# Industrial Symbiosis (IS) in Plastics: A Caribbean cluster-based case for a viable Caribbean Circular Economy

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## Abstract

There are many, very successful examples of industrial symbiosis (IS) across the world, but few for the Caribbean and even less for Trinidad and Tobago. How can IS be an industry driver towards collective decoupling of the Caribbean SIDS's economic growth, which is currently dependent on a limited resource base, to adoption of clustered business models which maximize on resources including waste? To what extent can local business cases of IS scale up practices that are unique to the Caribbean circumstances when moving towards the circular economy? This paper investigates and curates how, over a five-year period, a viable local cluster of plastic recycling was cultivated with the environmental stewardship of Flying Tree Environmental Management (FTEM). The general flow of plastics consists of plastic raw material being converted in new products, which are then used and discarded, mostly in four (4) major landfills. As an NGO, FTEM has disrupted this flow with an accountability to the environment that extends the conventional bottom line and which shows promise for scalability, through clustering among profit and non-for-profit. The paper is unique in that it not only documents an account of the technical aspects and environmental benefits of the re/upcycling effort but also creates a space to incorporate learning in order to scale the effort regionally.

## Introduction

Industrial symbiosis (IS) is defined as a collective approach, which engages traditionally separate industries and other organizations, to exchange materials, energy, water and/or by products and collaborate on the shared use of assets, logistics, expertise and knowledge, for the competitive advantage

of all parties (Neves et. al. 2019; Laybourn, P. 2006; Lowe and Evans 1995). This sharing, results in benefits such as cost savings in the construction of facilities; saving of resources used in waste treatment; reduction of inefficiencies and job creation.

In traditional linear industrial systems, resources enter processing facilities and are converted into products and waste. In a circular economy, waste is converted into a resource for another entity via industrial symbiosis, thereby allowing materials to be used more sustainably (Figure 1), in this way improving the circularity of the industrial system. Industrial symbiosis therefore represents the steps towards realizing a circular economy, which for plastics, will reduce environmental concerns, especially pollution.

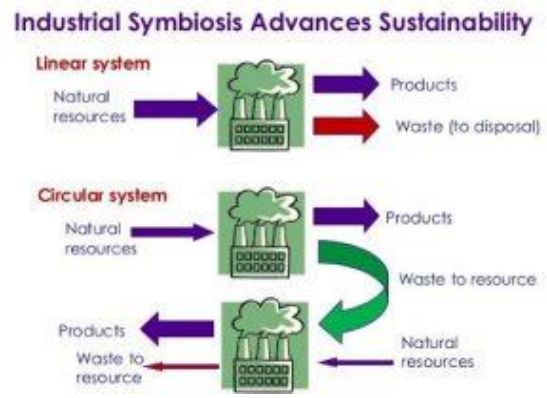



**Figure 1. Illustration of how industrial symbiosis advances sustainability.**

**(Illustration taken from: Symbiosis Project EU (https://symbiosisproject.eu/1147/)**

Some of the key factors that influence the development and success of industrial symbiosis are physical proximity; knowledge sharing and learning; the development of trust, as well as time, especially in terms of time needed to evolve industrial systems that facilitate symbiotic exchanges amongst companies (Neves et. al. 2019; Chertow 2000; Baas and Boons 2006). Industrial symbiosis is therefore a detailed, delicate process, requiring sensitivity in developing inter-organizational trust and industrially-supportive clusters, with a sound business exchange model that facilitates organizational cooperation in order to implement cost-saving, shared processes to maximize resources and help achieve mutually-beneficial economic, social and environmental goals. Risk mitigation considerations are included in the case-specific cluster business model, in order to safeguard partner interests and support a momentum for business to business transactions.

To value fully these economic, environmental and social benefits generated by IS programs, one must leverage the tools from those different fields: environmental impact of tonnes diverted from landfill;

economic impact of innovation and additional sales; social impact of learning opportunities and jobs protected and created (Lombardi and Laybourn 2006).

There are many, very successful examples of IS across the world, but few for the Caribbean and even less documented and realized for Trinidad and Tobago. In 2019, Lee Chan and Janes completed an assessment of industrial symbiosis of carbon dioxide emissions within the Point Lisas Industrial Estate and found that there exists an embryonic level of industrial symbiosis with room for growth. They also stated that attention is needed to be directed toward strategies to catalyze growth of the nascent industrial symbiosis in order to support thriving industry between existing business (Lee Chan and Janes 2019). So far, there has not been any documented case study of industrial symbiosis in plastics in Trinidad and Tobago and as such, this paper addresses the dearth of information locally by outlining one such case.

The goal of this paper is to investigate industrial symbiosis in plastics in Trinidad and Tobago by looking at a cluster-based case, within the local Trinidad and Tobago context, and interrogate whether the findings offer a pathway towards realizing a circular economy. This will be done by evaluating the industrial cluster supported by Flying Tree Environmental Management (FTEM), which has been upcycling of plastics for the past five (5) years. The following will be reviewed in this discussion:

- Overview of plastic flow locally, which will identify all the key players in this case study and where they fit into the life cycle;
- Summary of the services provided by FTEM as the central driver in their plastic symbiotic cluster;
- Summary the environmental, social and economic impacts of the cluster in the following ways:
    - Environmental impact of tonnes diverted from landfill;
    - Economic impact of innovation and additional sales;
    - Social impact of learning opportunities and jobs protected and created

## Plastics in Trinidad and Tobago

Trinidad and Tobago is identified as the 6th highest plastic polluter within the region. With no recycling facility on the island as well as limited collection, the country ranks 5th in the world for per capita production of mismanaged waste.

Trinidad and Tobago has tried to develop and implement plastic recycling locally since the 1980s however, with no success. A major hurdle for this is the lack of public education and awareness on plastics, especially in terms of its effective management as a reusable resource. This small, twin island state has at

least twenty (20) heavy-duty plastic producers locally, which produce a wide range of plastics including PVC and styrofoam. Trinidad and Tobago also has at least twenty (20) beverage companies that import PET plastics for their packaging. It is estimated that Trinidad and Tobago produces nearly 200,000 tonnes in plastic annually (Ganase 2019) of which, 26,000 tonnes are PET plastic containers which can be recycled (Doodnath 2020; Millette et. al. 2019). According to Dr. Sherwyn Millette, Sustainability Consultant at the College of Science, Technology and Applied Arts of Trinidad and Tobago (COSTAATT), this volume is enough to build a domestic, economically efficient recycling facility (Doodnath 2020). The lack of legislation and policy framework for recycling locally could be attributed to the lack of understanding of plastics as a pollutant and a renewable resource. As a result of this, Trinidad and Tobago has been slow to promote investment opportunities in waste plastic recycling and upcycling and is yet to unlock the economic potential for new businesses and job creation.

According to Millette et. al. (2019), the general flow of plastics of most local companies consists of plastic raw material being converted in new products, which are then used and discarded, mostly in four (4) major landfills. Plastics represent between 16-26% of the content in local landfills (GoTT 2015). Despite its negative connotation and impacts, plastic pollution offers opportunities for innovation and entrepreneurship in the development of industrial clusters for its efficient waste management.

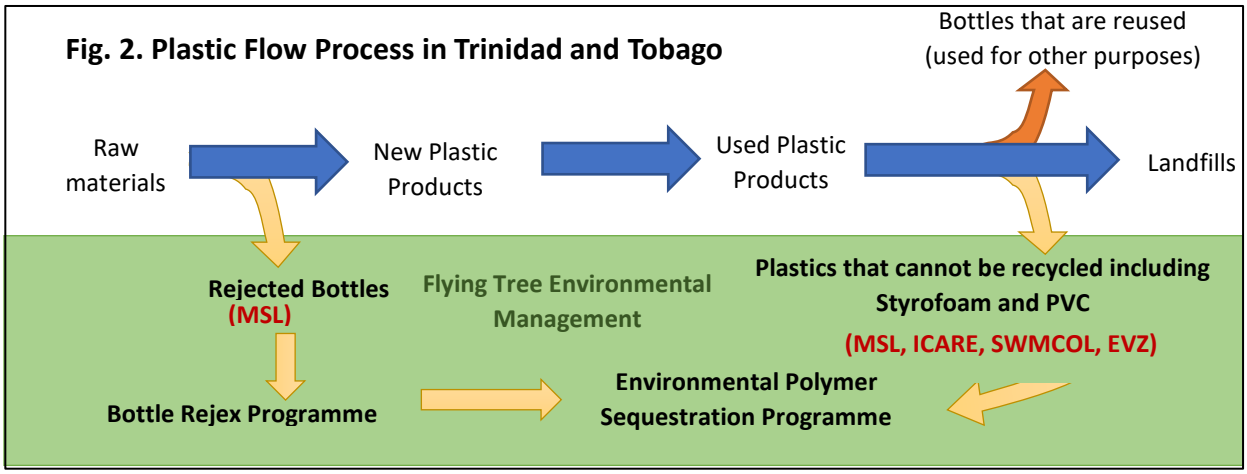
Seven (7) years ago, FTEM began research and development into local, open-sourced methodologies for upcycling waste plastics using concrete sequestration. Plastics have been scientifically proven to be a replacement for aggregate in concrete (Lei and Ozbakkaloglu 2016). The environmental benefits of concrete sequestration include reduced use of quarried materials and damage to the environment; removal of plastic pollutants that may affect biodiversity and food chains and reduced energy consumption (Soloaga et. al. 2014). However, plastics do not behave as well as aggregate in terms of compressive strength, elastic modulus, splitting tensile strength, and flexural strength in concrete (Lei and Ozbakkaloglu 2016). As such, FTEM's objective was to sequester plastics, in a cost and energy efficient manner, in concrete products designed to last. There is no available data on the reentering of concrete-sequestered plastics to the environment and such, a suitable design can see permanent results in terms of complete removal of the threat plastics pose to the environment.

In order to achieve concrete sequestration of plastics and environmental sustainability, FTEM facilitated an industrial cluster, consisting of the following stakeholders:

1. Milagros Solutions Ltd. (MSL) - a local plastic producing company;

2. ICARE - the national plastic recycling collection programme;
3. The Solid Waste Management Company Limited (SWMCOL) - the national waste management government agency and,
4. The Emperor Valley Zoo (EVZ) – a major private stakeholder, which consumes a lot of plastics.

FTEM entered a joint, cost-sharing ventures, where they conduct the recycling and clean-up activities on behalf of their partners in exchange for housing and equipment support. As part of this venture, FTEM collects rejected plastic waste from MSL, as well as used plastics from ICARE, SWMCOL and EVZ (Figure 1). They then process these plastics into useful products through two programme: Bottle Rejex Programme (BRP) and the Environmental Polymer Sequestration Programme (EPSP). It must be noted that they do not only process PET and HDPE plastics but also Styrofoam and PVC, which are not recyclable in Trinidad and Tobago.




## FTEM Services

In order to understand the synergies amongst the cluster stakeholders, it is necessary to review the services provided by the FTEM, which lies at the center of the industrial cluster (Figure 1). These services include:

- Education and Awareness;
- Clean-up exercises;
- Bottle Rejex Programme
- Environment Polymer Sequestration Programme (EPSP);
- Tree plantings and reforestation.

## Education and Awareness

Education and Awareness can positively influence consumer behavior toward responsible, green consumerism (Khan et. al. 2020), which is important since Trinidad and Tobago ranks so poorly in terms of plastic consumption. It is also a driver for industrial symbiosis because it bridges businesses, with mutual interests and gains, to facilitate the movement of greater quantities of waste, otherwise destined for landfills, through the upcycling process. The net gain is not just realized at the business level but also in terms of positive contributions with respect to plastic pollution mitigation.

An example of socially-beneficially cluster cooperation is FTEM's integration of its education and awareness services with the visiting public of EVZ tours. The uptake of FTEM's education and awareness effort has increased through heightened visibility at the Zoo. Accordingly, a plastic processing facility was established in the Zoo to upcycle all their plastics and convert them into benches, pavers and plant pots, which are used to improve the visitor experience. Patrons are allowed to be hands-on in the upcycling process as part of their Zoo experience. FTEM's education and awareness has not been limited to urban areas; they have also completed outreach to eleven (11) secondary schools over the past five (5) years, as well as participated in environmental and educational fairs and exhibitions across the country.



**Picture 1,2 & 3: Top: Pictures of Education and Awareness exercises at Marabella South Secondary School and Brazil High School. Bottom: Picture of the recycling facility at the Zoo.**

## Clean-up Exercises

**Picture 4: Clean-up on Manzanilla Beach**

An essential aspect of the work of this industrial cluster is clean-up exercises facilitated by FTEM. At least 20 cleanups have been conducted across the islands including in Manzanilla (Figure 4), Moruga, Caura, Matura, Chachachare, Down the Islands and Guapo. From these cleanups they have collected no less than 1.8 tonnes of plastics per cleanup, based on the number of bags collected, and these materials are also

processed into useful products. **Overall, FTEM have processed 36 tonnes of plastics from cleanups into upcycling products.**

## Bottle Rejex Programme (BRP)

BRP caters to bottles that are rejected from the production line, due to structural fault(s). Since they are unfit for their original purpose, they are repurposed through the Bottle Rejex Programme (BRP), which started in 2020 as a COVID response. Rejected bottles are either filled with product that are safe for the containers, for example liquid soap and hand sanitizer, or the bottles are converted to plant pots for container agriculture (Figure 5). When these products are provided to the customer, they are encouraged to bring the containers back for refilling, replanting or for sequestration. So far, the responses have been very positive towards this. **FTEM has upcycled 30,000 bottles or 1.44 tonnes of plastics in this way, thereby preventing them from entering the landfills.** The upcycling of rejected bottles provides further evidence of the industrial symbiosis within this plastic cluster.


**Picture 5 & 6: Bottles Rejex Products which includes refilling rejected bottles with soap or hand sanitizer or converting them into container agriculture.**

## Environment Polymer Sequestration Programme (EPSP)

Industrial symbiosis is also realized through FTEM's Environment Polymer Sequestration Programme (EPSP). The EPSP involves the sequestering of waste plastics are in concrete products, by replacing much of the aggregate with plastic chips. This programme started in 2015 and as indicated earlier, these plastics are collected from cleanups as well as from cluster partners.

The plastics are ground and sequestered in concrete to make upcycled products such as:

- Benches;

- Highway dividers;
- Pavers;
- Pots;
- Construction of walls and flooring.

**Over the past five years, FTEM has produced five hundred and fifty-six (556) products containing over seven (7) million plastic bottles, which is equal to eighty-eight (88) tonnes of plastics (Table 1).**

**Table 1: FTEM plastic sequestered products and its environmental benefits**

| Product | Numbers produced | Average number of plastics bottles sequestered | Weight of plastics sequestered (tonnes) |
|---|---|---|---|
| Benches | 40 | 640,000 | 7.7 |
| Highway dividers | 8 | 80,000 | 1.0 |
| Large pavers | 120 | 480,000 | 5.8 |
| Medium pavers | 30 | 90,000 | 1.1 |
| Small pavers | 250 | 50,000 | 0.6 |
| Pots | 100 | 200,000 | 2.4 |
| Construction | 8 | 5,824,000 | 69.9 |
| **TOTAL PRODUCTS** | **556** | **7,364,000** | **88.4** |

Over the past five (5) years, pavers were the most popular product, with a total of four hundred (400) being produced so far. Most of the plastics have been sequestered in concrete in building construction, such the EVZ hospital as well as flooring and walls at MSL. Since MSL and EVZ contributed all the plastics for the construction, this resulted in cost savings, for example EVZ realized savings of between 5-10% on the construction of their new spaces.

By providing opportunities for proper waste plastics disposal, **FTEM also reduced the cost of waste processing by at least 10% for MSL**. Most importantly, **they assisted MSL to decrease their waste to landfill by at least 12%**. Therefore, FTEM provided direct and indirect economic benefits to both MSL and EVZ.

The production of these upcycling products also resulted in social benefits which included:

1. Increased education and awareness on plastic pollution, especially in schools and at the Zoo. It is estimated that FTEM has engaged at least one thousand (1,000) persons through these exercises.
2. They have helped improved social spaces with benches, pots and pavers. Other than EVZ, other locations where these items have been installed include: Brazil Secondary School; Success

Laventille Secondary School; Australian High Commission; Cascadia Environmental Sport Trail; Autistic Society Trinidad and Tobago; Maracas Gardens and Manzanilla Beach.

3. Most importantly, FTEM's recycling and upcycling activities have increased job creation. **The organization currently employs two (2) persons permanently, with up to eighteen others on a temporary basis.**


**Picture 7,8 & 9: Example of the upcycled products created by FTEM.**


**Picture 10, 11 & 12: The picture of the left illustrates the highway dividers at the Zoo. The middle picture shows Styrofoam being chipped for sequestration in plastics. The last picture shows the sequestration of the Styrofoam into blocks, being used in a foundation for a factory.**

## Tree plantings and Reforestation.

Flying Tree Environmental Management (FTEM) got its name based on its work in reforestation. The Directors of this organization are both avid paragliders and they combined their love for the sport with love of the environment and began planting trees via paragliding. Hence, the name Flying Tree.

Within the industrial cluster, FTEM also offers the service of tree planting and reforestation as a means of carbon sequestration as well as rehabilitation of denuded areas. They have planted one hundred

thousand (100,000) trees over the past five (5) years via paragliding as well as via manual planting. **Based on calculations on the average sequestration (Eden Reforestation Project 2019), which quotes an average value of 3.4 kg of carbon per year per tree, it is estimated that the reforestation activities of FTEM has resulted in 1,140 tonnes of carbon captured over the past five (5) years.**



**Pictures 13, 14 & 15: Flying Tree Paraglider. Planting mangrove trees in the Nariva Swamp. Planted trees in the swamp.**

## GEF SGP Grant Upscaling

FTEM has been very fortunate to have recently received a grant to upscale their initiatives. The grant funding will be used to:

- Educate and build capacity in plastic upcycling in two (2) communities;
- Set up two (2) satellite sequestration facilities, one (1) in Trinidad (Kernahan) and one (1) in Tobago (Roxborough). This will provide the equipment to expand upcycling. The communities can now collect plastics from traditional steams from beaches to be included into products;
- Finally, set up 2 small businesses to sell products made from sequestered plastics.

For this project, FTEM has designed a miniaturized, mobile package plant, which can be easily transported and installed. This compact facility comes with its own electricity and water supply, thereby making it self-sufficient. These facilities can be easily installed at any location or can be easily shipped to other country. It is hoped that through this upscaling, FTEM will see an increase in terms of the economic, social and environment benefits discussed earlier.

## Social, Economic and Environmental benefits of IS

In order to fully value the benefits generated by the industrial plastic cluster, it is important to review the economic, environmental and social impacts, especially in terms of tonnes diverted from landfill; economic impact of innovation and additional sales; social impact of learning opportunities and jobs protected and created (Lombardi and Laybourn 2006). Based on the information provided, the following are the benefits derived from the industrial cluster described:

1. **Economic:**
   a) Savings in terms of construction materials for the partner companies and entities for example, the Zoo saw a savings of between 5-10% on the construction of their new spaces;
   b) Reduced cost of waste processing by at least 10%, as was the case for Milagros;
   c) Decreased waste production by at least 12%. With the establishment of the two (2) satellite factories under GEF SGP, it is hoped that this percentage would at least bring greater benefit to all parties.
2. **Environmental:**
   a) Prevented over seven million (7,364,000) bottles, or eighty-eight (88.4) tonnes of plastics, from ending up in the landfills;
   b) Collected thirty-six (36) tonnes of plastics from beaches, thereby reducing negative impacts of plastics on marine biodiversity;
   c) Upcycled thirty thousand (30,000 bottles or 1.44 tonnes) for MSL, into useful products which not only provided relief to persons during COVID but also prevented these bottles from going to the landfills;
   d) Planted one hundred thousand (100,000) trees over the past five (5) years, which is equal to sequestering eleven (11.34) tonnes of carbon sequestered.
3. **Social:**
   a) Increased education and awareness on plastic pollution, especially in schools and at the Zoo;
   b) Improved social spaces with benches, pots and pavers at seven (7) locations;
   c) Most importantly, they have increased job creation, with twenty more persons being employed than before. It is hoped that they will increase the jobs created when the two factories open in Kernahan and Roxborough.

FTEM is core to the industrial plastic cluster in Trinidad and Tobago and through their facilitation and partnership, much has been achieved. Further, FTEM is also directly contributing towards the country's realization of the following Sustainable Development Goals (SDGs) 9[1] and 12[2].

Like in Point Lisas, the plastic industrial cluster facilitated by FTEM is another example of nascent industrial symbiosis in Trinidad, with a focus on plastics. This paper provides added local evidence and lends validity to the call by Lee and Janes (2019) for strategies which enhance nascent industrial symbiosis, with a scope and scale beyond the oil and gas sector. Clear policies and incentives need to be developed and provided to support industrial symbiosis, especially in terms of plastics and carbon emissions, which are two major environmental issues locally.

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[1] **SDG Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation** - By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities;

[2] **SDG Goal 12: Ensure sustainable consumption and production patterns** - By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.

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