems are intrinsically linked, especially in a coastal, highly-populated state such as Florida. Solutions cannot only exist for a subset of the population - all boats must rise for sustainable, resilient communities. Several groups are doing great work in this area across the state, including advocating for pollution-reduction policies, future-ready infrastructure, chief resilience staff roles in local governments, and good, equitably available jobs (CAP, 2021). Looking to the future, tying these interconnected issues of pollution, public health, climate, resilience, and circularity will be extremely valuable for increasing political will and public buy-in for positive change in FL.

> **“During the hurricane, everything was full, so it [waste and litter] couldn't go anywhere. People really started understanding it doesn't just stay in [the city]. Our**

stormwater system is headed on over to the river. It really starts at home and it starts with education and just don't put it on the ground." – Government Official

"They [younger generations] have that lack of faith that anything is going to change about it. I personally can bring cloth bags to the store, but they are like, "Why do I care when this company is going to put this much CO2 in the atmosphere anyway?" – Government Official

On litter exacerbating flooding: **"The floatables are largely litter. People think that if they can't find a bin, they can put litter in the storm drain then it isn't littering. Really [storm drains] are just a direct conduit to the Bay." -Government Official**

Several stakeholders noted that public health messages often resonate strongly with Florida and for Floridians. It may be beneficial to do state-wide, consistent, powerful messaging on how increasing circularity and decreasing plastic pollution and littering can affect public health. Research has shown clear ties between plastic products and human health. Plastic particles have been found in human blood, human placentas, and human tissue, and plastic additives - which include known carcinogens, neurotoxicants, and endocrine disruptors - have been detected in human breast milk and human urine (Asimakopoulos et al., 2013; Mercogliano et al., 2018; Ragusa et al., 2021; Leslie et al., 2022; Landrigan et al., 2023). There is a growing consensus that the impacts of plastic on human health are more intricate and insidious than previously thought, and many scientists and organizations worldwide are highlighting the need to simultaneously address toxins and pollutants associated with plastic to reduce human harm and mitigate public health risks (Gross et al., 2021; Muncke, 2021; Morrison et al., 2022; Landrigan et al., 2023; Geueke et al., 2024). Feedback from stakeholders suggested that these types of messages could be useful in Florida.

> **"Cleanup groups do a lot of education, but it's pretty fragmented. There isn't one campaign that has reached everyone." -Government Official**

> **"How do you reach people with messages of connectivity with human impacts on the environment? It needs to be visual - needs to be connected to what people care about, needs to connect to something that they can actually do." -NGO**

There are shared local-level and state-level challenges observed across the state, but also ample opportunities for interventions at all levels from the bottom-up and top-down across the FL.

5.3.3 Product Design

5.3.3.1 Fast-Moving Consumer Goods (FMCG)

In total, 821 FMCG products were sampled across all three cities. This included 191 beverage products, 340 candy products, 226 chip products, and 64 tobacco products. Across all categories, 13 different material types were identified, and nearly 50% all items were packaged in multilayer plastic film (Figure 5.3). Out of the top five most common material types found, four are considered difficult to recycle (multilayer plastic film, multi-material items, single-layer plastic film, and other hard plastics) and were not accepted in any curbside or drop-off recycling locations in CAP cities in Florida. Only around 1% of all FMCG products sampled were packaged in plastic alternatives - 99% of products were packaged in some type of plastic or a material with a plastic coating.

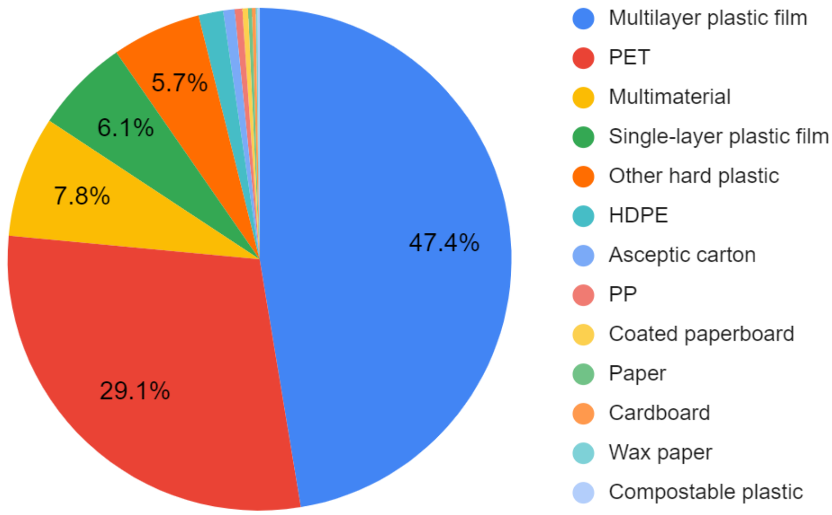

Figure 5.3: Breakdown of material type for all FMCG sampled in Florida

In some Florida CAP cities, nearly all (98%) of certain product categories, such as chips, were packaged in multilayer plastic film. Across all Florida cities, beverage products were predominantly packaged in PET. Candy products had the highest diversity of packaging materials among Florida CAP cities, which has been found in other CAP locations in the US such as Athens, GA and Blytheville, AK. Similar overall FMCG item trends have been observed in CAPs in other US cities. Multilayer plastic film has been the predominant material type among FMCG items overall in CAPs in all US cities conducted to date. PET has also consistently been the dominant material type among beverages.

5.3.3.2 Food Vendor Products

In total, 302 to-go foodware products were sampled from 84 food vendors and restaurants across all three cities. This included 84 to-go food containers, 66 cold beverage cups, 63 straws, 61 utensils, 19 hot beverage cups, and 9 cup lids. Across all products, 20 different material types were identified, 12% of which were plastic alternatives such as paper, and 6% of which were compostable plastic such as PLA (Figure 5.4). However, it is worth noting that there is no separate waste stream for compostable plastic or an industrial composter within the state of Florida to support those materials.

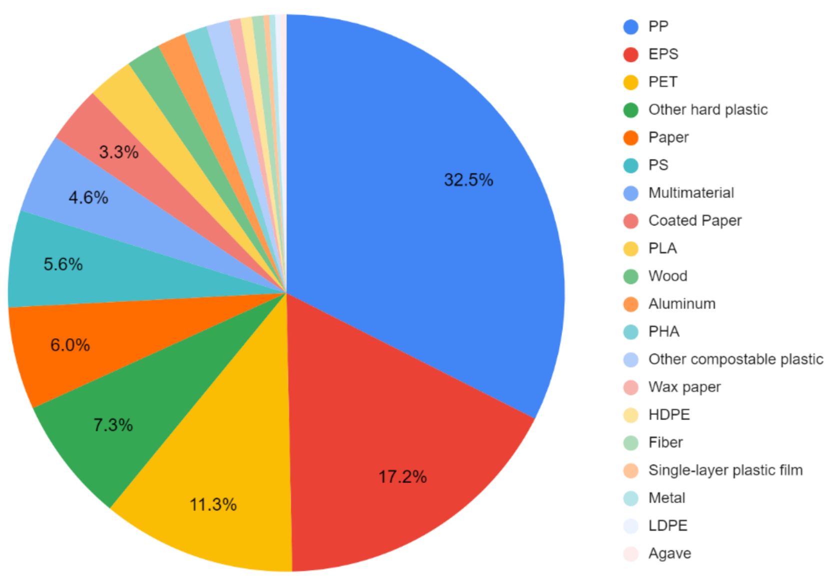

Figure 5.4: Breakdown of material type for all to-go foodware items sampled in Florida

Among the 302 products total, 274 were cups, to-go containers, straws, and utensils that could be compared across all Florida CAP cities. Hot cups and cup lids were only sampled in Miami and not in the other two locations. PP was the most common material type found among utensils and straws sampled, cups were predominantly made of EPS or PET, and the most common material for food containers was EPS. Food containers had the most diverse material types (Figure 5.5).

The data demonstrate a strong presence of expanded polystyrene (EPS), which was the second most abundant material type observed. There were also high amounts of polypropylene (PP) and EPS observed in the litter surveys across all three cities. EPS has been a major focus of local and national legislation in the US in recent years, in part due to its abundance in litter, its difficulty to recycle, and the known human and environmental hazards from its manufacture and use (EPA, 2000; Coelho, 2022). In 2021, Surfrider released a study of over 1,000 plastic reduction policies across all US states and territories, including 268 related to EPS (Surfrider, 2021). Data has also suggested that these types of regulations help to reduce EPS litter. As of 2023, the amount of plastic foam foodware items collected through the International Coastal Cleanup in Maryland since the state's ban took effect in October 2020 had reportedly dropped by 65% (Rachal, 2023).

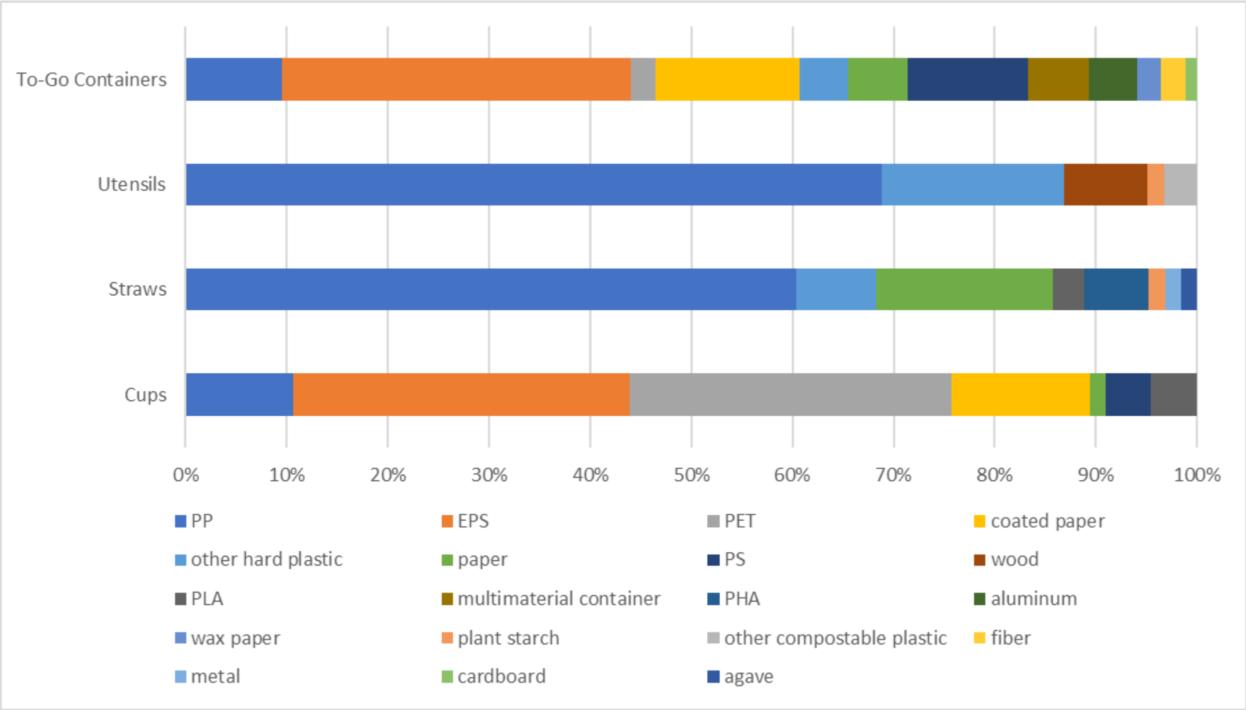

Figure 5.5: Breakdown of material type for all to-go foodware items sampled in Florida, based on comparable product types

The CAP cities in Florida generally had a higher diversity of material types across all categories of to-go foodware when compared with CAPs from other US cities. Florida cities also had a comparable or higher average presence of compostable plastic in their to-go items compared to other CAP cities in the US - as high as around 10% of to-go items in some Florida cities and around 6% when averaged across the state. For example, compostable plastic was found in 12% of to-go items in Hilo, HI, 8% of to-go items in Savannah, GA, 8% in Ann Arbor, MI, 6% of to-go items in Atlanta, GA, in 3% of to-go items in Minneapolis, MN, and in 1% or less of to-go items observed in several smaller cities in GA, MS, MO, and AK.

Only a small amount of food vendors and restaurants did not offer straws or utensils automatically or provided them by request only. For example, this was only observed in 10 locations in Orlando. Several cities in CA and NY have implemented ‘only upon request’ ordinances for utensils in to-go food orders, such as Los Angeles and Westchester County

(Austin, 2021; Westchester Gov, 2023). In 2022, the city of Gainesville, Florida also passed an 'only upon request' ordinance, and a similar process was attempted in Miami but has not been successful due to disputes over whether it violates the preemption (Harris, 2022). However, this could be an effective method to limit the sheer quantity of problematic plastics that are distributed through to-go foodware in a given city, and cities and countries could potentially follow Gainesville's lead in developing ordinances that do not go against the preemption. Several reuse organizations, advocates, and policy playbooks include the 'only upon request' ordinance as a viable option for reducing litter, ensuring a just and equitable transition away from SUP, and overall benefiting the environmental health of a given location (Gordon, 2022; Ecology Center, 2024).

5.3.4 Use

Of all restaurants and convenience stores sampled across all CAP locations in Florida, 91% offered plastic as their predominant to-go bag material type, most commonly HDPE film plastic. Only around 18% provided a reusable bag alternative such as paper or fabric, priced at around $2 more than the standard plastic ones that were most often offered free of charge. Some SUP shopping bags had language printed on them, such as, "Please return to a participating store for recycling," or "Recycle if clean and dry." One plastic shopping bag found in Miami had a "How2Recycle" website printed on it to guide consumers to a location where they could recycle their bags. However, in general, messaging and incentives for consumers are not strong enough to drive the use of reusable shopping bags or decrease the use of SUP bags.

Differences were also observed across CAP cities in FL. Miami had the lowest proportion of to-go bags that were plastic at 84%, 73% of which were HDPE and the remaining 27% were LDPE or black plastic film. The non-plastic bags observed were paper distributed free of charge.

In Orlando, 97% of stores offered predominantly HDPE plastic takeaway bags and only 3 stores offered paper bags at check-out free of charge. Around 30% of stores in Orlando offered reusable bag options, all of which were offered at an additional cost to the consumer between $0.69 and $4.00. In the Florida Keys, 100% of to-go bags sampled were HDPE plastic. According to the FDEP stakeholder surveys from the 2021 Update to the Retail Bag Report, 75% of business respondents did not provide reusable bags to their customers. However, surveys among residents showed that 31% of respondents recycle their SUP grocery bags at a local store or drop-off site and 66% reuse them (Townsend et al., 2021).

Alternatives to SUP items were also surveyed in grocery stores in all CAP cities. Products included common food ware (cups, straws, cutlery, plates, bowls), household items (cleaning wipes, sponges, laundry detergent, sandwich bags, trash bags, household cleaner), and personal care items (body soap, hand soap, dental floss, shampoo, conditioner). Looking across all item types, alternatives (compostable, biodegradable, concentrated, reusable, refillable, or bulk) were on average 20x more expensive than their SUP counterparts (Table 5.2). When broken down by use type, reusable items were comparatively the most expensive, averaging around 140x higher cost per unit than SUP options. Alternative materials, such as compostable plastic and paper, were on average around 3x more expensive per unit than SUP options. Some refillable and bulk items were actually found to be cheaper - around 0.3x the cost per unit - of SUP on average. When broken down by material type, reusable silicone items (such as Stasher sandwich bags) and reusable stainless-steel items (such as Swell water bottles) were among the most expensive alternative options, averaging 227x and 29x more expensive than SUP options, respectively. Other material types such as aluminum, paper, and compostable plastic were between 2x and 8x more expensive than SUP options on average. Bamboo items as well as plastic and multi-material packaging designed for refill pods and bulk purchases were found to be on average slightly cheaper than SUP options.

Table 5.2: Price comparisons for SUP and alternative items from grocery stores in FL

Product	Use Type	Average x more or less expensive than SUP options
Sandwich bags	Reusable	222.97
	Single-use alternative material	1.17
Straws	Reusable	101.62
	Single-use alternative material	2.81
Cups	Reusable	20.74
	Single-use alternative material	1.72
Bowls	Single-use alternative material	10.42
Utensils	Single-use alternative material	5.94
Cleaning wipes	Single-use alternative material	1.93
Conditioner	Single-use alternative material	3.49
	Refillable	0.74
Shampoo	Single-use alternative material	2.48
	Refillable	0.95
Plates	Single-use alternative material	1.30
Laundry detergent	Concentrated	3.29
	Single-use alternative material	0.31
Body Wash	Refillable	4.58
	Single-use alternative material	0.79
	Concentrated	-0.18
	Bulk	-0.40
Household cleaner	Refillable	1.27
	Concentrated	0.82
Trash bags	Single-use alternative material	0.81
Hand soap	Concentrated	1.32
	Refillable	0.80

	Single-use alternative material	0.26
	Ocean-bound plastic	-0.72
Dental floss	Single-use alternative material	0.45
Sponge	Single-use alternative material	0.41
Deodorant	Single-use alternative material	0.38
Dish soap	Refillable	-0.42

While alternatives to SUP were consistently more expensive across all three CAP locations, there were some specific differences between them. In some cases, personal care products sold unwrapped or through refill schemes were still within comparable ranges to single-use items, though they were still overall more expensive when grouped. Similarly, some cities had items, such as concentrated body wash, bulk soap, refillable dish soap, and hand soap made from ocean-bound plastic packaging, that were cheaper than the SUP options in the grocery store. In all cities, reusable water bottles and reusable sandwich bags were the most expensive items compared to their SUP counterparts. In the Florida Keys, SUP alternatives were around 3x more expensive than SUP items on average, compared to 16x more expensive on average in Orlando and 118x more expensive on average in Miami (which was skewed by a particular brand of reusable silicone sandwich bags).

Several organizations advocate for reuse and demonstrate pilot projects in the US that have been successful. Studies have shown that reusable items beat all types of single-use items in environmental measures of LCAs, reuse saves businesses money for on-site dining 100% of the time, and the reuse economy presents significant opportunities for businesses, investors, and consumers. These studies also note that, in order to effectively and equitably transition towards reuse, several key challenges need to be addressed at the local level, including bolstering public education, ensuring infrastructure and opportunities for job creation, adjusting health codes and policies if needed, and developing incentives for both businesses and customers upfront (Gordon, 2021). Given the context of SWM in the state, it will be important for Florida to develop mechanisms and enabling conditions that can support reuse going forward, particularly among foodware.

5.3.5 Collection

5.3.5.1 Waste Generation

The US had a national per capita waste generation rate of 0.89 tons/person/year in 2018 (EPA, 2018). The State of Florida had a slightly higher per capita average of 2.28 tons/year in 2021, which increased to 2.35 tons/person/year in 2023 (FDEP, 2022; FDEP 2023). The three CAP locations in Florida were around the state average in 2022, with per capita rates of 1.86 tons/year in Miami-Dade County, 2.46 tons/year in Orange County, and 3.84 tons/year in Monroe County.

5.3.5.2 Plastic in the Waste Stream

According to FDEP, only around 7% of the collected waste in 2022 in Florida was reportedly plastic (FDEP, 2022). The CAP cities in Florida, also in more densely populated urban areas, had higher proportions of plastic in their waste stream. According to county-level data, of the over 4.3 million tons of MSW collected in Miami-Dade County in 2020, around 16% was identified as plastic, though there are likely plastic polymers in other categories of MSW such as Textiles, Miscellaneous, and Other Paper. Over 50% of the MSW collected in Miami-Dade in 2020 was comprised of C&D Debris, Other Paper, Food, and Other Plastics. Waste and plastic waste generation rates are higher in Miami-Dade County at-large than US averages, as the county waste generation rate is 7.9 lb/person/day at 16% plastic and the US average is 4.9

lb/person/day at 12% plastic (FDEP, 2020). A waste characterization study conducted at the Waste Management MRF in 2019 found that plastic products (including a combination of both Plastic Bottles and Other Plastics) comprised nearly 23% of MSW generated in Orange County, which is also higher than the national average (UF, 2019; EPA, 2023). A similar waste characterization conducted in 2012 at the transfer station that services Key West found 40.5% compostables, 17% paper products, 13.5% containers (majority plastic), and an overall total of 71% items that were considered recyclable fiber/containers and compostables (Kessler Consulting, Inc., 2012).

5.3.5.3 Collection Mechanisms

According to FDEP, 59% of MSW generation in Florida comes from commercial sites, 29% from residential single-family homes, and 12% from residential multi-family homes. This proportion has remained relatively consistent over the last 5 years (FDEP, 2022). Around 40% of commercial units, 48% of the population living in single-family homes, and 13% of the population living in multi-family homes in Florida are actively participating in recycling services available to them (scheduled service and on-call service), despite the fact that between 60% and 90% of those commercial and residential units have access to recycling services (FDEP, 2022). Studies have suggested that municipalities in Florida should aim to have single-stream recycling with high participation rates that targets high-commodity materials so that the benefits of recycling outweigh the greenhouse gas (GHG) emissions associated with collection, transport, and processing (Maimoun et al., 2016; Townsend et al., 2022). The current mismatch between collection and processing is exacerbated by a highly transient population and a large proportion of seasonal visitors and residents, often coming from areas with different recycling requirements. This leads to confusion on what items can be recycled in different municipalities.

5.3.5.4 Waste Haulers

Many stakeholders noted the high number of waste haulers that operate in their area, and Florida consistently ranks among the top US states with the highest number of popular waste hauling companies (Waste Today, 2020). While several counties in Florida have waste hauling franchise systems, such as Tampa and Santa Rosa, the state legislature passed SB 694 in 2021 to limit the expansion of franchising. According the bill, any counties that still have an open market waste hauling system - estimated at around a dozen at the time - have to provide 3 years notice and the equivalent of 18 months' gross receipts/profits to any private waste hauling company displaced by a franchising system. Several cities and counties in Florida, including Broward County, have explored options for de-privatizing certain parts of their waste collection system in response to recent cost increases by several major waste and recycling companies (Rosengren, 2021).

Among CAP locations in Florida, most cities had a high quantity of non-franchised waste haulers operating on regular contracts with the county that had minimal flexibility. Differences also existed in collection mechanisms and regularity between residential and commercial sites. In most cases, waste collection from commercial properties is required by the city, but some cities provided the collection directly and some required the commercial entities to find a private hauler. In general, access to waste collection was high among commercial units, but varied between multi-family units and single-family homes. Participation in those collection services was similarly variable when not mandated by the county or city. In some locations, monthly costs for waste collection - predominantly for single-family homes - is covered through city property taxes, but that is often not the case for multi-family homes or commercial properties.

In several CAP locations, waste haulers had long distances to travel to dispose of collected waste. This was raised in many stakeholder interviews, along with a need for enhanced infrastructure such as trucks, transit stations, and staff capacity. This is also demonstrated in the relatively long distances between waste processing infrastructure across the state (see Section 5.3.6.2).

5.3.6 End-Of-Cycle

5.3.6.1 Waste Fate

According to the FDEP, in 2022, just over 50 MT of MSW was collected in the state of Florida, 51% of which was landfilled, 41% was recycled, and 8% was incinerated (also known as ‘waste-to-energy (WtE) in Florida, as all incineration facilities there generate energy) (FDEP, 2022). This is higher than the US national average recycling rate of 32%, however, this falls short of the Florida State Legislature’s goal of reaching a recycling rate of 75% by 2020, enacted through the Energy, Climate Change and Economic Security Act of 2008 (FDEP, 2010). Although only around 7% by mass of all the collected municipal solid waste in 2022 in Florida (including C&D waste and yard waste) was reportedly plastic, the recycling rate for those items was less than 5% on average (FDEP, 2022).

There are specific differences between the three CAP locations in Florida when it comes to waste disposal. Miami-Dade County and Orange County, among the most populous counties in Florida, have landfill rates higher than the state average and recycling rates lower than the state average. In 2022, 61% of MSW was landfilled in Miami-Dade County, 31% was recycled, and 9% was incinerated for energy. Also in 2022, Orange County landfilled 71% of its MSW, recycled 26%, and incinerated or for energy 0%. Monroe County, where the Florida Keys are located, has waste disposal proportions more similar to the state average - in 2022, 47% of MSW in Monroe County was landfilled, 44% was recycled (which includes C&D waste, around 50% of which by weight gets recycled), and 9% was incinerated for energy (FDEP, 2022).

Waste generation, along with state population, has been increasing annually since 2010 and has been increasing on average since SWM reporting started in the state in 1988 (Figure 5.6). The proportions of waste that are landfilled, recycled, or incinerated for energy over time remain relatively the same, apart from a few notable exceptions. One is the Solid Waste Management Act (SWMA) of 1988 which preceded a brief decrease in landfill quantities and an increase in recycling and incineration quantities. Those landfilling proportions generally started to increase again after 1996, around the time that the recycling goal of the SWMA was limited to counties over a certain size. The proportion of waste recycled compared to landfilled appears to have increased generally after the Energy, Climate Change and Economic Security Act of 2008, which increased the statewide recycling goal; however, the recession in the US at that time may have also contributed to the observed decrease in waste generation overall around that time. Around 2012 and 2014, the overall waste generation rate began to increase again, and a brief period can be seen when the recycling quantity increased and the landfill quantity slightly decreased, potentially due to recommendations in 2010 by DEP following the Energy, Climate Change and Economic Security Act, a chance in the Florida Legislature's methodology for calculating recycling rate in 2012, or other factors around that time. Interestingly, while studies have found that the plastic scrap import ban in China in 2018 disrupted recycling markets and displaced recyclable content in the US (Brooks et al., 2018), it doesn't appear to coincide with a major decrease in recycling proportionally in Florida, and all MSW disposal quantities appear to decrease or plateau around that time (Figure 5.6, Table 5.3). While these events may be correlations as opposed to causation, these patterns could suggest the power that both global and local policies have on the waste fate in the state.

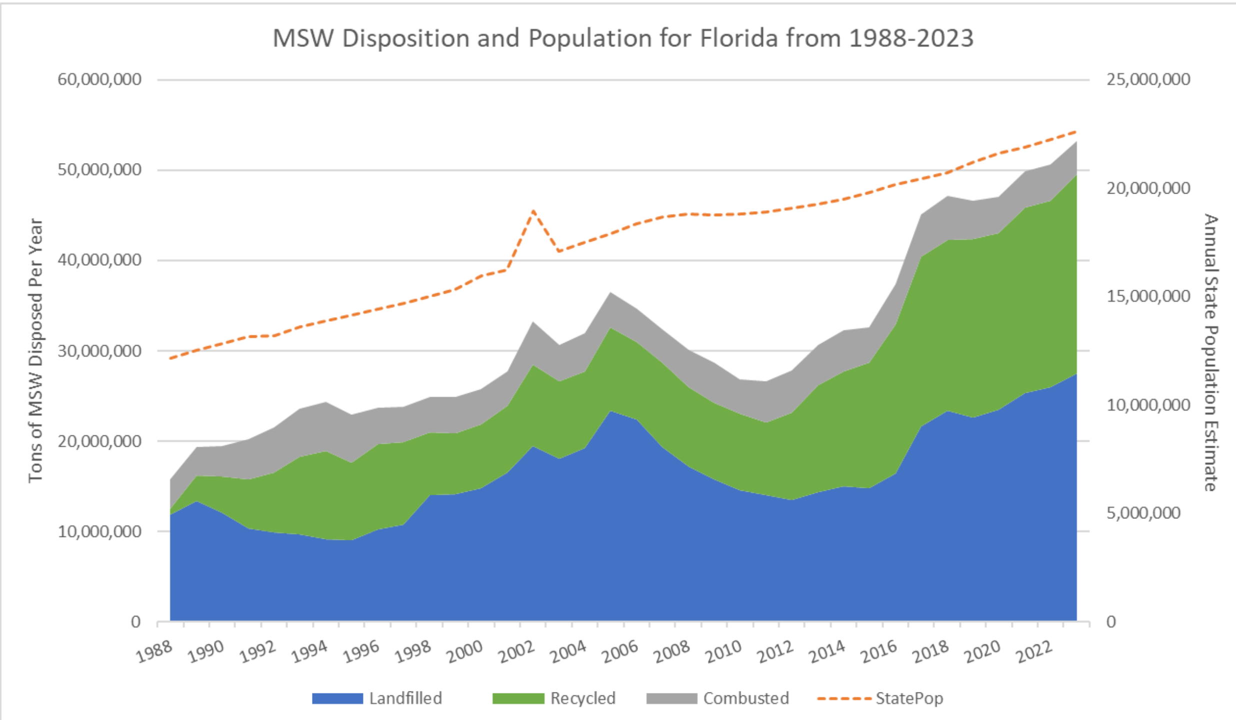

Figure 5.6: Disposition of Municipal Solid Waste and Estimates Total Population of Florida from 1988-2023, excluding Recycling Credits for Renewable Energy and Yard Trash Beneficially Using Landfill Gas (based on data from FDEP, 2023)

Table 5.3: Key Events for SWM in Florida (based on data from FDEP 2008 and FDEP 2021)

1988	• The Solid Waste Management Act (SWMA) sets a goal of recycling 30% of waste in all counties in the state by the end of 1994 • SWMA identifies "Minimum 4" materials and sets a 50% recycling goal for each material: Aluminum cans, Glass bottles, Plastic bottles, Newspaper • FDEP Recycling & Education Grants start • Materials banned from sanitary landfills: C&D, lead, acid batteries, tires, used oil, white goods, yard trash • Solid waste and recycling annual reporting for counties to DEP starts; DEP annual reporting to Legislature and Governor starts
1993	• The 30% MSW recycling goal is changed to MSW reduction goal and it applies only to counties over 50,000 population • Steel cans are added to "Minimum 5 materials" for 50% recycling goal • Recovered Materials Dealers must begin annually reporting to DEP the tonnage they processed (Rule effective 1995)

	• ADF (Advance Disposal Fee) on beverage containers goes into effect • Countries start being charged $2 per ton if newsprint is recycled less than 60%
1995	• ADF (Advance Disposal Fee) on beverage containers is sunsetted by Legislature • Landfill tipping rates increase again
1996	• The 30% MSW reduction goal is changed to apply only to counties over 75,000 population.
1997	• Innovative Recycling & Waste Reduction Grants introduced
2001	• Recycling & Education Grants are sunsetted
2002	• FDEP Innovative Recycling & Waste Reduction Grants are codified into statute, cities added to counties for eligibility, legislature makes final decision as to who gets grants • Countries now required to recycle a "significant portion" of the "minimum 4 out of 8" materials: Aluminum cans, Steel cans, Plastic bottles, Office paper, Glass bottles, Cardboard, Newspaper, Yard trash • The 30% MSW reduction goal is changed to apply only to counties over 100,000 population • County annual reporting requirements to DEP are reduced, but not eliminated • DEP reporting requirements are reduced to "periodically"
2007	• FDEP Innovative Recycling & Waste Reduction Grants broadened to include all solid waste, not just MSW
2008	• The Energy, Climate Change and Economic Security Act and House Bill 7135 increase the state recycling goal to 75% of the waste stream by 2020 (goal is aspirational rather than regulatory, counties and cities are not specifically mandated to reach it.) - any solid waste used for the production of renewable energy counts towards the goal (includes waste to energy and landfill gas) • The recession in the US may have led to less purchasing, less waste generation, less disposal • Innovative Recycling & Waste Reduction Grants are sunsetted
2010	• DEP directed to prepare recommendations for the Legislature by January 2010 on how to accomplish state recycling goal, but DEP cannot implement its recommendations until the Legislature gives it authority to do so • Yard trash is allowed to be accepted at Class 1 landfills if it uses active gas collection and has beneficial use of the gas - can also be accepted at Class 1 landfills for mulching or landfill cover • Counties over 100,000 are mandated to reach the 75% recycling goal by 2020; state goal still in effect • Legislature directs DEP to create Recycling Business Assistance Center, recycling recognition program for private businesses, and voluntary certification for MRFs
2012	• 2-year interim goals set for state recycling goal • Legislature enacts new methodology for calculating recycling rate - revised to reduce the amount of energy recycling credits received for countries recycling 50% or more by means other than renewable energy (renewable energy credit for each megawatt-hour generated from MSW is reduced from 2 tons to 1.25 tons)
2016	• Any owner or operator of any material recovery or disposal facility that accepts dedicated loads of C&D debris is required to evaluate the economic feasibility of processing to remove recyclable materials prior to disposal • DEP initiates a public/private partnership with waste industry groups to address rising single stream contamination rates and boost residential participation in curbside recycling statewide
2018	• China's National Plastic Scrap Import Ban (National Sword) goes into place

5.3.6.2 Waste Infrastructure

Florida, along with much of the US, has largely followed the EPA's transition from solid waste management towards sustainable materials management (SMM). The concept originated in an EPA report in 2002 titled, "Beyond RCRA: Waste and Materials Management in the Year 2020," and was further defined by the EPA in a 2009 report titled, "Sustainable Materials Management: The Road Ahead" (EPA, 2020). In an effort to assess the ability to implement this concept in a Florida-specific context, the Hinkley Center released the "Florida Solid Waste Management: State of the State" report in 2018. The report explored prospective alternative waste management systems that would help the state increase its recycling rate and decrease its environmental footprint (Townsend et al., 2018). While most of the methods represented a higher cost than current methods, they all led to higher recycling rates and most led to less GHG emissions and energy use. In 2020, the Hinkley Center took those findings further and developed the HC [Hinkley Center] 18/19 Tool, which can be used by Florida local governments and FDEP to estimate and compare environmental footprints of different SWM techniques based on specific waste streams, composition, disposition, and life cycle assessment impact factors (Townsend et al., 2020). Between multi-level reporting and innovative research initiatives, Florida is progressive regarding its history of SWM and transition towards SMM, and it is clear that many institutions support this transition and see the importance of diversified waste management for the state and its people.

In that vein, there is a wide range of waste infrastructure and methods of management across the state. According to the FDEP, as of 2022, there were 191 registered compost facilities in Florida (though there are only 66 according to the Sustainable Packaging Coalition, and only 1 accepts bioplastic), 110 landfills both operational and closed (94 public, 16 private), 18 material recovery facilities (MRFs), and 11 operating waste-to-energy (WtE) facilities. The majority of landfills in the state are publicly owned at the county level, while the majority of MRFs and WtE facilities are owned by private companies (FDEP, 2022). The Florida Statutes outline that all counties oversee their own solid waste disposal facilities, and therefore local governments cannot develop their own plans for disposal unless approved by the county (Florida State Legislature, 2023). This can make integrated SWM difficult at the local level. These patterns can be seen when infrastructure data are compared against LandScan, which provides an estimate of ambient population density or societal activity for a given area (Figure 5.7), and also when compared against the Human Development Index (HDI), which takes into consideration a health dimension, education dimension, and standard of living dimension to generate a normalized, simplified metric of human development for a given location (Figure 5.8) (UNDP, 2022; Sims et al., 2023). Across FL, HDI ranges from a low of around 0.67 to a high of around 1.1. These comparisons and patterns, coupled with on-the-ground data like CAP, can also be used to help identify potential areas of need for different types of waste management capacity.

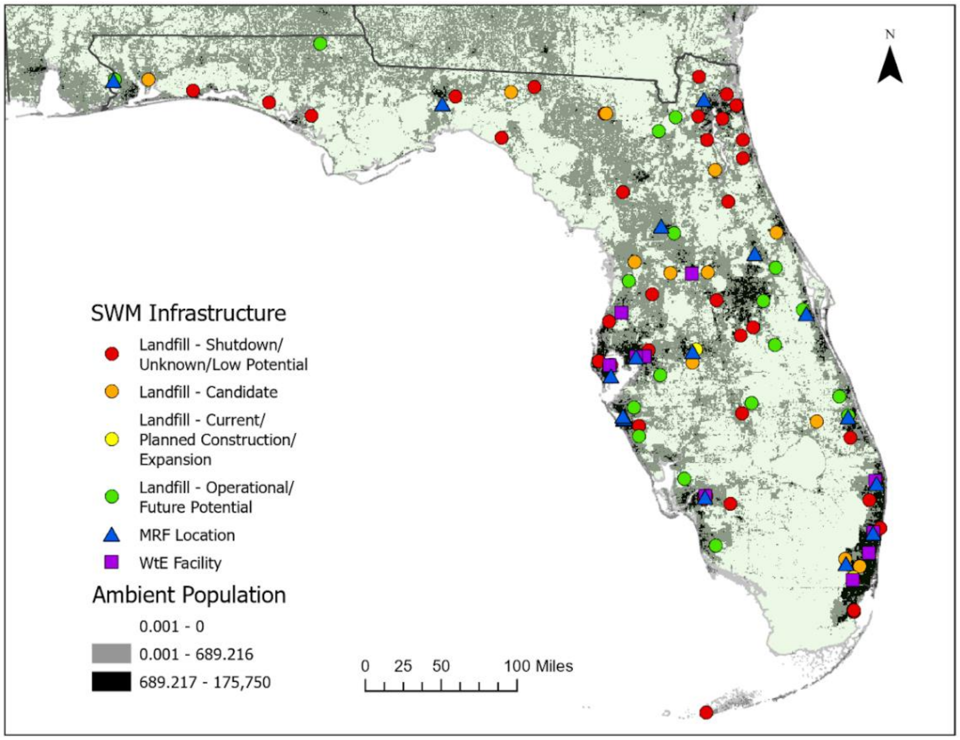

Figure 5.7: SWM Infrastructure in Florida mapped with LandScan data

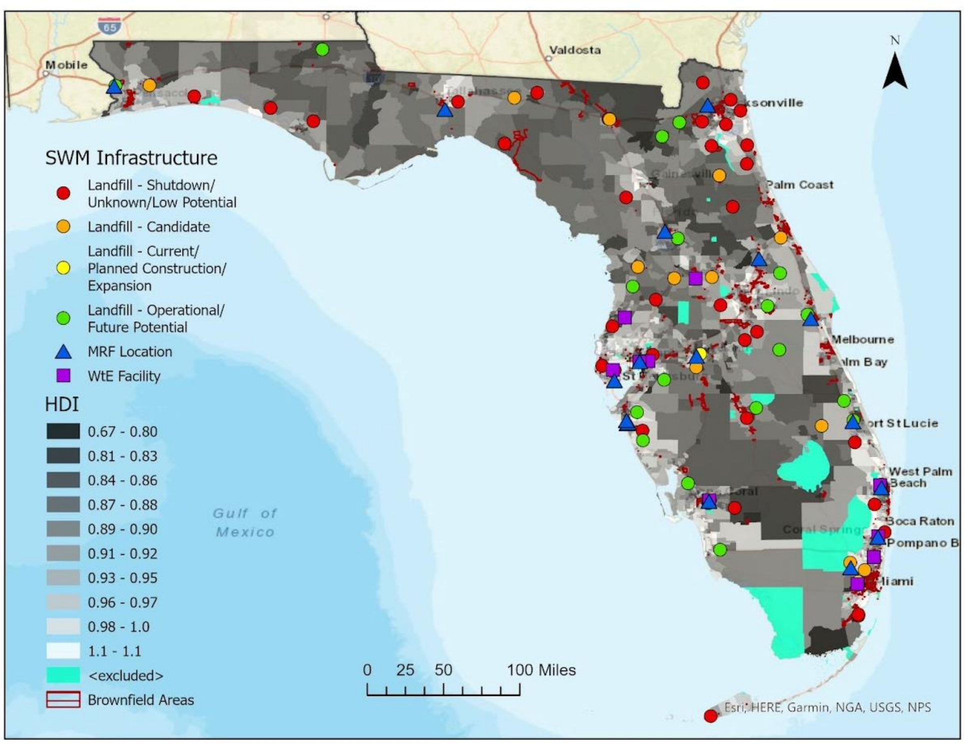

Figure 5.8: SWM Infrastructure in Florida mapped with HDI data

Based on observations from Figure 5.7 and Figure 5.8, with data provided by FDEP, SWM infrastructure is fairly fragmented across the state. In general, there are few MRFs compared to landfills and WtE facilities. Not all MRFs are located near landfills or affiliated with one, which could suggest co-locating opportunities to optimize waste transport and management. There are multiple closed or low potential landfills (only four are planned or under construction) and often there are new WtE facilities observed in locations with multiple recently closed landfills (Figure 5.9, Figure 5.10). There are still large swaths of mid-population, likely rural areas, particularly in the panhandle and western side of the state, that have minimal operational SWM infrastructure in general (Figure 5.11). Even in some densely populated areas, such as Jacksonville in the northeast of the state and Orlando near the center of the state, haulers must still travel long distances from urban centers to reach operational landfills, and the infrastructure in general is widely dispersed across the city region (Figure 5.12). In areas such as the Florida Keys and western Florida, there are extremely long distances (some nearly 200 miles) between operational landfills or between cities and the closest operational landfill. Patterns that may indicate areas of concern around environmental justice are also observable in these types of visual analyses. For example, many landfills and brownfield sites across the state line up with areas of low HDI, and those areas are more likely to have lower access to SWM infrastructure (Figure 5.9, Figure 5.10, Figure 5.11, Figure 5.12). Solutions in the future need to work to address these challenges.

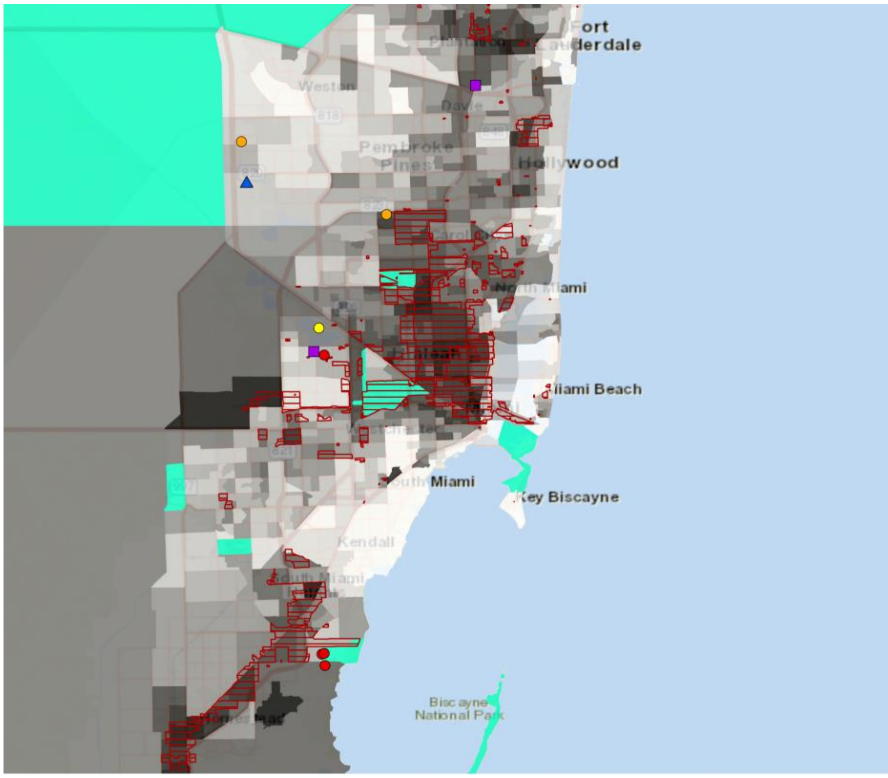

Figure 5.9: Demonstration of how brownfield sites in SE Florida line up almost exactly with low HDI areas, how closed landfills and WtE sites are mostly found in low HDI areas, and WtE facilities near closed or inoperable landfills

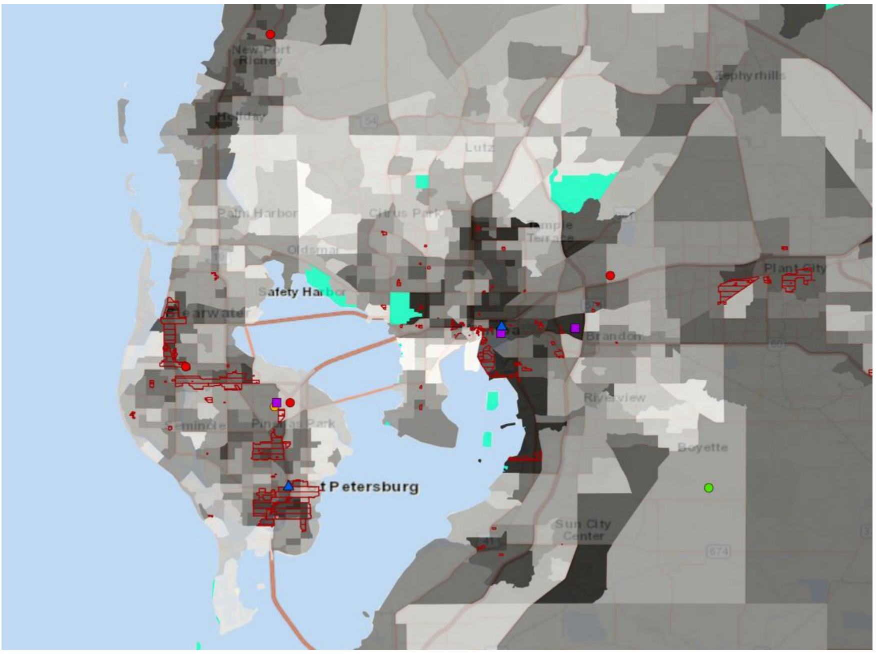

Figure 5.10: Other example of where brownfield sites line up with low HDI areas, where multiple closed landfills and new WtE plants are in proximity, and where closed landfills are in low HDI areas

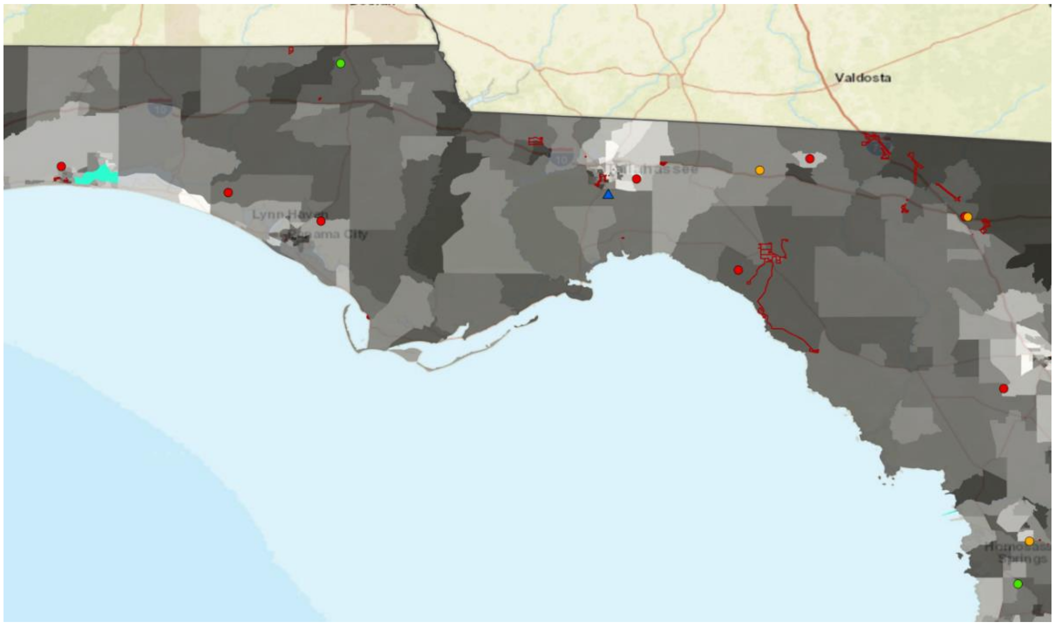

Figure 5.11: Example in the panhandle area where there is very limited infrastructure, low ambient population, low HDI, and closed landfills in vulnerable floodplain areas along the coast

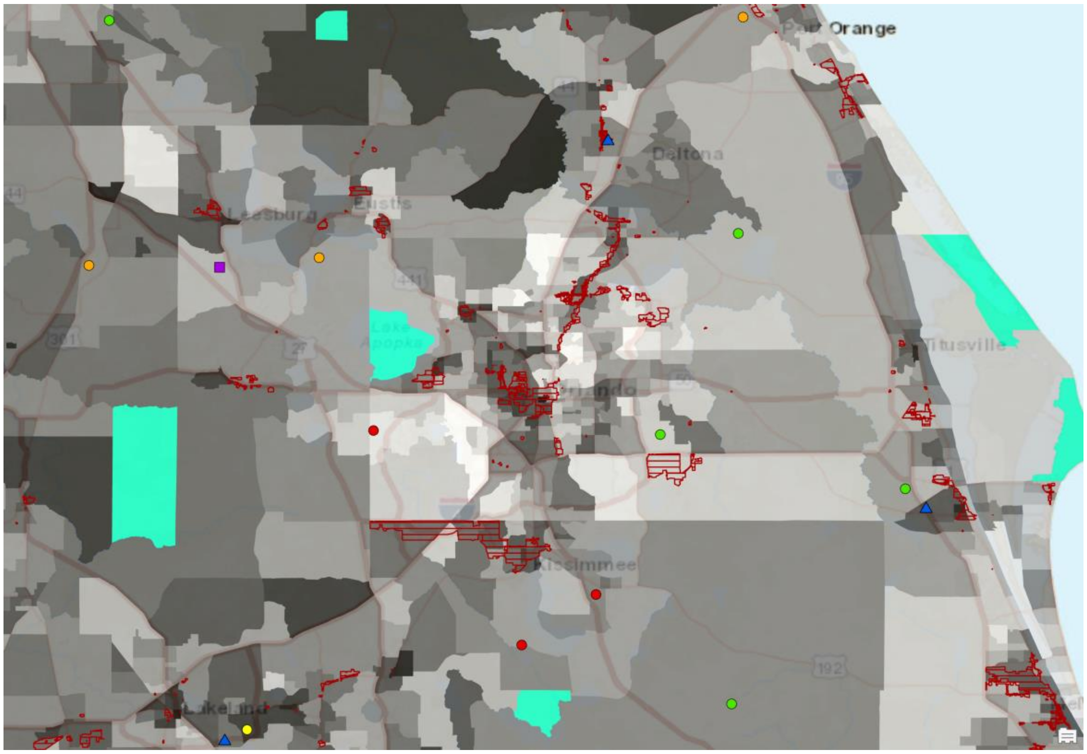

Figure 5.12: Example of an area of high ambient population in central Florida where brownfield sites follow path of low HDI areas, recycling facilities are scarce, and WtE facilities are being developed near closed landfills

According to GIS Analysis using the Nearest Neighbor spatial analysis tool, the observed mean distance between landfills in Florida was around 12km, the observed mean distance between WtE plants was around 37km, and the observed mean distance between MRFs was around 81km. This demonstrates the relative abundance and proximity of different waste disposal options, with recycling being potentially the most difficult to access. These are Euclidean distances based on chordal distance measured according to geographic coordinates provided by FDEP. According to the Nearest Neighbor ratio, MRFs and WtE facilities were more widely dispersed across the state (ratio = 1.26 and 1.11, respectively), while landfills exhibited a more clustered distribution (ratio = 0.4).

5.3.6.3 Landfill

According to the EPA's Landfill Methane Outreach Program, as of March 2024, there were 75 open landfills in Florida. An additional 58 were categorized as Shutdown or Low Potential, meaning the landfill is closed and does not meet the technical criteria for Candidate status, and also does not contribute to landfill gas contributions (Table 5.4) (EPA, 2024). Among all 110 operational and non-operational landfills in Florida, 71% have landfill gas collection systems. Among those that are privately owned, the most common company is WM, which owns around 8% of all landfills in FL. The three other private companies - Waste Connections, Republic Services, and Retirement Corporation of America, Inc. - each owns around 2% of landfills in the state, respectively (EPA, 2024).

Table 5.4: Status of all landfills in Florida (EPA LMOP, 2024)

Landfill Project Status	***Count***
Shutdown	*32*
Low Potential	*26*
Operational	*25*
Candidate	*13*
Unknown	*8*
Planned	*3*
Future Potential	*2*
Construction	*1*
TOTAL	***110***

FL's combination of high population density along coastlines, low-lying topography, porous geology, and high susceptibility to tropical storms and flooding made its landfills particularly vulnerable. At least 30% of municipal landfills in Florida are located within FEMA's 100-year flood hazard zone (Nicholls et al., 2021). Nearly all landfills assessed in Florida as part of the CAP were nearing the end of their life, and all three locations had around 10 years of capacity left in the landfills that service their area (CIL, August 2021; CIL, February 2024; CIL, March 2024).

It is clear that waste diversion will be critical for Florida going forward. While landfilling in some cases may be the best option for certain categories of waste, and landfilling is still the most common form of SWM in the state by mass, it is critical to divert waste streams that have other, and, in many cases, more sustainable, options for management. Recommendations from FDEP status reports following the 75% recycling goal also recommended implementing statewide landfill bans for certain materials, such as C&D waste (FDEP, 2019).

5.3.6.4 Recycling

While Florida has had statewide recycling goals since 1988, implementation and progress against those goals has varied. The Solid Waste Management Act (SWMA) of 1988 from the Florida Legislature set a goal of recycling 30% of waste in the state by the end of 1994. Over time, this goal has fluctuated between a recycling goal and a waste reduction goal, has had a varying list of priority material types for recycling, and has been restricted to only apply to counties with an increasingly high population (FDEP, 2008). The current statewide recycling goal of 75% was enacted in 2008 and was introduced as an aspirational goal without strict county mandates. The legislature requested a report from FDEP by 2010 to provide recommendations on how to achieve the goal and interim goals were set at 2-year intervals. The statewide interim recycling goals were accomplished for 2012 and 2014, but not for 2016 or 2020. According to FDEP, the statewide recycling waste for MSW was 41% in 2022. There is no provision in the statute for the goal to sunset after 2020 and FDEP continues to work towards the 75% goal today (FDEP, 2021).

Before the 2008 recycling goal was set, the state had started and sunsetted several initiatives that attempted to increase recycling across the state. These included the Recycling & Education Grants that were launched in 1988 and ran through 2001. The state also launched the Innovative Recycling & Waste Reduction Grants in 1997 which was funded from 10% of the Solid Waste Management Trust Fund on an annual basis through 2008 (FDEP, 2008). Through both programs, the FDEP awarded millions of dollars to counties across Florida to enhance recycling and reduce MSW. While they had sunsetted by the time of the 2020 75% goal launch, these programs set the foundation for recycling support in Florida and are still looked at as models today (FDEP, 2021).

After the 75% goal was launched - between the years 2008 and 2020 - Florida implemented several programs to re-stimulate recycling among businesses, schools, municipalities, and the public across the state, building in part from recommendations from the FDEP to the state legislature in 2010 (FDEP, 2010). These include the FDEP Recycling Business Assistance Center, the Florida Recycling Loan Program, the Recycling Recognition Program, The Florida DEP Business Recycling Tracking Tool, the Southern Waste Information eXchange, and the Florida Recycling Workgroup. In 2016, the FDEP launched a public/private partnership with waste industry groups to address single-stream recycling contamination rates and boost residential participation in curbside recycling. There has also been county-level guidance on the statewide goals and periodic benchmarks. FDEP also launched a statewide education and awareness campaign titled, "Rethink. Reset. Recycle." (FDEP, 2021). However, the state still struggles with high contamination rates, low public participation in recycling programs, high processing costs, and a volatile recycling market (Townsend et al., 2022). While mechanical recycling is widely accepted as a critical part of building a CE going forward, it is important to note that issues around collection, sorting, material property deterioration, costs, discrepancies in recyclate composition and quality, and concerns around human and environmental health remain (Schyns, 2021).

While it is important to note that the statewide recycling rate for Florida is higher than the national average in the US of 32%, despite these efforts the state has still fallen short of its ambitious targets. Even the highest national municipal solid waste recycling rate globally, currently held by Germany, is just below 60% (WPR, 2024). In 2017 and 2019, FDEP was asked to complete a status report on the 75% goal with a progress update and key recommendations (FDEP, 2017; FDEP 2019). Both reports recommended reinvesting in the Recycling and

Education Grant Program and the Innovative Recycling Grant program, with a particular focus on covering initial capital costs, operations, recycling education, and expansion of projects for local governments across the state. The reports also recommend amending the statute to apply the recycling goal to cities with a population greater than 50,000 - as opposed to the current prioritization for "large counties" over 100,000 - and to shift from a weight-based recycling goal towards a broader SMM goal. At the local level, the reports recommend that local governments mandate commercial recycling, increase procurement of recycled content products in state and local governments, colleges, and universities, and encourage K-12 general education on recycling, composting, and waste diversion. Incentives are also encouraged for companies that are expanding their recycling infrastructure or using recycling materials, such as tax deductions, low-interest loans, credits, and other end-user rebates. As a disincentive and potential for aiding in state funding efforts, the state could also explore adding disposal surcharge for Class I landfills and WtE facilities, or other less favorite SWM methods (FDEP, 2017; FDEP, 2019).

Several other state organizations, such as the Florida Recycling Partnership Foundation (FRP), have provided a similar series of recommendations focused on the role of businesses in recycling, reuse, and education (FRP, 2024). In 2022, the University of Florida (UF) prepared a report for FRP on various scenarios to optimize household curbside recycling in Florida. The report found that, under most circumstances, providing curbside recycling collection results in a net cost to a local government and residents, but this cost is a relatively small percentage (16-26%) of the overall waste management system cost, which further emphasizes the need for local level support to offset municipal SWM budgets and provide incentives to local residents. Importantly, the report also found that targeting a specific material type or a small suite of materials - even if the recycling rate for that material or stream is lower than that of all MSW -

optimized the recycling system for local governments and residents by lowering costs and reducing GHG emissions. This included high-value plastics such as PET and HDPE. In contrast, mixed plastic waste streams were among the most problematic and contaminated. The report stated that the most effective method for mitigating the cost of recycling is by reducing contamination, and emphasizes that this will be critical for municipalities in Florida going forward (Townsend et al., 2022).

As of 2022, there were 18 nationally registered MRFs in the state of Florida - around ⅙ the quantity of landfills in the state - most of which are owned by private companies (FDEP, 2022). According to 2024 data from The Recycling Partnership, 90% of single-family homes in Florida had access to recycling (85% through curbside pick-up, 5% through drop-off), and 16% of multi-family homes in Florida had access to recycling. Across all Florida households, 66% had access to recycling and 34% did not. This puts Florida in the lower half of all household access to recycling among US states, which ranges from a high of 97% of households (Delaware) to a low of 34% (North Dakota). The report also found that, among all households that do have access to curbside recycling in Florida, 67% participate, which is higher than the national average of 59%, but well below the highest participation rate of 72% (Hawaii). Florida was among the top three US states for the quantity of recyclable material lost annually (meaning recyclable material that is either not collected due to a lack of access to curbside collection or exclusion of that material in curbside collection), estimated at around 2.4 million tons per year (TRP, 2024). By commodity, with the exception of PET (22%) and HDPE (27% for natural and 24% for colored), the residential recycling rates for plastic were low compared to other material types; the rate was 8% for PP, 2% for Plastics # 3, 4, 6, 7, and less than 1% for bulky rigid plastic and film plastic. Comparatively, the residential recycling rate for cardboard was 34%, 25% for mixed paper, 23% for glass containers, and 23% for aluminum cans (TRP, 2024).

Participation rates and contamination rates varied across CAP cities in FL. As the CAP locations were mostly larger, urban locations, the access to recycling was usually higher than the state average, typically around 90%. Participation in those programs differed between location and also between commercial, multi-family, and single-family homes, often ranging between 40-70%. Contamination rates varied between cities, with some reportedly as high as 70% and some as low as 20%, though all locations cited contamination as a key challenge for household and commercial recycling (CIL, August 2021; CIL, February 2024; CIL, March 2024). The city of Orlando is an example of a recent successful recycling initiative that was built from the ground-up in 2023, the city implemented an ordinance mandating recycling for all multifamily and commercial properties, which was preceded by a 4-year long community engagement and education process. Studies have suggested that participation rates have increased and contamination levels have decreased, which is also attributed to community- and property-specific, tailored outreach by the city's solid waste management commission to optimize recycling and allow for flexibility (CIL, March 2024).

Florida should continue working towards its 75% recycling goal, but there will need to be additional support for local infrastructure and education. Incentives, including potentially through EPR or DRS, should also be incorporated to increase participation and reduce contamination rates. It may be beneficial for the state to build upon its "minimum 8" list of materials to prioritize waste streams to further streamline the process. There may be statewide and regional opportunities to build recycling markets to offset some of the processing costs that have been prohibitive in the past. In the future, it will be important to ensure that recycling or diverting waste is more accessible and affordable than landfilling or dumping.

5.3.6.5 Compost

According to FDEP, there were 191 registered compost facilities in Florida for the 2024/2025 fiscal year, 119 of which accept material from the public, and the majority (93%) of which accept only yard waste. Only 13 of those facilities accept vegetative waste and 18 are registered as source-separation organics composting facilities (FDEP, 2024). Although it doesn't appear on the FDEP list, there appears to be one composting facility (JFE Compost in Okeechobee County) that accepts compostable plastics. This facility appears on a list of composting facilities in the US from the Sustainable Packaging Coalition, which shows 66 composting facilities in Florida (including all locations that accept compostable material for processing, including landfills, recycling facilities, county solid waste management offices, transfer stations, and yard waste processing facilities) (SPC, 2024). Among those facilities, 83% accept only green waste (yard waste). Apart from the one private operation in Okeechobee County, there are no large-scale and public industrial composting operations in Florida that accept compostable plastic.

According to the USDA, there are 4,700 industrial composting facilities in the US that create compost and soil amendments for use in agriculture and other sectors. Compostable plastic can be processed in this way into biomass, water, and carbon dioxide, but the term 'bioplastic' can denote that the product is 'biobased' and may or may not be 'biodegradable,' (USDA, 2018). The compiled Product Design data from the Florida CAPs identified 20 different material types among to-go items, 12% of which were plastic alternatives such as paper that could potentially be composted, and 6% of which were compostable plastic such as PLA. The CAPs in Florida demonstrate a growing mismatch between material types entering Florida communities and the capacity to dispose of them in a manner that diverts from landfill (e.g., compost or recycling), as well as confusion around product labeling among consumers and disposal options among businesses (CIL, August 2021; CIL, February 2024; CIL, March 2024).

It is clear that composting has a key role to play in SWM in Florida moving forward. The status reports for the 75% recycling goal highlighted the need for community composting training programs and education, a statewide assessment of composting capacity and collection processing infrastructure needed to expand the market in Florida, and incentives for companies that are expanding composting infrastructure or using compost/compostable materials (FDEP, 2017; FDEP 2019). Despite its importance in the SWM landscape, the infrastructure does not currently exist to support the needed advances, particularly for industrial composting. It will be important to ensure that products and materials align with the SWM infrastructure and needs of communities.

5.3.6.6 Waste-to-Energy (WtE)

As of 2022, FDEP reported 11 operating WtE facilities across Florida (FDEP, 2022), which includes the combustion of waste with energy recovery. As can be seen in Figure 5.7 and Figure 5.8, many WtE facilities are being developed in major urban centers across Florida, particularly in locations where landfills have recently been closed or where there are multiple inoperable landfills. Florida reportedly incinerates more waste than any other state in the US (by mass) and has passed recent legislation, such as SB 1764 in 2022, to put hundreds of millions of dollars towards building up infrastructure for incineration with energy recovery across the state. The bill includes the state covering costs for incinerators due to reduced electricity sales revenues as well as granting subsidies to build new incinerators and expand existing ones

(Rosengren, 2022; EJN, 2024). In March 2022, the former Chief of Staff of the US EPA wrote an article in The Floridian condemning the legislation, stating that: "Such a policy flies in the face of basic recycling standards which are built on extending the useful life of products and materials as long as possible to the benefit of local jobs, environmental outcomes, and a more circular economy. Not giving up and lighting them on fire." (Gunasekara, 2022). It is clear that there are mixed sentiments across the state on the viability and sustainability of trash incineration.

A further complication is that, under the current recycling goals and legislation of the state, the burning of trash counts towards "renewable energy recycling credits" for counties. According to FDEP, this was intended to be a temporary measure to initially boost recycling across the state - "While renewable energy credits are realized from materials sent for incineration, future expectations are to leverage economies of scale to divert as much recyclable material to processors and obtain full recycling credit." (FDEP, 2021) - but legislation such as SB1764 would transform it into a permanent measure subsidized by Florida taxpayer funds (Gunasekara, 2022).

This recent expansion of WtE in the state has been hotly contested among community groups, the media, and private industry in recent years. According to annual data reported to FDEP, the state's trash incinerators were reportedly responsible for 1/3rd of the industrial air emissions of highly toxic mercury in the state from 2011-2022. The average household income for areas where WtE plants exist in Florida is around $53K/year and 70% of incinerators in Florida are located where people of color are disproportionately impacted (EJN, 2024). There have been acute incidents that have heightened arguments around WtE in the state recently - in 2023, the trash incinerator in the City of Doral, Florida caught fire and burned continuously for nearly three weeks. This resulted in reports of poor air and water quality, human health issues, and environmental contamination (Burkhardt et al., 2023). As of September 2024, there has also been significant pushback and controversy in the community over the location of a proposed new plant in Miami-Dade County due to safety and environmental justice concerns (Da Silva, 2024; Luscombe, 2024; Wynne, 2024). Some studies have also found that WtE in general is less efficient, more costly, and affiliated with more human and environmental health concerns than other types of energy generation and other methods of managing waste (Baptista and Perovich, 2019; Gunasekara, 2022; EJN, 2024).

While WtE may be the most sustainable, viable, and equitable option for managing some types of waste in Florida, the overall process is widely considered to not be in support of a truly circular transition. Studies have demonstrated that, given a range of SWM options in Florida including WtE, a system with targeted recyclables that focuses on high-value materials can ultimately reduce environmental impacts and system costs (Anshassi and Townsend, 2024). Further, given the concerns around landfill development, the current recycling goals in the state, and the landscape of EJ issues, Florida should be prioritizing waste reduction and not investing in infrastructure that may ultimately result in dependence on a waste disposal method that causes more human and environmental harm.

5.3.7 Leakage

In total, 101 100 m^2 litter transects were conducted across all three CAPs in Florida (40 in Miami, 34 in Orlando, 9 in Key Largo, 9 in Marathon, and 9 in Key West). Sites were selected and transects were conducted based on the Site Selection and Leakage methodology outlined in Jambeck et al., 2024. A full list of items and material categories used for data collection through the Marine Debris Tracker app is in the Appendix (Table A2).

Macro- and microplastic have been found in high concentrations in estuaries and along coastlines around Florida, with peaks observed after high rain events (Hardesty et al., 2016; McEachern et al., 2019). It was estimated that in 2020 alone, roughly 7,000 tons of plastic entered Florida's marine environment (Townsend, 2021). Studies have raised alarms on the impacts of plastic pollution on local endangered species, such as manatees, sea turtles, and birds of prey, particularly as it relates to ingestion and entanglement (Carlin et al, 2020; Eastman et al., 2020; Gowans et al., 2023). Beyond environmental concerns, one study estimated the cost of plastic debris on beaches to Florida's tourism at $7 billion per year (Adam et al., 2021). Florida is in the process of implementing the Florida Marine Debris Reduction Plan for 2020-2025, building upon the first Florida Marine Debris Reduction Guidance Plan that was developed by the state in 2017. This plan is largely focused on mitigating abandoned and derelict fishing gear and vessels and less on land-based sources of pollution and is coordinated by the NOAA Marine Debris Program in collaboration with local state agencies (NOAA, 2017; NOAA, 2020).

Florida is one of the most active participants in the OC's International Coastal Cleanup (ICC) every year among US States, logging between 300-500 surveys/year since 2010. In the 2014 ICC cleanup alone, Florida documented 715,107 litter items, the second highest count per state behind California, equivalent to nearly 6 lbs of litter/mile of coastline (Hardesty et al., 2016). During the ICC in Florida in 2023, 42% of the litter items collected by count were common single-use plastic items including cigarette butts, food wrappers, plastic bottles, plastic bottle caps, straws/stirrers, and grocery bags (see Figure 5.13) (OC, 2024). While data from the ICC and others have shown that a significant portion of the coastal litter in Florida is from land-based sources - as well as an estimated 80% of marine litter globally - the majority of funding and support for litter mitigation in Florida has historically gone towards cleanup, with 5% or less going to prevention and enforcement respectively (Jambeck et al., 2001; Eunomia, 2016; OC, 2024).

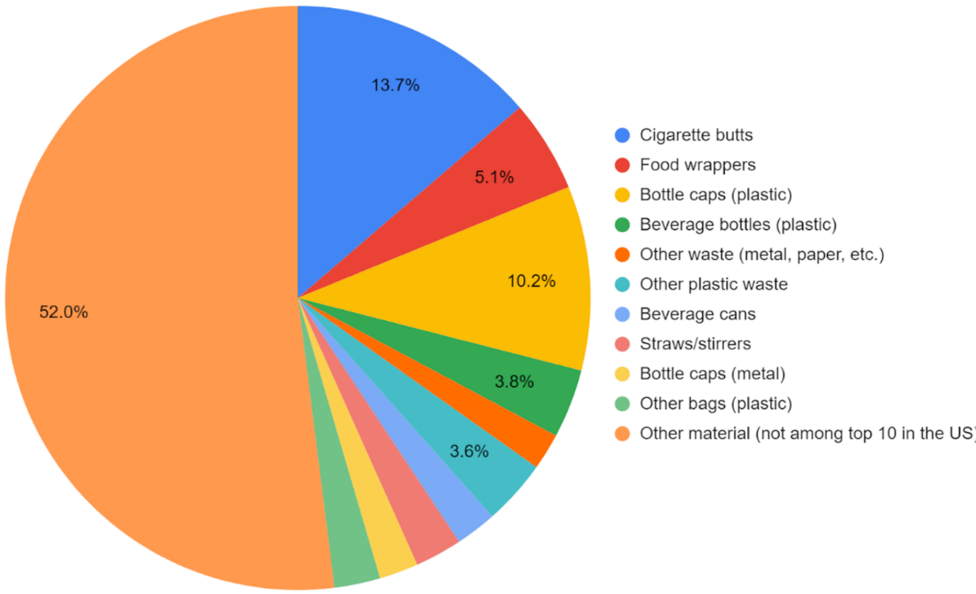

Figure 5.13: Breakdown of litter items documented through ICC in Florida in 2023 (Data Source: OC, 2024)

Although the CAP litter transect data is typically collected within communities and along sidewalks and roadways, a similar pattern was observed to that of the ICC data for Florida. Overall, the most common material type found for litter items was plastic fragments (28% of all litter), followed by food plastic (16%) and tobacco products (16%). Interestingly, the next three most common material types were glass (10%), paper (8%), and metal (7%) (Figure 5.14).

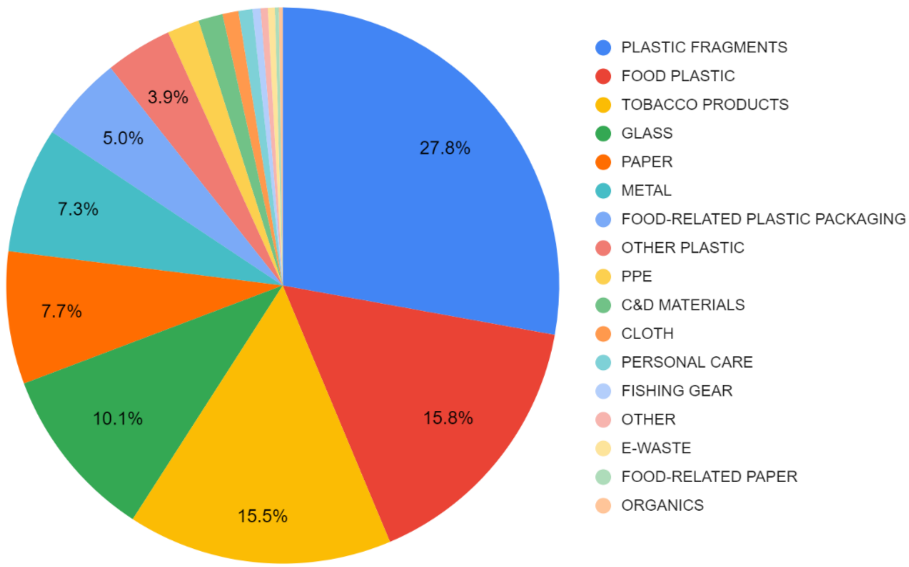

Figure 5.14: Material breakdown of all litter items surveyed across all Florida CAPs

When comparing leakage characterization across the various CAP locations across the state, there are some similarities (Figure 5.15). Plastic fragments continue to be the most common material type found in litter across all three locations. Food-related plastic was the second most common material type in Miami and Orlando, while tobacco products was the second most common material type in the Florida Keys. The abundance of glass litter was lower in Orlando when compared to Miami and the Florida Keys, though paper litter was higher in Orlando comparatively, and metal litter remained similar across all three CAP locations. PPE litter was higher in Miami, but this could be because Miami was the earliest CAP conducted during the COVID-19 pandemic, which caused an increase in PPE litter worldwide (Ammendolia et al., 2021; Roberts et al., 2022).

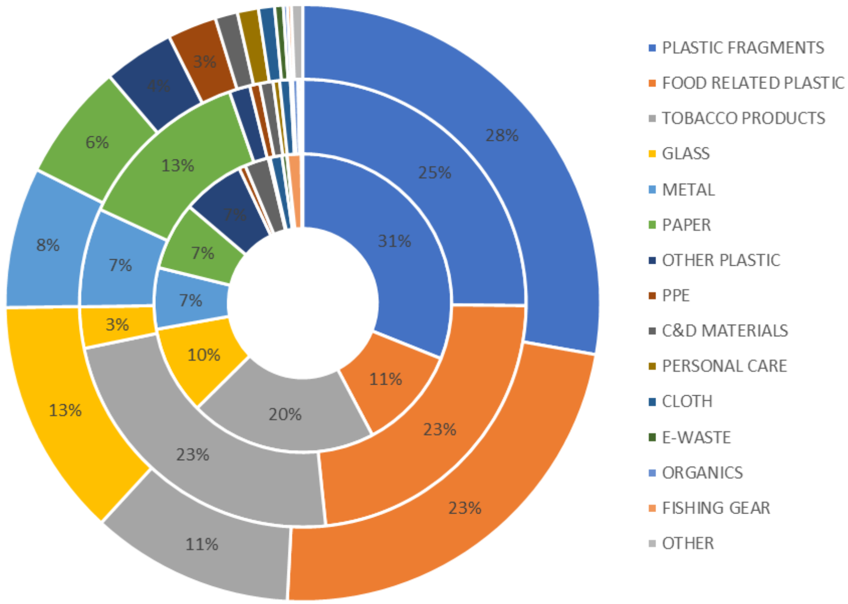

Figure 5.15: Material breakdown of all litter items surveyed in Florida CAPs - Miami (outer), Orlando (middle), Florida Keys (inner)

Among the top ten litter items observed across all CAP locations in Florida, seven were single-use plastic items (Figure 5.16). This included the top two most common litter items, cigarettes and hard plastic fragments, as well as film fragments, plastic food wrappers, foam fragments, plastic bottles and plastic bottle caps. This is similar to what has been observed in Florida through the annual International Coastal Cleanup (OC, 2024). The items are also among the most problematic from a collection and waste management standpoint, as they are often lightweight items made of low-value polymers in the traditional recycling industry.

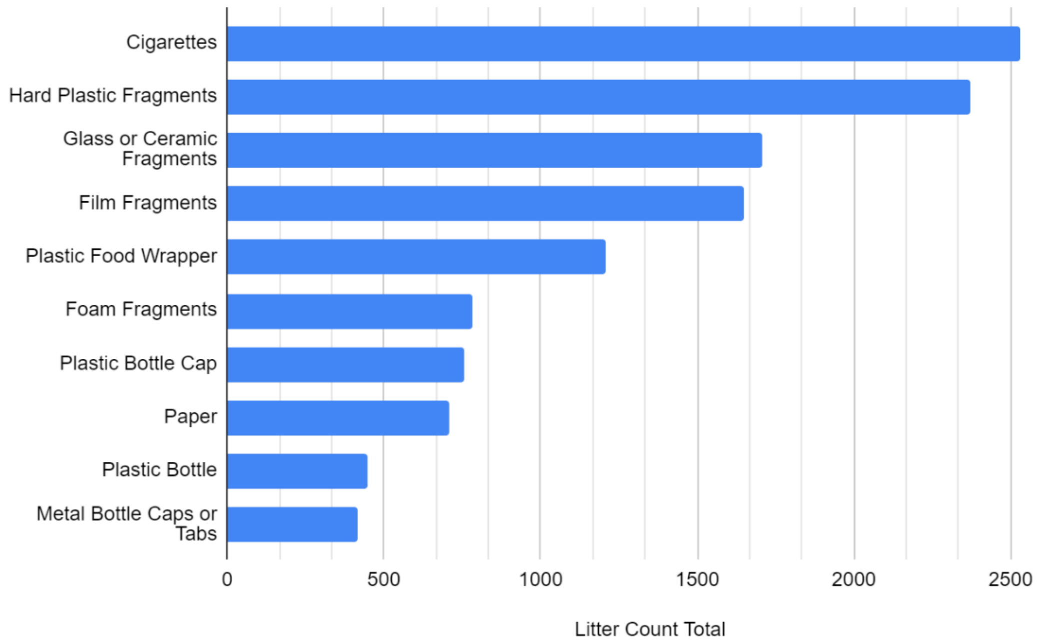

Figure 5.16: Top 10 most common litter items surveyed in Florida CAPs

Litter densities and top litter items were also compared across the CAP locations in Florida. The average litter density across all transects in Florida was 1.69 items/m^2, ranging from a high of 6.42 items/m^2 to a low of 0.02 items/m^2. Miami had the highest average with 2.53 items/m^2, followed by 1.16 items/m^2 in the Florida Keys and 1.12 items/m^2 in Orlando. The state-wide average is slightly higher than other CAP locations in the US, such as an observed litter density of 0.55 items/m^2 in Cape Girardeau, MI, 0.68 items/m^2 in Minneapolis, MN, and 0.77 items/m^2 in Blytheville, AR. The city-wide averages are similar to other cities in the US, such as 1.10 items/m^2 in Vicksburg, MS, 1.14 items/m^2 in Atlanta, GA, and 1.20 items/m^2 in Athens, GA.

Cigarettes, hard plastic fragments, and film plastic fragments were among the top five litter items when averaged for each CAP location in Florida. Distinctions can be seen between the CAP locations and between ambient population densities within each location (Table 5.5).

For example, plastic string and packing tape litter were more commonly observed among the top five litter items in the Florida Keys locations, while plastic food wrappers were more commonly observed among the top five litter items in Orlando and Miami. In Key Largo, Marathon, and Orlando, the highest litter densities were found in the high ambient population areas, whereas in Key West and Miami, the highest litter densities were found in the low ambient population areas. As Key West and Miami had the highest actual ambient population density when averaged across litter transect areas for each CAP location in Florida, this could suggest that the busy city centers have effective waste management, street cleaning, and other services, while areas that have less ambient population may not have as much access to those services.

Table 5.5: Litter densities and top litter items for all CAPs in FL

Area/City	Population Tertile (persons/sq km)	Top 5 Litter Items	Litter Density (count/m^2)
Key Largo	**Overall**	**1) Cigarettes, 2) Hard Plastic Fragments, 3) Plastic String/ Tape/ or Packing Straps, 4) Film Fragments, 5) Paper**	**0.63**
	Upper (206-277)	1) Cigarettes, 2) Plastic String/ Tape/ or Packing Straps, 3) Film Fragments, 4) Hard Plastic Fragments, 5) Paper	0.8
	Middle (68-206)	1) Hard Plastic Fragments, 2) Cigarettes, 3) Glass or Ceramic Fragments, 4) Plastic String/ Tape/ or Packing Straps, 5) Film Fragments	0.52
	Lower (0-68)	1) Cigarettes, 2) Hard Plastic Fragments, 3) Paper, 4) Film Fragments, 5) Other C&D	0.57
Marathon	**Overall**	**1) Cigarettes, 2) Film Fragments 3) Hard Plastic Fragments, 4) Glass or Ceramic Fragments, 5) Paper**	**1.48**
	Upper (143-889)	1) Film Fragments, 2) Cigarettes, 3) Hard Plastic Fragments, 4) Paper, 5) Plastic Food Wrapper	3.11
	Middle (44-143)	1) Cigarettes, 2) Hard Plastic Fragments, 3) Paper, 4) Film Fragments, 5) Plastic String/ Tape/ or Packing Straps	0.62
	Lower (0-44)	1) Glass or Ceramic Fragments, 2) Hard Plastic Fragments, 3) Film Fragments, 4) Cigarettes, 5) Plastic String/ Tape/ or Packing Straps	0.71

Key West	**Overall**	**1) Cigarettes, 2) Hard Plastic Fragments, 3) Glass or Ceramic Fragments, 4) Film Fragments, 5) Paper**	**1.38**
	Upper (1,139-2,921)	1) Cigarettes, 2) Metal Bottle Caps or Tabs, 3) Hard Plastic Fragments, 4) Bolts/ Nails/ & Screws, 5) Paper	0.71
	Middle (249-1,139)	1) Hard Plastic Fragments, 2) Glass or Ceramic Fragments, 3) Cigarettes, 4) Film Fragments, 5) Paper	1.54
	Lower (0-249)	1) Cigarettes, 2) Glass or Ceramic Fragments, 3) Hard Plastic Fragments, 4) Film Fragments, 5) Plastic String/ Tape/ or Packing Straps	1.89
Miami	**Overall**	**1) Hard Plastic Fragments, 2) Glass or Ceramic Fragments, 3) Cigarettes, 4) Film Fragments, 5) Plastic Food Wrapper**	**2.53**
	Upper (3,537 - 21,860)	1) Glass or Ceramic Fragments, 2) Cigarettes, 3) Hard Plastic Fragments, 4) Metal Bottle Caps or Tabs, 5) Paper	2.46
	Middle (1,135 - 3,536)	1) Hard Plastic Fragments, 2) Cigarettes, 3) Plastic Food Wrapper, 4) Glass or Ceramic Fragments, 5) Film Fragments	1.48
	Lower (1 - 1,134)	1) Hard Plastic Fragments, 2) Film Fragments, 3) Glass or Ceramic Fragments, 4) Foam Fragments, 5) Plastic Bottle Cap	3.79
Orlando	**Overall**	**1) Cigarettes, 2) Plastic Food Wrapper, 3) Paper fragments, 4) Hard Plastic Fragments, 5) Film Fragments**	**1.12**
	Upper (1,415 - 16,265)	1) Cigarettes, 2) Hard Plastic Fragments, 3) Paper Fragments, 4) Plastic Food Wrapper, 5) Film Fragments	1.73
	Middle (849 - 1,415)	1) Cigarettes, 2) Paper Fragments, 3) Plastic Food Wrapper, 4) Film Fragments, 5) Hard Plastic Fragments	0.39
	Lower (6-849)	1) Cigarettes, 2) Plastic Food Wrapper, 3) Film Fragments, 4) Paper Fragments, 5) Hard Plastic Fragments	0.89

When comparing litter densities across Florida to other factors that some studies have examined as correlative (Youngblood et al., 2021; Youngblood et al., 2022), some state- and city-wide patterns emerge. For example, when comparing transect litter density to ambient population for each transect across the state (retrieved from LandScan 2022, Sims et al., 2023), the top 20 highest litter densities across the state can be found within the roughly lowest 50% of ambient population, and there is a high concentration of high litter density transects in areas with an ambient population of less than 2,000 persons/km^2. This could suggest a lack of access to waste collection and infrastructure in areas with lower ambient population. This, however, varies based on city. In Miami and the Florida Keys, there is, in fact, a very slight negative correlation between the two variables (R^2 = 0.0295 in Miami [0.0015 if you remove litter transects from unpopulated Pace Picnic Island], R^2 = 0.0053 in the Florida Keys), and in Orlando the positive relationship is only slightly higher than state-wide (R^2 = 0.0059).

When comparing litter density to the Human Development Index (HDI) for the United States (University of Chicago, 2023), there was a visible slight correlation relationship between litter density and ambient population. State-wide, only four out of 101 transects did not have HDI data available (at Virginia Key Beach Park and one other location in Miami). The transects at Pace Picnic Island in Miami were removed from this analysis because the high HDI for that area could be misrepresentative as the island is not actually populated. A slight negative correlation was observed between HDI and litter density across the state, with lower litter densities observed in areas with higher HDI (R^2 = 0.1655) (Figure 5.17). This overall negative correlation was observed across each individual CAP location as well, with the Florida Keys demonstrating the strongest correlative relationship (R^2 = 0.4573 in the Florida Keys, R^2 = 0.124 in Miami [with Pace Picnic Island transects omitted], R^2 = 0.1179 in Orlando). Coupled with data on waste disposal areas and access to waste infrastructure across the state, these patterns suggest that areas with low HDI are more likely to have low waste infrastructure and high quantities of litter, which may be exemplary of the social justice dimension of waste management in Florida.

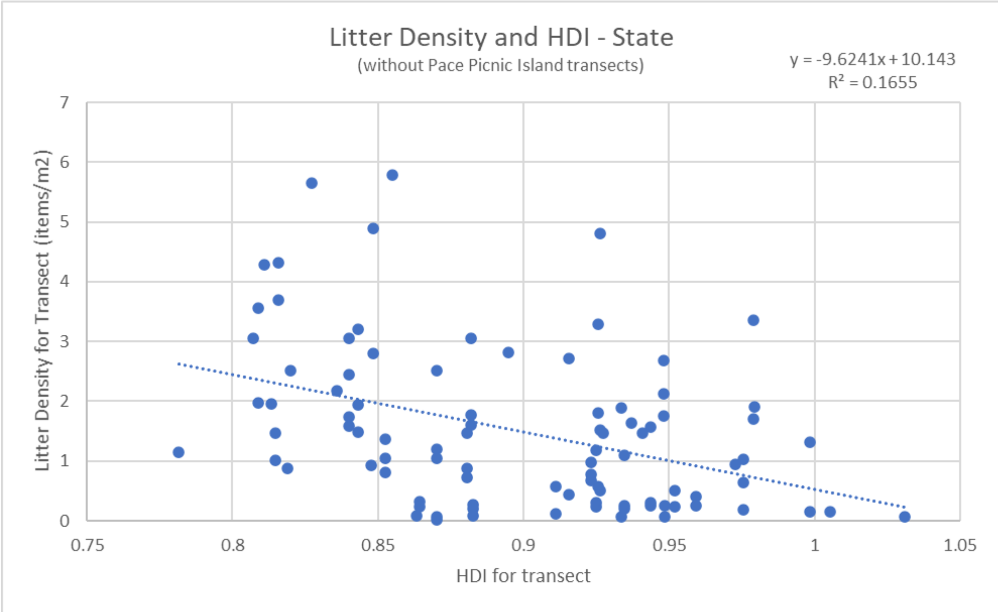

Figure 5.17: Litter Density compared against HDI for all Florida Transects

While this initial analysis does not take into consideration the potential combination of these variables together, it is intended to be used as an example of how the state could prioritize areas for SWM collection, SWM infrastructure, recycling equipment and education grants, litter cleanup, and others. Further research should be conducted to refine these variables that can be used for prioritization and help determine key factors for SWM support at the local level across the state.

It is important to note that as a state with a large coastline that is densely populated, Florida also has unique challenges related to litter and associated impacts on storm drain clogging, flooding, and natural disaster management. Evidence of this could be seen in the aftermath of both Hurricane Helene and Milton in September and October 2024, and the record-breaking daily precipitation numbers in the state in June 2024, which was expected to be a once-in-a-500-1,000-year event (Aguirre, 2023; Doermann, 2024; Lavietes and Siemaszko, 2024). All CAP locations in Florida included interviews where stakeholders discussed challenges that high quantities of litter and open dumping pose for flood mitigation, infrastructure damage, and safety in the city, particularly following heavy rainfall or major storm events. Larger storm debris following such events also poses a unique set of challenges for removal, cleanup, and waste management, which can be further exacerbated by existing litter and open dumping (Holpuch, 2024; Lavietes and Siemaszko, 2024).

5.4 Common Challenges and Opportunities

Table 5.6: Common Statewide Challenges and Opportunities in Florida

CAP Spoke	Common Statewide Challenges (narrative) and Opportunities (bullets)
Input	Across all FMCG sampled across all Florida CAPs, around 78% had manufacturing locations within the US, and around 10% of the total had manufacturing locations within Florida. In some cities, over 90% of FMCG had domestic manufacturers. Several countries in Latin and South America, including Mexico, Brazil, and Venezuela, also imported a large portion of convenience items into FL. While Florida is home to a large number of convenience products and food manufacturers (particularly bottling companies), there is no state-supported or mandated EPR or DRS mechanism. PET plastic beverage bottles and caps represent a high amount of litter identified across the state, even though those items are universally accepted in curbside recycling. • Explore options for statewide deposit return system (DRS) or extended producer responsibility (EPR) initiatives (EPR-style policies reportedly could increase the state residential recycling rate by 209% (TRP, 2024) • Statewide EPR could also engage regional manufacturers and distributors, such as those in Latin and South America, to achieve economies of scale • Engage parent companies and manufacturers located in Florida on the redesign of delivery systems and product packaging, particularly for the most problematic items (e.g., single-use plastic snack bags, food containers, cups, etc.)
Community	Florida is home to a high quantity of tourists, transient populations, and very diverse communities. Interventions need to be tailored to reach those distinct parts of each community. There are business opportunities around building a CE in Florida, both through voluntary and regulatory measures (e.g., the Miami 305 model). Frustration was expressed around plastic ban preemption at the state level from community members, companies, and government representatives alike. There is some confusion and skepticism around curbside recycling in the state. Several stakeholders explained that people often don't know the fate of their trash after they throw it in the bin, and they feel their responsibility as consumers doesn't extend beyond that point. More open communication from government and waste haulers to residents on end-points of recycling in order to restore trust in the system and encourage recycling practices • Consistent, tailored, local messaging around the impacts of plastic pollution, including potential human and public health impacts for Floridians

	• Tailored education, outreach, and meaningful engagement of communities in decisions, including outreach through avenues that make sense for different parts of society (e.g., Spanish-speaking radio, beach cleanups, events, etc.) • Statewide K-12 education on SWM, recycling, reduction, diversion, composting, littering, and other related topics - students could visit local landfills, MRF, other SWM infrastructure, etc. • Coordinated statewide awareness campaign on CE and how it fits into larger themes of sustainability and resilience - this could be built into pride of place for the state, its people, its natural resources, and its environment • Cross-Florida learning network around waste reduction, CE, zero waste, etc. to share best practices and learnings (for example, Orlando wants to learn from Miami 305) • Build upon sustainability networks that exist for municipalities across Florida and incorporate learnings from specific cities (e.g., DFO's zero waste community groups in Miami-Dade)
Product Design	MLP is the top material type among convenience items sampled in FL. PP and EPS are also found among convenience items and foodware, and can be problematic for curbside recycling and litter. Compostable alternatives to SUP are expanding, especially in foodware and in urban areas, but there is no large-scale or widespread industrial composting infrastructure in the state. • Target MLP and EPS in particular for redesign initiatives, especially with FL-based manufacturers • State government and FL-based businesses could focus on reduction or on matching infrastructure with compostable or biodegradable alternatives being introduced. • Consistent labeling and messaging around material types, recycling guidance, etc. at the state level • Guidance for businesses on what alternative options are available to them that meet their local SWM criteria in order to help with decision-making
Use	Alternative materials (such as stainless steel, PLA, and paper) in common household, personal care, convenience, and foodware items are typically more expensive to consumers across Florida, but some bulk/refill options are less expensive. There is little incentive or infrastructure across the state for reuse, and the high quantities of tourists and visitors further complicate the bring-your-own model. • Creative incentives for residents as well as visitors for BYO bags and containers may be helpful. • Learn from Green Event Guides (such as the Guide to Green Works for Events in Orlando and the Waste Reduction Program for the Ultra Music Festival in Miami), and consider mandating something similar at the state level for all municipalities (e.g. requirements through event contracts or location permits) • Encourage and/or mandate at the state or municipality level Green Procurement for local governments • Enhance grant and investment opportunities for repair cafes and similar systems across the state • Explore state or city-wide 'only upon request' policies for plastic straws, plastic utensils, plastic bags, and other problematic SUP items

Collection	In most places across Florida, there is close to 100% access to household waste collection and only slightly less for household recycling collection, but participation rates for recycling are low. Recycling education is not getting through to tourists and visitors. There are high amounts of contamination and high variation in contaminants across neighborhoods. Waste haulers have to travel long distances to manage waste across the state. • Tailored collection solutions (modeled after Orlando and their recycling ordinance outreach) • Need communication on best practices for waste disposal & recycling tailored to tourists and visitors that is also available in multiple languages • Promote the use of "Oops" stickers on bins to reduce contamination, plus funding for enforcement such as fines for repeat offenders
End-of-Cycle	FL's recycling rate is around 40%, which is higher than the US average but still falls below its 75% statewide goal. Most SWM systems in Florida include single-stream recycling and have high contamination rates, minimal support for enforcement, and low levels of household participation. Similarly, policies mandating recycling among different types of residences (e.g., commercial, single-family homes, multi-family homes) are fragmented. There is minimal autonomy over SWM infrastructure at the city level due to county level requirements. It is consistently cheaper for haulers to landfill waste instead of recycle, but there is low landfill capacity and many challenges with landfill infrastructure in FL. Recyclables have to travel long distances, which costs haulers a lot of money to transport, and volatile end markets mean that processors are also not incentivized to recycle. WtE is being considered for growth, but comes with local public concerns for human health and the environment. Public composting exists for yard waste but very minimally for other compostable items such as biodegradable plastics. • State could require local governments to have recycling mandates for commercial properties, multi-family homes, and single-family homes - this could be done through lease agreements • Diversion and reduction can be prioritized - we can switch from a mentality of "*we have such high waste generation rates, so zero waste isn't an option*" to "*we have such high waste generation rates, so we HAVE to work towards reduction, diversion, and zero waste*" • Reinvest in state-led recycling education and equipment grants • Initiate state-led community composting grants • Explore capacity and collection/processing infrastructure analysis for composting across the state - explore options for industrial composting, especially in and around urban areas with high quantities of compostable plastic • Amend the Florida Energy, Climate Change and Economic Security Act to apply recycling goals to cities with a population greater than 50,000 • Develop incentives for businesses and universities within Florida that are expanding composting and recycling infrastructure and/or using compost and recycled materials in their own FL-based operations - these could include tax deductions, available low-interest loans, end-user purchase rebates, recycling credits for their municipalities, etc. • Promote measures to disincentivize disposal at landfills and increase funding for recycling and compost - e.g., statewide ban for landfilling certain materials (e.g., portions of C&D and yard waste), a surcharge to waste disposal instead of recycling, etc.

Leakage	Overall, the most common material type found for litter items across Florida was plastic fragments (28% of all litter), followed by food plastic (16%) and tobacco products (16%). Among the top ten litter items observed across Florida CAPs, seven were single-use plastic items. This included the top two most common litter items, cigarettes and hard plastic fragments, as well as film fragments, plastic food wrappers, foam fragments, plastic bottles, and plastic bottle caps. Stakeholder interviews and local waste management strategies and priorities demonstrated challenges around open dumping in the CAP locations. Litter poses unique challenges in Florida related to stormdrains, flooding, and associated climate issues. Recent evidence of this could be seen in the aftermath of record-breaking daily precipitation in the state in June 2024, Hurricane Helene in September 2024, and Hurricane Milton in September 2024. The prevalence of SUP takeaway bags can also be seen in relatively high quantities of plastic film litter, and high quantities of plastic foam litter could be coming from the use of EPS takeaway containers. As a coastal state that is tourism-dependent, susceptible to storms and flooding, and has a high coastal population density, Florida needs to minimize waste leakage as much as possible. • Litter and leakage could be incorporated into other strategic planning for the state around climate and resilience, especially for flooding, sea level rise, storm intensity increases, etc. • Could overturn state-level SUP ban pre-emption • Tobacco/cigarette litter - Monroe law on beaches could be state-wide • Reinvigorate statewide messaging around keeping Florida clean, not littering, protecting the natural environment, and tie to state identify • All Keep Florida Beautiful affiliates could use MDT for their annual inventories; Community groups and cleanups could also use it to track change over time and track the impacts of interventions • Capacity, staff, funding, and enforcement for illegal dumping detection and penalties (e.g., cameras, citizen reporting, fines, etc.) - consider pilot projects in a few problematic areas

5.5 Product-Specific Opportunities

Key for tables:

- **(S)** - opportunity to be taken at the state level
- **(L)** - opportunity to be taken at the local level
- **(S&L)** - opportunity that can be taken at either the state or local level

**NOTE:* Opportunities have been aligned with CAP spokes, but not all spokes are represented for each product, as only the most impactful are included here

5.5.1 PET Beverage Bottles

It has been estimated that in 2021 alone, 220,000 tons of PET liquid refreshment bottles were consumed in Florida, the equivalent of around 0.01 tons/person (Townsend et al., 2022). MRF operators across the state consistently reported that PET, particularly clear PET, is among the most cost-effective commodities for recycling. Especially among plastic material types, PET recycling markets are generally among the most stable and reliable. From recycling optimization modeling scenarios conducted for the state, where low-commodity materials were removed in some cases, PET was consistently included in the high commodity list of recycled items that should remain (Townsend et al., 2022). In those same scenarios, if post-consumer PET was successfully collected and reprocessed across the state, that post-consumer PET could be used to supply between 50-100% of the state's demand for PET - this remains the case even with a 'high commodity only' recycling scenario outlined in the scenario-planning study and a recycling rate of 75% (Townsend et a., 2022). Among the CAP store surveys, PET was consistently the most common material type found among beverages. Plastic bottle caps were the 7th most common litter item found across all Florida CAPs and plastic bottles were the 9th most common litter item. This pattern was even observed in locations where large bottling brands have on-the-ground B2B initiatives - in those cities, plastic bottles themselves were not in the top 10 most common litter items, but bottle caps were (CIL, March 2024).

Table 5.7: Opportunities for PET Beverage Bottles

Product	CAP Spoke	Opportunity
	Input	• **(S)** State-level policy to support EPR - this could be started locally or led by industry, but would ideally be covered under a statewide

PET Beverage Bottles		umbrella policy in collaboration with bottling industries with a large footprint in the state • **(S&L)** State or local deposit return system (DRS) - this could start with one brand and one grocery store line across the state, or could start in one city, and could be modeled off of other examples in the US such as those from New York, Massachusetts, Michigan, Iowa, Vermont, or others (NCSL)
	Community	• **(L)** Local government communication around safe drinking water and encouraging reuse and refill • **(S&L)** Job opportunities around EPR - companies in the Business Coalition for the Global Plastic Treaty could champion jobs in this space, while also prioritizing 'design for recyclability' principles and increasing recycled content to meet corporate goals (this would also have relevance for Scope 3 goals, for optimizing transportation, keeping funding and resources within the state, and boosting local economies)
	Product Design	• **(S)** State-level guidelines around design to streamline recycling and increase awareness - this could include requiring the cap be made of the same polymer as the bottle, uniform messages around recycling with the cap on, optimizing label printing to be compatible with recycling, etc.
	Use	• **(L)** Local government procurement guidelines and ordinances could be put in place to limit the distribution of plastic water bottles at events, and instead require vendors and permittees to provide reuse and refill options • **(L)** Expand refill stations in public areas (like Woosh Refill Station in Miami) - identify opportunities for business partnerships and grants for infrastructure like this • **(S&L)** Incentive reuse and refill for beverages at restaurants and grocery stores
	Collection	• **(S&L)** Expand recycling infrastructure to decrease distances and increase access (especially in rural areas) - this could be addressed at the local level through state-led recycling grants, EPA SWIFR grants, or could be mandated at the state level (e.g., statewide commitment to have recycling drop-off at X distances across the state, increase participation to X, ensure 100% access to collection, etc.) • **(S&L)** Florida Beverage Association's Every Bottle Back initiative needs to be expanded and effectively communicated, with incentives for people to return their bottles, infrastructure in rural areas, consistent messaging to the public, etc.
	End of Cycle	• **(S)** Consider policies around incorporating recycled content for in-state manufacturers/bottlers • **(L)** Some cities may want to consider multiple-stream recycling, and/or limiting to only certain types of plastic accepted (e.g., # 1, 2, and 5) to limit contamination and optimize quality

		• **(S&L)** Recycling end-market support and building economies of scale - this could happen at the local, state, or regional level, and could potentially engage companies based in Latin/South America and the Caribbean that have a big footprint in FL
	Leakage	• **(S&L)** Explore DRS opportunities where anyone could deposit PET bottle and get money back, a voucher, or other incentive to keep PET litter out of the environment and give it value

5.5.2 Plastic Grocery Bags

Plastic grocery bags are a particularly problematic item for waste management and environmental litter. They are known to be a top contaminant in recycling streams, an issue that was raised by all Florida CAP cities, and they can cause major damage to recycling and landfill machinery. A survey of MRF operators across Florida in 2021 found that 67% reported costly shutdowns and equipment damage due to plastic bags and films (Townsend et al, 2021). A MRF from one Florida CAP city reportedly has to replace 2-3 of their sorting screens every month due to clogging by plastic bags (CIL, August 2021). There are some options for consumers in Florida to recycle their plastic bags at drop-off locations, such as through the Wrap Recycling Action Program, but these options are limited and there has been skepticism about their validity (Gutman, 2023). The thin HDPE and LDPE film plastic that they are most often made of also has little to no value in the recycling sector and cannot go through curbside recycling programs (Karidis, 2022; Doshi & Dowding, 2023). Plastic bags present unique challenges when they become litter, particularly for coastal and marine species found in Florida such as turtles, cetaceans, sea birds, and others that may ingest them or become entangled in them (Townsend et al., 2021). According to the Florida CAP surveys, 91% of restaurants and convenience stores offered plastic as their predominant to-go bag material type, most commonly HDPE film plastic. It was found that only around 18% provided a reusable bag alternative such as paper or fabric, priced at around $2 more than the standard plastic ones that were most often offered free of charge. Similarly, a 2021 survey of businesses across Florida by FDEP found that 75% of businesses did not provide reusable bags. That same survey found that 82% of residents and 90% of government stakeholders in Florida reported a willingness to support additional waste reduction, reuse, and recycling through increased fees (Townsend et al., 2021). As of 2019, there were 566 local or state laws in the US related to plastic bags, and plastic bags were the most common plastic material type targeted for such policies (Surfrider, 2019). Film fragments were the fourth most common litter item found across all Florida CAPs. Film fragments, plastic grocery bags, and other plastic bags comprised 11% of litter items found among Florida CAPs.

Table 5.8: Opportunities for Plastic Grocery Bags

Product	CAP Spoke	Opportunity
Plastic Grocery Bags	Community	• **(L)** Garner and mobilize local support against any future state-level legislation that gets adapted after the failure to pass SB 1126 and HB 1641 in 2024, which would have further expanded the SUP bag preemption • **(S&L)** Develop incentives for residents and tourists to bring their own bags, in locations that don't have regulations against SUP - make it easier for people, make it a normal part of life, incorporate the ethos into tourism messaging for FL • **(S&L)** Distribute reusable bags to vulnerable or low-income populations across the state, explore other methods of increasing accessibility and eliminating upfront cost barrier
	Product Design	• **(S&L)** Instead of encouraging businesses to automatically switch to paper bags, push incentives for reuse and reusable materials upfront - businesses need to know the implications of switching and which options are available to them
	Use	• **(S)** The Florida legislature could remove the state-level ban preemption and allow for local ordinances that restrict the use, sale, and distribution of SUP bags • **(L)** Implement 'only upon request' ordinances for certain types of stores and restaurants that don't contradict the existing preemption • **(L)** Mandate regulatory fees for the use of SUP takeaway bags by consumers, which can be encouraged among businesses on a voluntary basis initially - build the case for the impacts associated with these voluntary measures (e.g., Plastic Free MB, Miami 305) and expand across the state

		• **(L)** Explore requirements that enhance the availability and use of SUP alternatives - e.g., mandate that alternative bags be made available at checkout for stores and food vendors, require stores to provide money off for those that bring their own bags, create incentives (e.g., tax breaks, subsidies) for companies that use these measures
	Collection	• **(L)** Where it does not already exist, explore options for a separate waste stream and collection location only for SUP takeaway bags - coupled with expanding education, drop-off locations, etc. - to ensure that the bags never end up in recycling where they can cause contamination and equipment damage • **(S&L)** Local and state messaging needs to be clear that EPS cannot be included in curbside recycling collection (plus enforceable 'oops' stickers accompanied by warnings, fines, etc.)
	Leakage	• **(L)** For cities in Florida that have been able to implement regulations around SUP takeaway bags, they could conduct a CAP (or portions of CAP) to see whether the interventions outside of the preemption are having an impact - capture lessons learned and share with other locations across the state that want to take similar steps, and continue to communicate messaging that these bans can work (cities and municipalities can also use tools like the Single-use Plastic Bag Ban Waste Reduction Calculator and the Debris Tracker app to advocate)

5.5.3 Expanded Polystyrene

FDEP estimates that single-use carryout packaging comprises around 11.7-13.6% of MSW in Florida (Townsend et al., 2021). EPS comprised 17% of all to-go foodware sampled across the Florida CAPs, the second most common material identified after PP, which is often more readily recyclable as a material. However, consumers in Florida have limited options for recycling auxiliary to-go food containers in general (Townsend et al., 2021). EPS as a material is difficult to recycle, can be hazardous to human health when processed, and has low value in the recycling market (EPA, 2000). As of 2023, 11 US states and 250 cities and counties had passed restrictions on EPS, and the Farewell to Foam Act has been proposed by Senator Van Hollen of Maryland that would eliminate the sale or distribution of covered EPS products by food service providers, manufacturers, distributors or retailers across the US starting Jan. 1, 2026 (Rachal, 2023; Congress.gov, 2024). Foam fragments were the 6th most common litter item identified among Florida CAPs. Foam fragments, EPS plastic cups or lids, EPS containers, and EPS cups comprised a combined 7% of litter among Florida CAPs, despite the fact that several cities had some form of local policy limiting the distribution of EPS. Data have shown that state-level policies that are well enforced and implemented have been associated with decreases (up to 65% in 3 years) of foam litter observed (Rachal, 2023).

Table 5.9: Opportunities for Expanded Polystyrene

Product	CAP Spoke	Opportunity
EPS	Input	• **(S)** Explore state-level limitations on local production - not only for EPS distribution but also in-state production of EPS, importing EPS products into the state, etc. to limit the supply chain in FL
	Community	• **(L)** Assess the impact of voluntary plastic-free programs for businesses, such as Plastic Free MB and Miami 305, to garner support for local ordinances and preemption reversal • **(L)** Garner and mobilize local support against any future state-level legislation that gets adapted after the failure to pass SB 1126 and HB 1641 in 2024, which would have expanded the SUP preemption to auxiliary takeout containers such as EPS
	Product Design	• **(S&L)** The state, counties, and cities could, to the highest extent possible, remove the use of EPS entirely and encourage the use, availability, and affordability of alternatives that work with local SWM infrastructure
	Use	• **(S)** Explore options for state-level legislation similar to the statewide smoking ban on beaches that opens municipalities up to EPS regulations (could model after Oregon state law) • **(L)** Implement 'only upon request' ordinances for certain problematic items, like EPS cups and lids, or bans on certain types of EPS materials entirely, modeled after locations in Florida that have already done this (e.g., Gainesville, Tampa, Largo, St. Petersburg) • **(L)** Encourage Green Procurement guidelines for cities and municipalities (modeled after what Miami is working on) • **(S&L)** Several places in Florida are already restricting EPS use for events, concerts, stadiums, hotels, and other smaller-scale systems - ensure that there is support and potentially a learning network across the state for municipalities that are addressing alternatives

	Collection	• **(S&L)** Local and state messaging needs to be clear that EPS cannot be included in curbside recycling collection (plus enforceable 'oops' stickers accompanied by warnings, fines, etc.)
	End of Cycle	• **(S&L)** Industrial composting infrastructure needs to be made available for compostable alternatives to EPS in areas that frequently use them (especially cups and food containers), with clear guidance for households, businesses, incentives for switching, etc.
	Leakage	• **(L)** Encourage use of tools like the Debris Tracker app to track litter in local areas and provide data to advocate for the changes that the municipality/city wants to see

5.5.4 Multilayer Plastic Food Packaging

Multilayer plastic film was the most common material type identified among consumer products for all Florida CAPs. Multilayer plastic is difficult to capture and contain in the waste stream, difficult to separate into its original constituents and recycling, and has little value in the recycling market (Plastics Engineering, 2024). Over 30% of litter found among Florida CAPs was food plastic or a food-related type of plastic packaging, most commonly multilayer plastic food packaging. Plastic food wrappers alone were the 5th most common litter item found across the Florida CAPs, comprising around 7% of all litter items. Food wrappers alone represented 5% of litter identified along Florida coastlines through the International Coastal Cleanup (OC, 2024). Studies are also increasingly demonstrating the potential harm to human health of plastic packaging and the food contact chemicals associated with those materials (Muncke et al., 2020; Geueke et al., 2024).

Table 5.10: Opportunities for Multilayer Plastic Food Packaging

Product	CAP Spoke	Opportunity

MLP Food Packaging	Input	• **(S)** Explore opportunities for state-wide EPR on MLP items specifically - this could start with one major company or brand with a large footprint or headquarters in Florida (e.g., Nestle, Mars), or a major distributor (e.g., Walmart, Target), and/or model from other US states like Oregon • **(L)** Explore opportunities for local-level DRS with cash return or other incentives for MLP (and other similar items, such as tertiary plastic film packaging)
	Community	• **(L)** Consistent, tailored, local messaging around intersections of plastic packaging, pollution, and public health to raise awareness around concerns and alternatives available • **(S&L)** Identify and support job opportunities around alternatives to MLP, reuse systems, and alternate delivery systems - with an initial focus on local supply chains - that can reduce the need for and distribution of problematic MLP items
	Product Design	• **(S)** Consider implementing state-wide incentives, mandates, requirements, aspirational goals etc. around meeting the APR Guidelines for film manufactured and distributed in the state • **(L)** Pilot viable alternatives in Florida that match SWM system where options exist (e.g., compostable candy or chip wrappers)
	Collection	• **(L)** Where it does not already exist, explore options for a separate waste stream and collection location only for MLP - coupled with expanding education, drop-off locations, etc. - to ensure that MLP doesn't end up in recycling or as litter

5.5.5 Cigarettes

Cigarettes were the single most common litter item identified across all Florida CAPs, comprising 14% of all litter surveyed in the state, and were among the top five litter items overall for each individual Florida CAP city (CIL, August 2021; CIL, February 2024; CIL, March 2024). Cigarettes are also the most common litter identified on Florida coastlines by the International Coastal Cleanup (OC, 2024). Tobacco products in general comprised 16% of all litter found in Florida by material type. Solid waste collection and management for tobacco products is difficult, as cigarette butts often require separate collection due to fire hazards, cigarettes and tobacco products are often small and lightweight, and tobacco products are often consumed on the go. Most tobacco packaging surveyed across the Florida CAPs was coated paper cartons with single-layer plastic film wrapping, but some urban areas had a high diversity of tobacco product material types, including plastic vapes, tobacco sachets, cigarillos with plastic tips, and metal tins. This material diversity further exacerbates SWM challenges. Cigarettes and tobacco products are bad for human health, are bad for the environment, and the use and litter of these items should be eliminated to the highest extent possible.

Table 5.11: Opportunities for Cigarettes

Product	CAP Spoke	Opportunity
Cigarettes	Input	• **(S&L)** Promote local or state level restrictions on import, look to local manufacturers and distributors for funding for litter prevention
	Community	• **(S&L)** Consistent, tailored, and localized outreach and education around the Florida Clean Air Act to raise awareness of the law and also the importance of eliminating cigarette littering and allowing for clean air and a clean environment for all Floridians
	Product Design	• **(S&L)** Consider local ordinances and/or state-level legislation that would streamline the material for tobacco packaging - e.g., prohibiting the sale of sachet packaging, only allowing cardboard cartons, having specific guidelines around vapes or other packaging materials, etc.
	Collection	• **(S&L)** Model off 'butt cans' in Arizona and other creative, localized, cigarette-specific disposal options to enhance cigarette butt collection - expand both infrastructure for collection and education around health impacts, implications of littering, associated fines, etc.
	Leakage	• **(S)** Expand upon the Florida Clean Air Act and similar legislation - while the current law gives local municipalities jurisdiction in regulating smoking at beaches and state parks, this could be expanded to a state-level mandate • **(S)** Use SB 602 / HB 321 which prohibits the intentional release of balloons statewide as a model for similar statewide legislation around intentionally littering cigarette butts, smoking on public beaches and parks, etc.

5.6 Conclusion

The meta-analysis conducted across three CAPs in Florida demonstrates the shared needs and opportunities both at the local and state levels. The initial three CAPs in Florida illuminated challenges related to a population with high diversity and large quantities of visitors, frustration around the local impacts of state-level policy decisions, and skepticism around recycling. Litter transects, store surveys, and stakeholder interviews identified problematic items for consumers, businesses, waste management, and leakage, including MLP film, EPS, and industrially compostable plastic items. The CAPs found high quantities of domestic and FL-based manufacturing for convenience items, particularly for beverage bottling, but a general lack of EPR or DRS mechanisms that may incentivize re-capture. Reuse, refill, and alternative options remain expensive and difficult to access, both for businesses that want to incorporate them and for consumers that want to use them. Despite high coverage for waste collection and curbside recycling, all CAPs found difficulties around household participation, contamination, and education. There was a ubiquitous mismatch between materials available in cities, consumer demand for those materials, and waste management readily accessible for those materials that would divert from landfill, such as compost or recycling. Reduction and diversion of waste from landfill is critical in the state, yet current incentives are focused on expanding WtE while infrastructure and markets to support widespread reduction, composting, and recycling are still lacking. Litter in Florida - found to be predominantly SUP items - poses a unique threat to communities in Florida where it is intrinsically tied to issues of resilience, stormwater management, and human health.

Shared opportunities were also identified through the meta-analysis. Locally tailored and statewide education and outreach is needed to reach a wide range of communities on reduction and recycling practices, with a focus on re-building trust in SWM systems. Ample job opportunities exist around building a CE in Florida, particularly around EPR, DRS, reuse and refill. FL-based manufacturers and bottlers could be engaged on rethinking packaging design and product delivery systems. State policies have historically pressured consumers to increase recycling and decrease littering, while avoiding policies that would explore upstream interventions such as product redesign, product bans, and EPR. As state-level EPR policies gain traction in other states such as Oregon and Colorado, there may be opportunities for Florida to engage businesses in creative solutions and new job opportunities that put responsibility, incentive, and capacity back on the producers to take back their packaging. Lessons can be learned from local ordinances and guidance around Green Events and Green Procurement for local government operations, which could also be expanded statewide. Both local and state policy changes could be made to target problematic SUP items, including EPS and grocery bags, such as overturning the state-level ban preemption or expanding ‘only upon request’ regulations. Infrastructure and end-markets need to reflect the material types that are present in communities across Florida, and special attention should be paid to opportunities around industrial composting and recycling to reach statewide recycling and waste reduction goals. Both local and state level opportunities were also identified for the most problematic SUP items identified through the CAPs, including PET beverage bottles, plastic grocery bags, EPS, MLP, and cigarettes. Potential interventions range from local voluntary measures to changes in policy at the state legislature.

While some data and trends from the three initial CAP cities in Florida could be compared and extrapolated, it is important to note that they were conducted in urban and relatively affluent areas of the state. Further CAPs could be conducted, particularly in rural areas of Florida, to capture a wider swath of data representative of the whole state. If CAP training were to be digitized and made openly available, there may be opportunities for local groups and universities across the state to conduct the CAP methodology independently and use the data as they see fit. Some groups, such as Debris Free Oceans (DFO) in Miami, are already using and revisiting aspects of the CAP data to engage the local community, garner support among local businesses, and advocate for city and municipal policies to reduce waste and leakage. This model could be expanded across the state and present an opportunity to demonstrate the utility of local data to inform state and regional decision-making. Further opportunities for state-level action may exist given the right enabling conditions, political will, local support, and data to support decision-making.

The state of Florida has a long history of marine debris management, solid waste management reporting, and ambitious goals around recycling, but there has been a lack of emphasis on upstream interventions based on learnings from those downstream programs. While strong support and action exists at the city and municipality level across Florida to address plastic pollution and waste reduction, there is a mismatch between local and state-level decision-making. There is a unique opportunity to build a community of cities and municipalities around Florida that can use CAP data to inform interventions at the local level, and to simultaneously create a community of practice that can advocate for sustainable and equitable state level changes. With the combination of building local-level support and international action to address plastic pollution and waste, now is a critical time for Florida to bring together bottom-up and top-down interventions to holistically address the plastic crisis.

Chapter 6 : Dissertation Conclusion

6.1 Research Objectives and Takeaways

The goals of this work were to investigate the application of CAP and adapt the methodology in different contexts and use cases; examine the use of CAP as an effective, replicable, and scalable tool to quantify CE for plastic in various contexts and for different use cases worldwide; and support local and global needs around the quantification of CE and the use of that quantification to prioritize interventions. The objectives included developing comprehensive understanding of the role of CE and circularity with respect to plastic packaging in academic literature within the last five years; conducting a meta-analysis of CAP in six different cities and contexts as a tool to set a baseline and inform interventions to prevent plastic pollution; deploying CAP in the context of SIDS and complementing it with marine litter and waste management assessments to create a holistic baseline and identify opportunities for optimizing circular materials management of plastic items for the entire country; and using multiple city-level CAPs to share lessons learned and best practices regionally and to drive state-level change in the US. This four-fold approach establishes the need for the CAP methodology, tests its utility, and demonstrates its impact in different contexts.

The United Nations Human Rights Council considers having a clean, healthy, and sustainable environment to be a basic human right. As such, access to safe and affordable materials, circular systems, effective waste collection and management, and environments devoid of harmful open waste dumps and litter should also be a global human right. Similar to other environmental issues such as CO_2 emissions, there is a gap between parties responsible for product manufacturing and waste generation and those that most often bear the oversized impact, such as fenceline communities, the global south, and smaller rural areas. Historically, the polluter has not paid, and that burden on municipal governments, consumers, informal waste workers, and others has grown. Awareness around this is building, and so are the legal arguments - in September 2024, the Attorney General of California launched a lawsuit against Exxon Mobil for decades of falsehoods around plastic recycling, which could create legal precedence for countless similar lawsuits. While waste generation may be a basic human function, this does not have to translate to a waste-filled world. Interventions need to be as diverse as the range of waste types and practices worldwide to ultimately close the loop and prevent leakage, and tools like CAP can help to identify and prioritize those interventions.

With the United Nations Global Plastics Agreement, the development of National Action Plans, and a growing number of policies at multiple levels of governance worldwide related to the reduction of plastic pollution, CAP and similar holistic models that are comparable across contexts and that make data and methods accessible will be critical. This body of work demonstrates the capabilities of using CAP in various contexts and at different scales to drive meaningful change in cities and countries around the world. The adapted protocol and the data collected through this work ultimately provide a basis from which future work in the space of circular economy for plastics can grow. Importantly, this work has already begun to inform decision-making and drive positive changes in the locations in which the fieldwork is being carried out.

6.2 Key Findings, Insights, and Implications

Topic	Key Findings & Insights	Implications

The value of CE and circular materials management in building resilience at the global and local level, especially for plastics	● Cities and nations worldwide are finding CE increasingly relevant and tied to other key priorities, such as sustainability, resilience, impacts of climate, social issues, economic issues, and human health, particularly with the global and interconnected nature of plastic use, trade, and pollution ● Co-benefits of CE and circular systems include human health and well-being, waste and pollution reduction, and economic and business opportunities ● The ‘plastics crisis’ has evolved over a relatively short amount of time - we can design, innovate, and collaborate our way out of it for a better future, but change needs to happen urgently ● There can be - and needs to be - a CE built for plastics in particular	● Now is the time to take action and alter course for future generations - with the UN Global Agreement, unprecedented national action, and large amounts of funding coming into this space, CE needs to be tied to the other critical social, environmental, and economic issues of our time so they can be addressed simultaneously ● CE should be incorporated into holistic strategic planning for cities, islands, regions, and nations
Global need for shared data, metrics, and nomenclature around circular materials management	● CE has been gaining attention as a solution to the plastic pollution crisis, but the ability to quantify and measure circularity over time varies across geographies and sectors ● There is a general lack of understanding in academic literature of the distinction between circularity / CE and sustainability, recycling, and waste management ● There is not one harmonized set of metrics	● Platforms like CAP are critical to put data in the hands of decision-makers and local communities that are best positioned to implement change ● Shared metrics are critical for the UN Global Plastics Agreement, including for developing national action plans

	that can be used worldwide to measure CE ● There is a general need for data, particularly at the local level, to make circular interventions actionable and effective ● Many communities, cities, and countries are aware of CE and seem to want to move towards more circular systems, but are unsure of where to start or how to prioritize interventions	● Countries and communities need to be able to share and compare CE metrics ● Shared CE metrics are needed to measure the effectiveness of interventions, the Global Agreement, and national action plans over time and adapt as necessary ● Data needs to drive decision-making in this space
Importance of encompassing the full life cycle in CE quantification, interventions, and policies	● No single solution can operate in a vacuum when making a sustainable and just transition towards a more circular economy ● All parts of the life cycle need to be able to talk to each other and learn from each other - e.g., litter that is found downstream can inform interventions upstream, what is problematic for SWM can be dealt with in material design and awareness, etc.	● The UN The Global Agreement, grant programs, and other CE interventions and funding sources need to look across the full life cycle ● Any harmonized CE metrics need to incorporate the full life cycle ● Flexibility and innovation across the life cycle (and connections across) should be encouraged in R&D and academic research
Importance of involving multiple sectors and perspectives in CE	● Local government, academia, NGOs, the informal waste sector, and industry all have a role to play in moving towards a CE ● CAP stakeholder interviews have shown the	● The UN Global Agreement negotiations need to involve all perspectives so that “all boats rise” in the transition towards CE

quantification, interventions, and policies	wide range of perspectives in this space, all of which are valid and all need to be part of the solution ● Ideas for interventions can come from anywhere, not just high-income countries and/or The Global North	● There is a need for funding and support for innovative partnerships in this space, particularly public-private partnerships
Unique role of cities in circularity	● Cities are where the 'rubber meets the road' for implementing interventions - CAP city partners want data to inform their decisions, they know this is a critical time for action, and they know their context best ● Researchers, practitioners, and decision-makers need to ensure that the right data gets into the right hands to make the most effective decisions for a community ● Cities are testing grounds for CE - we've seen interventions work at multiple scales and under a range of conditions, with the right data and the right leadership ● When it comes to CE, it is critical to think globally and also act locally - that is where support is needed for implementation to work	● The UN Global Agreement, grants programs, and other CE interventions should be tailored to the unique needs of cities and provide local support ● Cities need tools for collecting their own data and making their own decisions on interventions ● Policy at any level needs to recognize this unique role of cities and allow for flexibility and autonomy
Unique role of SIDS in circularity	● Islands essentially represent the opportunities and challenges of a standalone circular system - they are often highly dependent on import and export, lack developable space, are	● The UN Global Agreement, grants programs, and other CE interventions should be tailored to the unique needs of SIDS and

	surrounded by fragile marine environments, and have strong cultural contexts, all of which need to be considered in decision-making around CE ● Islands are an ideal location to build circular systems - reduction and diversion are key in islands due to the lack of space, the economic context, and the reliance on the natural environment	provide local and regional support ● CE initiatives in island areas need to work regionally - there is value in shared learning, building economies of scale, and fostering innovating partnerships across industry, waste companies, NGOs, and researchers at the regional level
Potential for open data methods and platforms to drive local circularity	● While shared, global datasets, metrics, and policies are critical, local communities are largely responsible for implementing CE measures, and those stakeholders need a unique set of tools to collect data and inform decisions at that scale and in their own context ● Data can be used to directly support the development of intervention proposals for cities to receive funding (Urban Ocean) ● Data can inform National Action Plans, inform public awareness & education campaigns, and justify funding for key infrastructure (Dominica) ● Data can inform city task forces, working groups, and future projects, and create novel partnerships across sectors (Florida)	● CAP (and similar methods) needs to be open-source and widely accessible ● It is important to be able to look at CAP data and trends across contexts ● Local communities need to be able to share lessons learned and opportunities for CE interventions, such as through open-source data, case studies, and resource libraries ● CAP data should be used to measure change over time, built into monitoring and evaluation plans, and used to adapt interventions as needed
Potential for shared	● There is no single silver bullet solution to end	● The UN Global Agreement should

learning networks to build circularity regionally and across common contexts	plastic pollution and/or optimize CE, there are endless opportunities to learn from each other ● Building effective economies of scale is critical for CE, especially for rural, remote, and island areas ● Positive outcomes can be seen when communities talk to each other about what works and what doesn't when building a CE ● There are opportunities for using local data to inform state and regional-level decision-making	support these types of learning networks, particularly those that can also support interventions and use data to inform the most effective interventions at a local scale ● A CAP intervention library could be created to capture and share case studies around the world

6.2 Future Directions

- The CE literature review could be reconducted with the same search parameters in another five years, or after the Global Plastic Instrument is ratified and implemented, in order to study any changes and determine any outstanding needs in the space.
- CIL is finalizing the CAP training platform to reach more cities around the world and enable them to set baselines, track change over time, measure the impact of interventions, and adapt as needed. This platform could also be trialed and refined through future Urban Ocean cohorts.
- CIL is finalizing the CAP database with city dashboards, metadata visualizations, and downloadable data that is open to the public.
- CIL could create a digital 'library' of examples and successful community interventions resulting from CAP as a living resource on the CIL website.

- The use of CAP by cities and municipalities could be further encouraged to build upon recent and ongoing/upcoming progress in this space (e.g., using data to advocate for critical waste management infrastructure, inform NAPs that support the Global Agreement once ratified, develop city-level ordinances for plastic pollution prevention, etc.)
- Dominica is in the process of finalizing, socializing, and ultimately implementing the Waste Management and Plastic Pollution Prevention National Action Plan for the country, informed by CAP. This plan should be completed and fully implemented by the Dominica Solid Waste Management Corporation and partners along with a comprehensive monitoring system so that the country can adapt interventions as needed going forward.
- The Dominica Solid Waste Management Corporation is planning to use the CAP data to advocate for funding for a MRF on the island, support pilot industrial composting infrastructure, and inform an island-wide school and public outreach campaign on sorting at source. CIL could continue to support DSWMC to ensure they have the data and messaging that they need for this work.
- The Dominica Solid Waste Management Corporation is proposing to the Organization of Eastern Caribbean States to host a Caribbean-wide solid waste management meeting for practitioners to identify waste streams, opportunities for building economies of scale for recycling, and sharing best practices for SWM. This should capitalize on the momentum built from existing regional pilots and collaboration around the Global Instrument through OECS, IUCN, CARICOM, the Alliance of Small Island States, and others, and is something CIL could participate in as well.

- Capacity could be built between the University of Georgia, The Dominican State College, and the Dominican Bureau of Standards for ongoing litter and microplastics monitoring in waterways, coastal areas, and offshore areas around the island.
- CAPs could be expanded to additional cities around Florida, ideally through a network of NGOs and/or Universities and potentially in collaboration with the Ocean Conservancy and their Shores Forward program. A learning network across the state should be created to share data and lessons learned; this network and data could be mobilized to inform and support local and state-level interventions.
- The NGO Debris Free Oceans has been using the CAP data to mobilize the community in Miami-Dade County and advocate for policy change at the local level. They are planning to capture and share some of those lessons learned so that this can be replicated across Florida, and their story should be used as a model for open-source science to inform interventions and prevent plastic pollution in Florida.

Appendix

Table A1: Guidelines for determining life cycle stage of publications

Life Cycle Stage	What Is Included
Production	- Extended Producer Responsibility (EPR) - Changing the way companies manufacture, disperse, and/or sell FMCGs - Logistics, supply chain, stocking - Extraction and manufacturing (but not design) - Environmental impacts of production and manufacturing processes
Community	- Consumer/stakeholder attitudes, perspectives, or behaviors (related to any stage of the life cycle) - Influencing factors for consumer choices or behaviors - Social impacts and interactions - Education, outreach, awareness campaigns, students - Legislation, policy, impacts of bans, etc.
Material/Product Design	- New materials (e.g., compostable, biodegradable, non-fossil based) - Exploring non-fossil fuel-based or petroleum-based plastics - Evaluating qualities of new products (but not for EOL) - e.g., strength, waterproofing, polymer qualities
Use/Reuse	- Products intended for reuse (e.g., durable plastics, not reusing post-consumer plastic waste) - Viability, challenges, barriers, opportunities, etc. of reuse systems and economies - Deposit-return schemes
Collection	- Anything to do with collection infrastructure - bins, trucks, routes, sorting (at the household level only) - Public or private waste collection infrastructure - Optimization or assessment for collection routes or methods
End-of-Cycle	- Everything that happens after collection, including any type of processing (sorting, landfill, recycling, compost, WTE), for traditional plastic but also bioplastic, compostable plastic, alternatives, etc. - Also includes anything that happens post-consumer, even if framed as ‘reusing' or 'upcycling' plastic waste - Materials that are made by incorporating post-consumer plastic waste and/or recycling plastic content (e.g., concrete, asphalt) - Sorting or tracking technology that happens at SWM locations - Discussions around redesign that optimize EOC (e.g., designing for mechanical recycling) - Assessing the quality or characteristics of material that has gone through EOC - has been recycled, converted to energy, composted, etc.
Leakage	- Anything focused on litter, waste leakage, or mismanaged waste - Anything related to marine litter (including repurposing of it) - Associated environmental plastic/impacts - Discussion of plastic as pollution/environmental pollution - Studies on how plastic behaves/breaks down in the natural environment
All	- The paper assesses the full life cycle, from production/manufacturing through to end of cycle

Table A2: Full List of Litter Items and Associated Material Categories from the Site Assessment List in Marine Debris Tracker

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
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
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

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