Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

STUDY ON THE VALUE CHAIN ASSESSMENT OF SINGLE-USE PLASTICS (SUPS) & THE ALTERNATIVES IN 2 CITIES IN MAHARASHTRA & 2 CITIES IN TAMIL NADU

SUBMITTED TO

THE DEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT GMBH (GIZ)

Submitted By

SOCIAL LAB
Environmental Solutions Pvt. Ltd.

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01 INTRODUCTION

The Indo-German Support Project for Climate Action in India (CAP), implemented by GIZ, aims to quantify the climate co-benefits of development programs through robust data and methodology development. The project is working with a consortium (comprising Oxford Policy Management, Council on Energy Environment and Water and Perspectives Climate Group) for the preparation of the methodology.

As part of this effort, GIZ commissioned Social Lab to conduct a value chain assessment (VCA) of banned Single-Use Plastic (SUP) items and their alternatives in two cities each in Maharashtra and Tamil Nadu. This primary data-driven study will support the consortium in finalizing a climate co-benefit methodology.

1.1 OBJECTIVES OF THE STUDY

The study aimed to achieve the following main objectives:

DEVELOP	CAPTURE
A VCA methodology aligned with the CPCB SOP (June 2024) and consortium expectations	Primary data covering the entire value chain of banned SUP items and their alternatives, encompassing material extraction, transportation, production, distribution, use, and disposal stages.

For emissions data, the study focused on material extraction, transportation, and manufacturing stages, given that the study boundary was defined as ‘cradle to gate.’

STUDY OUTPUTS

The major output of the study is a comparative analysis of the entire value chain of SUP items and their alternatives. Specifically, it involved:

- Gathering primary data to design a methodology for assessing the climate impact of single-use plastics and their alternatives through a life-cycle approach
- Mapping SUP items and their alternatives available in the market
- Assessing consumer preferences related to plastic use
- Characterizing plastic waste and SUPs (aligned with SOP guidelines)
- Mapping recycling and end-disposal channels for SUPs and their alternatives

1.2 STUDY BOUNDARY

Geographical Focus

The study was conducted in four cities: Navi Mumbai and Vengurla in Maharashtra, and Chennai and Coimbatore in Tamil Nadu. Field surveys covered the stakeholders within the respective city boundaries. However, in case of manufacturers and recyclers, the scope was extended to the state level, encompassing suppliers to the selected project cities.

Coverage of SUP Items

The study covered all 21 banned single-use plastic items (as per the GoI 2022 notification), representing six categories. However, the manufacturer survey focused on three categories—carry bags, plastic sheets, and cutlery items—and their alternatives, in line with the framework developed by the consortium.

List of 21 banned single-use plastic items (as per the GoI 2022 notification)

01 PLASTIC STICKS

- Ear buds
- Balloon
- Candy
- Ice-cream
- Straw

02 CARRY BAGS

- <120 micron

03 PLASTIC SHEETS

- <50 micron

04 CUTLERY ITEMS

- Plates
- Cups
- Glasses
- Spoons
- Forks
- Stirrer
- Knives
- Trays

05 PLASTIC WRAPPING AND PACKAGING FILMS

- Sweet Box
- Invitation cards
- Cigarette packets

06 OTHERS

- Plastic flags
- PVC banners <100 µm
- Polystyrene for decorations

(Source: SOP for Assessment & Characterization of Plastic Waste by CPCB (June 2024))

1.3 APPROACH & METHODOLOGY

The study included seven types of surveys as listed below.

The methodology for each survey was developed in line with the "SOP for Assessment & Characterization of Plastic Waste" (CPCB, June 2024) and is explained below.

Table 1.1 Survey Design

01 SUP Manufacturer's Survey (State Level)

Aspects Captured

I. Facility Emissions Data

- Electricity consumption (KWH)/ ton
- Use of renewable electricity
- Use of combustion fuel

II. Upstream (Procurement) Emissions Data

- Estimated emissions from virgin granule production
- Transport-related emissions, including source locations, mode of transport, type of fuel, and distance travelled

III. Other Facility Data

- Share of recycled granules
- Water consumption
- Waste generation & disposal methods
- Employment generated

IV. Challenges

Sample Covered

➤ **Maharashtra**

18 companies - covering 8 industrial clusters from 4 cities (Chh. Sambhaji Nagar, Pune, Bhiwandi & Daman)

➤ **Tamil Nadu**

14 companies - covering 5 industrial clusters from 2 cities (Chennai & Coimbatore)

Note:

- The companies covered overall included both current and former manufacturers of SUP items, namely carry bags, plastic sheets, and cutlery.
- Companies and clusters in Tamil Nadu were chosen in consultation with TNGC.
- Daman was included due to the presence of a cluster of SUP manufacturing companies.

02 SUP Alternatives Manufacturers Survey (State Level)

Aspects Captured

I. Facility Emissions Data

- Electricity consumption (KWH)/ ton
- Use of renewable electricity
- Use of combustion fuel

II. Upstream (Procurement) Emissions Data

- Estimated emissions from raw material extraction
- Transport-related emissions, including source locations, mode of transport, type of fuel, and distance travelled

II. Other Facility Data

- Water consumption
- Waste generation & disposal methods
- Employment generated

IV. Challenges

Sample Covered

➤ **Maharashtra**

11 manufacturers, covering paper, PLA (corn-starch based), and bagasse-based products

➤ **Tamil Nadu**

10 manufacturers, covering paper, Areca, Jute and cloth-based products

Note:
Selection of companies based on confirmation & supply to project cities

03 Market Survey (City Level)

Aspects Captured

- ★ Market usage of SUPs and their alternatives
- ★ Types of SUP alternatives used
- ★ Qualitative data (awareness level, issues faced)

Sample Covered

➤ **Maharashtra**
- Navi Mumbai: 6 market areas
- Vengurla: 1 market area

(Vengurla ULB informed that there is only 1 market area.)

➤ **Tamil Nadu**
- Chennai: 6 market areas
- Coimbatore: 4 market area

Note:
- Within each market area, 9 types of commercial establishments were covered in line with the CPCB's SOP.
- Market areas were chosen in consultation with the ULBs and covered all regions of the city.

04 Consumer Survey (City Level)

Aspects Captured

- ★ Extent of usage of SUPs and their alternatives
- ★ Types of SUP alternative used
- ★ Qualitative data (awareness level, issues faced)

Sample Covered

➤ **Maharashtra**
- Navi Mumbai: At-least 100 consumers/ market area (total: 609)
- Vengurla: 25 consumers/ market area (total: 25)

➤ **Tamil Nadu**
- Chennai: At-least 100 consumers/ market area (total: 622)
- Coimbatore: At-least 100 consumers/ market area (total: 418)

Note:
The sample size was determined based on the city size, as per SBM guidelines.

05 Collection Vehicle Survey (City Level)

Aspects Captured

Plastic and SUP composition assessment at the MRF (as per SOP formats & methodology)

Sample Covered

20% of sample size envisaged in the SOP i.e.,

➤ **Maharashtra**
- Navi Mumbai: 9 collection vehicles
- Vengurla: 3 collection vehicles

➤ **Tamil Nadu**
- Chennai: 9 collection vehicles
- Coimbatore: 9 collection vehicles

06 MRF Survey (City Level)

Aspects Captured

★ **Waste Flow Assessment**

★ **Disposal channels of plastic, SUPs and their alternatives**

★ **Issues & Recommendations**

Sample Covered

➤ **Maharashtra**
- Navi Mumbai: MRFs (1 Centralized & 1 decentralized MRF)
- Vengurla: 1 MRF (centralized)

➤ **Tamil Nadu**
- Chennai: 3 Major MRFs (decentralized)
- Coimbatore: 3 Major MRFs (decentralized)

07 Recyclers Survey (State Level)

Aspects Captured

I. Facility Emissions Data
- Electricity consumption (KWH)/ ton
- Use of renewable electricity
- Use of combustion fuel

II. Upstream (Procurement) Emissions Data
- Transport emissions (sources, mode of transport, fuel & distance)

III. Other Facility Data
- Category of scrap used
- Water consumption
- Waste generation & disposal methods
- Employment generated

IV. Challenges

Sample Covered

➤ **Maharashtra**
- 10 recyclers, covering plastic recyclers (8) and paper recyclers (2)

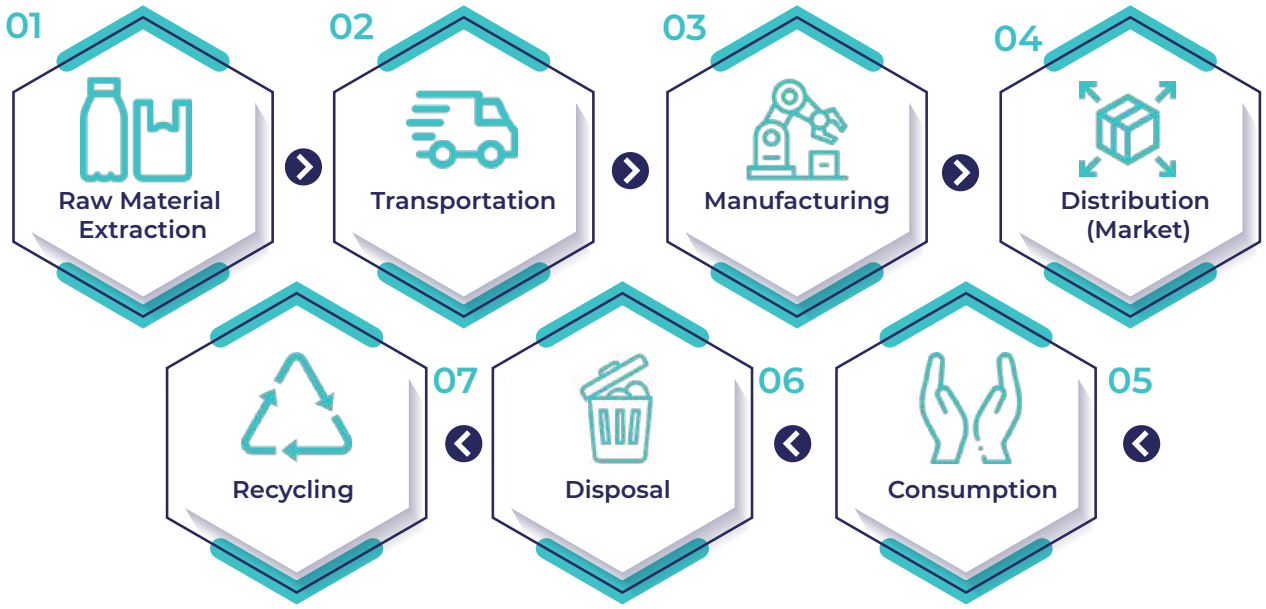
➤ **Tamil Nadu**
- 11 recyclers, covering plastic recyclers (8) and paper recyclers (3)

Note: Selection of recyclers based on confirmation

02 KEY FINDINGS
Value Chain Assessment

The value chain assessment of SUPs and their alternatives highlight key findings across each stage of the chain. For every stage, observations are summarized at the State level, for Maharashtra and Tamil Nadu. The city-wise findings are provided in a separate report.

The value chain typically comprises seven stages: raw material extraction, transportation, manufacturing, distribution, consumption, disposal, and recycling.



Since this study begins with the manufacturing stage, data from the earlier stages—raw material extraction and transportation—has been integrated under this stage. The findings are presented below sequentially, starting with the manufacturing stage.

2.1 SUP MANUFACTURING

The manufacturing of banned single-use plastics (SUPs) is not officially reported but continues informally, primarily in certain pockets of Diu Daman, Gujarat, and to some extent in Maharashtra and Tamil Nadu. To capture manufacturing-related aspects—particularly emissions data—a survey of SUP manufacturers was undertaken. Manufacturers were identified through informal networks within the plastic manufacturing sector.

For this study, Daman was also included due to the presence of a concentrated cluster of SUP manufacturing units. For representation purposes, Daman has been considered under Maharashtra. The coverage of SUP manufacturers in Maharashtra (including Daman) and Tamil Nadu is as follows:

TABLE 2.1 SUP MANUFACTURERS SURVEY: COVERAGE

STATE	NO. OF COMPANIES	INDUSTRIAL CLUSTERS / CITIES	SUP ITEMS COVERED NOTE	NOTE
Maharashtra (including Daman)	18	8 clusters across 4 cities: Bhiwandi, Pune, Chhatrapati Sambhaji Nagar, Daman	1. Carry bags 2. Plastic sheets 3. Cutlery items	Includes both current and former SUP manufacturers
Tamil Nadu	14	5 clusters across 2 cities: Chennai & Coimbatore	1. Carry bags 2. Plastic sheets 3. Cutlery items	• Includes both current and former SUP manufacturers • Companies/clusters were selected in consultation with Tamil Nadu Green Climate Company (TNGC).

The key findings of the SUP manufacturers survey are presented below under three categories: Emissions data, Other Facility data, and Challenges.

2.1.1 EMISSIONS DATA

In line with a Cradle-to-Gate scope, emissions data were captured for both the production facility and upstream processes (raw material extraction and transportation). The types of emissions data collected are outlined below..

Facility Missions

- Electricity consumption (KWH/ton)
- Use of renewable electricity
- Use of combustion fuel

Upstream (Procurement) Emissions

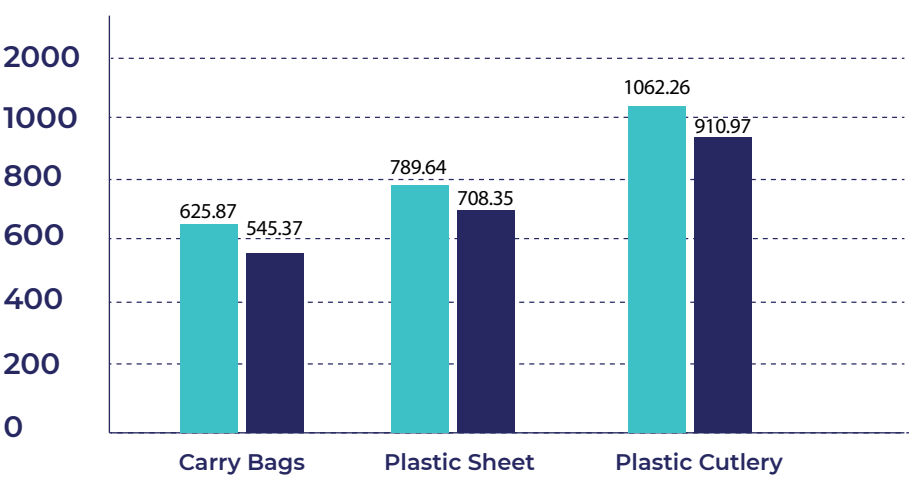
- Estimated emissions from virgin granule production
- Transport-related emissions, including source locations, mode of transport, type of fuel, and distance travelled

Facility Emissions

Electricity consumption (KWH/ton)

Emissions data vary across manufacturers depending on the type of polymer, production processes, and supplier network. These parameters are captured for each manufacturer in the metadata accompanying this report and can be used for emission calculations. Below, a state-wise common scenario is presented for Facility emissions and Upstream emissions.

Avg. Electricity Consumption (KWH/ton): SUP Manufacturers



On average, electricity consumption is highest for plastic cutlery, followed by plastic sheets and carry bags.

A slight state-wise variation is observed, with Tamil Nadu showing marginally lower values compared to Maharashtra.

USE OF RENEWABLE ELECTRICITY

None of the manufacturers surveyed in Maharashtra (including Daman) and Tamil Nadu reported the use of renewable electricity. This is attributed to multiple factors, including limited space, high investment costs, and lack of incentives..

USE OF COMBUSTION FUEL

None of the manufacturers surveyed use combustion fuels at their facilities, as all production processes are electricity-driven.

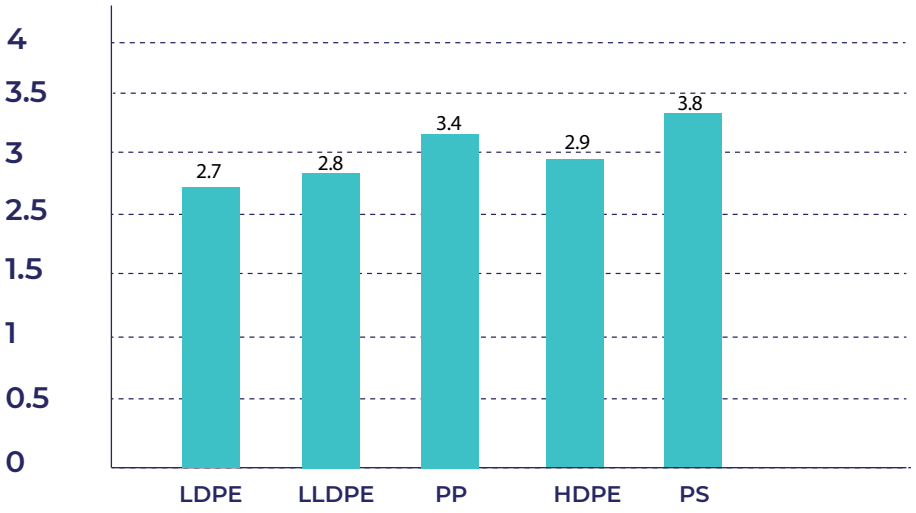
In summary, facility-level emissions from SUP manufacturing are entirely indirect, arising solely from electricity consumption, with no direct emissions reported.

Upstream Emissions

Virgin granule production

Emissions from virgin plastic granule production are estimated for common polymer types using published national and international sources. No state-wise variation in emissions has been reported.

Virgin granule production: Emissions Estimate (Ton CO2 equ./Ton)



As per published sources, Emissions are highest for PS, followed by PP and HDPE. LDPE, LLDPE, and HDPE exhibit emissions within a similar range.

(Sources: TERI (2015), Shakti–BEE (2012), CEA (2023), PlasticsEurope (2021), LBNL (2021). See References for details.)

Transport-related emissions

The data points considered for assessing transport-related emissions include source location, mode of transport, fuel type, and distance between the source and the facility. Significant variation was observed across manufacturers, and the detailed dataset is provided in the accompanying metadata. General observations are summarized below..

Table 2-2 Summary: Transport related emissions

	Maharashtra	Tamil Nadu
Sources of virgin granules	Local traders, supplied through major granule manufacturers such as Reliance and GAIL	Same
Locations of granules manufacturers	Reliance 1. Nagothane, Raigad 2.Patalganga, Khalapur, Raigad 3. Nagpur, Maharashtra 4. Silvassa, Dadra & Nagar Haveli 5. Surat, Gujarat GAIL 1. Pata (Auraiya, UP)	Same (no nearby plants)
Mode of Transport	Truck (25 T capacity)	Same
Avg. distance manufacturers	• o400 Kms (granule manufacturer to trader) • 15- 25 Kms (trader to SUP facility)	• 1500 Kms (granule manufacturer to trader) • 15- 25 Kms (trader to SUP facility)
Fuel used	Diesel	Diesel

Key Insights.

Virgin granule procurement for SUP manufacturing is primarily routed through local traders who source materials from major producers such as Reliance and GAIL. Although sourcing channels are similar across both states, the absence of nearby production plants in Tamil Nadu results in much longer transportation distances. Consequently, upstream emissions from transport are significantly higher in Tamil Nadu compared to Maharashtra.

2.1.2 OTHER FACILITY DATA

In addition to emissions, data on other environmental and social parameters were collected. These included the share of recycled granules, water consumption, waste generation and disposal practices, and employment generated. The observations were consistent across manufacturers in both states, with the exception of employment generation, which showed some variation. A summary of the key observations is presented below.

ASPECT	OBSERVATIONS
01 Share of Recycled Granules	✓ Manufacturers largely rely on virgin material. A small share of companies (around 20%) uses 5–20% recycled granules, sourced only from their own process waste. ✓ None reported using externally purchased recyclates, citing food-grade restrictions and inconsistent quality.
02 Water consumption	✓ Water use in plastic manufacturing is generally minimal. It is not required in most cases, except in processes such as cooling, cleaning, or during higher-volume production runs. ✓ Even where water is needed, companies reported that it can be largely reused within the system, with only about 5% losses. This makes overall water consumption relatively low compared to other resource inputs.
03 Waste generation and isposal practices	✓ Waste generation in plastic manufacturing typically ranges between 2% and 10%, mainly from processing losses. Most of this waste is reprocessed—either through in-house recycling, job work, or by sending it to scrap dealers. ✓ The reprocessed material is then used as recycled granules within production, helping to reduce the overall burden on virgin granules..
04 Employment generated	**Employment levels varied across states.** ✓ In Maharashtra, 18 manufacturers together employed 454 people, equivalent to about one person per 2.4 tons of monthly production. ✓ In Tamil Nadu, 14 manufacturers employed 273 people, translating to one person per 0.97 tons of monthly production. These figures indicate higher labor intensity in Tamil Nadu compared to Maharashtra, though no direct correlation with production scale could be established.

2.1.3 CHALLENGES

Manufacturers in both states reported facing similar challenges, including:

- High electricity costs and limited uptake of solar energy, due to high upfront investment and space constraints.
- Use of recycled content is limited by food-grade restrictions and poor granule quality. Shortage of registered recyclers, further burdened by the high GST rate on recycling activities.
- Inflow of low-grade plastics from other states (e.g., Diu), owing to the absence of effective trade barriers.
- Lack of incentives for compostable plastic (PLA) bags made from starch, reducing their commercial viability.
- Cumbersome inspection processes, where authorities often confiscate material or detain vehicles instead of using standardized gauges to measure thickness.

2.2 SUP ALTERNATIVES MANUFACTURING

The manufacturing of alternatives to banned single-use plastics (SUPs) is growing but remains fragmented across material types such as paper, cloth, wood, bagasse, and other bio-based materials. To capture manufacturing-related aspects—particularly emissions data for comparison with SUP items—a survey of SUP alternative manufacturers was undertaken. Manufacturers were identified through published sources and sectoral networks.

The coverage of SUP alternatives manufacturers in Maharashtra and Tamil Nadu is as follows:

MAHARASHTRA

★ **Numbers Of Company:** 11

★ **SUP Alternatives Covered**

Paper-based products
- Cutlery items (plates, cups, glasses)
- Paper bags
- Paper straws
- Paper earbuds

Bagasse-based products
- Cutlery items (plates, spoons, bowls)

PLA (Corn-starch–based) products
- Cutlery items (plates, spoons)

TAMIL NADU

★ **Numbers Of Company:** 10

★ **SUP Alternatives Covered**

Paper-based products
- Cutlery items (plates, cups, glasses)
- Paper bags

Areca-based products
- Cutlery items (plates, tray, spoon)

Jute-based products
- Jute bags

Jute-based products
- Cloth bags

Overall, the survey ensured comprehensive coverage of different types of SUP alternative products, including paper, bagasse, PLA (corn-starch), areca, jute, and cloth-based items. The key findings of the SUP manufacturers survey are presented below under three categories: emissions data, other facility data, and challenges.

2.2.1 EMISSIONS DATA

Similar to SUP manufacturers survey analysis, the emissions data were captured for both the production facility and upstream processes (raw material extraction and transportation). The types of emissions data collected are outlined below.

Facility Emissions

- Electricity consumption (KWH/ton)
- Use of renewable electricity
- Use of combustion fuel

Upstream (Procurement) Emissions

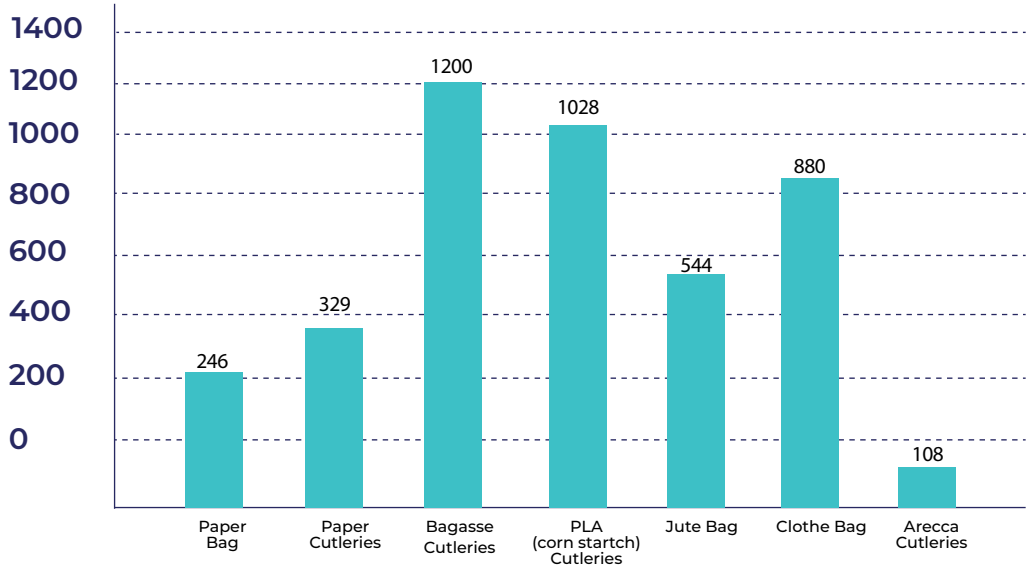
- Estimated emissions from raw material production
- Transport-related emissions, including source locations, mode of transport, type of fuel, and distance travelled

Here again, emissions data vary across manufacturers depending on the type of SUP alternative, production processes, and supplier network. These parameters are captured for each manufacturer in the metadata accompanying this report and can be used for emission calculations. Below, a state-wise common scenario is presented for Facility emissions and Upstream emissions.

Facility Emissions

Electricity consumption (KWH/ton)

Avg.Electricity consumption (KWH/ton): SUP Alternative Manufacturers



On average, electricity consumption was highest for bagasse cutleries, followed by PLA (corn-starch) cutleries and cloth bags. On the other hand, it was lowest for areca cutleries, followed by paper bag.

Use of renewable electricity

None of the manufacturers surveyed in Maharashtra and Tamil Nadu reported the use of renewable electricity. This is again attributed to multiple factors, including limited space, high investment costs, and lack of incentives.

Use of combustion fuel

None of the manufacturers surveyed use combustion fuels at their facilities, as all production processes are electricity-driven.

In summary,

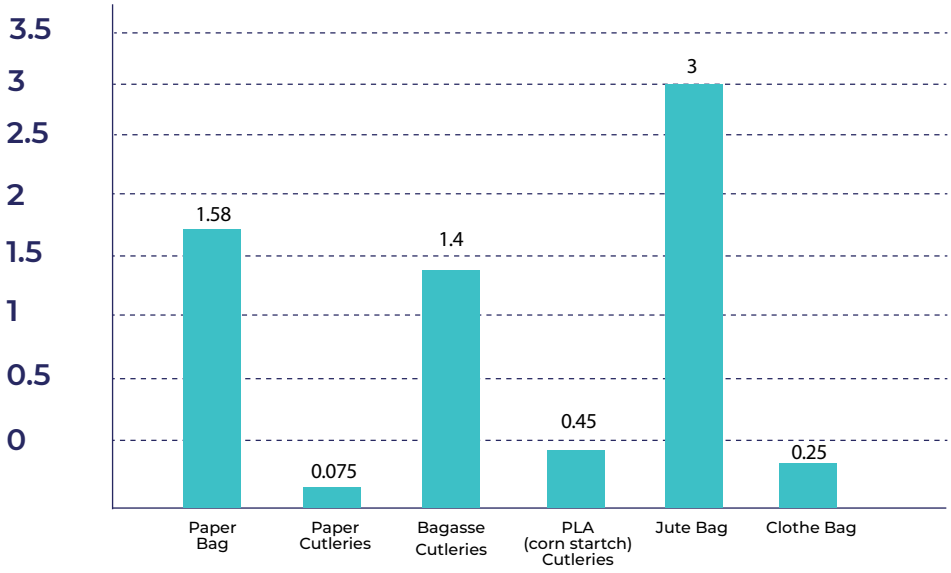
Facility-level emissions from SUP alternatives manufacturing are entirely indirect, arising solely from electricity consumption, with no direct emissions reported.

Upstream Emissions

Raw material extraction

Emissions from this stage were estimated for the covered material types—paper, bagasse, PLA, jute, cloth, and areca leaves—using published national sources.

Emissions (TCo2/T): Raw Material Extraction & Production (SUP Alternative)



(Sources: PCRA (2022); TERI (2021); CPCB (2020); Shakti Sustainable Energy Foundation (2022); Ghosh & Mondal (2021); Singh & Sharma (2020). See References for details.)

As per published sources, emissions are highest for cloth, followed by paper and PLA (cornstarch). On the other hand, they are lowest for bagasse, followed by areca leaves.

It is important to note that bagasse cutlery has relatively low emissions at the raw material extraction stage but high electricity consumption during production. In contrast, paper bags show the opposite trend, with higher emissions from raw material extraction but lower electricity use in production. These variations highlight the need for an integrated assessment when comparing different SUP alternatives among themselves and against SUP items. Such a comparative assessment is presented in Chapter 3.1.3..

Transport-related emissions

The data points considered include source location, mode of transport, fuel type, and distance between the source and the facility. Similar to SUP manufacturers, notable variations were observed across these manufacturers. The detailed dataset is provided in the accompanying metadata, while the general observations are summarized below.

Common Observations for Tamil Nadu & Maharashtra.

SOURCES OF RAW MATERIALS

Local/ Interstate Manufacturers

MODE OF TRANSPORT

Variable (Lorry 16 T/ Truck 10 T etc.)

AVG. DISTANCE

Variable (depending upon source)

FUEL USED

Diesel/ CNG

Key Insights

For both Maharashtra and Tamil Nadu, raw material sources are broad, covering both local and interstate manufacturers. The mode of transport is variable and typically involves medium to large trucks (e.g., 10T trucks or 16T lorries). The average transport distance also varies depending on the source location. Diesel is the predominant fuel used, with some instances of CNG, and this remains consistent across both states.

2.2.2 OTHER FACILITY DATA

In addition to emissions, data on other aspects such as water consumption, waste generation and disposal practices, and employment generation were collected. The observations were consistent across manufacturers in both states, with the exception of employment generation, which showed some variation. A summary of the key observations is presented below.

★ Water Consumption

Water use is generally not required or minimum. In the case of bagasse-based production, water is used but can be effectively reused through Effluent Treatment Plants (ETPs).

★ Waste generation and disposal practices

Waste generation across facilities was observed in the range of 1–5%, mainly arising from cutting and soiled materials. This waste is typically channeled to scrap dealers/ waste collection vehicles for further processing, indicating the presence of an informal recovery pathway.

★ Employment generated

Employment levels varied across states.

- In Maharashtra, 288 workers were employed across 11 manufacturing units, translating to roughly one worker per 1.45 tonnes of monthly production.
- In Tamil Nadu, 70 workers were engaged across 10 manufacturers, equivalent to one worker per 1.16 tonnes of monthly production.

These figures indicate slightly higher labor intensity in Tamil Nadu compared to Maharashtra, though no direct correlation with production scale could be established.

2.2.3 CHALLENGES

SUP Alternative Manufacturers in both states reported facing similar challenges, including:

High Electricity Tariff

The cost of electricity is high, which increases the overall cost of production.

Limited Use of Solar Energy

Solar energy is not widely used because of high installation costs and lack of space for panels..

High GST

A higher GST rate makes SUP alternatives more expensive compared to plastic products.

Low Market Demand

Demand for alternatives is still low, as many buyers are not fully aware or find them costly.

Lack of Clusters

The sector lacks strong clusters that bring together suppliers, manufacturers, and buyers. This limit shared facilities, market linkages, and economies of scale.

Shortage of Trained Labour

There is a lack of skilled workers for operating machines and handling production processes..

2.3 DISTRIBUTION (MARKET)

The next stage is distribution, where both banned SUPs and their alternatives move from manufacturers to markets and retailers. To understand usage patterns of SUPs and their alternatives, a market survey was carried out in all four project cities.

The coverage of the market survey in Maharashtra and Tamil Nadu is as follows:

State	City	No. of Market Areas Covered	No. of Shops Covered
Maharashtra	Navi Mumbai	6	229
	Vengurla	1	32
Tamil Nadu	Chennai	6	226
	Coimbatore	4	169

In Maharashtra, the survey covered 7 market areas with a total of 262 shops, while in Tamil Nadu, 10 market areas were covered with 375 shops. The selection of market areas was based on city size and aimed to ensure representation from all regions of each city. Within each area, the survey included nine types of commercial establishments, along with one religious site and one tourist site, in line with CPCB's SOP.

The survey findings are elaborated below.

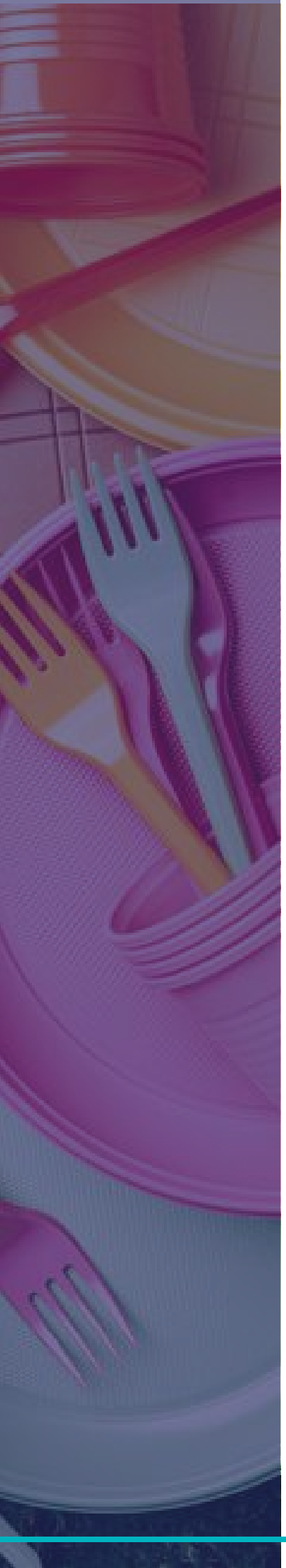
2.3.1 MARKET USAGE OF SUPS AND THEIR ALTERNATIVES

The percentage of shops selling items from different SUP categories is presented below for both Maharashtra and Tamil Nadu. The usage patterns are broadly similar across the two states, with the following key insights.

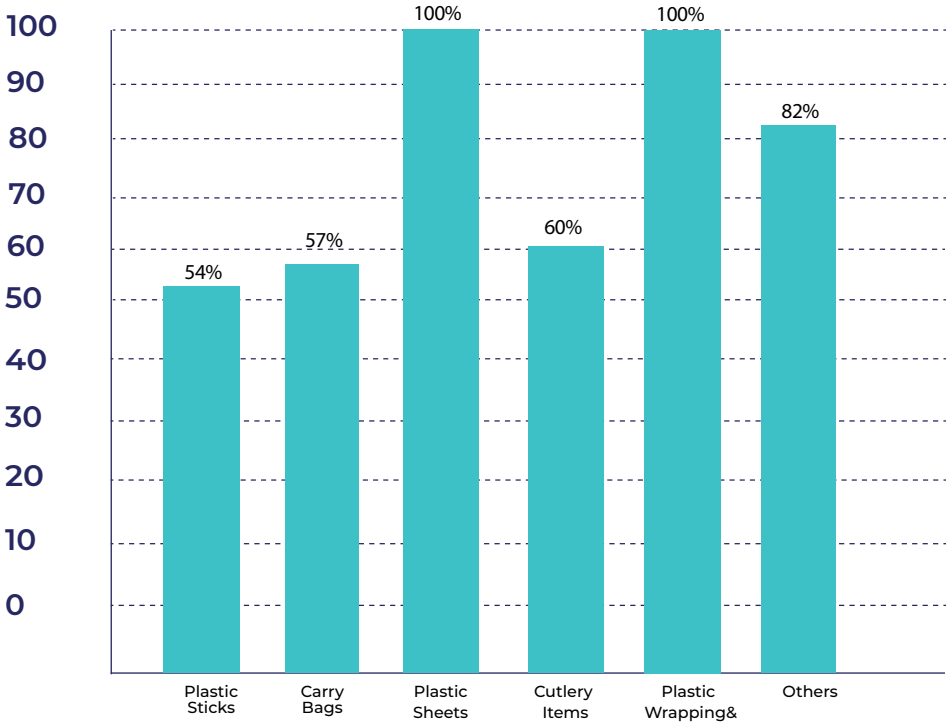
Key Insights

Items such as plastic sticks, carry bags, and cutlery were observed to be moderately present across shops, with a notable share also selling their alternatives. Interestingly, a portion of shops stocked both SUPs and alternatives together, reflecting a mixed usage pattern.

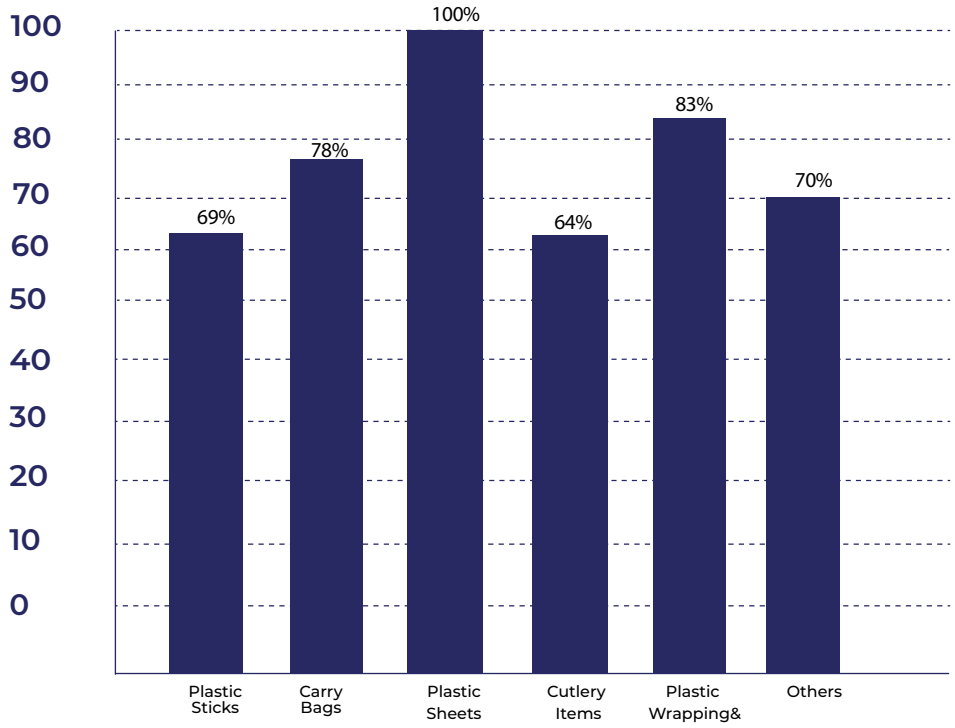
On the other hand, plastic sheets, wrapping materials, and packaging films were available in nearly all shops. Items under the "Others" category—such as plastic flags, PVC banners, and polystyrene used for decorations—were also frequently observed.



Market Usage Of SUPs: Maharashtra



Market Usage Of SUPs: Tamil Nadu



Available SUP Alternatives

SUP alternatives were largely similar in both states, covering common categories such as paper, wooden, and stainless-steel products. The only notable differences were bagasse-based products, seen only in Maharashtra, and areca leaf-based products, found only in Tamil Nadu.

Material	SUP alternatives observed
Paper Based	Ear Bud, Bag, Straw; Cutleries- Paper Cups, Glass, Plate; Paper based decors
Wooden Based	Ear Buds, Candy Stick, ice cream Sticks, Ballon Sticks; Cutleries- Spoon, Fork, Knives
Stainless Steel Based	Cutleries - Cups, Spoon, Forks, Glasses, Plates, Trays, Knives
Bagasse Based (in MH)	Cutleries- Cup, Glass, Plate, Spoon
Arecca Leaves based (in TN)	Cutleries- Cup, Glass, Plate, Spoon

A few photos of SUPs and their alternatives seen in the market are given below.

Maharashtra

Plastic Carry Bags <120

Plastic Spoon &
Wooden Spoon (both)

Tamil Nadu

Plastic Carry Bags
<120 microns

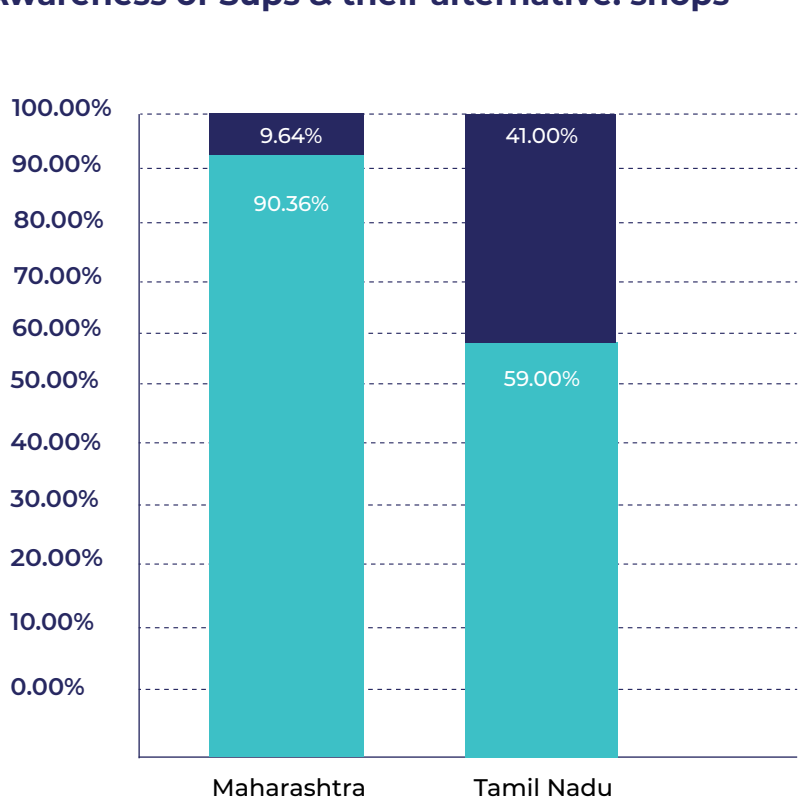
Arecca Leaves Cutlery

2.3.2 OTHER ASPECTS

The other aspects analyzed include the level of awareness and the challenges faced at the shop level.

A. AWARENESS OF SUPS AND THEIR ALTERNATIVES

Awareness of Sups & their alternative: shops



The level of awareness about SUPs and their alternatives is high in Maharashtra, while moderate in Tamil Nadu.

B. CHALLENGES IN ADOPTING SUP ALTERNATIVES

The key challenges reported in both Maharashtra and Tamil Nadu include higher cost, lack of demand, and limited availability of alternatives. The percentage distribution of these challenges is presented below:

Challenge	Maharashtra % Share	Tamil Nadu % share
Higher Cost	59%	44%
Lack of Demand	24%	36%
Limited Availability of Alternatives	17%	20%

2.4 CONSUMPTION

The next stage is consumption, where both banned SUPs and their alternatives reach end-users through shops, retailers, and other points of sale. To understand actual usage practices and preferences related to SUPs and their alternatives, a consumer survey was conducted across all four project cities.

The coverage of the consumer survey in Maharashtra and Tamil Nadu is as follows:

State	City	No. of Consumers Surveyed	No. of Market Areas Covered
Maharashtra	Navi Mumbai	609	6
	Vengurla	22	1
Tamil Nadu	Chennai	622	6
	Coimbatore	418	4

In Maharashtra, the survey covered 634 consumers across 7 market areas, while in Tamil Nadu, 1,040 consumers were surveyed across 10 market areas. The sample size was determined in line with SBM guidelines, taking into account the size of each city.

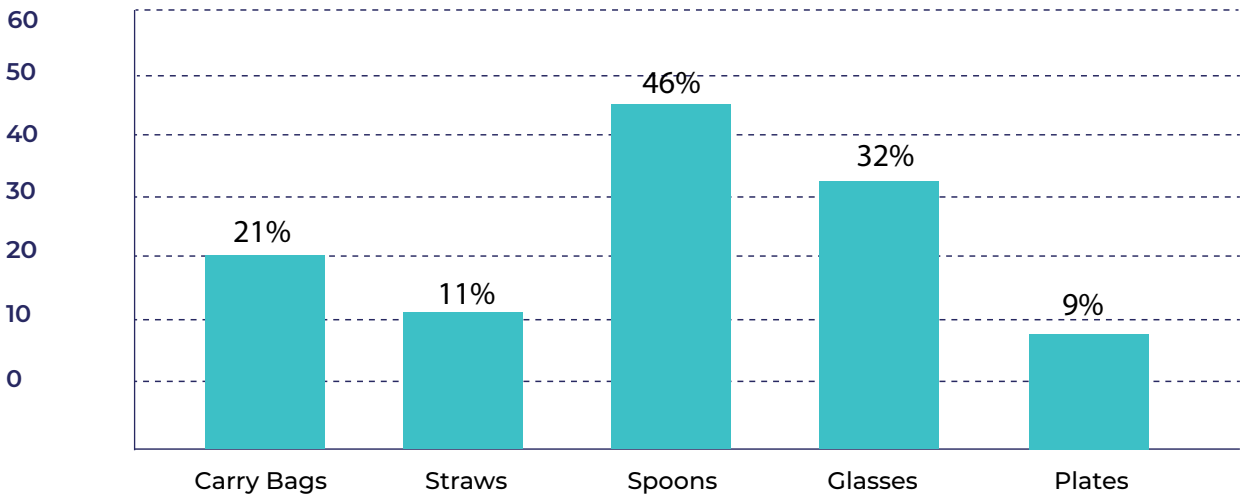
The survey findings are elaborated below

2.4.1 CONSUMER USAGE OF SUPS AND THEIR ALTERNATIVES

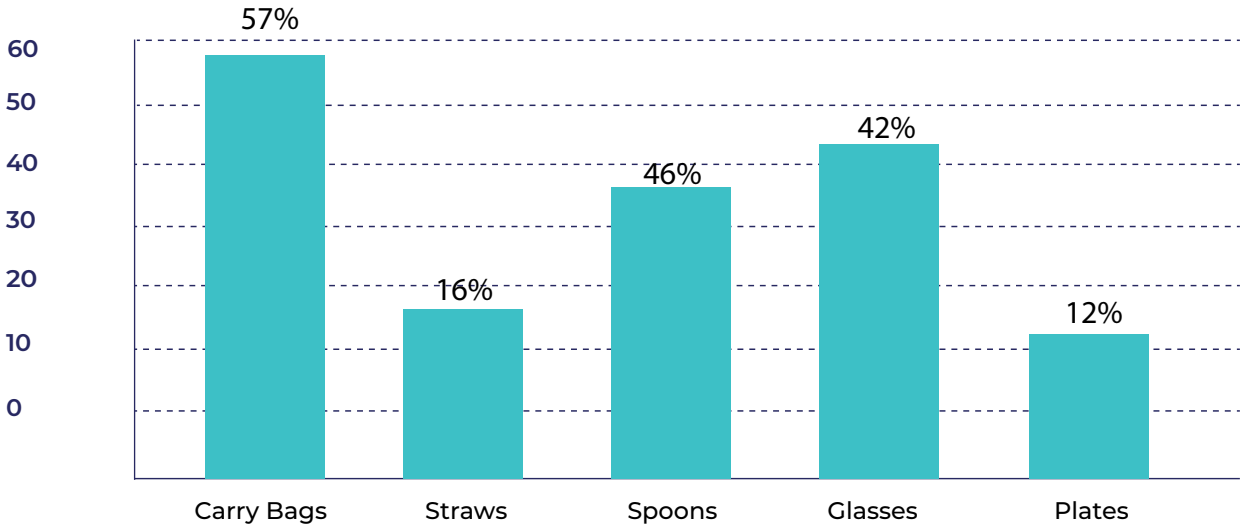
Consumer usage of SUPs and their alternatives was broadly in line with market availability. Respondents reported using both categories. Plastic spoons, carry bags, and glasses were among the most frequently used SUP items, whereas plastic straws and plates were less common, with alternatives being the preferred choice.

The state-wise observations are outlined below.

Consumer Usage of SUPS: Maharashtra



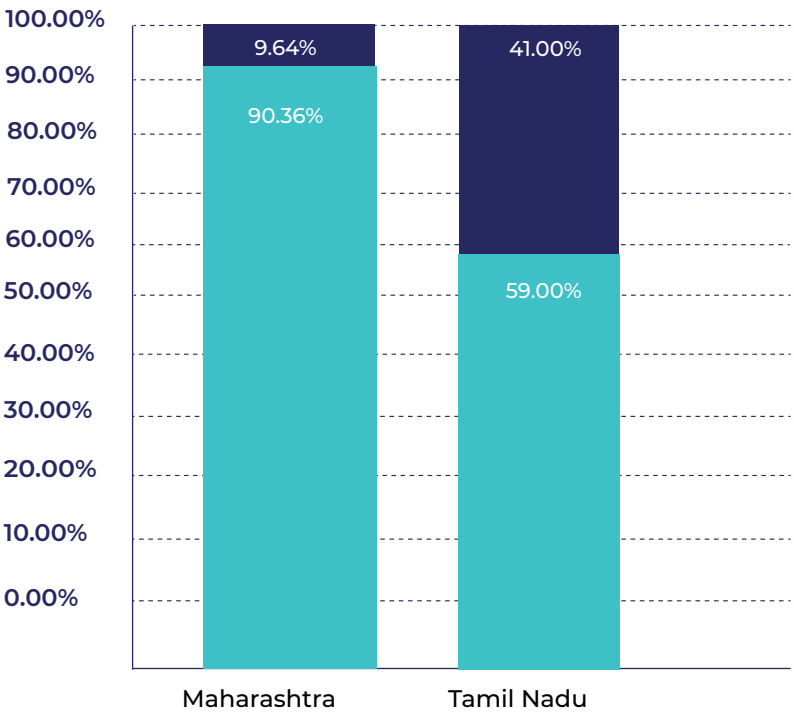
Consumer Usage of SUPS: Tamil Nadu



2.4.2 OTHER ASPECTS

The other aspects analyzed include the level of awareness and the challenges faced in adopting SUP alternatives.

A. Awareness of hazards of SUPs and their alternatives



A significant variation was observed in awareness levels between Maharashtra and Tamil Nadu.

In Maharashtra, awareness was relatively high at 90.36%, whereas in Tamil Nadu it was lower, at 59%.

B. Challenges in Adopting SUP Alternatives

In both states, the major challenges to adopting SUP alternatives were identified as high cost and limited availability. In Tamil Nadu, however, limited awareness of the hazards of SUPs and the available alternatives also emerged as a significant barrier.

2.5 DISPOSAL

Post-consumption, SUPs and their alternatives enter the waste stream and are collected through municipal collection vehicles. From there, they are transported to waste processing plants, commonly referred to as Material Recovery Facilities (MRFs). A small portion of waste, however, may leak into the environment if disposed of in the open. In addition, certain valuable dry waste fractions — such as paper or PET bottles — may be diverted directly to scrap dealers rather than reaching the MRFs.

Assessing waste composition at the disposal stage, particularly plastics and SUPs and their disposal channels, is crucial. To gather this data, surveys were conducted at 2–3 major MRFs in each city. The composition of plastic and SUPs was assessed by analyzing the waste from selected collection vehicles in line with CPCB's SOP.

The coverage of MRFs and collection vehicles in each city is presented below.

State	City	MRFS Covered	Collection vehicles surveyed
Maharashtra	Navi Mumbai	1 Centralized MRF (out of 1) 1 Small Decentralized MRF (out of 3)	9
	Vengurla	1 Centralized MRF (out of 1)	3
Tamil Nadu	Chennai	3 Major Decentralized MRF (out of 49)	9
	Coimbatore	3 Decentralized MRF (out of 6)	9

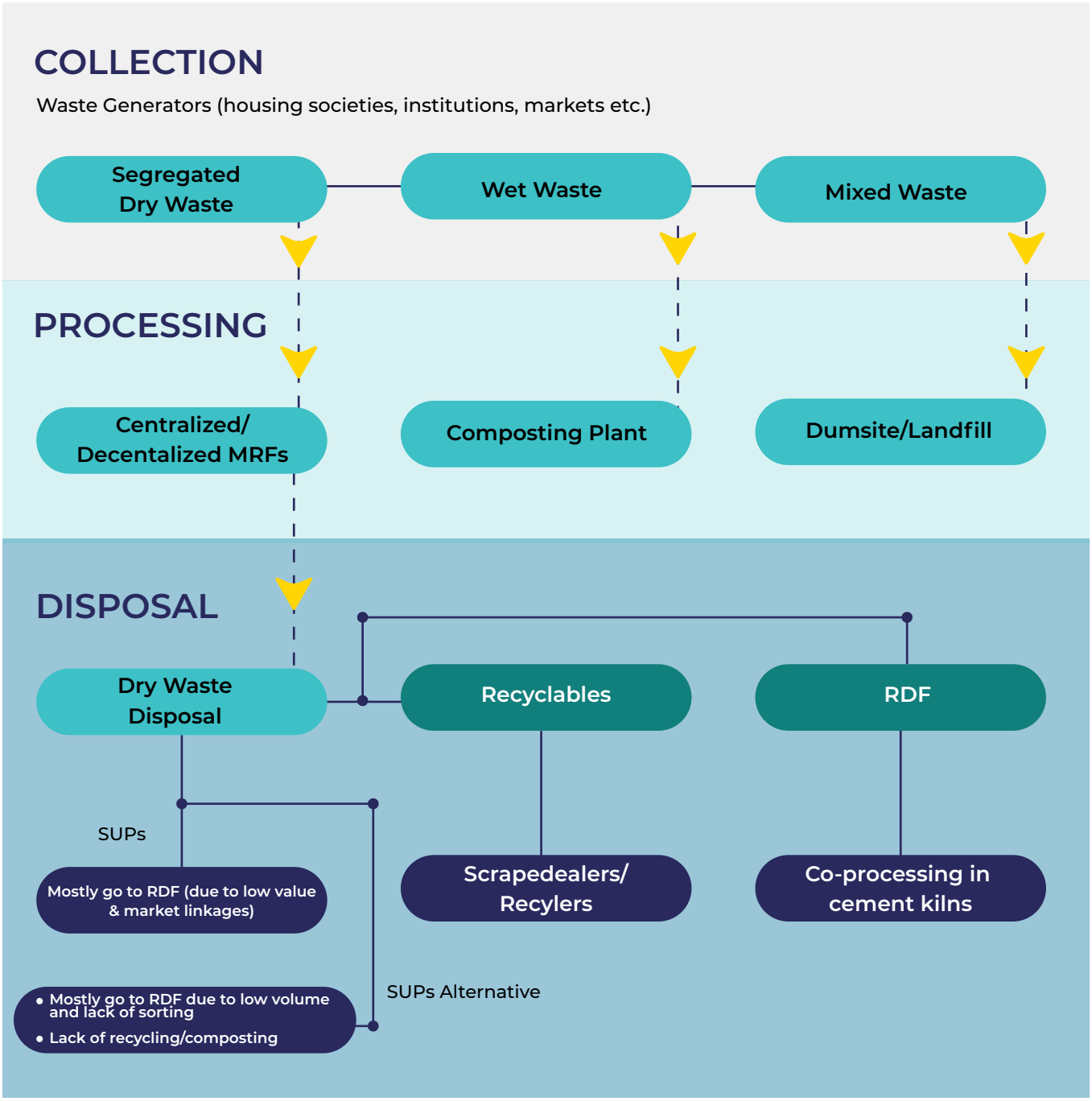
The overall sample size was determined based on city size, in line with CPCB's SOP. Collection vehicles covered five area types (MIG, HIG, LIG, commercial, and semi-commercial), while MRFs were chosen to ensure geographic representation.

The key findings at the disposal stage are presented in terms of waste flow at MRF, waste assessment, and issues & recommendations.

2.5.1 WASTE FLOW AT MRF

The following diagram shows the typical waste flow at the MRF, including incoming and outgoing waste streams, which is explained thereafter.

Figure 2.1 Common Waste Flow Diagram (MRF)



Typically, a city has a centralized waste processing facility (MRF) along with a network of decentralized MRFs that together handle the city's dry waste. However, the system varies depending on geography, waste generation, and space availability. Among the project cities, both cities in Tamil Nadu operate entirely on a decentralized MRF model with no centralized facility, whereas in Maharashtra, both cities maintain a centralized MRF.

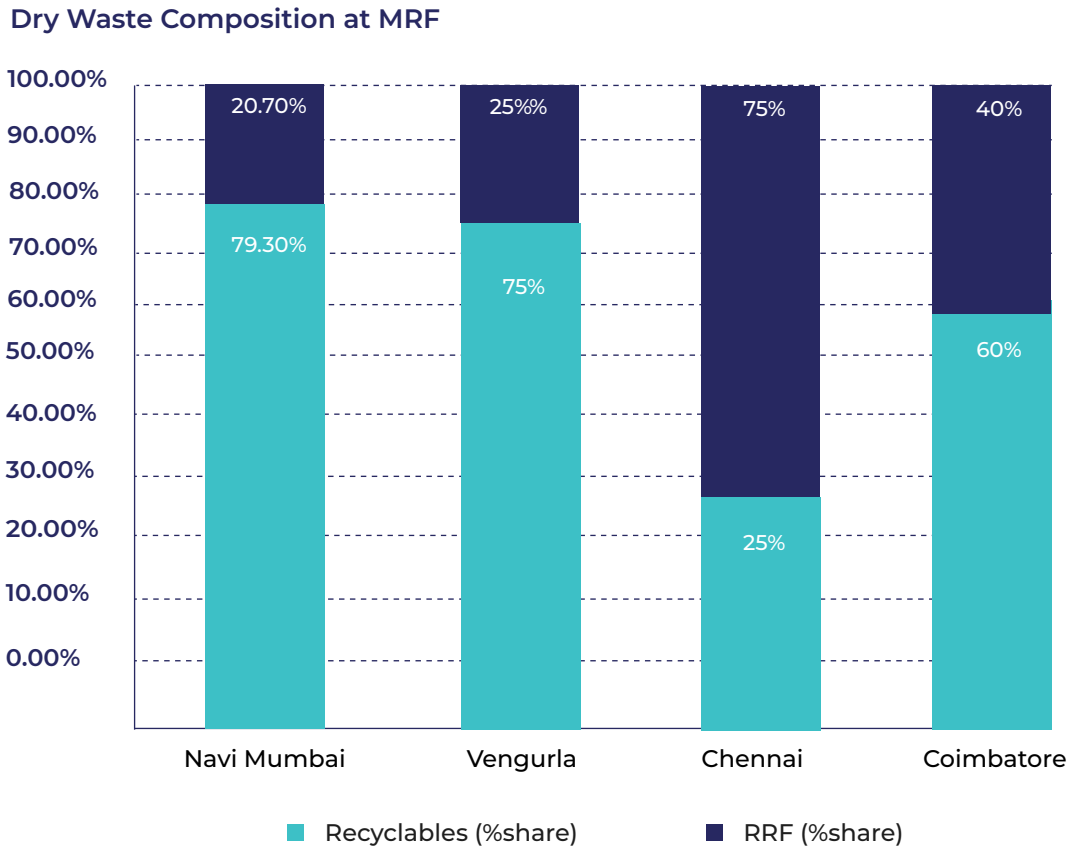
Door-to-door collection is managed through municipal vehicles, which transport segregated dry waste to MRFs for further sorting. Wet waste is sent to composting plants, while mixed waste is disposed of at dumpsites. The level of source segregation varied across cities: it was good in Vengurla (MH), moderate in Navi Mumbai (MH) and Coimbatore (TN), and low to moderate in Chennai (TN).

At the MRFs, dry waste is further sorted into two streams: recyclables and non-recyclables. Recyclables are channelled to scrap dealers and authorized recyclers, while the non-recyclable fraction (RDF) is sent to cement plants for co-processing. Single-Use Plastics (SUPs), owing to low value and contamination, largely enter the RDF stream, with the exception of clean carry bags that are occasionally recycled. Similarly, most SUP alternatives are neither recycled nor composted; instead, they also end up in the RDF stream, primarily due to low volumes and inadequate sorting.

The next section presents the composition of dry waste, plastic waste and SUPs at the MRFs.

2.5.2 WASTE ASSESMENT

A. DRY WASTE COMPOSITION



It is important to note that the share of recyclables is **higher in both Maharashtra** cities, driven by better segregation levels and stronger market linkages. In contrast, it is lower in **Tamil Nadu**, where segregation is low and market linkages are lacking, particularly for low-value plastics such as PP and HM carry bags. **In Chennai, open dumping at secondary storage points, along with the direct recovery of high-value waste from collection vehicles**, further reduces the amount of recyclables that reach MRFs.

Recyclables include paper, cardboard, metals, high-value plastics (PET, HDPE, LDPE), and e-waste, while RDF includes soiled waste, multilayer plastics (MLP), cloth, footwear, mats, bags, thermocol, etc.

B. PLASTIC WASTE COMPOSITION

The plastic composition at the MRFs was assessed across seven categories in line with CPCB's SOP. Plastic composition was broadly similar across the four cities, with minor variations. The average composition is presented below.

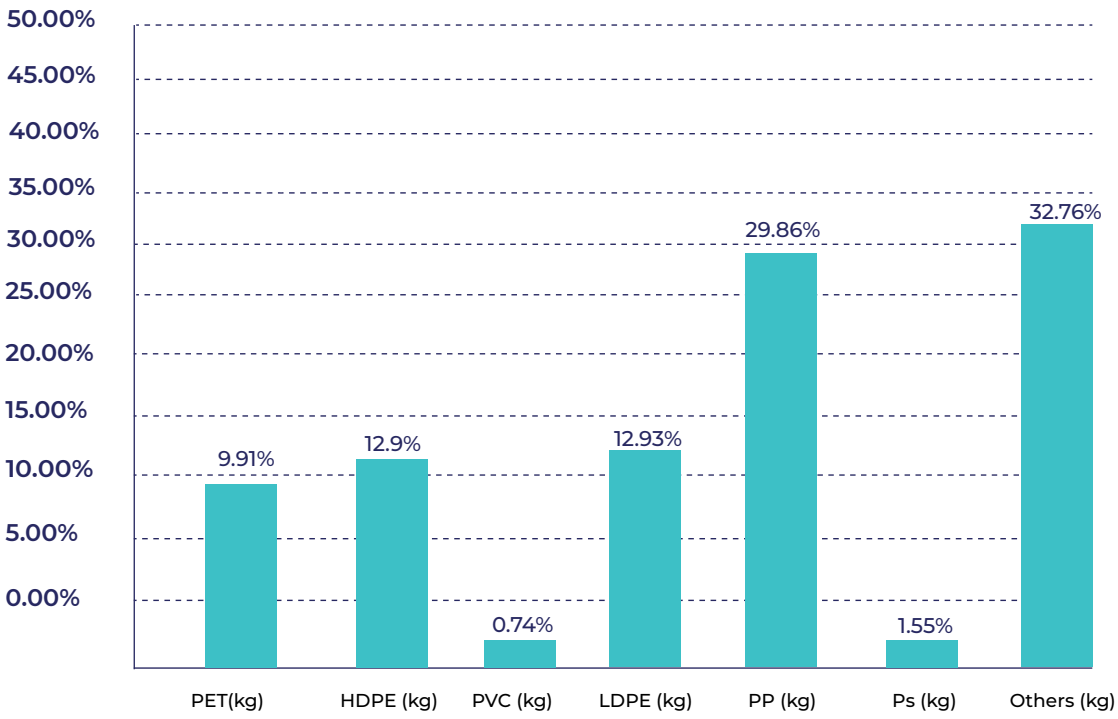
Key Insights

Dominant Categories: Low-value plastics such as PP, LDPE, and "Others-MLP etc." form the bulk of the plastic waste stream.

Moderate Contributors: High-value plastics like PET and HDPE make up a smaller share, as they are often segregated and removed earlier by sanitation workers and housekeeping staff, and therefore do not typically reach the MRF.

Minor Contributors: PVC and PS appear only in trace amounts, contributing negligibly to the overall mix.

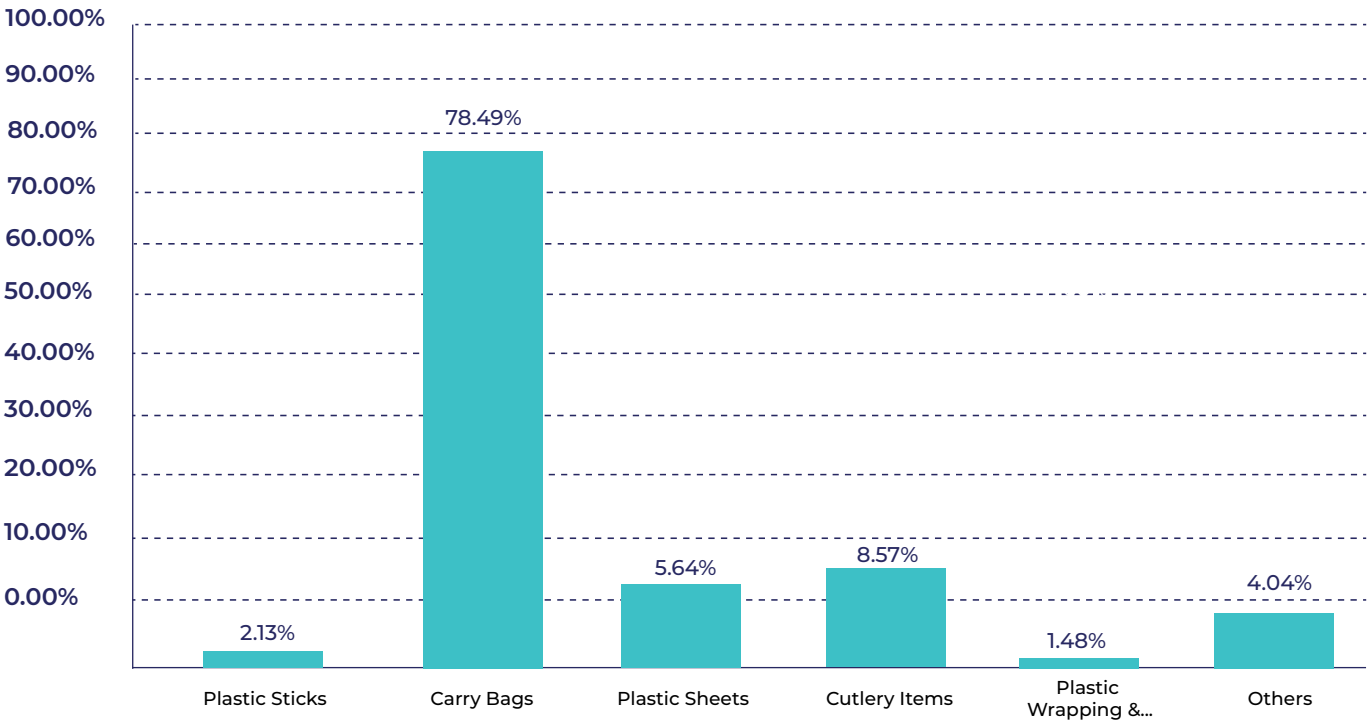
Avg. Plastic composition at MRF



C. SUPS COMPOSITION

The SUP composition at the MRFs was assessed across six categories and 21 sub-categories in line with CPCB's SOP. At the major category level, the composition was broadly similar across the four cities, with only minor variations. The average composition is presented below.

Avg. SUP composition at MRF



Key Insights

Carry bags dominate the SUP waste stream, forming the largest share (78.5%)

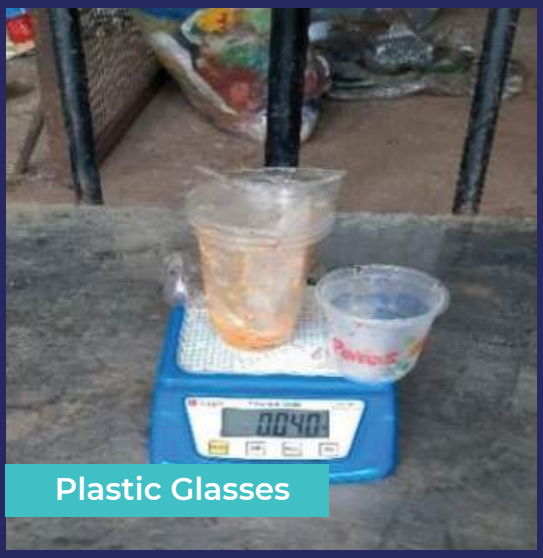
Cutlery items are the next significant contributor (8.57%).

Plastic sheets, wrapping and packaging materials, and plastic sticks make up smaller portions (13%).

Other categories — such as plastic flags, PVC banners, and polystyrene used for decoration — contribute only marginally.

A few photos of waste assessment at the MRFs are given below.


Dry Waste Sorting


Plastic Glasses


Plastic Spoons


Sorted Plastic Waste

2.5.3 ISSUES & RECOMMENDATIONS

Key Issues

- **A large share of dry waste still goes to RDF.**
- **SUPs, especially plastic carry bags and cutlery, remain high in volume but are rarely recycled.**
- **Recovery of SUP alternatives for recycling or composting is also very low.**

  Main reasons:
  - Poor segregation at source leading to contamination
  - Lack of market linkages for low-value materials

Recommendations

01. Promote better segregation at the household level

02. Improve sorting efficiency at MRFs

03. Build market linkages for non-recyclables like low-value plastics, MLP, cloth, footwear, and thermocol

2.6 RECYCLING

Recycling pertains to the last step of the value chain. While only a small share of banned SUP items and their alternatives are actually recycled, it remains important to examine the role of recyclers. The recyclers survey aimed to gather emissions data, similar to the SUP manufacturers survey, as well as assess other environmental and social parameters and the challenges faced by the recyclers.

The coverage of recyclers survey in Maharashtra and Tamil Nadu is as follows:

State	No. Of Recyclers	Type
Maharashtra	10	• Plastic (flexibles) recyclers - 8 • Paper recycler - 2
Tamil Nadu	11	• Plastic (flexibles) recyclers - 8 • Paper recycler - 2

The survey covered both plastic and paper recyclers, since paper products are common SUP alternatives. While recycling is better than landfilling or incineration, it still produces emissions. The survey findings are presented below starting with the emissions data, followed by other facility data and the challenges faced.

2.6.1 EMISSION DATA

Similar to SUP manufacturers survey analysis, the emissions data were captured for both the production facility and upstream processes (raw material extraction and transportation). The types of emissions data collected are outlined below.

Here again, emissions data vary across manufacturers depending on the type of material, production processes, and supplier network. These parameters are captured for each recycler in the metadata accompanying this report and can be used for emission calculations. Below, a state-wise common scenario is presented for Facility emissions and Upstream emissions.

FACILITY EMISSIONS

- **Electricity consumption (KWH/ton)**
- **Use of renewable electricity**
- **Use of combustion fuel**

UPSTREAM (PROCUREMENT) EMISSIONS

Transport-related emissions including

- Supply locations,
- Mode of transport,
- Type of fuel
- Distance travelled

FACITY EMIISSIONS

★ Electricity consumption (KWH/ton)

- Recycled Plastic Granuels (PP/LD/HM): 502.5 KWH/ton
- Recycled Kraft paper: 289.9 KWH/ton

Overall, recycled plastic granules require more electricity per ton compared to recycled Kraft paper.

★ Use of renewable electricity

None of the recyclers surveyed in Maharashtra and Tamil Nadu reported the use of renewable electricity. This is again attributed to multiple factors, including limited space, high investment costs, and lack of incentives.

★ Use of combustion fuel

None of the recyclers surveyed use combustion fuels at their facilities, as all production processes are electricity-driven.

In summary,
facility-level emissions from recyclers are entirely indirect, arising solely from electricity consumption, with no direct emissions reported.

UPSTREAM EMISSIONS

The upstream emissions only cover the transport-related emissions from the source of supply up to the recycling facility.

The data points considered include supply location, mode of transport, fuel type, and distance between the supplier and the recycler's facility. Similar to SUP manufacturers, notable variations in this data were observed across the covered recyclers. The detailed dataset is provided in the accompanying metadata, while the general observations are summarized below.

	Maharashtra % Share	Tamil Nadu % Share
Sources of scrap	Crapyards/ local companies	Same
Mode of Transport	Variable (Tempo 1 T/ Truck 10 T etc.)	Same
Avg. distance	Variable (depending upon source)	Same
Fuel used	Diesel/ CNG	Same

Key Insights
Scrap materials are sourced from scrapyards and local companies. The mode of transport varies, ranging from small 1-tonne tempos to larger 10-tonne trucks, with distances depending on the source location. Diesel is the predominant fuel used, with some use of CNG, and these factors together determine the transport-related emissions for moving scrap to recycling facilities.

2.6.2 OTHER FACILITY DATA

In addition to emissions, data on other aspects such as water consumption, waste generation and disposal practices, and employment generation were collected. The observations were consistent across manufacturers in both states, with the exception of employment generation, which showed some variation. A summary of the key observations is presented below.

WATER CONSUMPTION

Water use at plastic recycling plants is generally minimal or nil, as washing lines are often not used. In cases where washing is required, daily water consumption ranges from approximately 500 to 2,000 litres

WASTE GENERATION AND DISPOSAL PRACTICES

Waste generated during recycling, mainly from cutting and soiled materials, ranges between 1% and 6% of the input material. This waste is either reused within the factory as feedstock or sent to scrap dealers for further processing.

EMPLOYMENT GENERATED

Employment levels varied across states.

- In Maharashtra, 307 workers were employed across 10 recycling units, translating to roughly one worker per 216 tonnes of monthly production.

- In Tamil Nadu, 267 workers were engaged across 11 recyclers, equivalent to one worker per 1 tonne of monthly production.

These figures indicate considerably higher labor intensity in Tamil Nadu compared to Maharashtra, though no direct correlation with production scale could be established.

2.6.3 CHALLENGES

Recyclers in both states reported facing similar challenges, including:

HIGH ELECTRICITY TARIFF

Electricity costs are high, increasing operational expenses and affecting overall profitability.

HIGH GST COST

High GST makes recycled products more expensive and also makes it difficult for recyclers to register under EPR, which requires GST-compliant bills.

LACK OF TRAINED LABOUR

There is a shortage of skilled workers to operate machinery and manage recycling processes effectively.

SHORTAGE OF CLEAN SCRAP MATERIAL

Many collected materials are contaminated or mixed with non-recyclables, requiring additional sorting and reducing the overall yield of usable recycled material.

03 CONCLUSION & RECOMMENDATIONS

This chapter consolidates the findings of the value chain assessment and outlines key insights for future action. It begins with a comparative analysis of SUPs and their alternatives across the value chain. This is followed by an emissions comparison of specific SUP products and their alternatives, adopting a Cradle-to-Gate approach. Finally, a set of recommendations are presented to address systemic challenges in the value chains of both SUPs and their alternatives.

3.1 COMPARATIVE ANALYSIS OF VALUE CHAIN: SUPS VS SUP ALTERNATIVES

The comparative analysis between SUPs and their alternatives is presented sequentially across each stage of the value chain. .

1. MANUFACTURING

The comparative analysis between SUPs and their alternatives is presented sequentially across each stage of the value chain.

Key Insights

SUP manufacturing continues informally in clusters despite regulatory restrictions. Production is predominantly based on virgin raw materials, with only a negligible share of recycled inputs due to food-grade limitations and poor quality of recycled granules. Facility-level emissions arise entirely from electricity use, as operations are fully electricity-driven, while upstream emissions stem from polymer production and transportation. Other environmental parameters include minimal water requirements and moderate waste generation, much of which is reprocessed internally.

In contrast, the manufacturing base for SUP alternatives is fragmented and material-specific, covering paper, bagasse, areca, jute, cloth, and PLA (starch-based) products. Production processes vary widely: some materials require higher electricity and water inputs, while others are relatively less resource intensive. Similar to SUPs, Facility-level emissions arise entirely from electricity use, as operations are fully electricity-driven, while upstream emissions are linked to raw material extraction and transportation. Waste generation is generally lower and is either channeled through scrap dealers for recovery or disposed of via municipal collection systems.

In summary, facility-level emissions are generally higher for SUP alternatives due to energy-intensive processes, whereas raw material extraction contributes more emissions in the case of plastics; transport-related emissions vary significantly across geographies, making direct comparison difficult. SUP manufacturing is challenged by limited recycled content, high electricity costs, shortage of registered recyclers, and cumbersome.

inspection process, while alternatives face high electricity tariffs, high GST, lack of clustering, and low market demand.

The Comparative Analysis at the Manufacturing Stage is presented below.

PARAMETER WISE COMPARISON

PARAMETER	SUPS	SUP ALTERNATIVES
Manufacturing Status	Not officially reported but continues informally	Growing but fragmented across material types such as paper, cloth, wood, bagasse, and other bio-based materials
Emissions Data Facility Emissions • Avg. Electricity consumption (KWH/ton)	Highest for plastic cutlery (985), followed by plastic sheets (749) and carry bags (585)	Highest for bagasse cutlery (1200), followed by PLA cutleries (1028), while lowest for Arecca cutleries (108) followed by paper bag (246)
• Use of renewable electricity	Not used	Not used
• Use of combustion fuel	Not used (all processes are electricity-driven)	Not used (all processes are electricity-driven)
Upstream Emissions • Raw Material Extraction (Ton CO2 equ. / Ton)	**Virgin granule production-** Emissions between 2.7 to 3.8 (lowest for LDPE & highest for PS)	**Raw material extraction-** Emissions between 0.075 to 3 (lowest for bagasse pulp & highest for cotton roll)
• Transport related emissions	Variable- **higher for Tamil Nadu** (as granule manufacturers located in MH & Gujarat)	Variable- depending on material type, sources and vehicle type
Other Facility Data • Water consumption	Generally, not required & wherever required, can be reused	Generally not required, except, bagasse products where it can be reused through ETP
• Waste generation & disposal	Ranges between 2% and 10% (processing losses) Mostly reprocessed (through recyclers/ scrap dealers)	Ranges between 1% and 5% (processing losses) Mostly reprocessed (through scrap dealers/ waste collection vehicles)

PARAMETER	SUPS	SUP ALTERNATIVES
• Employment generated	MH: 1 person per 2.4 T (monthly production) TN: 1 person per 0.97 T (monthly production) (No direct correlation with production scale)	MH: 1 person per 1.45 T (monthly production) TN: 1 person per 1.16 T (monthly production) (No direct correlation with production scale)
Challenges	• Low share of recycled content due to food-grade restrictions and poor granule quality • Shortage of registered recyclers • Cumbersome inspection processes	• High electricity tariff • High GST • Low Market Demand • Lack of clusters

2. DISTRIBUTION (MARKET)

Key Insights

SUPs continue to dominate distribution channels because of their strong supply networks, low cost, and easy availability. Despite regulatory restrictions, items such as carry bags, sheets, and cutlery are still commonly stocked in markets, including by small retailers. Awareness among traders is higher in Maharashtra compared to Tamil Nadu, but this has not led to major changes in stocking practices.

In contrast, the distribution of SUP alternatives is more limited and scattered. Commonly observed items include paper bags, as well as bagasse- and areca-based cutlery, while other categories are less frequently stocked. The higher cost of alternatives and limited demand, make them less attractive for retailers to stock consistently.

The Comparative Analysis at the Distribution Stage is presented below.

PARAMETER	SUPS	SUP ALTERNATIVES
Market Usage	**Common SUP items:** Carry bags; Plastic sheets: Wrapping/packaging films; Flags, PVC banners, polystyrene décor **Less common SUP items:** Plastic sticks; Cutlery (No significant variation across Maharashtra and Tamil Nadu)	**Common SUP Alternatives** ★ **Carry bags:** Paper bags (MH & TN) ★ **Cutlery:** • Paper based cutlery (MH & TN) • Bagasse based cutlery (MH) • Areca leaf-based cutlery (TN) ★ **Earbuds:** Paper & wooden based (MH & TN)
Level of Awareness among shops	**High in Maharashtra, while Moderate in Tamil Nadu**	
Challenges	**Challenges in adoption of SUP alternatives** • Higher cost • Lack of demand • Limited availability	

3. CONSUMPTION

Key Insights

SUPs remain the default choice for most consumers due to their low cost, convenience, and widespread availability. Items such as plastic carry bags, spoons, and glasses are among the most frequently used, while cutlery and sheets also see regular use. Even though awareness of SUP hazards is high in Maharashtra and comparatively lower in Tamil Nadu, this has not significantly reduced consumer usage of SUPs.

In contrast, the uptake of alternatives is partial and uneven. Paper and cloth bags and Paper based cutleries are the most commonly adopted substitutes, while bagasse and areca-based cutlery are used less regularly. Broader adoption of SUP alternatives is constrained by cost, durability, and limited availability.

The Comparative Analysis at the Consumption Stage is presented below.

PARAMETER	SUPS	SUP ALTERNATIVES
Consumer Usage	**Commonly used SUP items:** Plastic carry bags, spoons, and glasses **Less commonly SUP items:** Plastic straw & Plastic plates	**Commonly used SUP Alternatives:** Paper bags, Paper based cutlery items and Paper straw **Less commonly used SUP Alternatives:** Wooden and bagasse-based cutlery, Jute bag
Level of Awareness among consumers	**High in Maharashtra, while Moderate in Tamil Nadu**	
Challenges	**Challenges in adoption of SUP alternatives** • Higher cost • Lack awareness (observed in case of Tamil Nadu) • Limited availability	

4. DISPOSAL

Key Insights

SUPs and their alternatives are mainly disposed of through formal collection channels and enter the dry waste stream at Material Recovery Facilities (MRFs). However, some fraction also leaks into the environment through open dumping. At the MRFs, SUPs predominantly comprise of carry bags (~75%), followed by smaller shares of cutlery (especially, spoons), sheets, packaging, and sticks. Most of these items are of low-value and often soiled or contaminated leaving limited scope for recycling. As a result, they are finally sent to RDF for co-processing in cement plants.

In case of SUP alternatives, they make up only a small share of the waste stream and usually arrive mixed with other dry waste. Due to their low volumes and frequent contamination, they are rarely sorted separately and are also diverted to RDF instead of being recycled or composted. In summary, both SUPs and their alternatives face end-of-life challenges, with very low recovery for recycling or composting and RDF remaining the primary disposal channel.

The Comparative Analysis at the Disposal Stage is presented below.

Avg. Dry Waste Composition (at MRF)

Common: SUPs & SUP Alternatives

- **Recyclables Share:**
  ~75% (Navi Mumbai & Vengurla)
  ~55% (Chennai & Coimbatore)
- **Non-Recyclables (RDF) Share:**
  ~25% (Navi Mumbai & Vengurla)
  ~45% (Chennai & Coimbatore)

(In Chennai & Coimbatore, RDF share is lower than MH project cities due to relatively lower segregation level causing waste contamination and lack of market linkages for low value plastic such as HM, PP, MLP etc.)

Types of Recyclables, RDF, and their Disposal Channels

Common: SUPs & SUP Alternatives

Recyclables

- Types: Paper, cardboard, metals, high-value plastics (PET, HDPE, LDPE), and e-waste
- Disposal channel: Scrap dealers and autho-rized recyclers

Non-Recyclables (RDF)

- Types: Soiled waste, multilayer plastics (MLP), cloth, footwear, mats, bags, thermocol, etc.
- Disposal channel: Cement plants for co-processing

Avg. Plastic Waste Composition (at MRF)

Common: SUPs & SUP Alternatives

Dominant Categories (~75%): Mostly low-value plastics

- Polypropylene (PP), low-density polyethylene (LDPE), and multilayer plastics (MLP)

Moderate Contributors (~22%): High value plastic (~75%)

- Polyethylene terephthalate (PET) and high-density polyethylene (HDPE)

Minor Contributors (~3%): Mix Grades

- Polyvinyl chloride (PVC) and polystyrene (PS), which are found only in trace amounts.

(Note: No major variation in plastic composition was observed across cities. The share of high-value plastics is relatively low because much of it is removed earlier by sanitation workers and does not reach the MRF.)

Disposal channels of SUPs and their alternatives

Common: SUPs & SUP Alternatives

SUPs disposal channels:

Owing to low value and contamination, largely enter the RDF stream, with the exception of clean carry bags that are occasionally recycled.

SUP Alternatives disposal channels:

Mostly neither recycled nor composted; and end up in the RDF stream, due to low volumes and inadequate sorting

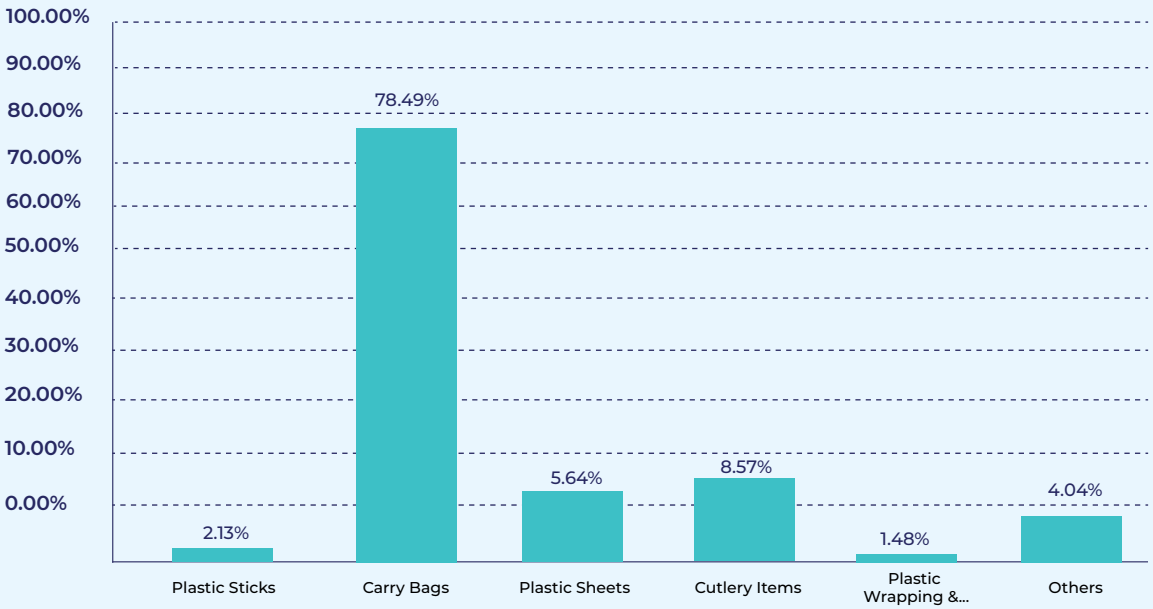
Challenges

Common: SUPs & SUP Alternatives

- **A large share of dry waste still goes to RDF.**
- **SUPs, especially plastic carry bags and cutlery, remain high in volume but are rarely recycled.**
- **Recovery of SUP alternatives for recycling or composting is also very low.**

- **Main reasons:**
  - Poor segregation at source leading to contamination
  - Lack of market linkages for low-value materials

Avg. SUP Composition at MRF



- Carry bags dominate the SUP waste stream, forming the largest share (78.5%)
- Cutlery items are the next significant contributor (8.57%).
- Plastic sheets, wrapping and packaging materials, and plastic sticks make up smaller portions (13%).
- Other categories — such as plastic flags, PVC banners, and polystyrene used for decoration — contribute only marginally.

5. RECYCLING

Key Insights

As noted in the disposal stage, most banned SUP items such as carry bags, cutlery, sheets, and plastic straws are of low value, often soiled, and therefore rarely recycled. The recycler network for these plastics is limited, with many units operating outside formal EPR registration, which weakens compliance and traceability. For SUP alternatives, recyclable material streams include paper, wood, and cloth, with paper having the most established network. However, discarded alternative items like used paper bags or cutlery are generally not used as feedstock.

From an emissions perspective, recycled Kraft paper is less energy-intensive than recycled plastic granules. This makes paper products more favorable than plastic products when considering the recycling stage.

The Comparative Analysis at the Recycling Stage is presented below.

PARAMETER	COMMON: SUPS & SUP ALTERNATIVES
Status of Recycling	• The network of plastic recyclers is limited (especially, flexibles), and most are not registered under EPR. • For SUP alternatives, recycling is dominated by paper-based recyclers; however, they typically do not use discarded SUP alternative items (e.g., paper bags) as feedstock.
Emissions Data Facility Emissions • Avg. Electricity consumption (KWH/ton)	Recycled plastic granules require more electricity per ton compared to recycled Kraft paper. • Recycled Plastic Granuels: 502.5 KWH/ton • Recycled Kraft paper: 289.9 KWH/ton
• Use of renewable electricity	Not Used
• Use of renewable electricity	Not used in both plastic & paper recycling (all processes are electricity-driven)
Other Facility Data • Water consumption	Water consumption is minimal as washing lines are often not used. In cases where washing is required, daily water consumption ranges from approximately 500 to 2,000 litres.
• Waste generation & disposal	• Ranges between 1% and 6% (reject waste) • Mostly reprocessed (through scrap dealers)
• Employment generated	• MH: 1 person per 216 T (monthly production) • TN: 1 person per 1 T (monthly production) (Note: The variation does not directly correlate with production scale; rather, it reflects higher mechanization levels in Maharashtra.)
Challenges	• High electricity tariff • High GST • Shortage of Clean Scrap Material

SUMMARY OF VALUE CHAIN

The value chain assessment shows that SUPs form the major share at every stage when compared to alternatives. SUP Manufacturing is largely informal, dependent on virgin raw materials, and uses little recycled content because of food-grade restrictions and poor quality of recycled granules. Distribution networks are strong, keeping SUP items such as carry bags, sheets, and cutlery widely available even after restrictions. Consumption continues at high levels because of low cost and convenience, despite higher awareness of hazards in Maharashtra than in Tamil Nadu. At the disposal stage, carry bags make up the bulk of the SUP waste stream, followed by cutlery (especially, spoons), sheets, and packaging, most of which are soiled and end up as RDF. Recycling is limited mainly to PET and HDPE, while most banned items are not recovered.

SUP alternatives, on the other hand, are produced from a range of materials such as paper, bagasse, areca, cloth, and PLA. Their production processes vary, with some requiring higher electricity and water while others are less resource-intensive. In markets, paper bags and some bagasse- and areca-based cutleries are available, but overall distribution is limited and demand remains low.

Consumption is selective, with paper-based alternatives being the most commonly used, while other alternatives see little uptake. In disposal, because of low volumes and contamination, alternatives are not recovered separately at MRFs for recycling/ composting. Most end up being sent to RDF along with plastics.

Looking ahead, both SUPs and their alternatives need stronger value chains to become sustainable. For SUPs, this means reducing dependence on virgin inputs, lowering electricity use, shifting towards renewable energy, and improving recovery of banned items for recycling. However, key challenges remain, including the shortage of registered recyclers, waste contamination, and lack of market linkages for recycling. For alternatives, the priority is to reduce production costs, improve product quality, and build stronger customer demand. Yet, they continue to face challenges such as lack of production clusters, high GST, and weak recovery systems for recycling and composting.

3.2 EMISSIONS COMPARISON: SUP VS SUP ALTERNATIVE PRODUCTS

Next, building on the value chain analysis, the study compares the emissions of key SUP products and their major alternatives. The emissions comparison has been carried out for two major SUP categories—carry bags and cutlery—along with their key alternatives covered in this study. The assessment follows a ‘Cradle to Gate’ approach, covering emissions from raw material extraction up to production at the facility. Data on emissions from raw material extraction have been drawn from published national and international sources, as cited in the references. Since the focus of this study was limited to collecting emissions data rather than undertaking emission calculations, the comparison provides only preliminary insights. These results would require further validation through detailed emission calculations.

The analysis begins with carry bags, where the comparison covers alternatives such as paper bags, jute bags, and cloth bags, as presented in the table below.

Emission Comparison: Carry bags

Category	Type	Facility emissions		Raw Material (tCO2 equ. /ton)	Transportation Emissions
		Avg. Electricity consumption (MWH/ton)	Fuel		
SUP	Plastic Bag	585.62	-	2.7 to 3.8	Variable
SUP Alternatives	Paper Bag	246	-	1.58	Variable
	Jute Bag	544	-	0.45	
	cloth Bag	880	-	3	

Key Insights

Since transportation-related emissions vary depending on the material type and source, the comparison here is based on facility emissions and raw material extraction stage emissions. On this basis, **paper bags appear to be a better option than plastic bags. Jute bags also perform well** due to low emissions at the raw material stage. However, a more holistic comparison is needed that also considers **disposal stage emissions,** depending on whether the material is recycled, sent for energy recovery, composted, or landfilled. **Reusability** or product life is another important factor. For example, a cloth bag can be used many times over a long period before disposal, whereas a paper bag is typically used only a few times.

Next, the comparative assessment is done for cutlery, as presented in the table below, covering the alternatives of paper-based, bagasse-based, PLA (corn starch), and areca leaf-based products.

Emission comparison: Cutleries

Category	Type	Facility emissions		Raw Material (tCO2 equ. /ton)	Transportation Emissions
		Avg. Electricity consumption (MWH/ton)	Fuel		
SUP	Plastic Cutlery	986.6	-	2.7 to 3.8	Variable
SUP Alternatives	Paper Cutleries	329	-	1.58	Variable
	Bagasse Cutleries	1200	-	0.075	
	PLA (Corn starch) Cutleries	1028	-	1.4	
	Arecca Cutleries	108		0.25	

Key Insights

Based on facility emissions and raw material extraction stage emissions, all SUP alternative options perform better than plastic cutlery. Among them, areca leaf cutlery shows the lowest emissions. Bagasse cutlery has higher facility-level emissions but very low emissions at the raw material stage, while paper cutlery has a more balanced profile across both stages.

As in the case of carry bags, a more holistic comparison is needed for cutlery as well, considering disposal stage emissions and product reusability. For example, paper cups often have a plastic lining that makes recycling difficult, leading them to energy recovery or landfill. This reduces their appeal, while bagasse cups may offer a better option in such cases.

Other considerations

Apart from emissions, factors such as cost, availability, and product application are also crucial in determining the suitability of products. For example, bio-based compostable products such as PLA carry bags and PLA cutlery made from corn starch or other bio-starch resemble plastics and offer similar benefits. For SUP manufacturers, transitioning to PLA is relatively easy, as it requires almost the same machinery. However, the availability of PLA feedstock is limited, and there is no industrial composting infrastructure in place. If PLA products are not disposed of through industrial composting and instead end up in landfills, they cause similar environmental harms as plastics. Therefore, a holistic emissions assessment along with these other factors is essential. Greater focus may be placed on **alternatives derived from agro-residues,** such as bagasse and areca leaves.

3.3 RECOMMENDATIONS

Based on the findings of the study, this section outlines actionable recommendations for different stakeholders. The recommendations are organized by stakeholder group—Plastic Manufacturers, SUP Alternative Manufacturers, Recyclers, Urban Local Bodies, Consumers, and Policymakers.

Stakeholder 01

Plastic Manufacturers

- **Ensuring EPR compliance:** Register under EPR to formalise operations and increase the use of recycled content
- **Energy efficiency:** Carry out regular energy audits and adopt measures to reduce electricity consumption
- **Renewable energy adoption:** Transition gradually to solar and other renewable energy sources

Stakeholder 02

SUP Alternative Manufacturers

- **Product quality improvement:** Improve durability and usability of the product
- **Energy efficiency:** Carry out regular energy audits and adopt measures to reduce electricity consumption
- **Renewable energy adoption:** Invest in solar/other renewables supported by targeted policy incentives

Stakeholder 03

Recyclers

- **Formalisation:** Register under EPR to earn EPR credits for upscaling production as well as accessing government tenders
- **Improving quality of feedstock:** Collaborate with ULBs/industry and invest in sorting and cleaning facilities
- **Renewable energy adoption:** Invest in solar/other renewables supported by targeted policy incentives
- **Capacity building:** Train workers to overcome shortage of skilled labourincentives

Stakeholder 04

Urban Local Bodies (ULBs)

- **Robust collection system:** Ensure regular waste collection with 100% coverage to avoid plastic leakage
- **Strengthen source segregation:** Creating awareness among the people and sanitation workers about segregation and daily monitoring
- **Awareness about hazards of SUPs:** Discouraging use of single-use plastic items and promoting reusable alternatives such as cloth bag, jute bag and stainless-steel based alternatives

Stakeholder 04

Urban Local Bodies (ULBs)

- **Improve sorting and recovery:** Upgrade MRF operations, invest in cleaning facilities, and train staff to increase recovery efficiency
- **Separate streams for SUPs and alternatives:** Ensure proper sorting of low-value dry waste, SUPs, and SUP alternatives to enable recycling or composting
- **Build market linkages:** Develop networks for managing low-value non-recyclables such as MLP, cloth, footwear, and thermocol

Stakeholder 05

Consumers

- **Source segregation:** Practice household-level segregation into three categories—dry waste, wet/organic waste, and hazardous waste.
- **Responsible behaviour:** Avoid littering and ensure proper disposal of waste.
- **Reduce SUP use:** Minimise the use of SUP items and prefer alternatives such as bagasse or paper, with priority given to reusable options.
- **Awareness and communication:** Share information within the community on the hazards of SUPs and the benefits of sustainable alternatives.

Stakeholder 06

Policymakers

1. SUP Ban enforcement and boundary checks

- Impose trader-level barriers and strengthen boundary checks to prevent cross-border and inter-state movement of banned SUP items.
- Standardise enforcement practices by using gauges for thickness checks instead of arbitrary confiscations or detentions.

2. Strengthening EPR compliance

- Ensure plastic producers meet targets for recycled content and recycling
- Promote wider registration of recyclers, linking it with benefits such as reduced GST. This will incentivize greater onboarding, enhance production capacity, and facilitate their participation in government tenders.

Policymakers

3. Fiscal reforms and market incentives

- Rationalize GST rates on SUP alternatives to enhance their competitiveness, and extend similar reforms to recyclers to encourage registration on the EPR portal and greater formalization.
- Introduce carry bag charges to discourage unnecessary consumption and shift demand toward reusable options.
- Provide fiscal incentives for solar panel installation by SUP alternative manufacturers to lower energy costs and promote sustainable production.
- Extend targeted incentives for establishing processing infrastructure—such as cleaning and pre-processing facilities to improve feedstock quality for recyclers, and industrial composting units for PLA and other biodegradable products.

4. Promoting agro-residue-based alternatives

- Encourage wider adoption of bagasse, areca, and crop residue-based products through fiscal incentives, R&D support, and supportive procurement policies.
- Strengthen networks of bagasse pulp manufacturers, bagasse product manufacturers, and farmers by creating clusters. This will ensure reliable feedstock supply and achieve economies of scale.

5. Exploring feasibility of PLA-based bio-plastics

- PLA-based bio-plastics, made from agro-starch (corn), offer some advantages—reduced fossil dependence, similar applications as plastics, and compatibility with existing machinery. However, their viability is constrained by limited feedstock, poor recovery systems, lack of composting facilities, and low-value compost output.
- A detailed feasibility assessment is required to compare its environmental impacts, life cycle emissions, costs, and infrastructure needs with plastics and other alternatives such as paper, bagasse, and wood.

6. Evidence and data systems

- Commission life cycle assessment (LCA) studies, with a focus on life cycle emissions, to provide robust evidence for policy-making.
- Encourage ULBs and state agencies to systematically maintain waste flow data to enable accurate monitoring and informed decision-making.

Stakeholder 06

Policymakers

7. Workforce development

- Launch government-backed training programs to address the shortage of skilled labour in recycling and alternative manufacturing

8. Awareness and behaviour change

- Run national- and state-level campaigns to communicate the hazards of SUPs and the benefits of alternatives

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