PROMISE
PREVENTION OF MARINE LITTER IN THE LAKSHADWEEP SEA

Project Funded by:
switchasia
Funded by the European Union

India

(Output Paper)

Combined report on Material Flow Analysis and Source to Sink activities in India

Authors:
Paolo Facco and Aparna Rajeev Thekke Kurungott – adelphi Research gGmbH
Rajat Batra – STENUM Asia

October 2024

Project Implemented by:
The Maldives National University
adelphi
Sri Lanka
PARLEY
STENUM Asia
teri The Energy and Resources Institute

Imprint

Suggested citation: PROMISE (2024): Combined report on Material Flow Analysis and Source to Sink activities in India

Authors: Paolo Facco and Aparna Rajeev Thekke Kurungott (adelphi Research gGmbH, Germany), Rajat Batra – STENUM Asia

The project team expresses its gratitude to all the participants for a very valuable and highly appreciated contribution.

Photo credits: Project PROMISE

Project Website: www.projectpromise.eu

Email: facco@adelphi.de

Project Contribution to SDGs:

Contents

List of Tables:

List of Figures:

List of Abbreviations:

MFA	Material Flow Analysis
NGO	Non-Government Organisation
PADI	Professional Association of Diving Instructors
PET	Polyethylene Terephthalate
PROMISE	Prevention of Marine Litter in the Lakshadweep Sea
SDGs	Sustainable Development Goals
SME	Small and Medium Enterprises
S2S	Sources to Sinks
SUP	Single-Use Plastics
SWM	Solid Waste Management

1. Executive Summary

The "Prevention of Marine Litter in the Lakshadweep Sea (PROMISE)" project, implemented by adelphi Research gGmbH and STENUM Asia, addresses the critical issue of marine litter at Kovalam Beach, Kerala. By utilizing a comprehensive Material Flow Analysis (MFA) and the innovative "Sources to Sinks" (S2S) methodology, the project seeks to understand waste generation patterns, particularly within the tourism sector, and their impact on marine ecosystems.

Engaging local authorities, Non-Governmental Organizations (NGOs), and Small and Medium-sized Enterprises (SMEs), the project developed and tested methodologies for assessing and mitigating marine litter. Initial assessments at Kovalam Beach in 2021 laid the foundation for more detailed studies conducted in 2023. The results revealed that plastics constituted 69% of the total waste by item count and 85% by weight, with single-use plastics such as bottles and packaging being the most prevalent. This highlights the pressing need for improved waste management practices.

Key findings indicate that tourism-driven activities, including hotels, guesthouses, and vendors, are primary sources of waste, with significant increases during peak tourist seasons. Current waste management practices were found to have critical gaps, including inadequate segregation and over-reliance on informal collectors. Seasonal variations further exacerbate these challenges, necessitating adaptive and targeted waste reduction strategies.

The S2S methodology provided valuable insights into waste pathways by assessing waste management practices across multiple hotels and guesthouses. For example, plastic bottles emerged as a significant waste fraction, underscoring the need for targeted strategies to reduce plastic waste. The study also emphasized the importance of aligning waste management systems with seasonal tourism dynamics to optimize efficiency.

Recommendations from the study include strengthening waste management infrastructure, enforcing stricter regulations, fostering partnerships among stakeholders, and implementing public awareness campaigns. By addressing these challenges, the PROMISE project aims to reduce plastic waste entering the Lakshadweep Sea, thereby contributing to marine biodiversity conservation and sustainable tourism development in the region.

2. Material Flow Analysis (MFA) activities

To establish a knowledge base for the status of marine litter along the shorelines of Lakshadweep Sea, MFA of plastic waste entering into Lakshadweep Sea from selected project locations need to be carried out. The MFA consists of two key data collection activities:

- Manual sampling of waste from beaches
- Interviews with relevant stakeholder groups

PROMISE's MFA project team composed of adelphi Research gGmbH and STENUM Asia, developed a data collection methodology in June 2021 and ran its first pilot project in November 2021 in India. Based on the experience and findings from this first MFA project, the PROMISE team has revised the updated the methodology. For the second pilot project in India, the team identified Kovalam Beach, Kerala *(8°23' 22.1496"N, 76° 58' 32.0052"E)* as a suitable location to carry out the MFA activities.

The activities were conducted on the 21st of April 2023.

The identified beach of approx. 220-meter length is shown in the figure below.

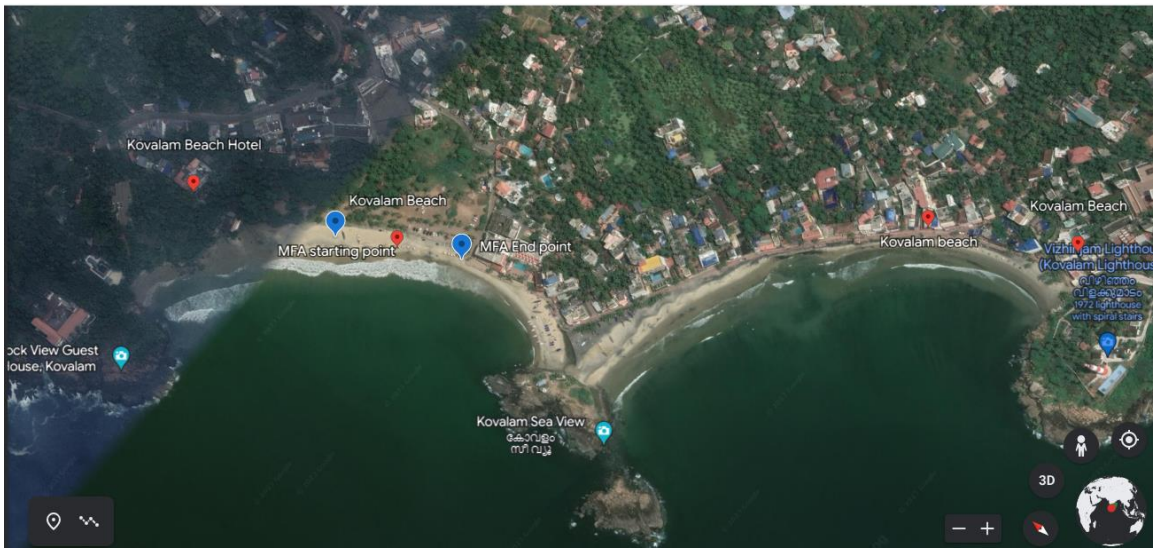

Figure 1: Satellite Image of Kovalam Beach

3. MFA Methodology

As a first step, the selected beach area was divided into segments of 10 m each by the STENUM Asia team. Then, the team members walked through each of the segments and classified them into three

different categories based on visual inspection of the litter/ pollution present in that segment. The three segments were classified as follows:

- Low Pollution Segment
- Medium Pollution Segment
- High Pollution Segment

Then, the team picked one of the 10 m segments from each category and marked it for manual sampling. This was followed by manual collection and analysis of the plastic litters in the three selected segments. The data collected during the analysis will be then used to estimate the total level of pollution for the entire beach.

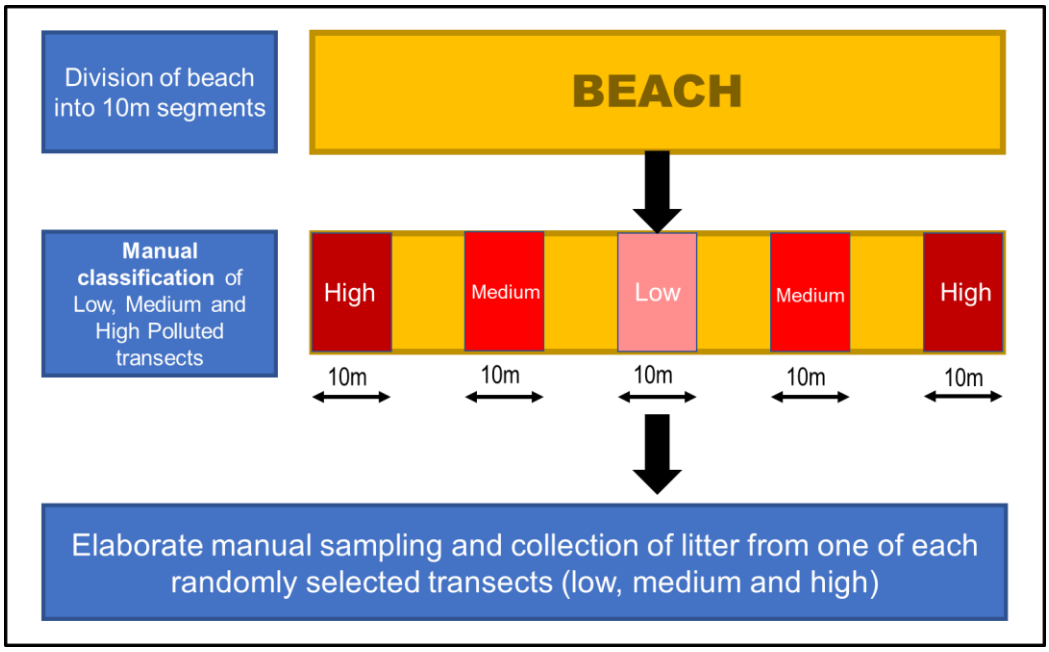

Figure 2: Data Collection Methodology

4. Manual Beach Sampling

On the 21st of April 2023, the PROMISE Team composed of experts from STENUM Asia conducted an inspection of Kovalam Beach and divided the area of the beach into 10 m segments. After visual inspection of each of the segments, they were then classified into the three categories. Then one segment from each category was randomly selected with approximate size of L: 10 meters W: 15 meters was marked with a signalization tape.

Figure 3: Marking of segments on the beach

The team then started the manual collection of all the litters present in each segment started following this order:

1. High pollution segment
2. Medium pollution segment
3. Low pollution segment

The litter collected from each of the three segments was put in jute bags which was labelled according to the pollution level of the segment. Then the collected waste items were carefully cleaned and sorted. The main objective of cleaning was to remove water and sand from the items collected. This was cleaning carried out by gently brushing the item or with a cloth. Care was taken to prevent (or minimise) the disintegration of the items during the cleaning process. While cleaning the items were sorted out and categorised based on type of item and use (i.e. plastic bottle, cigarette buts, paper and cardboard, etc.). Once the segregation was concluded, the items in each category were counted and weighed. All

the (raw) data has been saved on the PROMISE Box folder, while the analysed data is presented in this report.

Figure 4: Cleaning and sorting of waste collected from the beach

Figure 5: Waste collected from High Pollution segment

Figure 6: Waste collected from Medium Pollution segment

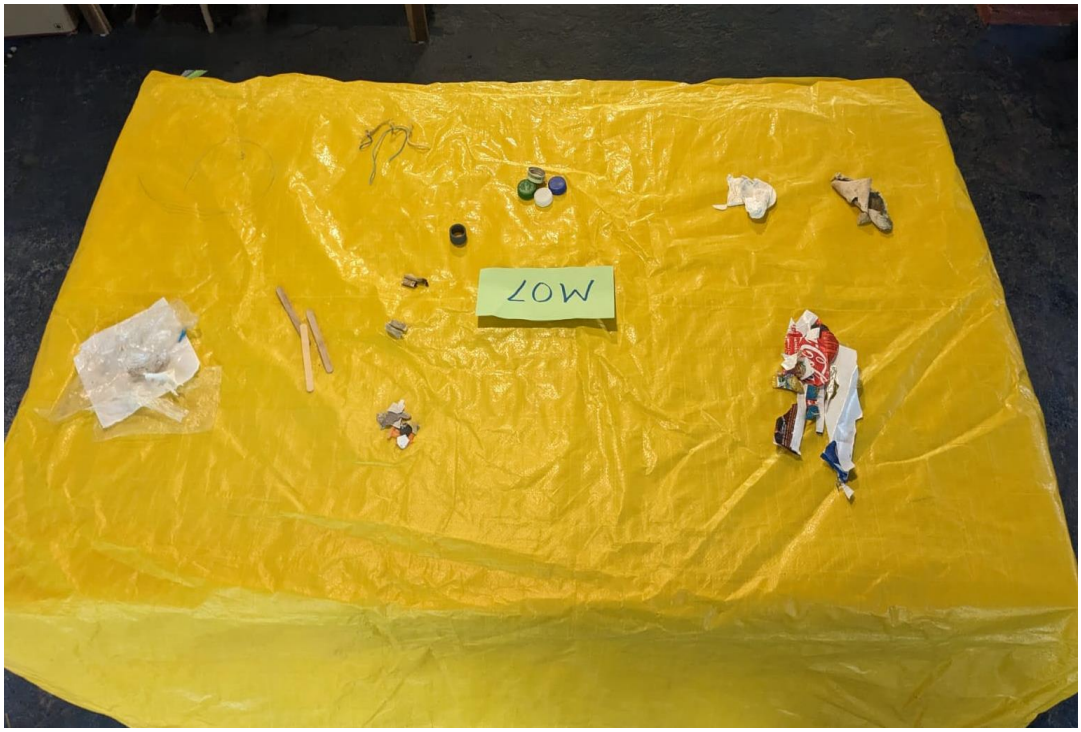

Figure 7: Waste collected from Low Pollution segment

The material distribution analysis in the high pollution transect shows that plastic is the most prevalent material, making up 54.3% of the total number of items and 78.4% of the total weight. Among plastic items, plastic bottle caps & rings are the most common, followed by general plastic caps and pieces of plastic containers.

Styrofoam follows at 12.7% of the items and 2.8% of the total weight, mainly in the form of granulated or laminated Styrofoam packaging fragments.

Textile, paper and cardboard, and wood each represent smaller proportions of the items and weight, with cigarette butts being the most common paper and cardboard item and cutlery being the primary wood item.

Table 1: Items collected in the high-pollution segment

Material	Article	Quantity (n. items)		%	Weight (Kg)		%
Plastic	Plastic bottle caps & rings	11	188	54.3%	0.021	0.2835	78.4%
	General plastic caps	7			0.0115		
	Paste and cream tubes (plastic)	1			0.007		
	Plastic containers (including lid) (pieces of plastic containers)	33			0.0645		
	Disposable cutlery (plastic)	7			0.006		
	Plastic wrapping and packaging & bags (LDP)	9			0.0105		
	Plastic bags	1			0.0085		
	Swabs	3			0.0005		
	Straws	1			0.0015		
	Nylon ropes	64			0.069		
	Toys	6			0.008		
	Multi-layered plastic packaging	23			0.0165		
	Molten plastic	3			0.008		
	bulk plastic bag	1			0.0115		
	Gromet	1			0.001		
	LOLLIPOP Sticks	3			0.001		
	paper straws	4			0.008		
	Cotton string	6			0.008		
	Button	1			0.0005		
	Medicine strip	1			0.0005		
	Lighters	2			0.0205		
Styrofoam	Styrofoam packaging fragments (granulated or laminated)	44	44	12.7%	0.01	0.01	2.8%
Textile	Eye mask	1	1	0.3%	0.006	0.006	1.7%
Paper and Cardboard	Cigarette butts	19	86	24.9%	0.004	0.034	9.4%
	Disposable cups (paper or cardboard)	1			0.0035		
	Newspaper and other bits of paper	57			0.019		
	Tissue	2			0.005		
	Tobacco with paper	7			0.0025		
Wood	Cutlery	2	23	6.6%	0.007	0.027	7.5%
	Ice cream popsicles	14			0.0195		
	Matchsticks*	7			0.0005		
others	Bidi	4	4	1.2%	0.001	0.001	0.3%
		346		100%	0.3615		100%

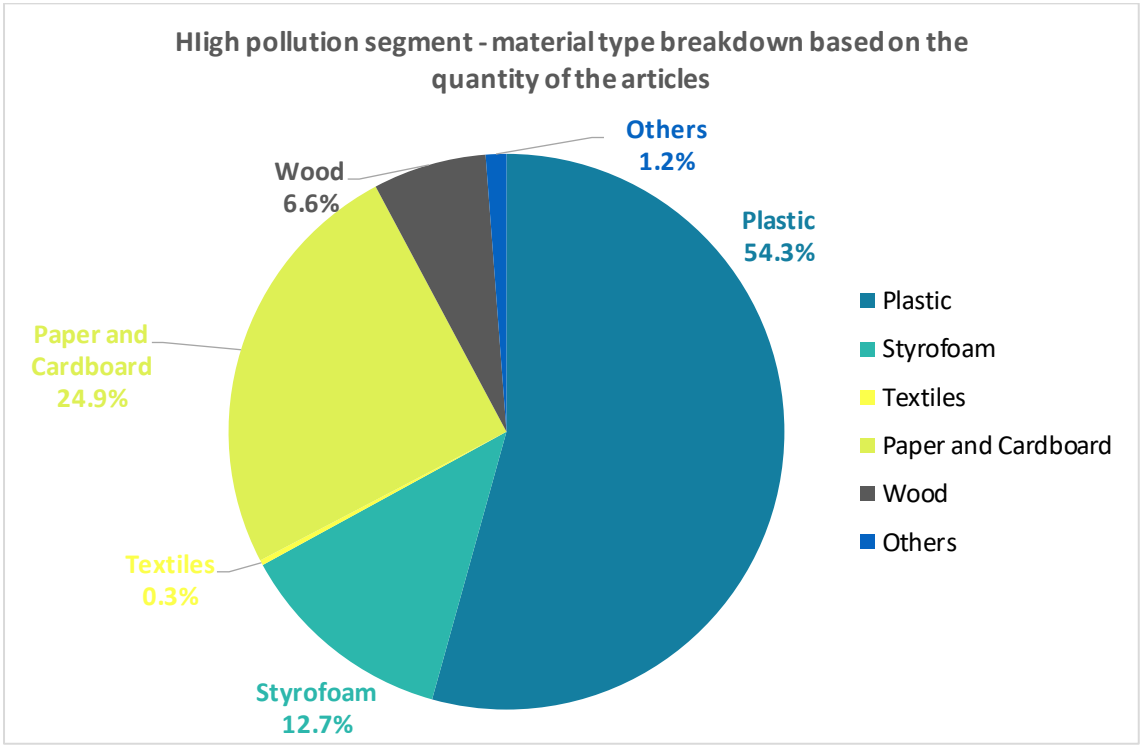

Figure 8: High Pollution Segment – Based on Quantity of Articles

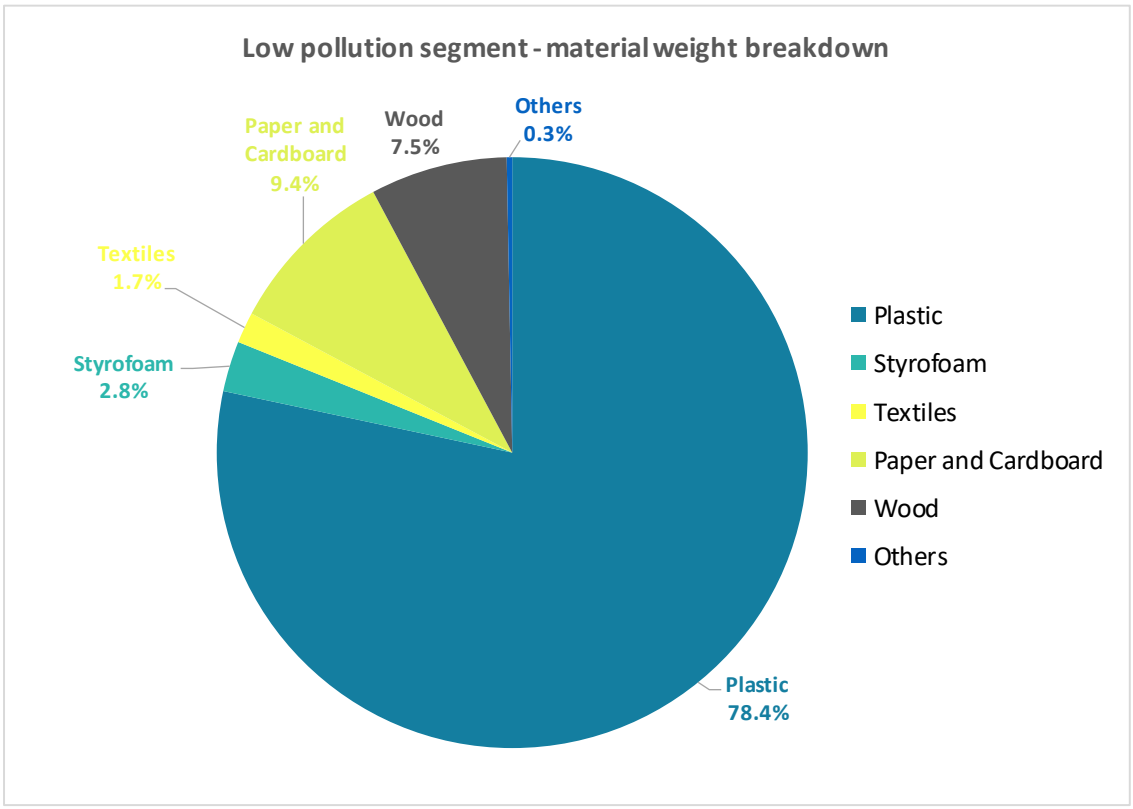

Figure 9: Low Pollution Segment – Based on Weight of Articles

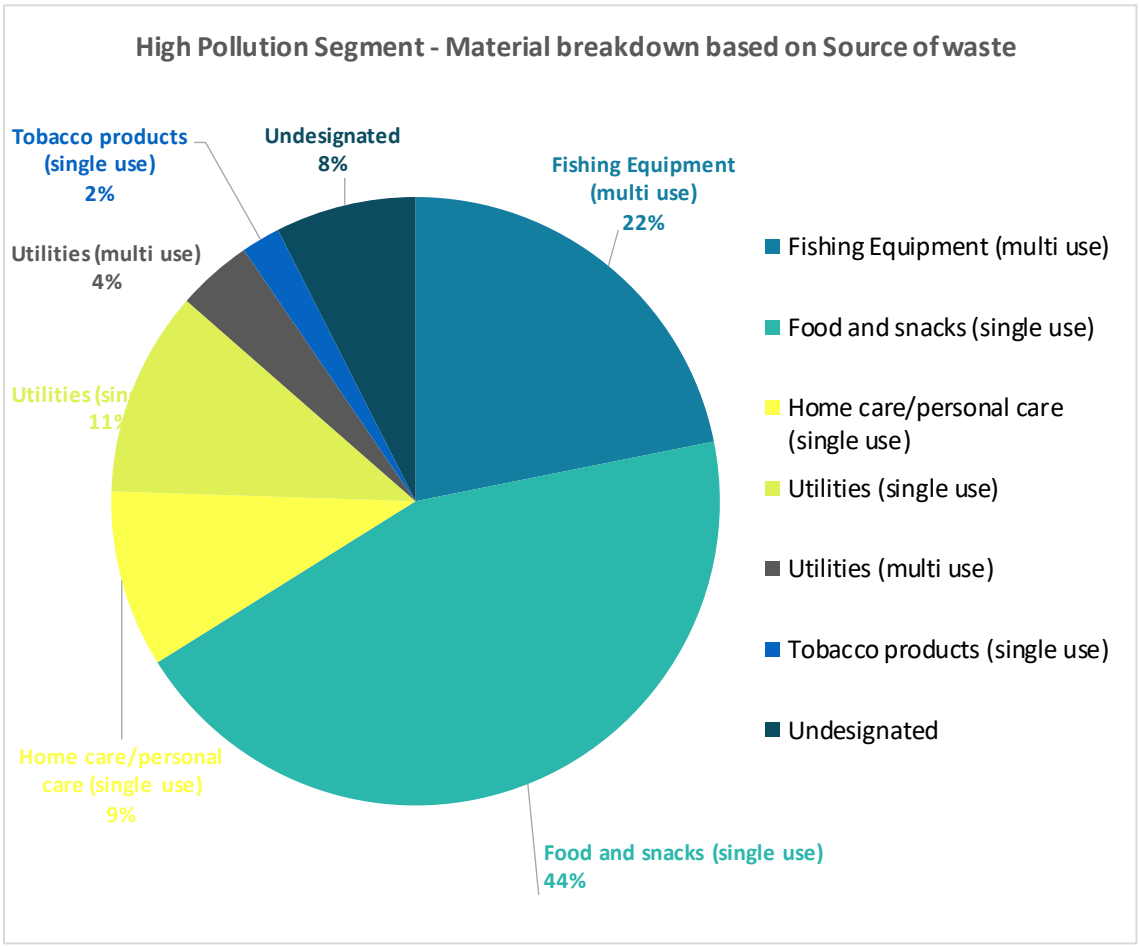

Figure 10: High Pollution Segment – Based on Source of Waste

The material distribution analysis in in the medium pollution segment indicates that plastic is the most prevalent material, making up 83.3% of the total number of items and 91.2% of the total weight. Among plastic items, hard plastic fragments are the most common, followed by plastic bottle caps & rings, and general plastic caps.

Textiles, paper and cardboard, wood, rubber, and metal each represent smaller proportions of the items and weight. Cigarette butts are the most common paper and cardboard item, and cutlery is the primary wood item.

Table 2: Items collected in the medium-pollution segment

Material	Article	Quantity (n. items)		%	Weight (kg)		%
Plastic	Plastic fragments (hard)	33	140	83.3%	0.047	0.2795	91.2%
	Plastic bottle caps & rings	12			0.0285		
	General plastic caps	7			0.0105		
	Food container "Delivery" (plastic)	1			0.018		
	Disposable cutlery (plastic)	3			0.003		
	Plastic bags (Unbranded)	13			0.011		
	Foams	7			0.0345		
	Swabs	3			0.001		
	Straws	4			0.002		
	Toothbrushes	1			0.0145		
	Nylon ropes	28			0.021		
	footwear	1			0.0175		
	Toys	4			0.0035		
	Moist tissue	1			0.0105		
	Multi-layered plastic packaging	21			0.0375		
	carry bags	1			0.0195		
Textiles	Textile fragments (undefined)	1	4	2.4%	0.0055	0.0055	1.8%
	Cotton strings	3					
Paper and Cardboard	Cigarette butts	2	12	7.1%	0.0005	0.01	3.3%
	Fragments of paper and documents	8			0.0005		
	cigarette packs	2			0.009		
Rubber	Undefined rubber fragments	2	2	1.2%	0.0005	0.0005	0.2%
Wood	Cutlery	2	9	5.4%	0.003	0.0105	3.4%
	Ice cream popsicles	5			0.0075		
	Matchsticks*	2			0		
Metal	Aluminium foil	1	1	0.6%	0.0005	0.0005	0.2%
		168		**100%**	**0.3065**		**100%**

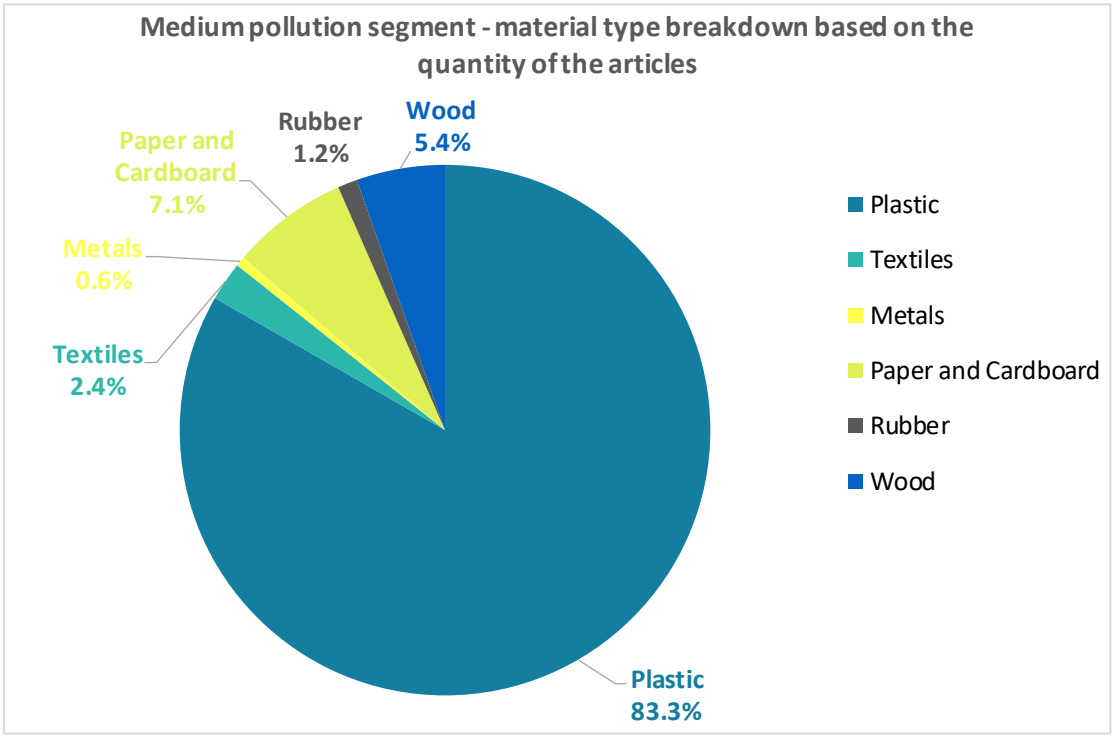

Figure 11: Medium Pollution Segment – Based on Quantity of Articles

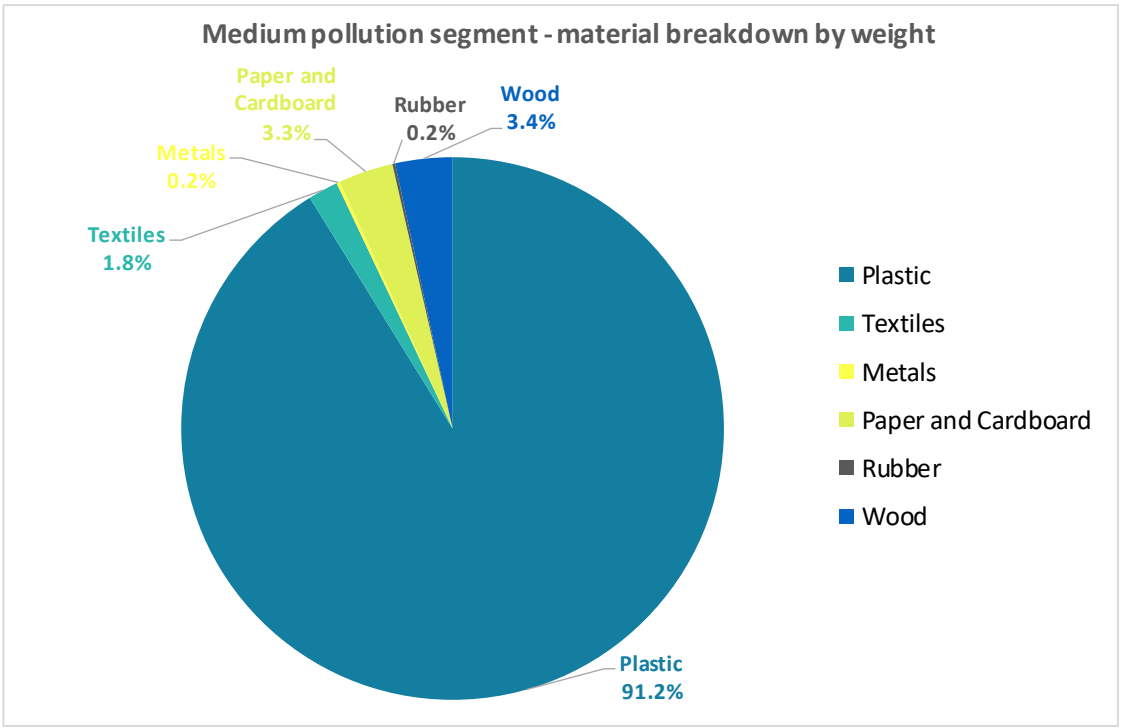

Figure 12: Medium Pollution Segment – Based on Weight of Articles

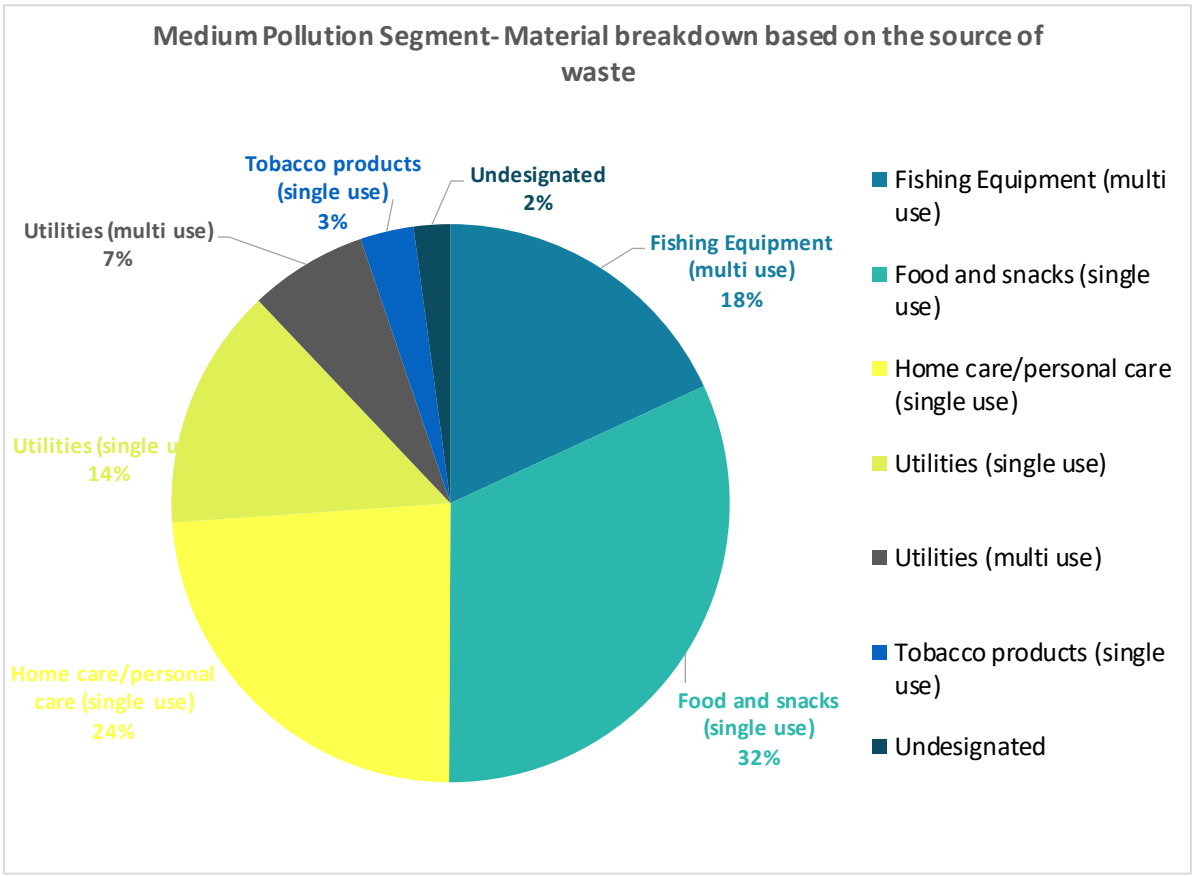

Figure 13: Medium Pollution Segment – Based on Source of Waste

For the low pollution transect, the analysis shows that plastic is the most prevalent material, comprising 84.7% of the total number of items and 54.7% of the total weight. Among plastic items, loose plastic fragments are the most common, followed by hard plastic fragments and plastic bottle caps & rings. Paper and cardboard, rubber, and wood each represent smaller proportions of the items and weight. Cigarette butts are the most common paper and cardboard item, while undefined rubber fragments and ice cream popsicles are the primary rubber and wood items, respectively.

Table 3: Items collected in the low-pollution segment

Material	Article	Quantity (n. items)		%	Weight (kgs)		%
Plastic	Plastic fragments (loose)	6	50	84.7%	0.003	0.0205	54.7%
	Plastic fragments (hard)	15			0.004		
	Plastic bottle caps & rings	3			0.004		
	General plastic caps metal	1			0.001		
	Foams	6			0.0015		
	Nylon ropes	4			0.001		
	Multi-layered plastic packaging	11			0.0025		
	fishing line	2			0.0005		
	Milk packet	2			0.003		
Paper and Cardboard	Cigarette butts	2	5	8.5%	0.0005	0.0095	25.3%
	Tobacco with paper	2			0.0005		
	Fragments of cardboard	1			0.0085		
Rubber	Undefined rubber fragments	1	1	1.7%	0.0035	0.0035	9.3%
Wood	Ice cream popsicles	3	3	5.1%	0.004	0.004	10.7%
		59		100%	0.0375		100%

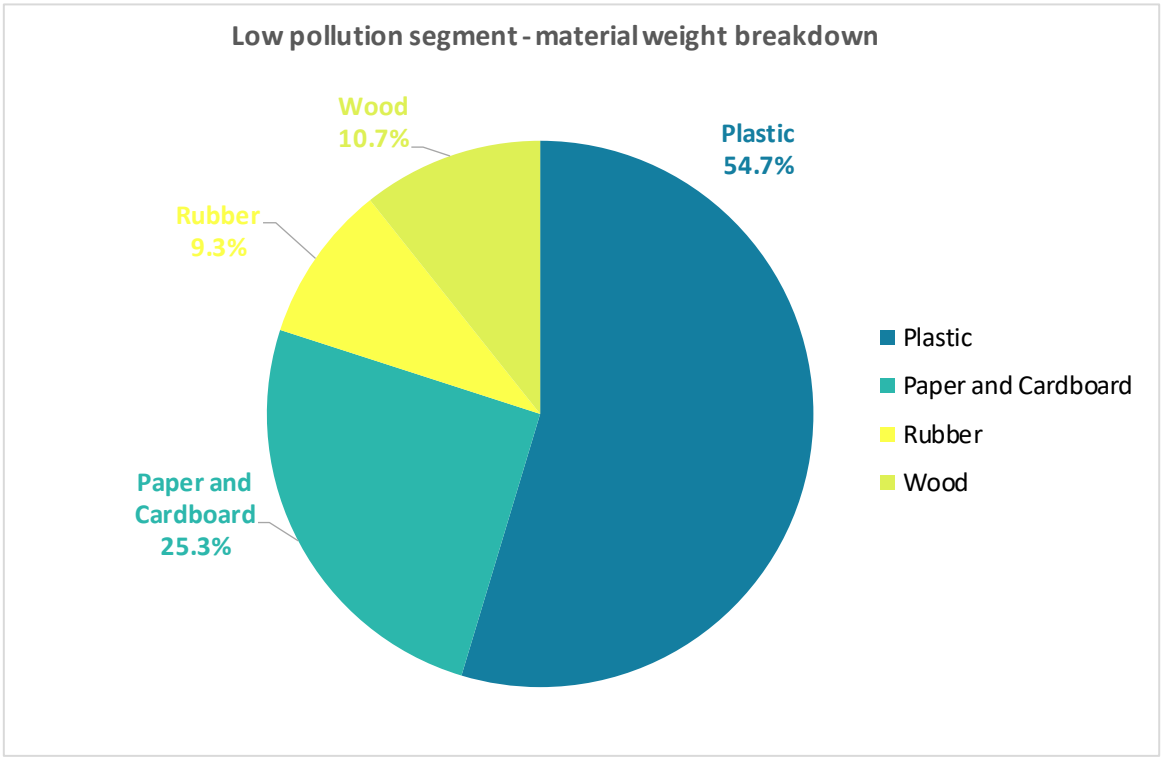

Figure 14: Medium Pollution Segment – Based on Source of Waste

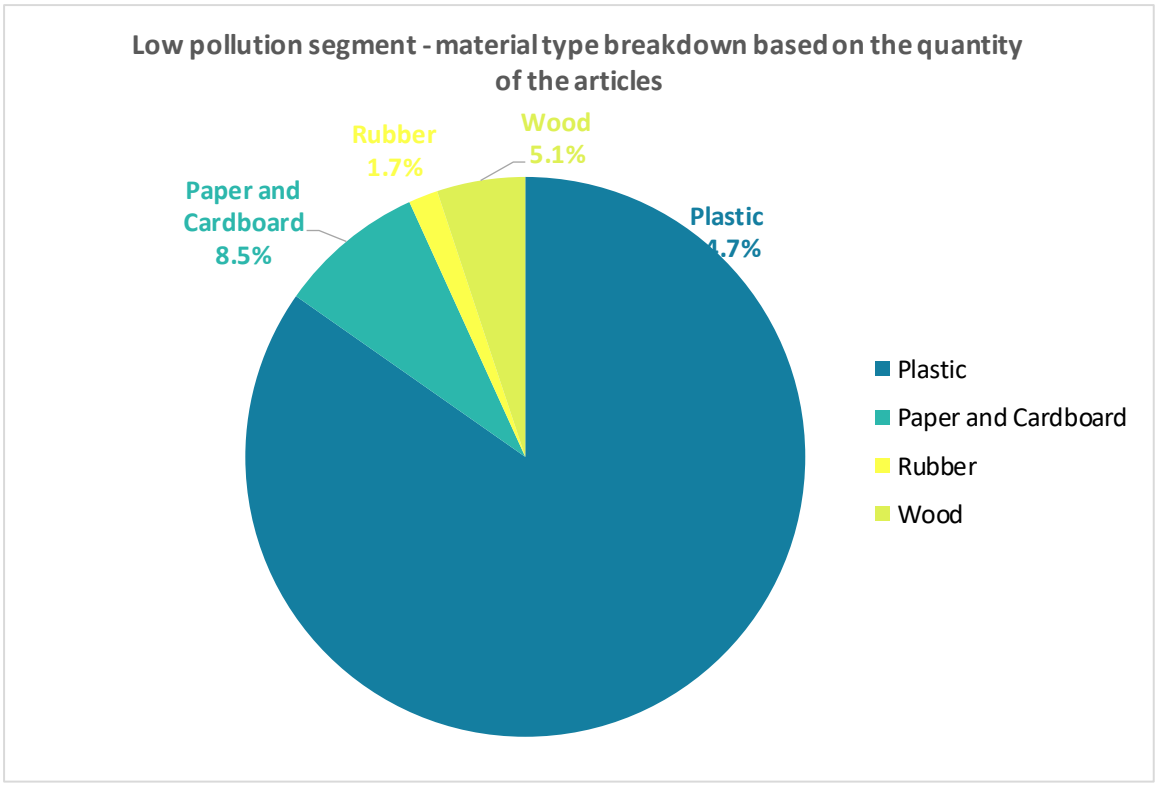

Figure 15: Low Pollution Segment – Based on Source of Waste

Data elaboration

Of the 22 segments identified during the visual inspection, 6 were classified as high pollution, 10 as medium, and 6 as low pollution.

Assuming that each type of segment has the same pollution characteristics (number and weight of items) of the ones manually sampled, it is possible to extrapolate figures regarding the pollution present in the selected 220 meters of the beach. The table below shows the estimated number and weight of the items present in Kalutara beach.

Table 4: Extrapolation of items number and weight for Kalutara beach

Material	Total number of items	% of number items	Total weight of the items (g)	% of the items weight
Plastic	2,828	69%	4,608	85%
Styrofoam	264	6%	60	1%
Textile	46	1%	86	2%
Paper and Cardboard	636	15%	304	6%
Rubber	50	1%	60	1%
Wood	234	6%	280	5%
Others	52	1%	30	1%
Total	**4,110**	**100%**	**5,428**	**100%**

The data extrapolated for the entire beach show that plastic is the most prevalent material, constituting 69% of the total number of items and 85% of the total weight. Styrofoam follows at 6% of the items and 1% of the total weight. Textiles, paper, and cardboard, as well as wood, rubber, and other materials, each make up smaller proportions of the items and weight, with textile representing 1%, paper and cardboard 15%, wood 6%, rubber 1%, and others 1% of the total items. Overall, the findings highlight the significant impact of plastic waste in the analysed article and underscore the need for effective waste management strategies to address this environmental challenge.

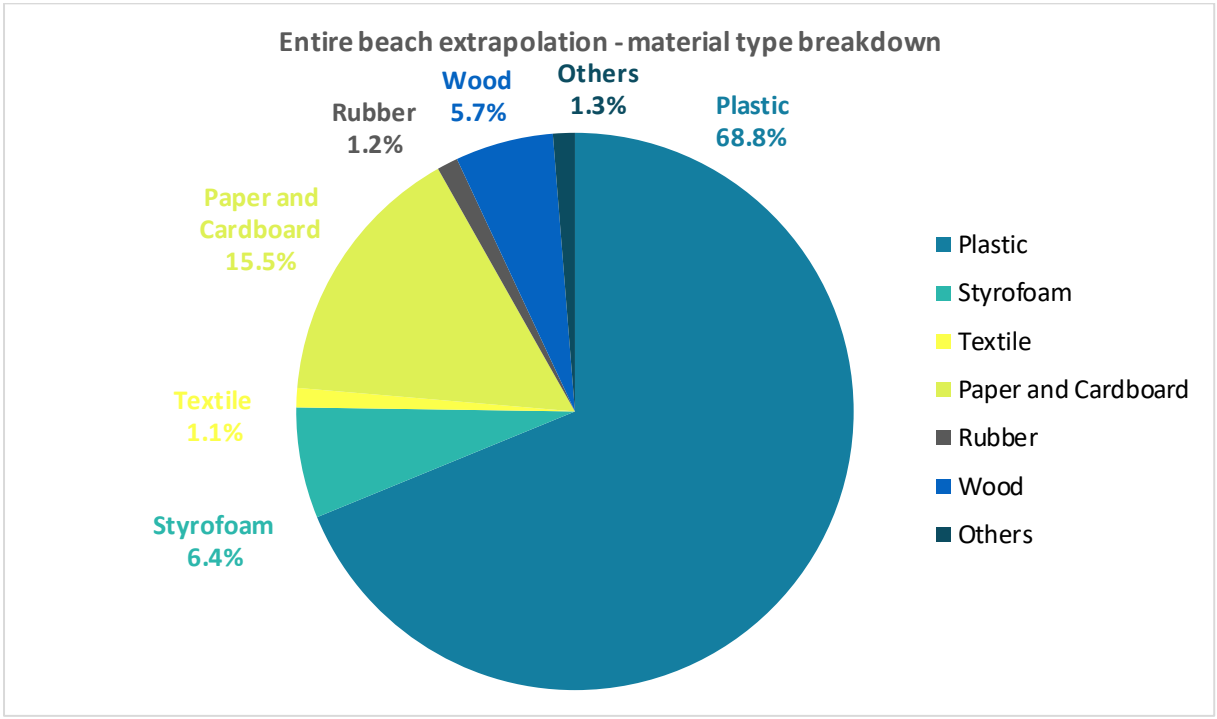

Figure 16: Entire Beach Extrapolation – Based on the Type of Material

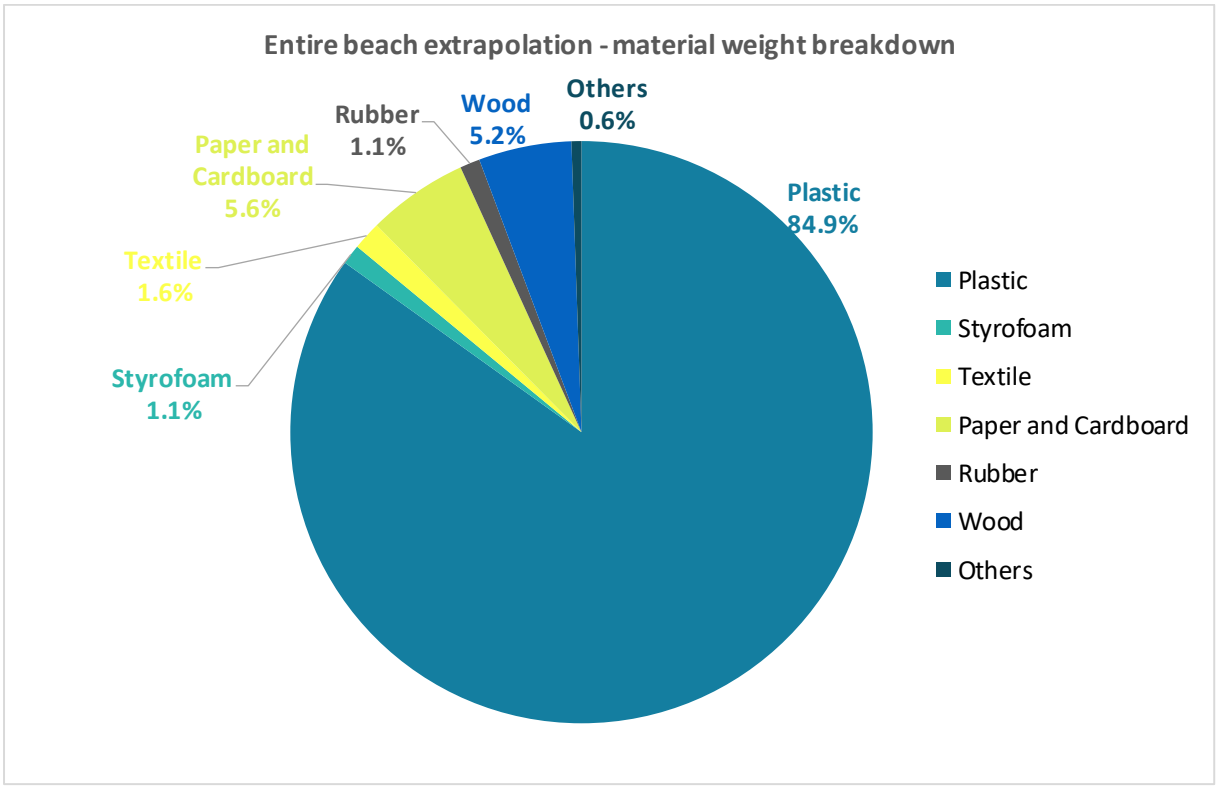

Figure 17: Entire Beach Extrapolation – Based on the Weight of Material

5. Interviews with local stakeholders

Through interviews with different stakeholder groups active in the pilot area, the project team aims to understand the waste management behaviours, the most generated type of plastic waste, and their leakage points. Leakage points can be both in terms of lack of waste management practices (e.g., not regular collection) and locations where materials get disposed of.

The collection of these information can help to understand the connection between litter and generation source within the cluster and to define specific actions and targets for the PROMISE project.

The STENUM Asia team was in the Kovalam area between March 20 and 23, 2023, and conducted a total of 15 interviews with four main groups of stakeholders:

- A representative of the local authority
- Stakeholders from the private sector, with a focus on SMEs associated with the tourism sector in the region.
- Stakeholders involved in waste collection, including one formal and two informal waste collectors
- One stakeholder from the NGO sector

Local Authority

The STENUM team spoke to Ibrahim, a lifeguard in Kovalam, who explained that Ecopreserve is responsible for collecting waste from the beaches and surrounding areas. To his knowledge, only plastic bottles are separated and sold, all other waste is given to Ecopreserve for treatment. He explained that waste washes up on the beaches especially in September and that a lot of waste is generated during the tourism season. Although he says that local SMEs have a waste collection/beach cleaning committee, he points out the problem of some local SMEs discharging their wastewater into the sea and not using proper waste collection methods, creating an unpleasant odour.

SMEs

In Kovalam the SMEs present are vendors, hotels, restaurants and diving schools. Nine vendors were interviewed between the 20th and 23rd of March.

1. SME 1

A seller of the SME 1 who is at the beach from 10 a.m. to 7 p.m. daily except from June to August because of the monsoon, told the STENUM team that waste generation is highest on Sundays. The SME does not practice waste separation and burns the mixed waste in the evening, according to the interviewee. Since the waste is mixed and disposed of or incinerated by the company itself, there is no monitoring of the amount of plastic waste generated and no waste fee has to be paid. Only in exceptional cases are PET bottles collected and taken away by the informal waste collectors.

2. SME 2

The second interview was conducted the owner of SME 3, who stated that about one kilogram of waste is generated daily and is collected by "Ecopreserve". While there is a general trash garbage can in front

of the business that is also used by non-customers of the store, plastic is separated from other types of waste by the business, but is not sold to recyclers or informal collectors, nor is it treated on site. The collection fee for collected waste is Rs 200 per month.

3. Local vendors

Additionally, a coconut vendor who sells 50 to 100 coconuts daily, explains that coconuts are the only type of waste he produces and disposes of in a separate garbage bag. The used coconuts are collected by informal waste collectors for a fee of 60 rupees per bag.

Figure 18: Interview with the coconut vendor

A "Chana Masala" vendor, generating only waste in form of bowls and spoons, does not track how much waste he disposes of each day into his own trash cans. According to him, no plastic waste is generated, and the waste is burnt at the end of the day by himself.

4. SME 3

After interviewing four vendors, the project team approached several hotels on March 22, 2023. The first interview that day was with the owners of the Hotel. They indicated that between 20 and 25 kg of waste is generated daily, which is separated into food and plastic waste (about one kg per day) and

stored in a garbage can in the back. The food waste is then picked up daily by the Positive Change for Marine Life organization, while the plastic waste is picked up only once a week. No waste type is sold to the informal sector or treated in the hotel itself.

Figure 19: Interview with SME 3 (Hotel)

5. SME 4

The next interview took place the general manager of a Hotel. He told the project team that between seven and ten kilograms of waste are generated daily, which is separated into food and plastic waste (about two to three kilograms per day) and also stored in their own garbage cans on the premises. The waste is collected by two different collectors: Haritha Karma Sena, which receives Rs 250 from the hotel, and Ecopreserve, which receives Rs 750 from the hotel. While plastic waste is collected during the day, food waste is collected at night. The only material sold for further processing is glass bottles, which are given away for Rs 2 per bottle.

Figure 20: Interview with SME 4 (Hotel)

6. SME 5

In addition to vendors and hotel owners and managers, the waitress from a Café was also interviewed. She explained that the café does not monitor the amount of waste generated, but that waste is separated into food and plastic and stored in garbage cans in the back. Like the SME 4 (hotel), plastic waste is picked up by Ecopreserve during the day and food waste is picked up at night for Rs 1500 monthly. No plastics or other recyclable materials are sold to informal collectors or recyclers.

7. SME 6

The last type of SMEs the project team approached was diving companies. First, a diving master from was interviewed. According to him, the diving company generates very little waste, and quantities are not monitored. He estimated that no more than 2 kg of plastic waste is generated each week, including the plastic waste collected by PADI each day during dives. The little waste generated is stored in dedicated garbage cans and collected once a week by Ecopreserve for Rs 50 per month.

Figure 21: Interview with PADI in Kovalam

8. SME 7

Lastly, the instructor from SME 7 explained that they also do not generate enough waste to monitor it properly. The small amount of waste that accumulates is also collected by Ecopreserve, but no information was given about the collection fees, or the different types of waste collected.

Waste Collectors

Between the 20th and 23rd of May, the STENUM Team met one formal and two informal waste collectors in Kovalam.

The official waste collectors of Ecopreserve, explained that about 25 big bags, each weighing about 25 kg, are generated in the city every day. The mixed waste is collected from all SMEs, including hotels and tourism businesses, in Kovalam and taken to the segregation area daily. The collection charges for the hotels and tourism businesses range from Rs 500 to Rs 1000 per month. There is also regular beach cleaning in January and February. Although the waste is collected, there is no data on the final fate of the waste and there are no plastic recovery facilities nearby.

From the informal sector, the STENUM team interviewed a lady, who collects plastic bottles, cartons and beer bottles every day, including from hotels and other tourist facilities, but also from beaches. She collects about 20 kg of material per week and sells it to a third party, from whom the waste is taken to

Tamil Nadu for recycling. She has to compete with about two to three other informal collectors in an area that is not subdivided. She points out that waste collection is much more profitable during the tourist season because a bag is filled in one day, whereas it takes three days to fill a bag during the off-season.

Another informal waste collector informed that he collects only plastic and glass bottles from the beaches. He collects about five kilograms per day, working every day of the week, and gives the material to an unknown third party. He states that there are about four to five other informal collectors in an area that is not subdivided and that there is more litter to collect during the season.

Figure 22: Interview with informal waste collectors

NGOs

Regarding the NGO sector, the team spoke with the Community Engagement and Waste Management Manager of "Positive change for Marine Life". He informed the team that the NGO does not conduct beach clean-ups, but only conducts surveys of vendors to find out what alternatives there are to the

plastics used by vendors. According to him, the most common types of litter on the beaches are cut fruit pouches and ice cream boxes, which mainly come from local vendors. Possible measures to reduce the amount of waste include collecting Polypropylene and then handing it over to recyclers and raising awareness among vendors to stop using plastic products. So far, the NGO has provided paper straws to six different vendors and bowls and wooden spoons to two vendors over a period of several months.

Figure 23: Interview with "Positive Change for Marine Life"

6. Conclusions on the conducted MFA activities

The activities conducted in the Kovalam area in April 2023 allowed the Team to collect 18 samples, classified as following:

- 3 different data samples from manual sampling of waste from Kovalam beach
- 15 stakeholders' interviews conducted in Kovalam beach.

The manual sampling allowed the PROMISE team to collect insights regarding the type of waste present on the beach location. The analysis showed that the most common waste types present on the Kovalam Beach are:

- Single-use plastics and Multi-layered plastics
- Paper and Cardboard

Of these, the majority can be considered as disposable items. For example, PET plastic bottles caps, disposable cutlery items, and multi-layer packaging were found in high number in all three sampled segments. Furthermore, cigarette butts and nylon strings were also very common. Recyclable material such as PET bottles were not found during the sampling. This is due to the frequent collection of PET bottles along the beach by the informal waste collectors, as they can get revenue from such items that they consider commensurate with the effort invested in collection of the waste. Items that do not generate revenue commensurate to the effort for collection simply do not get picked up by the informal waste collectors.

In this study we also noticed fairly high amounts of alternative products to single use plastic (SUPs), such as paper straws (as opposed to plastic straws) and wooden spoons (as opposed to plastic spoons). This suggests that a shift towards more eco-friendly options is taking place. However, proper disposal of some of these (bio-degradable) products seems to still be a challenge.

Kovalam Beach, has many tourism-connected SMEs activities present on it. The beach also hosts a variety of vendors. Therefore, we can conclude that all the generated waste is discarded by:

- Tourists (local population as well as those visiting from outside Kovalam) visiting the beach.
- Vendors present on the beach and the associated sales activities (for example ice cream sticks near the location of the ice cream vendors).

The conducted interviews on the beach confirmed that a company named 'Eco Preserve' leads the waste management activities in the region. The waste from the SMEs is collected everyday by Eco Preserve and sent to the neighbouring states for recycling. The waste from the vendors is not collected by the company which makes the vendors responsible for their own waste management. With no option left with the vendors, the waste generated is burnt at the end of the day.

Positive Change for Marine Life, an NGO, also plays a significant role in the waste management activities of the Kovalam Beach. The NGO works with the vendors to educate them on the burning issue of plastic pollution and provides the vendors with alternatives to plastic cutlery to reduce the plastic waste generation at source to promote the shift away from SUP.

In this scenario the presence of some waste bin, in which the content gets regularly collected by local authorities (responsibility roles must be cleared between the stakeholders) could avoid high level of littering as those ones seen on site on March 2023.

From the interviews conducted with the SWM collector in the Kovalam Beach, it was understood that plastic waste and food waste gets collected every day from the licensed SMEs activities.

However, there were gaps observed between the solid waste management system created for Kovalam beach and the actual implementation on the ground. For example, waste segregation is not effectively ensured; there were many instances of food waste mixed in the bins meant for plastic waste.

The solid waste management practices in the Kovalam beach require further fine tuning by capacity building and awareness raising at municipal and SMEs respectively. With the existing infrastructure already in place, a more effective waste management system ought to be achieved. The gaps that exist can perhaps be fixed at low cost yet yield high impact.

7. Lessons learned and next steps

From the activities conducted several key lessons have been learned:

Limited Waste Separation and Recycling: many SMEs and vendors in Kovalam do not practice effective waste separation and recycling. While some efforts are made to segregate plastic waste, other types of waste are often mixed, leading to challenges in proper disposal and recycling.

Waste generation seasonality: Waste generation is significantly higher during the tourism season. The influx of tourists increases the amount of waste generated on Kovalam Beach, requiring better waste management strategies during peak tourist periods.

Limited Awareness and Disposal Practices: Some vendors and SMEs are not fully aware of proper waste disposal practices. Burning mixed waste is a common practice among some vendors, indicating a lack of understanding of sustainable waste management methods.

Positive Role of NGOs: NGOs, such as "Positive Change for Marine Life," actively engage with vendors to raise awareness about plastic pollution and provide eco-friendly alternatives to single-use plastics. Their efforts have resulted in positive changes and reduced plastic waste.

Need for Effective Monitoring: There is a lack of comprehensive data on the amount of waste generated and managed in Kovalam. Effective monitoring and data collection are crucial for better waste management planning and implementation.

Collaboration Among Stakeholders: Improved coordination between local authorities, private sector entities, waste collectors, and NGOs is essential for creating an effective waste management system in Kovalam. Clear roles and responsibilities among stakeholders can lead to more efficient waste collection and processing.

Potential for Behavior Change: The presence of alternative eco-friendly products, such as paper straws and wooden spoons, indicates a potential shift towards more sustainable choices. Encouraging behavior change among vendors and tourists can further reduce plastic waste.

The MFA study including the stakeholder interviews, at Kovalam (Kerala) helped the PROMISE team gain several specific insights. The experience of conducting this study further enriches the team's knowledge of on-ground realities and facilitated several lessons which will shape some of the next steps. These are:

- A detailed study such as the one conducted only provides insights at a point in time. Due to various external factors, such as tides, weather, tourist footfall (tourist seasons), the amount of litter observed on a specific section of the beach can vary significantly. Therefore, the PROMISE team (or subsequent researchers) may consider repeating such studies on the same stretch of the beach at another time, rather than to analyse another beach.
- Quantification of waste flows from SMEs, particularly small vendors is very challenging. Most of them do not weigh or track the quantities of waste they hand over to the formal waste collectors. PROMISE team may need to work closely and over several months with the SMEs and waste collectors in the area to quantify the waste flows.
- Our study found that hotels do not currently track their plastic waste generation. To address this issue, the PROMISE team considers introducing a user-friendly plastic footprint calculator. This tool will enable the hotels to effectively monitor and manage their plastic waste, allowing them to identify their major sources of plastic waste generation and make informed decisions

for waste reduction.

- Neither the hotels nor SMEs in the area seem to have high motivation for proactively avoiding waste on the beach. PROMISE team may consider spreading awareness on the role of beach cleanliness in promoting tourism based economic activity in the area.

8. Overview of the Source to Sinks (S2S) activities

The PROMISE project aims to tackle marine pollution by systematically analysing and reducing the inflow of plastic waste into the Lakshadweep Sea through extensive field studies and community-focused initiatives. This section has been prepared as an integral component of the Material Flow Analysis (Work Package 1) which aims to quantify the waste generated in tourism sector in India.

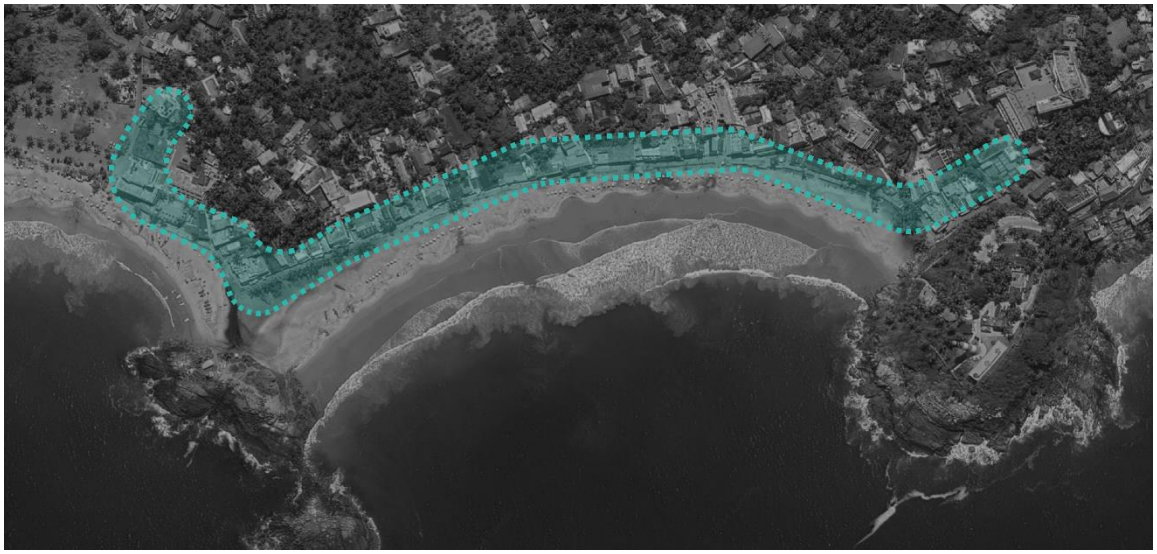

Figure 24: Satellite Image of Kovalam Beach

Based on the findings from the first and second MFA studies, plastic is the most common pollutant accounting for 68.8% of the debris collected during beach sampling activities. Additionally, paper and cardboard also had significant contributed to 15.5% of the total collected items. The project interviews revealed considerable challenges in existing waste management processes across various locations, pointing to inefficiencies in handling the materials efficiently. Even though the qualitative data were gathered extensively, quantifying the precise amounts of waste generated, collected, recycled, and disposed remained challenging. The figure below shows the composition of waste materials collected during the Material Flow Analysis on the beaches in Kovalam India in 2023.

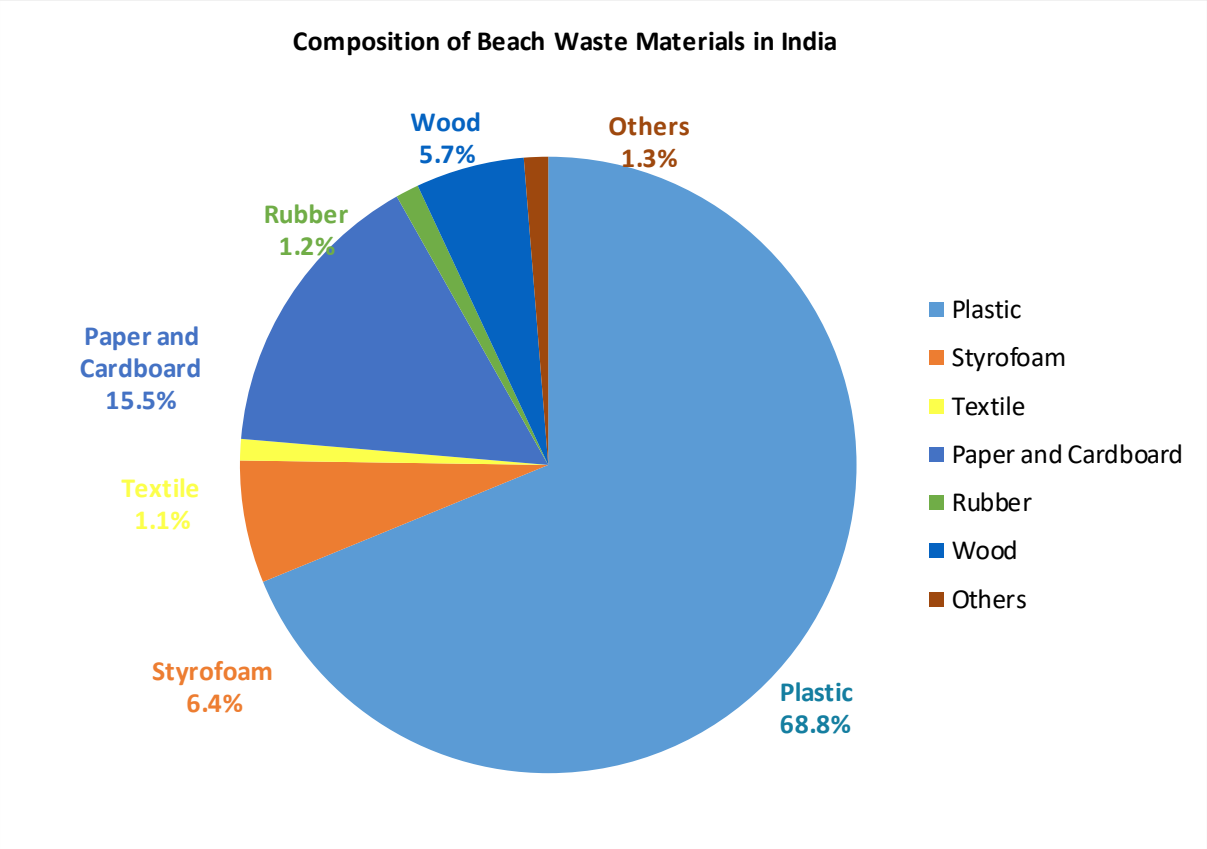

Figure 25: Composition of Beach Waste Materials in India

For a better quantification of the amount of waste generated in tourist activities (Hotels and Guesthouses) a new approach to collect and quantify data has been developed. The latter one assessed 11 hotels and 12 guesthouses in the proximity of Kovalam beach, to collect and analyses different types of waste generated along with the number of guests there.

9. S2S Methodology

A new methodology, called "Sources to Sinks" was developed by adelphi Research gGmbH and STENUM Asia to determine the quantity of waste generated in the tourism businesses and to understand how this waste is managed. This approach involves a detailed assessment of hotels and guesthouses within a 300-meter radius of each pilot location, including recording the number of beds and their yearly occupancy rates. 11 hotels and 12 guesthouses were selected in the location, based on their operational differences: hotels are defined as establishments providing restaurant services, whereas guesthouses did not offer such amenities.

The project outlined requires two main activities to be conducted in the pilot area, focusing on guesthouses and hotels. Initially, all guesthouses and hotels within the pilot area must be identified through interviews to gather crucial data. This data includes the annual number of guests and an understanding the waste management practices or 'fates' for different waste streams. Simultaneously,

the waste generated by these facilities were characterized. Due to time constraints, only two hotels and two guesthouses were chosen for the waste characterization.

Before this characterization, facilities were asked to set aside all waste produced on a specific day and provided with any necessary logistical support, such as providing a location to conduct the analysis. It's advantageous if the waste can be pre-separated, as this simplifies the subsequent steps. Additionally, it is important to know the guest count on the waste collection day to correlate the amount of waste generated with guest numbers.

Exploration on the waste management was necessary to further understand the types of waste produced. Waste disposal methods were categorized into several options: Formally collected, informally collected, dumped in the environment and burned. Formal waste collection is organized and regulated by municipal authorities or licensed companies, ensuring waste is managed according to legal and environmental standards whereas, informal waste collection is carried out by individuals or small groups without official oversight, often relying on collecting and selling recyclable materials for income.

The figure below shows how PROMISE team actively engaging in collection and segregation of waste from guest houses and hotels in Kovalam.

Figure 26: PROMISE team collecting waste

Figure 27: Waste Segregation by PROMISE Team

10. Waste Characterization

During the waste characterization phase, if waste had already been separated, the categories were checked and grouped; accordingly, if not, manual separation was necessary. Each category of waste was then weighed, and the data were accurately recorded. This methodical approach ensured a comprehensive understanding of waste generation and management practices within the selected guesthouses and hotels, providing valuable insights for effective environmental management strategies. For effective waste characterization, assessments were conducted in the morning to collect waste generated from the previous day only, enhancing the accuracy of the data. The process was strictly monitored to avoid the inclusion of waste from multiple days.

Many guesthouses and hotels already practiced waste separation, which significantly aided the analysis process. To ensure reliability and consistency in the data, waste characterization was ideally repeated

in the same guesthouse or hotel over two days, which did not need to be consecutive. This approach helped to understand daily variations and establish a more accurate baseline of waste generation patterns. Expanding the characterization to more guesthouses enhanced data granularity and accuracy. This method helped in gaining detailed insights into waste characteristics. Waste materials such as plastic, glass, paper, cardboard, metal, and other types were collected and segregated to calculate the average weight of the waste generated. This approach enabled the estimation of daily waste generation per guest, which could then be extrapolated to determine annual waste figures across all the hotels and guesthouses in vicinity of the Kovalam beach. It should be noted that organic waste was not considered for the analysis since such waste is not part of the focus of the PROMISE project.

Figure 28: Segregated waste from guest houses and hotels

Figure 29: Waste from guest houses and hotels weighed and quantified

11. Waste Composition

The waste characterization studies conducted at two hotel and the guest house revealed significant contrasts in waste generation and composition, correlating closely with the number of guests. The guest house hosting 38 guests, generated a total of 15.3 kilograms of waste, with glass bottles being the dominant material at 64.6% and 9.9 kilograms. Conversely, the hotel had 121 guests and produced a much larger amount of waste totaling 130.5 kilograms; here, glass bottles still led the waste composition but at a slightly lower percentage of 49.1%, though the weight was substantially higher at 64.1 kilograms.

Paper waste also varied greatly between the guest house and hotel. Hotel average recorded a significant level of 20.9% of its waste as paper (27.2 kilograms), whereas the guest house generated 5.8% (0.89 kilograms) of paper waste. Plastics were a major waste component in both cases; however, the types and proportions differed, with plastic bottles making up 15.1% in the guest house versus 5.4% in the hotel, which had a higher incidence of other plastic packaging at 11.8%. Metals and residual categories like e-waste, textiles, and shoes contributed minimally to both scenarios, suggesting a consistent trend across different hotel operations. These findings highlight the importance of targeted waste management strategies, especially for reducing glass and plastic waste, which are prevalent across varying scales of tourism sectors.

Given below tables illustrates detailed understanding on waste characterizations and composition in hotels and guest houses:

Table 5: Waste categorization and composition from two hotels in Kovalam

Material	Item	Weight [kg]	Total Weight [kg]	Percentage (%)	Total Percentage (%)
Plastics	Plastic bottles	7,1	26,2	5,4	20,0
	Straws	0		0,0	
	Other plastic packaging	15,4		11,8	
	Other plastic items	3,7		2,8	
Glass	Glass bottles	64,1	64,1	49,1	49,1
	Other glass items	0		0,0	
Paper and Cardboard	Paper	27,2	29,5	20,9	22,7
	Cardboard	2,3		1,8	
	Other papers (e.g. tissues)	0		0,0	
Metal	Cans	1,5	2,5	1,1	1,9
	Other type of metal	1,0		0,8	
Residual	*E-waste*	5,2	8,2	4,0	6,3
	Textile	2,3		1,8	
	Shoes	0,7		0,5	
TOTAL AMOUNT OF GENERATED WASTE		130,5			
TOTAL AMOUNT GENERATED PER GUEST		**1,5**			

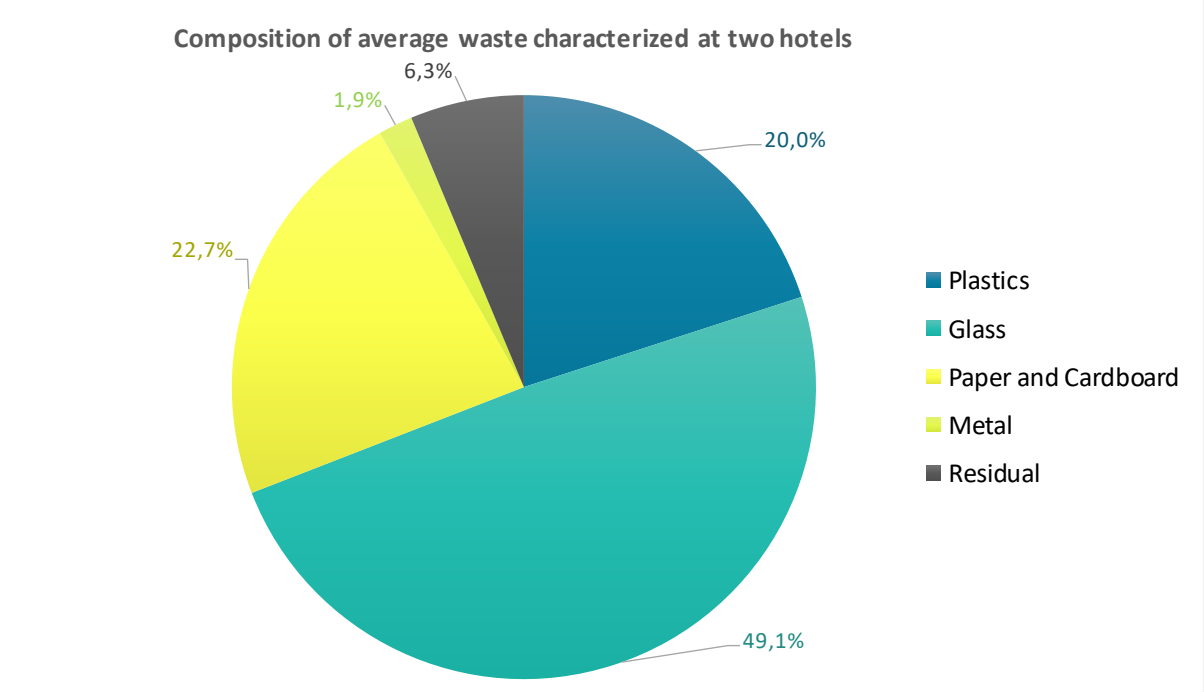

Figure 30: Percentage composition of average waste categorized from two hotels at Kovalam

Table 6: Waste categorization and composition from two guest houses in Kovalam

Material	Item	Weight [kg]	Total Weight [kg]	Percentage (%)	Total Percentage (%)
Plastics	Plastic bottles	7,1	26,2	5,4	20,0
	Straws	0		0,0	
	Other plastic packaging	15,4		11,8	
	Other plastic items	3,7		2,8	
Glass	Glass bottles	64,1	64,1	49,1	49,1
	Other glass items	0		0,0	
Paper and Cardboard	Paper	27,2	29,5	20,9	22,7
	Cardboard	2,3		1,8	
	Other papers (e.g. tissues)	0		0,0	
Metal	Cans	1,5	2,5	1,1	1,9
	Other type of metal	1,0		0,8	
Residual	E-waste	5,2	8,2	4,0	6,3
	Textile	2,3		1,8	
	Shoes	0,7		0,5	
TOTAL AMOUNT OF GENERATED WASTE		130,5			
TOTAL AMOUNT GENERATED PER GUEST		**1,5**			

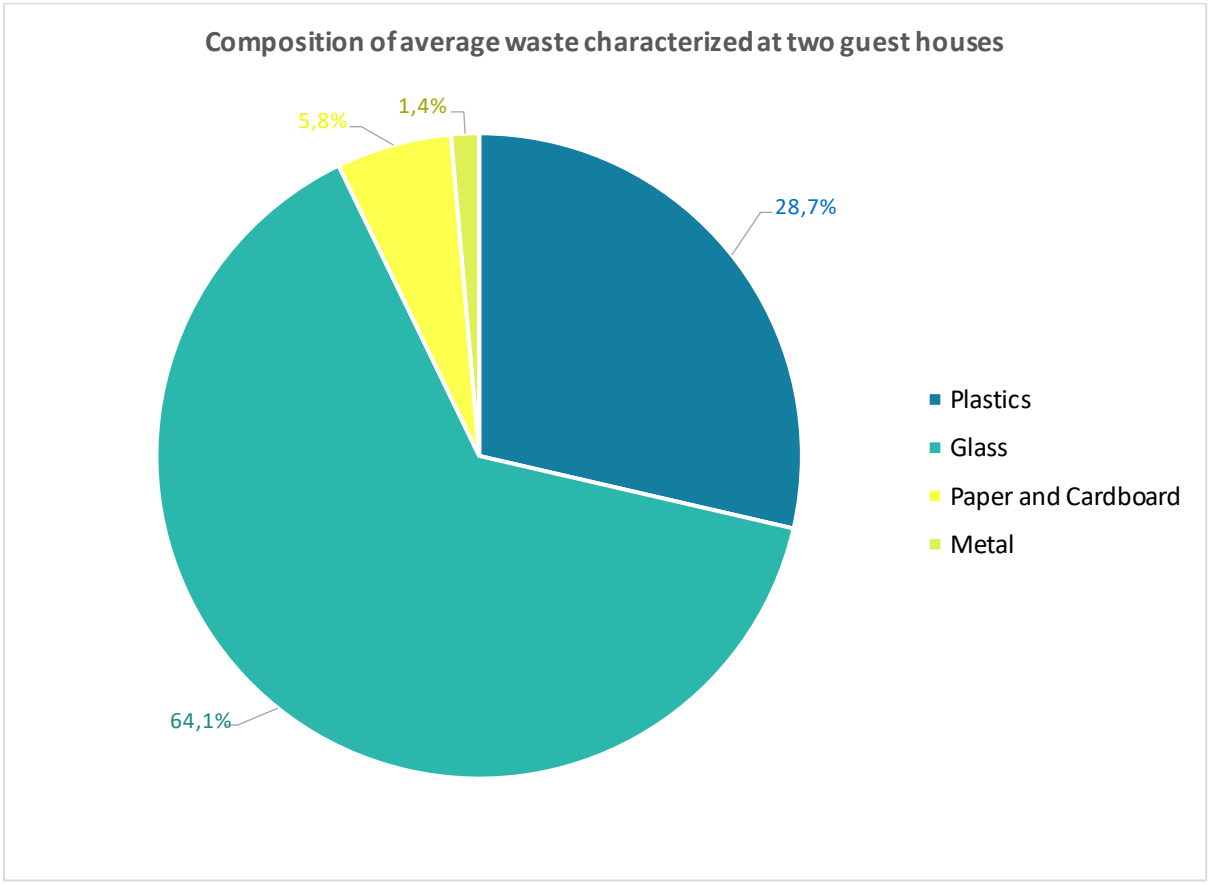

Figure 31: Percentage composition of average waste categorized from two guest houses at Kovalam

Waste generated from hotels for a year

The comprehensive breakdown of waste generated by various guesthouses over a year highlights a total generation of 59,538 kilograms of waste. The leading category of waste was glass bottles, accounting for 29,256 kilograms, followed by paper at 12,426 kilograms, and plastic packaging (excluding bottles) at 7,020 kilograms. The smallest waste category was other metals, totaling 477 kilograms.

In terms of waste management fate:

- Formally Collected: The majority of waste, particularly plastic bottles (3,224 kilograms), plastic packaging (4,449 kilograms), and paper (7,762 kilograms), was formally collected, reflecting a well-regulated waste management system.
- Informally Collected: A significant portion of waste, including glass bottles (13,218 kilograms), was informally collected, indicating reliance on non-formal waste channels that might not comply with regulatory standards.
- Burnt: Substantial amounts of waste, such as other types of plastics (2,571 kilograms) and cardboard (3,584 kilograms), were burnt, raising concerns about air pollution and health hazards from the release of toxic fumes.

- **Dumped in the Environment**: Some waste, specifically 991 kilograms, was directly dumped into the environment, highlighting critical environmental issues and the need for stricter waste disposal regulations.
- **Not Applicable (NA)**: Waste that was unaccounted for or handled in undefined ways amounted to several kilograms across various categories, underscoring potential inefficiencies or gaps in the waste tracking system.

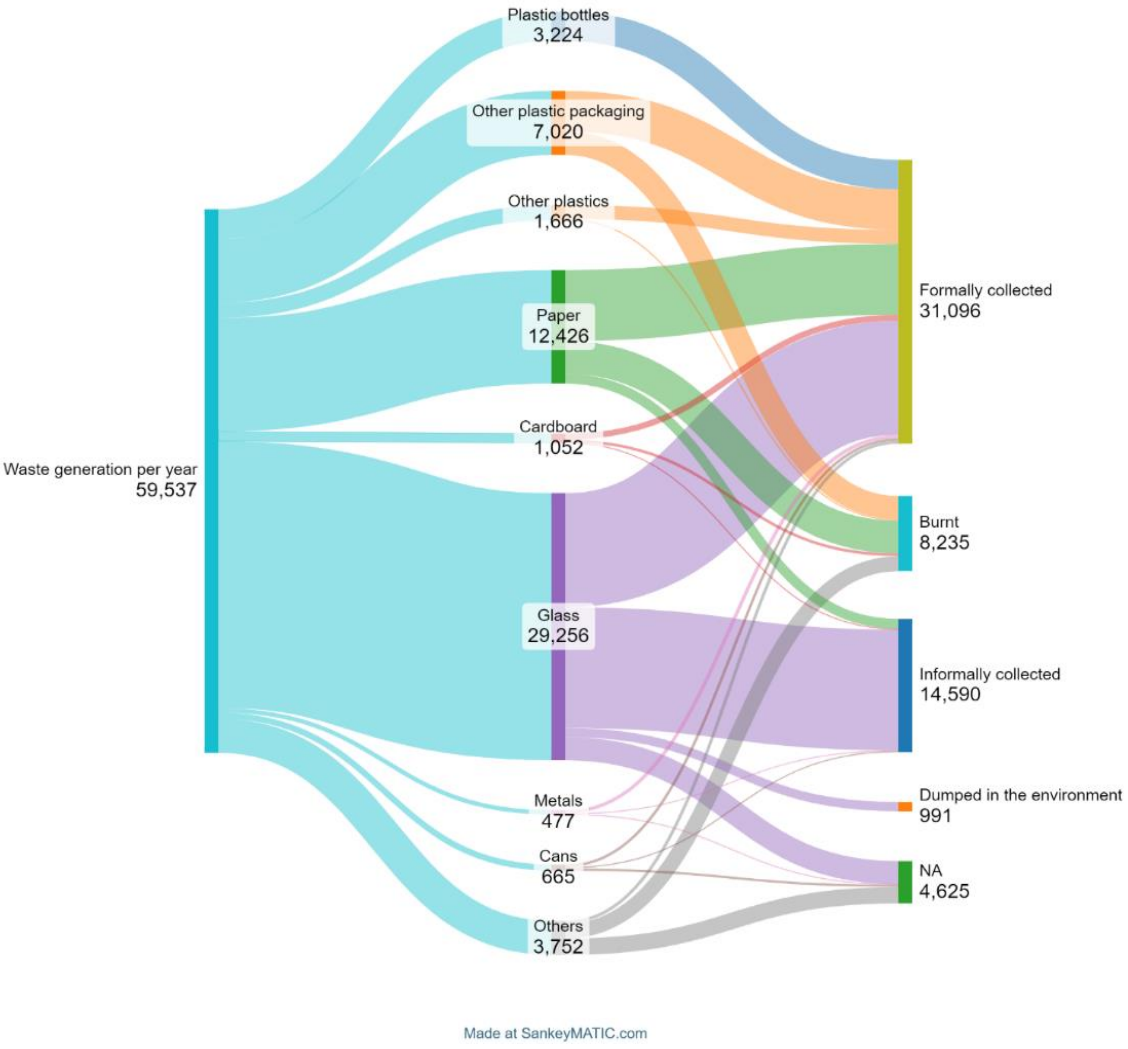

Figure 32: The Sankey diagram of the waste generated from the hotels for a year

Waste generated from guest houses for a year

The breakdown of waste generated by various hotels over a year shows a total waste generation of 10,335 kilograms. The primary waste types included glass bottles (7,274 kilograms), paper (654 kilograms), plastic bottles (1,703 kilograms), and other types of plastic (480 kilograms), among others. Notably, no waste was categorized under cardboard, other metals, or residual waste, which simplifies the waste profile for these hotels.

In terms of waste management fate:

- **Formally Collected**: A substantial portion of the waste was formally collected, including 5,886 kilograms of plastic bottles and 775 kilograms of other types of plastic. This indicates a robust waste management system for these materials.
- **Informally Collected**: Another significant portion, 4,198 kilograms of waste, was informally collected, highlighting reliance on less regulated or unofficial waste collection channels.
- **Burnt**: A smaller fraction, 258 kilograms, was burnt, posing potential environmental and health risks due to the release of pollutants.
- **Dumped in the Environment**: The most environmentally concerning method was the dumping of 850 kilograms of waste directly into the environment, which indicates severe waste management lapses and potential for significant ecological impact.
- **Not Applicable (NA)**: Finally, 61 kilograms of waste fell into the 'Not Applicable' category, suggesting some waste streams were unaccounted for or handled in ways not captured by typical waste processing metrics.

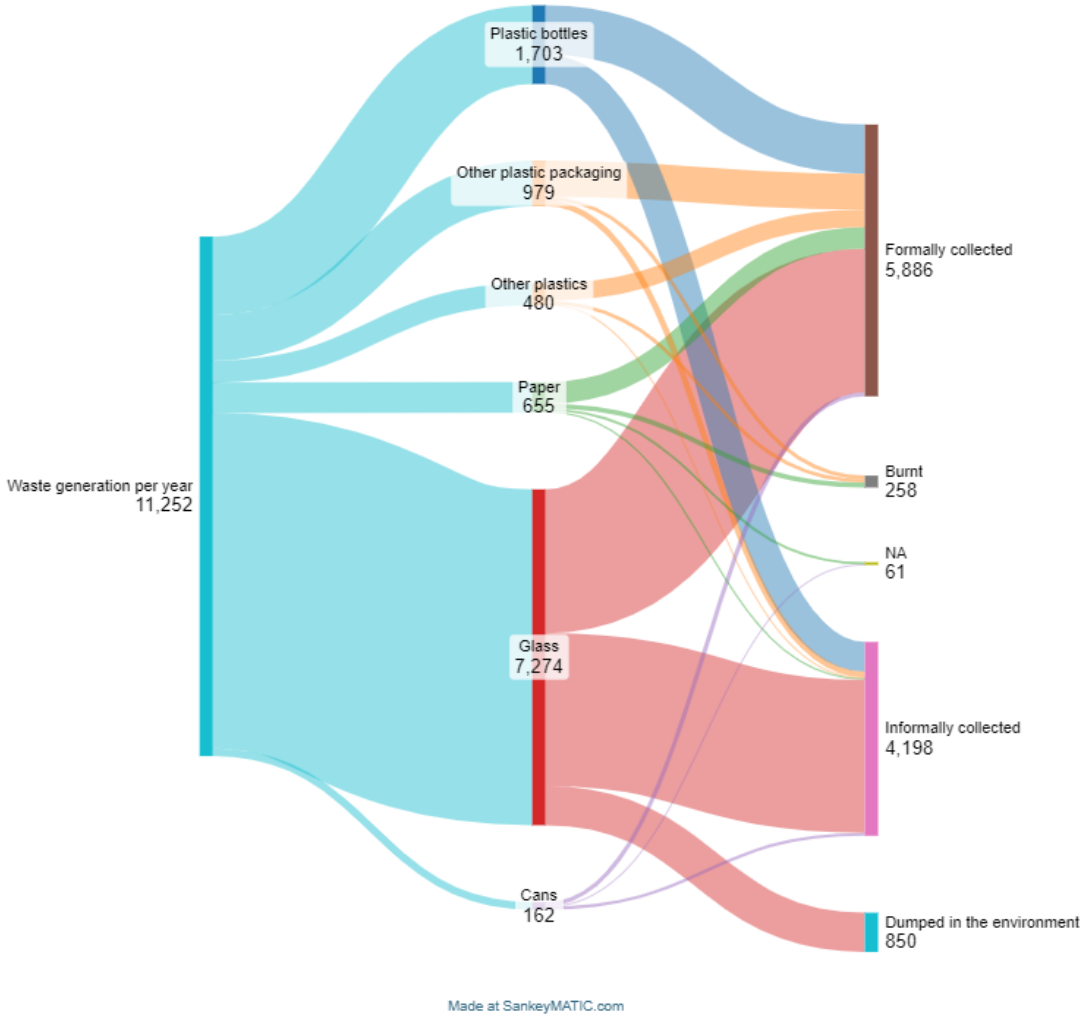

Figure 33: The Sankey diagram of the total waste generated in the guest houses for a year

Total waste generated from hotels and guest houses for a year

The total waste managed in hotels and guest houses for over a year amounted to 70,791 kilograms. The different categorizes of waste are with their subsequent fates outlined as formally collected, informally collected, burnt, dumped in the environment, or not applicable (NA) as follows.

- Formally Collected: The largest volume of waste, 36,982 kilograms, was formally collected, with glass bottles being the most significant contributor in this category at 15,617 kilograms. Other notable categories include paper and cardboard, with 8,227 and 657 kilograms collected, respectively.
- Informally Collected: A total of 18,789 kilograms were informally collected, with the highest among them being glass bottles again, at 16,528 kilograms. Plastic bottles and packaging were also informally managed, with 639 kilograms and 126 kilograms, respectively.
- Burnt: Waste totaling 8,493 kilograms was burnt, with other types of plastic (2,649 kilograms) and paper (220 kilograms) making up the major components of this category. This represents a significant environmental concern due to the pollutants released from burning plastics and other materials.
- Dumped in the Environment: The most environmentally harmful fate, dumping, accounted for 1,841 kilograms of waste, all of which were glass bottles. This highlights a critical area for improvement in waste management practices to prevent environmental contamination.
- Not Applicable (NA): The NA category, with a total of 4,686 kilograms, indicates waste that was not processed through regular waste management channels. This includes miscellaneous or unaccounted types of waste, possibly due to irregular handling or recording.

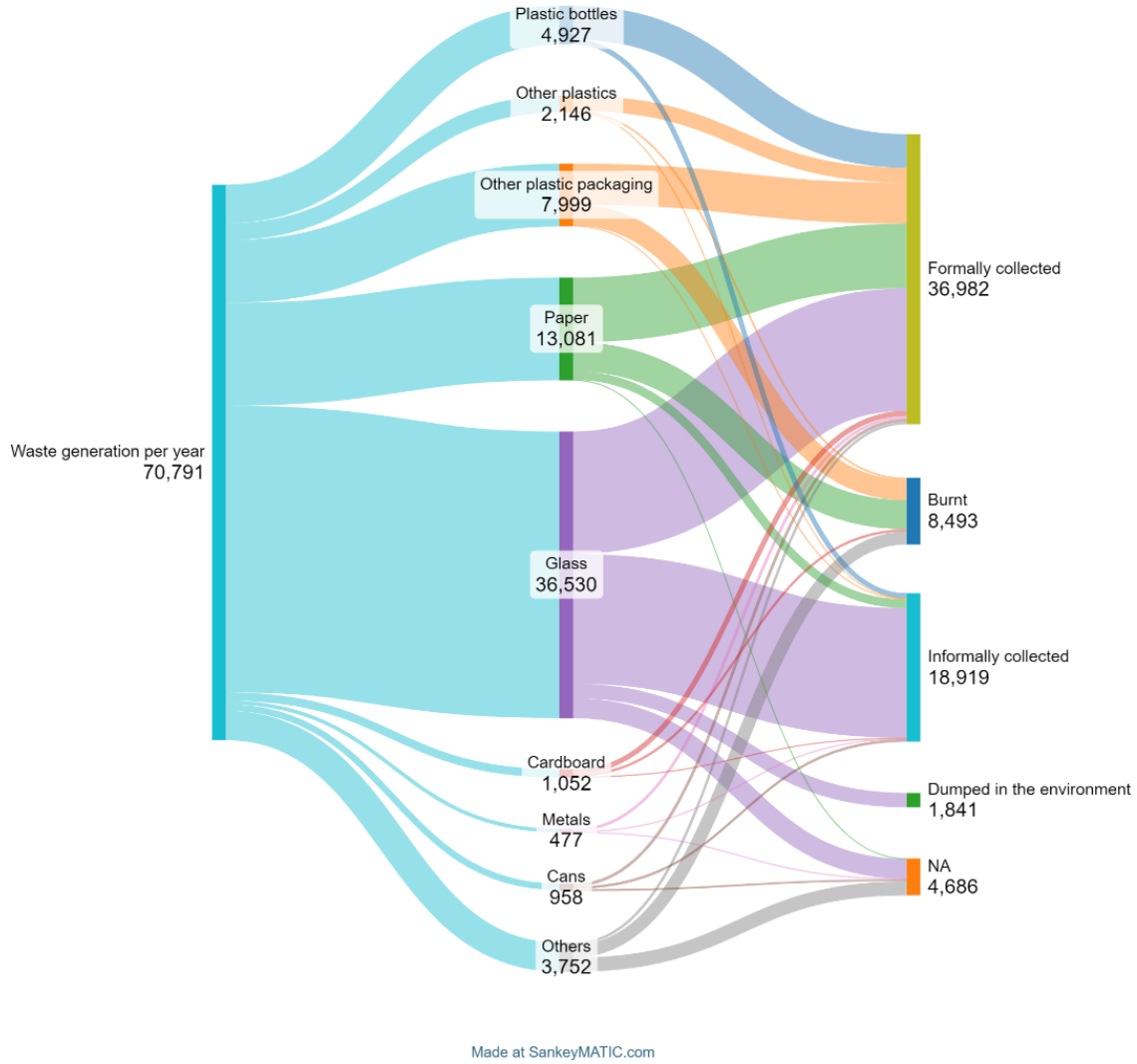

Figure 34: The Sankey diagram of total waste generated in hotels and guest houses for a year

12. Conclusion on the S2S activities

The "Sources to Sinks" activities carried out in the hotels and guesthouses surrounding Kovalam Beach have yielded pivotal insights into waste management practices within the local tourism sector. Through detailed waste characterization and stakeholder interviews, the project was able to map the journey of waste from its generation to its final fate. The significant findings indicate that glass bottles and plastic waste dominate the waste profile, underscoring the urgent need for targeted waste reduction strategies.

The data revealed that a substantial portion of waste, especially plastics and glass, was collected formally, demonstrating effective aspects of waste management already in place. However, a notable amount of waste was also managed informally or irresponsibly disposed of through burning or dumping in the environment. These practices pose severe risks to environmental health and marine ecosystems,

particularly given the proximity to the Lakshadweep Sea. In conclusion, the "Sources to Sinks" activities have been instrumental in highlighting the critical areas where interventions are necessary. Enhancing formal waste collection, improving recycling efforts, and implementing strict regulations against burning and dumping are essential steps towards sustainable waste management.

13. Overall conclusions and recommendations

The Material Flow Analysis (MFA) and Sources to Sinks (S2S) activities conducted at Kovalam Beach under the PROMISE project provided valuable insights into the flow of plastic waste and its management within the tourism sector. The results highlight significant challenges in managing marine litter, particularly plastic waste, originating from beach activities, local businesses, and tourist accommodations. Based on the findings from the Material Flow Analysis (MFA) and Sources to Sinks (S2S) activities, the following recommendations aim to improve waste management practices and reduce plastic pollution at Kovalam Beach, particularly within the tourism sector. The conclusions highlight critical challenges in managing plastic waste and provide insights into the key sources and inefficiencies within the current waste management system such as:

- Prevalence of Plastic Waste: Both the MFA and S2S activities identified plastic as the dominant material contributing to marine litter. Plastics constituted 69% of total waste by quantity and 85% by weight. Single-use plastics (SUPs) such as bottles, caps, and packaging are particularly prominent. The S2S assessment in hotels and guesthouses also revealed that plastics, along with glass, make up the largest waste fraction.
- Sources of Waste: The main sources of waste at Kovalam Beach are tourism-related activities, including SMEs (vendors, restaurants, hotels) and tourists. Hotels and guesthouses generate substantial amounts of plastic and glass waste, especially during peak tourist seasons.
- Ineffective Waste Management Practices: Gaps in waste management were observed, particularly in waste segregation, collection, and disposal. Many SMEs and informal vendors either burn their waste or do not segregate it, contributing to plastic pollution. Informal waste collectors play a crucial role in managing PET bottles and other recyclables, but they are often limited in scope and efficiency.
- Limited Awareness and Recycling: Despite some efforts by local authorities and NGOs, there is limited awareness about proper waste segregation and recycling practices among local businesses and tourists. Many vendors, for instance, burn their waste due to a lack of waste collection services, exacerbating environmental harm.

Based on the findings from the MFA and S2S activities, the following recommendations aim to improve waste management practices and reduce plastic pollution at Kovalam Beach, particularly within the tourism sector.

- Enhancing Waste Segregation and Collection: Improving waste segregation at the source, particularly among SMEs, hotels, and guesthouses, is essential. Authorities should implement strict monitoring and encourage better cooperation with waste collectors. Providing easily accessible waste bins and enforcing proper disposal practices can reduce the tendency to burn or dump waste.
- Strengthening Recycling Infrastructure: The study highlights the need for enhanced recycling facilities, particularly for plastics and glass. Introducing incentives for SMEs to segregate recyclables and connect with formal recycling networks can reduce the amount of waste ending up in landfills or

the ocean.

- **Awareness Campaigns**: Educational campaigns targeting tourists, vendors, and businesses should be intensified. NGOs like Positive Change for Marine Life can play a crucial role in promoting sustainable practices, such as using eco-friendly alternatives to SUPs and discouraging waste burning.
- **Tourism Waste Management Plans**: Tailoring waste management strategies for peak tourist seasons is necessary to handle the increased waste generation. Hotels and guesthouses should track their waste outputs and use tools like plastic footprint calculators to monitor and reduce their environmental impact.
- **Collaboration Among Stakeholders**: Coordinated efforts among local authorities, waste collectors, NGOs, and businesses are vital to ensuring an effective waste management system. Clear delineation of responsibilities and improved communication will foster better accountability and compliance with waste regulations.

By addressing these key areas, Kovalam Beach can significantly reduce its contribution to marine litter and set a model for sustainable tourism practices in coastal regions.