



Assessing Plastic Use and Pollution Within The Tourism Sector in Indonesia

This research was conducted in collaboration with:



Copyright @ 2026

By the United Nations Development Program Indonesia

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by means, electronic, mechanical, photocopying, recording or otherwise, without prior permission. Any use of information, in full or in part, should be accompanied by an acknowledgment of UNDP Indonesia as the source.

The views expressed in this publication are those of the author(s) and do not necessarily represent those of the United Nations, including UNDP, donor agencies, or UN Member States.

TABLE OF CONTENTS

List of Tables	v
List of Figures	v
Executive Summary	vi
1. Introduction	1
1.1 Tourism growth and environmental pressure	2
1.2 Plastic pollution in coastal and urban tourism	2
1.3 Indonesia policy context: National Marine Debris Action Plan (2018 -2025)	2
1.4 Research gap	3
1.5 Objectives and scopes	3
2. Conceptual Framework	4
2.1 Tourism plastic flow as a system	5
2.2 Mass-balance and sankey modeling approach	5
2.3 Leakage pathway typology	5
2.4 Tourism destination typology	6
2.5 Linking plastic pollution to tourism sustainability	6
3. Methodology	7
3.1 Study design	8
3.2 Sampling strategy and facility stratification	8
3.3 Facility survey instrument	8
3.4 Rapid Waste Audits (RWAs)	8
3.5 Waste management and infrastructure assessment	9
3.6 Leakage assessment and hotspot observation	9
3.7 Data analysis and extrapolation	9
3.7.1 Extrapolation framework and uncertainty boundaries	9
3.8 Sankey flow modeling	11
3.9 Quality assurance and ethics	11
3.10 Study limitation and uncertainty	11
3.1 Gender and social inclusion	12
4. Results	13
4.1 National overview of tourism plastic generation	14
4.1.1 Coastal mass tourism	14
4.1.2 Small island tourism	14
4.1.3 Urban cultural tourism	16
4.1.4 Emerging village tourism system	16
4.1.5 Synthesis of literature patterns and link to the present study	16
4.2 Mass Tourism system (Bali)	17
4.2.1. Waste management and composition	17
4.2.2. Management performance	18

4.3 Urban cultural tourism (Yogyakarta)	18
4.3.1 Waste management and composition	18
4.3.2 Management performance	19
4.4 Small island and event-based tourism (Lombok)	19
4.4.1 Waste management and composition	19
4.4.2 Management performance	20
4.5 Nature and marine tourism (Labuan Bajo)	21
4.5.1 Waste management and composition	21
4.5.2 Management performance	22
4.6 Comparative synthesis	22
5. Policy, Institutional Context, and Strategic Recommendation	24
5.1 National policy alignment	25
5.2 Institutional coordination challenges	25
5.3 Strategic recommendations	26
5.3.1 Immediate actions (1-2 years)	27
5.3.2 Medium-term actions (3-5 years)	27
5.3.3 Structural transformation (Beyond 5 years)	28
5.4 Financing cost framework	28
5.5 Monitoring, Reporting, and Verification (MRV) Framework	29
Conclusion	30
Documentation	31
References	33

LIST OF TABLES

Table 1. Core assumptions and uncertainty ranges used for extrapolation.	10
Table 2. Summary of tourism-related waste studies in Indonesia	15
Table 3. Typological distinction appears in waste origin.	22
Table 4. Recovery performance and residual burden of tourism waste	23
Table 5. Institutional roles, mandates, and gaps in tourism waste management	26
Table 6. Typology-based policy priorities.	26
Table 7. Cost structure and potential financing sources	28
Table 8. Proposed KPI framework for tourism waste management.	29

LIST OF FIGURES

Figure 1. Composition flow of tourism waste in a mass tourism destination in Bali, Indonesia (kg/visitor/day).	17
Figure 2. Management outcome flow of tourism waste in a mass tourism destination in Bali, Indonesia (kg/visitor/day).	17
Figure 3. Composition flow of tourism waste in an urban tourism destination in Yogyakarta, Indonesia (kg/visitor/day).	18
Figure 4. Management outcome flow of tourism waste in an urban tourism destination in Yogyakarta, Indonesia (kg/visitor/day).	19
Figure 5. Composition flow of tourism waste in a small island tourism destination in Lombok, Indonesia (kg/visitor/day).	20
Figure 6. Management outcome flow of tourism waste in a small island tourism destination in Lombok, Indonesia (kg/visitor/day).	20
Figure 7. Composition flow of tourism waste in a nature-based tourism destination in Labuan Bajo, Indonesia (kg/visitor/day).	21
Figure 8. Management outcome flow of tourism waste in a nature-based tourism destination in Labuan Bajo, Indonesia (kg/visitor/day).	21



EXECUTIVE SUMMARY

TOURISM AND PLASTICS IN INDONESIA:

16 million

visitors arrive in Indonesia each year

Up to 0.6 kg

of plastic waste generated per visitor each day

Up to 70%

of debris on Indonesian beaches is plastic

Most common plastic items:

water bottles, food and beverage containers, sachets, plastic bags, straws, lids, and tobacco-related waste.

Tourism is one of Indonesia's most dynamic economic sectors. It generates employment, supports regional development, and strengthens the country's global presence. Yet, alongside these benefits, tourism contributes significantly to plastic consumption and waste generation – particularly in destinations where infrastructure and governance systems are uneven.

This report presents a comprehensive baseline assessment of plastic use and pollution within Indonesia's tourism sector across four typologically distinct destinations: Bali (mass tourism), Yogyakarta (urban cultural tourism), Lombok (small island and event-driven tourism), and Labuan Bajo (nature and marine tourism). The study integrates facility-level waste audits, stakeholder engagement, infrastructure assessment, and mass-balance Sankey modeling to quantify plastic generation, management performance, and leakage risk.

KEY FINDINGS

1. Tourism Generates Significant Plastic Waste

Across destinations, total waste generation ranged between 0.5 and 2.4 kg per visitor per day, depending on typology and service intensity. Plastics consistently represented a substantial share of total waste, ranging between 32 and 38 percent across the four destinations.

This corresponds to approximately 0.47–0.61 kg of plastic per visitor per day in moderate-to-high intensity systems. Hotels and hospitality facilities are key contributors to this stream.

Plastic waste composition is dominated by:

- Bottled water (PET)
- Food and beverage packaging
- Multilayer sachets
- Plastic films and bags
- Straws, lids, and cigarette or tobacco related waste

These items are closely linked to single-use consumption patterns in tourism environments.

2. Leakage Risk Varies by Destination Typology

Leakage risk is not determined by visitor volume alone. It is shaped by infrastructure capacity, governance performance, and ecosystem sensitivity.

- Bali (Mass Tourism): High waste volume. Even small mismanaged fractions translate into significant environmental loads.
- Yogyakarta (Urban Cultural Tourism): Packaging-intensive consumption. Leakage pathways linked to stormwater and drainage systems.
- Lombok (Small Island and Event-Based Tourism): Infrastructure constraints and seasonal surges amplify mismanagement risk.
- Labuan Bajo (Nature and Marine Tourism): Ecosystem sensitivity and boat-based waste streams increase vulnerability despite moderate volumes.

Typology-based differentiation is essential for effective intervention design.

3. Management Performance Determines Environmental Outcomes

Across destinations, a substantial portion of waste is directed toward controlled disposal. However, unsorted fractions remain significant, particularly in smaller facilities and public spaces.

Leakage estimates, based on conservative-to-moderate scenario modeling, indicate that mismanaged fractions can persist in all typologies. While percentages may appear modest, cumulative effects are magnified by high visitor flows and ecological exposure.

The analysis confirms that improving segregation, strengthening infrastructure, and aligning supply chains can substantially reduce leakage without limiting tourism growth.

4. Literature Evidence Reinforces Structural Patterns

Previous empirical studies across Indonesia consistently demonstrate:

- High plastic dominance in coastal litter
- Significant waste intensity in hotels
- Seasonal surges linked to tourism peaks
- Limited quantification of per-visitor plastic intensity

This study advances the evidence base by linking generation, management, and leakage within a unified mass-balance framework.

STRATEGIC PATHWAYS

Transitioning toward plastics-reduced tourism requires a phased and typology-sensitive approach.

Immediate (1–2 Years)

- Establish standardized tourism waste intensity reporting (kg per guest-night, grams per visitor)
- Target the top five leaking plastic items

- Reform procurement practices in hospitality facilities
- Improve source segregation through mandatory logbooks

Medium-Term (3–5 Years)

- Align Extended Producer Responsibility (EPR) financing with territorial sales distribution
- Integrate tourism facilities into deposit-return and reverse logistics systems
- Introduce cross-subsidy mechanisms to support small islands
- Strengthen seasonal surge planning and transfer infrastructure

Structural (Beyond 5 Years)

- Develop destination-level circular economy platforms
- Establish marine-specific waste governance for boat-based tourism
- Integrate plastic reduction into tourism branding and certification schemes
- Institutionalize annual Sankey-based monitoring systems

CONTRIBUTION TO NATIONAL MARINE DEBRIS REDUCTION TARGET

“Tourism represents a strategic leverage point for achieving Indonesia’s 70% marine plastic debris reduction target.”

Indonesia has committed to reducing marine plastic debris by 70 percent under its National Plan of Action (2018–2025). Tourism represents a strategic leverage point for achieving this target.

By reducing mismanaged fractions, strengthening recovery systems, and preventing leakage in high-risk typologies, the tourism sector can meaningfully contribute to national reduction goals. Concentrated consumption in tourism nodes provides an opportunity for efficient material recovery and producer engagement.

CONCLUSION

“Tourism plastic pollution in Indonesia is a systemic issue. However, it is also a manageable challenge.”

Tourism plastic pollution in Indonesia is a systemic issue. It is embedded in supply chains, consumption behavior, and infrastructure capacity. However, it is also a manageable challenge.

This baseline assessment demonstrates that:

- Plastic intensity is measurable.
- Leakage pathways are identifiable.
- Governance gaps are addressable.
- Targeted interventions can produce meaningful environmental gains.

Indonesia has the regulatory foundation and sectoral momentum to transition toward plastics-reduced and circular tourism systems. By aligning environmental science, policy instruments, and tourism management, the country can position itself not only as a world-class destination, but as a global leader in sustainable tourism governance.

The pathway forward is clear. The next step is to coordinate implementation.





1. INTRODUCTION

1.1 Tourism Growth and Environmental Pressure

Tourism has become one of Indonesia's most dynamic economic sectors. Before the pandemic, international arrivals exceeded 16 million visitors annually. Domestic tourism has grown even faster, with hundreds of millions of trips recorded each year (BPS, 2023). Tourism contributes significantly to national GDP and supports millions of jobs across hospitality, transport, food services, and small enterprises. However, tourism growth also increases material consumption. Hotels, restaurants, cafés, and tourist attractions require water, energy, food, and packaging. Much of this consumption relies on single-use plastics (SUPs), especially bottled water, food containers, sachets, and takeaway packaging. As visitor numbers rise, waste volumes increase accordingly. In high-density destinations, tourism can generate between 0.5 and 2.5 kg of waste per visitor per day, depending on destination type and service intensity (UNEP, 2021). In Indonesia, this additional waste often exceeds the design capacity of local waste management systems. The result is not only operational strain but also elevated environmental risk. Tourism, therefore, presents a dual reality. It drives economic opportunity, yet it also intensifies environmental pressure when waste systems fail to keep pace.

1.2 Plastic Pollution in Coastal and Urban Tourism

Plastic pollution is not evenly distributed. It is concentrated in places where consumption is high and management capacity is uneven. Many of Indonesia's iconic tourism destinations are located along coastlines, rivers, or small islands. These areas are particularly vulnerable. Studies have shown that plastics constitute 30-70% of marine debris found on Indonesian beaches, especially near urban and tourism centers (Purba et al., 2019; Cordova et al., 2022). Plastic waste from land-based sources can enter rivers and coastal waters through mismanaged disposal, open dumping, spillage during transport, and stormwater runoff (Jambeck et al., 2015).

Tourism-related plastics have distinct characteristics. They are often lightweight, disposable, and linked to short-term consumption. Bottled water, takeaway food packaging, straws, sachets, and hotel amenities are common items found in coastal clean-ups. In small islands and marine parks, even small amounts of leakage can have disproportionate ecological impacts. Coral reefs, mangroves, and seagrass beds are highly sensitive to physical smothering and entanglement (UNEP, 2021).

In urban tourism destinations, leakage pathways differ. Plastics may enter drainage systems during rainfall and travel downstream to coastal zones. Thus, both coastal and inland tourism contribute to marine plastic pollution, though through different mechanisms. Plastic pollution in tourism areas is not merely a waste issue. It directly threatens the natural assets on which tourism depends.

1.3 Indonesia Policy Context: National Marine Debris Action Plan (2018 - 2025)

Indonesia has demonstrated strong political commitment to addressing marine plastic pollution. The National Plan of Action on Marine Debris (2018-2025) targets a 70% reduction in marine plastic debris by 2025. Complementary policies include:

- Presidential Regulation No. 97/2017 on Waste Management
- Presidential Regulation No. 83/2018 on Management of Marine Debris
- Ministerial Regulation No. 75/2019 on Producer Waste Reduction Roadmap (EPR framework)
- Provincial and municipal single-use plastic bans in regions such as Bali and Jakarta

These policies provide an important regulatory foundation. However, implementation varies across regions. Enforcement capacity differs. Monitoring systems are often fragmented. Sector-specific data for tourism remains limited. While municipal waste data exist at aggregate levels, there is limited empirical evidence that disaggregates plastic flows within tourism facilities. Without such data, policy

design risks relying on assumptions rather than measured flows. The tourism sector is therefore both a target and a potential partner in achieving national marine debris reduction goals.

1.4. Reesearch Gap

Despite increasing global attention to plastic pollution, reliable data on tourism-specific plastic flows in Indonesia remain scarce. Existing national estimates often extrapolate from municipal solid waste data without distinguishing between residential and tourism-driven waste streams.

Several critical gaps persist:

- Limited quantification of plastic waste intensity in hotels, restaurants, cafés, and attractions.
- Insufficient mapping of plastic flows from generation to disposal or leakage.
- A weak understanding of seasonal variation linked to tourist peaks.
- Limited integration of informal waste sector roles into tourism plastic assessments.

Moreover, few studies apply mass-balance approaches or Sankey flow modeling to tourism plastic systems at destination scale. Without understanding how plastics move through tourism value chains, interventions may target symptoms rather than structural drivers. This study addresses these gaps by combining facility-level data collection, waste audits, stakeholder engagement, and flow modeling.



1.5 Objectives and Scope

This study aims to develop a comprehensive baseline assessment of plastic use and pollution within Indonesia's tourism sector. The assessment focuses on four typologically distinct destinations

- Bali, a mass tourism with high international volume
- Yogyakarta, an urban cultural tourism
- Lombok, small island and event-driven tourism
- Labuan Bajo, nature-based and marine tourism

The objectives are to

1. Quantify plastic generation intensity in tourism facilities (kg/visitor/day; g/cover; g/guest-night).
2. Map plastic flows using mass-balance and Sankey modeling from generation to recovery, disposal, and leakage.
3. Assess waste management performance and infrastructure constraints
4. Evaluate policy effectiveness and institutional coordination.
5. Identify scalable pathways toward plastics-free and circular tourism systems.

By integrating environmental science, tourism analysis, and governance review, this report provides evidence-based insights to support Indonesia's marine debris reduction commitments and to inform international best practices under the Global Plastics Innovation Programme.

The following chapter introduces the conceptual framework used to analyze tourism plastic flows and leakage pathways.



2. CONCEPTUAL FRAMEWORK

2.1 Tourism Plastic Flow as a System

Plastic pollution in tourism cannot be understood as a simple waste issue. It is a system problem. Plastics move through interconnected stages, from procurement to consumption, disposal, recovery, and sometimes leakage into the environment. In tourism settings, plastic flows are shaped by visitor behaviour, facility procurement practices, waste segregation systems, municipal infrastructure, informal recycling networks and policy enforcement. Each stage influences the next. If segregation fails at source, recovery becomes inefficient. If collection coverage is incomplete, leakage risk increases. If supply chains prioritize single-use convenience, waste volumes escalate.

To capture these interactions, this study adopts a material flow perspective. Plastic waste is treated as a measurable stream that can be traced from generation to final fate. This approach aligns with global circular economy frameworks that emphasize system mapping over isolated interventions (OECD, 2022; UNEP, 2021). Understanding tourism plastic pollution therefore requires following the flow, not just counting the waste.

2.2 Mass-Balance and Sankey Modeling Approach

To operationalize the system perspective, this study applies a mass-balance framework. All plastic entering the tourism system must ultimately be recovered (recycled or reused), controlled disposal (landfill or regulated facility), mismanaged and leaked into the environment. The mass-balance principle ensures internal consistency. The sum of outputs must equal total generation, within defined uncertainty bounds.

Sankey diagrams are used to visualize these flows. They illustrate how plastic moves from Generation, Segregation, Collection, Diversion, Disposal and to Leakages. This method has been applied in waste system analysis globally to identify structural inefficiencies and leakage hotspots (Kaza et al., 2018; OECD, 2022).

In tourism contexts, Sankey modeling offers three advantages:

1. It distinguishes between inside-facility and outside-facility waste generation.
2. It quantifies mismanaged fractions that may contribute to environmental leakage.
3. It allows scenario-based analysis under different management performance levels.

Rather than presenting single-point estimates, this report uses conservative-to-moderate ranges to reflect uncertainty in occupancy, seasonal variation, and infrastructure performance. The Sankey framework therefore serves as both an analytical and communication tool. It translates complex waste dynamics into policy-relevant insights.

2.3 Leakage Pathway Typology

Plastic leakage does not occur randomly. It follows identifiable pathways. Based on field observations and literature, tourism-related leakage in Indonesia generally occurs through four primary routes, namely

- Public littering, a direct disposal in public areas near attractions or beaches
- Overflow and spillage, a waste escaping from collection points, especially during peak seasons
- Transport loss, spillage during hauling to landfills or transfer stations
- Open dumping and burning, common in small islands or peri-urban areas with limited infrastructure

In coastal destinations, rivers and stormwater systems act as conduits that transport plastics into marine ecosystems (Jambeck et al., 2015; Cordova and Nurhati, 2019). Leakage is therefore a function of both behavioral and structural factors. High tourist volumes alone do not guarantee high leakage. Instead, leakage emerges where

**Leakage risk = unsorted fraction x
mismanaged share x environmental
exposure**

This simplified relationship underpins the modeling approach used in subsequent chapters.

2.4 Tourism Destination Typology

Not all tourism destinations behave the same way. Waste generation intensity, composition, and leakage risk vary according to destination type. This study categorizes destinations into four typologies

1. Mass Tourism (Bali)

High visitor volume. Large hospitality supply chains. High per-day waste generation. Leakage risk driven by scale

2. Urban Cultural Tourism (Yogyakarta)

High domestic mobility. Strong culinary sector. Packaging-intensive consumption. Leakage driven by urban drainage systems

3. Small Island and Event-Based Tourism (Lombok)

Limited landfill capacity. High bottled water dependency. Seasonal surges. Leakage driven by infrastructure constraints

4. Nature and Marine Tourism (Labuan Bajo)

Boat-based waste generation. Sensitive ecosystems. Decentralized disposal points. Leakage driven by governance and monitoring gaps

Those typologies allow comparison across structurally different systems. It also prevents one-size-fits-all recommendations.

For example in mass tourism, reducing volume per visitor may yield the greatest impact. In small islands, strengthening controlled disposal may be more urgent; and in marine tourism, onboard waste regulation may be decisive. The typology therefore connects environmental science with tourism planning logic.

2.5 Linking Plastic Pollution to Tourism Sustainability

Tourism depends on environmental quality. Clean beaches, coral reefs, cultural landscapes, and urban aesthetics are core assets. Plastic pollution undermines these assets directly. Research shows that visible litter reduces tourist satisfaction and may influence destination choice (UNEP, 2021). Marine debris also threatens fisheries and biodiversity, which indirectly support tourism livelihoods. Thus, plastic pollution is not only an environmental externality. It is a tourism competitiveness issue. Transitioning toward plastics-free tourism aligns with broader sustainability goals, including circular economy transitions, climate mitigation through material efficiency, improved destination branding, and alignment with SDGs 12 (Responsible Consumption) and 14 (Life Below Water). The analytical framework developed in this chapter supports an integrated understanding of environmental integrity and tourism resilience.

The next chapter describes the methodology used to operationalize this framework in Bali, Yogyakarta, Lombok, and Labuan Bajo.





3. METHODOLOGY

3.1 Study Design

This study adopts a mixed-method, multi-site baseline assessment of plastic use and waste flows within Indonesia's tourism sector. The design integrates quantitative waste measurement with qualitative institutional and behavioral analysis. The analytical backbone follows the mass-balance framework introduced in Chapter 2. Plastic waste is treated as a measurable material stream. For each destination, we quantify plastic generation intensity, waste composition by product and polymer, management performance, and leakage proxies.

The study focuses on four destinations representing distinct tourism typologies

1. Bali, represent mass tourism
2. Yogyakarta, represent urban cultural tourism
3. Lombok, represent small island and event-driven tourism
4. Labuan Bajo, represent nature and marine tourism

By comparing these typologies, the study captures structural differences in waste generation and leakage dynamics.

3.2 Sampling Strategy and Facility Stratification

Sampling was structured around key tourism nodes hotels, cafés, restaurants, and tourist attractions (HCRT). Facilities were stratified to reflect differences in consumption intensity:

- Hotels by star class, room capacity, and ownership (chain vs independent)
- Restaurants and cafés by service type and seating capacity
- Attractions by visitor volume and type (beach, marine, cultural, park)

This stratified approach ensures representation across facility scales and operational models. Within each destination, facilities were selected through purposive and stakeholder-assisted recruitment. The goal was not statistical national representation, but robust destination-level baselines with sufficient variability for flow modeling.

3.3 Facility Survey Instrument

A structured survey instrument (20-30 minutes) was administered to facility managers. The survey captured

- Procurement patterns of plastic-intensive items
- Single-use plastic policies
- Refill and reuse practices
- Waste segregation procedures
- Collection contractors and disposal pathways
- Operational constraints

Occupancy data and service intensity metrics were collected for normalization. These include guest-nights for hotels, covers served per day for restaurants, and daily visitor counts for attractions. These data enable calculation of plastic intensity indicators, such as kg plastic per guest-night, grams plastic per cover, grams plastic per visitor. Normalization is essential to compare facilities of different sizes and to extrapolate flows to destination level.

3.4 Rapid Waste Audits (RWAs)

To complement survey responses, rapid waste audits were conducted at selected facilities. Audits lasted two consecutive days per facility.

Waste was segregated into

- Organics
- Paper
- Plastics
- Glass
- Metal
- Residual

Plastic fractions were further sorted by product category

- Bottles
- Sachets
- Cups and lids
- Straws
- Films and bags
- Foam foodware
- Cutlery

Where possible, polymers were identified visually (PET, HDPE, LDPE, PP, PS). Each category was weighed (kg) and, when relevant, volume recorded. Contamination levels and disposal routes were documented. RWAs provide empirical inputs for the mass-balance model and reduce reliance on self-reported data.

3.5 Waste Management and Infrastructure Assessment

Waste flows do not end at the facility. Therefore, municipal and private-sector interfaces were examined through interviews and site visits.

Data collected included:

- Collection coverage rates
- Fleet capacity and routing
- Landfill type and capacity
- Recycling throughput
- Role of informal waste pickers and waste banks

Infrastructure audits were conducted to assess:

- Segregation quality
- Storage conditions
- Collection frequency
- Evidence of spillage or overflow

This assessment links facility-level generation with downstream system performance.

3.6 Leakage Assessment and Hotspot Observation

Leakage cannot always be measured directly. Therefore, this study uses leakage proxies derived from observed uncollected fractions, overflow or spillage at transfer points, open dumping or burning, and litter transects near tourism hotspots. Standardized transects were conducted along selected beaches, riverbanks, and roadsides. Tourism-linked items were recorded and categorized. Leakage was estimated using a conservative-to-moderate scenario approach. The leakage proxy is calculated as a function of

**Leakage = unsorted x share x times
missmanaged x share x times
environmental x exposure**

This approach aligns with global waste modeling practices (Jambeck et al., 2015; OECD, 2022).

3.7 Data Analysis and Extrapolation

Facility-level intensity metrics were extrapolated to destination scale using tourism activity indicators total guest-nights, total covers served, and total attraction visits. Destination totals were calculated as

Total = plastic intensity x tourism activity

Uncertainty was addressed through sensitivity analysis (peak vs. shoulder season), scenario ranges (uncertainty bounds), cross-validation between survey and audit data. Comparability across destinations was maintained by standardizing categorization and density assumptions

3.7.1 Extrapolation Framework and Uncertainty Boundaries

The national estimates presented in this report are derived from a set of explicit extrapolation assumptions that translate site-level observations into destination and national scales. These assumptions are not neutral. They directly shape the magnitude and distribution of the final estimates.

At minimum four parameters drive the extrapolation (1) visitor volume (daily and seasonal variability), (2) waste generation rate (kg/visitor/day), (3) composition fractions (organic, recyclable, residual, leakage-prone items), and (4) management pathways (collected, treated, mismanaged, leaked).

Each parameter carries its own level of uncertainty (Table 1). Visitor data is often relatively stable in formal destinations. However, becomes less reliable in informal or seasonal sites. Waste generation rates vary widely across accommodation types and tourist behavior profiles. Composition data is sensitive to sampling design and sorting consistency.

approach. Instead of presenting a single value, estimates are bounded within a range (typically ± 5 -10%), reflecting variability in both data quality and behavioral factors. In order to enhance transparency in how the estimates are constructed, the core assumptions and corresponding uncertainty ranges applied in the extrapolation are presented in Table 1.

To avoid false precision, uncertainty ranges are introduced using a conservative-moderate scenario

Table 1. Core assumptions and uncertainty ranges used for extrapolation

Parameter	Definition	Data Source	Base Value / Range	Uncertainty Range	Notes
Visitor volume	Number of visitors per day (domestic and international)	Official tourism statistics, local authority data	Destination-specific (e.g. 2,000-25,000 visitors/day)	5-10%	Seasonal variation not fully captured in all sites
Waste generation rate	Waste generated per visitor per day	Field measurement (sample sites), literature comparison	0.5-2.4 kg/visitor/day	10%	Varies by tourism type (luxury vs budget, day-trip vs stay)
Waste composition	Fraction of waste by category (organic, recyclable, residual)	Waste audit data	Organic 40-60%; Recyclable 20-35% Residual 15-30%	5-10%	Sensitive to sorting method and sampling time
Plastic fraction	Share of plastic within total waste	Waste audit and literature	15-40% of total waste	5%	Includes SUP, packaging, multilayer
Leakage-prone fraction	Portion of waste likely to be mismanaged or leaked	Derived from field observation and proxy indicators	5-20% of total waste	5-10%	Higher in coastal and informal areas
Collection efficiency	Proportion of waste collected by formal system	Local government reports, field validation	60-90%	10%	Lower in small islands and remote destinations
Sorting rate (at source)	Share of waste sorted before collection	Field observation, interviews	10-40%	10%	Often inconsistent across facilities

Parameter	Definition	Data Source	Base Value / Range	Uncertainty Range	Notes
Recycling rate	Share of waste effectively recycled	Secondary data and waste flow estimation	10-30%	5-10%	Dependent on local market and logistics
Residual disposal	Waste sent to landfill or final disposal	Local authority reports	40-70%	5%	Includes mixed waste and rejects
Informal sector recovery	Waste recovered by informal actors	Interview and proxy estimation	5-15%	5-10%	Rarely documented formally

3.8 Sankey Flow Modeling

For each destination, a Sankey diagram was constructed to visualize flows from



Inputs were derived from:

- RWA-based generation data
- survey-reported management practices
- municipal throughput data
- leakage proxies

Mass balance consistency was maintained. Total outputs equal total generation within defined uncertainty margins. The Sankey model allows identification of structural bottlenecks. It highlights where interventions may produce the greatest reduction in leakage.

3.9 Quality Assurance and Ethics

Data quality was ensured through:

- Enumerator training
- Pilot testing of instruments
- Double-entry validation of selected records
- Scale calibration during audits
- Photographic documentation

All participating facilities provided informed con-

sent. Facility-level data are anonymized unless explicit permission is granted. Tourist surveys were voluntary and collected no personally identifiable information.

3.10 Study Limitation and Uncertainty

While this study provides one of the most comprehensive tourism plastic baselines conducted in Indonesia to date, several limitations must be acknowledged. Recognizing these constraints strengthens the interpretation of results and ensures transparency in policy translation.

The facility-level assessments were conducted using a stratified but purposive sampling approach. Although the sampling design captured diversity across hotel classes, restaurant types, and attractions, the study did not conduct a full census of all tourism facilities within each destination.

As a result, extrapolations to destination level rely on intensity normalization (kg per guest-night, grams per cover, grams per visitor) and tourism activity

data. While this approach is methodologically sound, actual system-wide variation may exceed the estimated range in certain peak periods.

Tourism systems are inherently dynamic. Waste generation intensity and composition fluctuate across peak and shoulder seasons, holiday periods, major tourism events, and weather patterns (particularly in coastal areas).

Although scenario ranges were applied to account for variability, the $\pm$ uncertainty bands may not fully capture extreme surge events. In small island systems such as Lombok and Labuan Bajo, temporary spikes may exceed modeled leakage estimates.

Leakage rates in this study were estimated using proxy modeling rather than direct measurement. Leakage was derived from the interaction between unsorted waste fractions, mismanaged waste share, observed infrastructure gaps, and environmental exposure pathways.

Direct quantification of plastic entering marine ecosystems requires long-term monitoring, hydrodynamic modeling, and tracer-based approaches, which were beyond the scope of this baseline assessment. Therefore, leakage estimates should be interpreted as conservative-to-moderate risk approximations rather than precise discharge values.

Waste audits were conducted using mass-based measurement (kg). However, coastal litter studies often report item-based densities (items per m²). Lightweight items such as cigarette butts and plastic films may appear disproportionately dominant in item counts while contributing relatively small mass. This methodological difference can create apparent discrepancies between facility waste composition and beach litter composition. The study recognizes this limitation and integrates both perspectives where possible.

Some facility-level information, particularly regarding segregation practices and collection routes, was self-reported by managers. While waste audits were used to validate responses, reporting bias cannot be fully excluded. Future monitoring frameworks should integrate digital reporting systems to enhance accuracy and traceability.

Despite these limitations, several patterns remain robust

- Plastic fractions in tourism waste are consistently high across typologies
- Hotels and hospitality facilities are significant contributors to local waste systems
- Infrastructure capacity strongly influences leakage risk
- Destination typology meaningfully shapes intervention priorities.

The core structural conclusions of this study are therefore unlikely to change under reasonable variation in parameter assumptions. Future research should prioritize longitudinal monitoring across seasons, integration of hydrological transport modelling, and enhanced digital traceability for EPR-linked flows.

Acknowledging this uncertainty in this tourism waste study in Indonesia does not weaken the findings. Instead, it clarifies the boundaries within which the results should be interpreted and applied.

3.11 Gender and Social Inclusion

The study integrates Gender Equality and Social Inclusion (GESI) considerations. Hotels, cafés, restaurants, and tourist attractions (HCRT) actors, informal waste pickers, waste bank operators, and local community actors were included in interviews. The analysis considers structural barriers faced by marginalized groups in waste and tourism value chains. This approach ensures that recommendations are not only technically sound but socially inclusive.



4. RESULTS

4.1 National Overview of Tourism Plastic Generation

Across the four study destinations, tourism waste generation intensity ranged between 0.5 and 2.4 kg per visitor per day, depending on destination type, facility scale, and service intensity. The mid-range estimates for each site cluster between 1.4 and 1.7 kg per visitor per day, reflecting moderate-to-high consumption systems in organized tourism corridors. Plastic constituted a significant fraction of total tourism waste. Across destinations, the plastic share ranged between 32% and 38% of total waste mass. This corresponds to approximately 0.47-0.61 kg of plastic per visitor per day in higher-intensity destinations.

The most common plastic product categories were bottled water (PET), food and beverage containers (PP, PS), multilayer sachets, plastic films and bags (LDPE), straws and lids, and tobacco-related plastic waste. Plastic waste composition reflects the convenience-oriented consumption patterns typical in tourism. In contrast to residential waste, the share of single-use plastics is visibly higher in hospitality settings.

Before presenting the primary findings of this study, it is important to situate the analysis within the broader empirical landscape of tourism-related waste research in Indonesia. A review of published studies across multiple destinations demonstrates a consistent pattern: tourism activities are strongly associated with increased plastic waste generation and litter density, particularly in coastal and small-island systems (Table 2).

4.1.1 Coastal Mass Tourism

Seasonal monitoring in southern Bali reported waste volumes reaching thousands of tons per season, with plastics forming a significant fraction of beach debris (Astawa, 2022). In Komodo National Park, litter transects conducted on Padar Island revealed that plastics constituted approximately 90% of observed items, with cigarette butts and food wrappers dominating (Cordova et al., 2021). Citizen science monitoring in Labuan Bajo similarly documented

plastic bottles, cups, and food packaging as dominant debris categories (Kamil and Kusnanto, 2018). These findings highlight a structural link between high visitor intensity and coastal plastic accumulation.

4.1.2 Small Island Tourism

Studies in Gili Trawangan show that the hospitality sector contributes more than 70% of total local waste generation (Sekito et al., 2019). Waste volumes increase significantly during high season (Wulandari et al., 2025). In Mandalika, meso- and macro-debris surveys show plastics representing a substantial fraction of beach litter (Widiyanti et al., 2023). Small islands face unique logistical constraints. Limited landfill space and high transport costs increase mismanagement risk.



Table 2. Summary of tourism-related waste studies in Indonesia

Location	Site	Method	Key Findings	Tourism Context	Reference
Bali (South)	Kuta Beach	Seasonal coastal survey	21–2100 tons/season; plastic and foam significant	Beach tourism; F&B; seasonal peaks	Astawa (2022)
Bali (Badung)	Nusa Dua	Daily waste observation	11 ton/day; 1.43 kg/room/day; 30% inorganic	Hotel-dominated waste	Widyarsana et al. (2022)
Nusa Penida	NP, NL, NC	Flow analysis	42% unmanaged; limited facility capacity	Island tourism	Widyarsana and Agustina (2020)
Labuan Bajo	8 beaches and port	Citizen science	Plastic bottles, cups dominant	Land and marine tourism	Kamil and Kusnanto (2018)
Padar Island	Hiking transect	Litter transect and FTIR	90% plastic; 0.14 item/m ² ; cigarette butts dominant	400–600 visitors/day hiking	Cordova et al. (2021)
Lombok (Gili)	Gili Trawangan	Waste generation analysis	Hotels contribute >70%; 8.6 ton/day total	Small island tourism	Sekito et al. (2019)
Lombok (Gili)	Gili Trawangan	Seasonal survey	Plastic increases in high season	Tourist seasonality	Wulandari et al. (2025)
Mandalika	Batu Berang	Beach transect	60% meso plastic	Event and coastal tourism	Widiyanti et al. (2023)
Yogyakarta	Malioboro	Daily volume obs.	Waste doubled during peak holidays	Urban tourism	Intandari (2025)
DIY Kulon Progo	Bidara and Congot	Daily composition	Plastic 36% (Bidara), 8% (Congot)	Beach warung activity	Rizaldi (2024)
Pangandaran	West and East Beach	Volume and transect	0.97–1.23 kg/bed/day; marine plastic 28%	Hotel and coastal tourism	Ashuri and Kustiasih (2020)
Mojokerto	Tanjungan Village	Daily observation	0.13 kg/capita/day; low awareness	Rural tourism	Tarigan et al. (2023)
Jakarta	Hotel Aston	Daily audit	0.92 kg/bed/day; 88% recyclable	Urban hotel	Purwaningrum et al. (2023)

4.1.3 Urban Cultural Tourism

In Yogyakarta (Malioboro), waste volumes reportedly doubled during peak holiday periods (Intandari, 2025). This surge reflects high visitor turnover and packaging-intensive culinary consumption. In Pangandaran, hotel waste intensity reached up to 1.23 kg per bed per day in non-star hotels, while marine debris fractions included substantial plastic components (Ashuri and Kustiasih, 2020). These studies indicate that tourism-driven waste intensification is not limited to island systems but also occurs in urban and peri-urban destinations.

4.1.4 Emerging Village Tourism Systems

In smaller tourism villages, such as Tanjungan, Mojokerto, per capita waste generation was lower (0.13 kg per capita per day), yet management systems remained limited (Tarigan et al., 2023). This suggests that scale alone does not determine risk; governance and awareness also play a role.

4.1.5 Synthesis of Literature Patterns and Link to Present Study

These literature findings support the need for a standardized, destination-level baseline assessment using mass-balance and Sankey modeling, as implemented in this study. First, tourism facilities, especially hotels, are major contributors to local waste generation. Several studies report waste intensity between 0.9-1.4 kg per bed per day in hotel systems (Ashuri and Kustiasih, 2020; Purwaningrum et al., 2023; Widyarsana et al., 2022). This aligns closely with the intensity ranges observed in this study (Section 4.2-4.5).

Second, plastics dominate visible coastal litter, particularly in high-density and marine tourism areas. Studies in Bali and Komodo National Park report plastic shares exceeding 80-90% in some transects (Cordova et al., 2021; Astawa, 2022). This is consistent with the high plastic fractions (32-38%) measured in facility-level waste composition in the present assessment.

Third, seasonality and event-based surges strongly influence waste generation. Evidence from Lombok and Yogyakarta shows clear spikes during peak tourism periods (Wulandari et al., 2025; Intandari, 2025). This supports the typology-based interpretation presented in Section 4.6, where capacity constraints amplify leakage risk during peak demand.

However, previous studies primarily focus on volume or composition. Few apply mass-balance or flow-based approaches linking generation to leakage. The present study extends this literature by integrating facility audits, infrastructure assessment, and Sankey modeling to quantify potential leakage pathways. This integration allows for a more policy-relevant interpretation of tourism plastic dynamics.

Across destinations, several consistent patterns emerge. These include single-use plastics dominate the inorganic fraction, waste generation correlates with visitor intensity and seasonality, hotels are major contributors to tourism waste streams, data on per-visitor plastic intensity remain limited and monitoring is often episodic rather than system-based.

Management performance varied significantly. While some facilities reported active segregation and recycling partnerships, a large share of plastics remained unsorted at source. In destinations with limited infrastructure, unsorted waste increased the probability of mismanagement. Sankey modeling at aggregate level indicates that a portion of plastics is recovered through formal and informal recycling, the majority is directed toward controlled disposal (landfills or dumps), and a smaller but environmentally significant fraction is mismanaged and at risk of leakage. Although leakage percentages may appear numerically small, high visitor volumes magnify environmental impact. The following sections present the primary destination-specific empirical findings generated under this framework.

4.2 Mass Tourism System (Bali)

4.2.1 Waste Generation and Composition

In Bali, tourism waste generation ranged from 0.9 to 2.4 kg per visitor per day, with a mid-estimate of approximately 1.70 kg per visitor per day. Plastic represented approximately 34% of total waste,

equivalent to 0.58 kg plastic per visitor per day. Waste generation occurred both inside facilities (hotels, restaurants) and outside (public areas, visitor-brought waste). The Sankey model shows that food waste remains the largest fraction overall, but plastics dominate the inorganic stream (Figure 1).

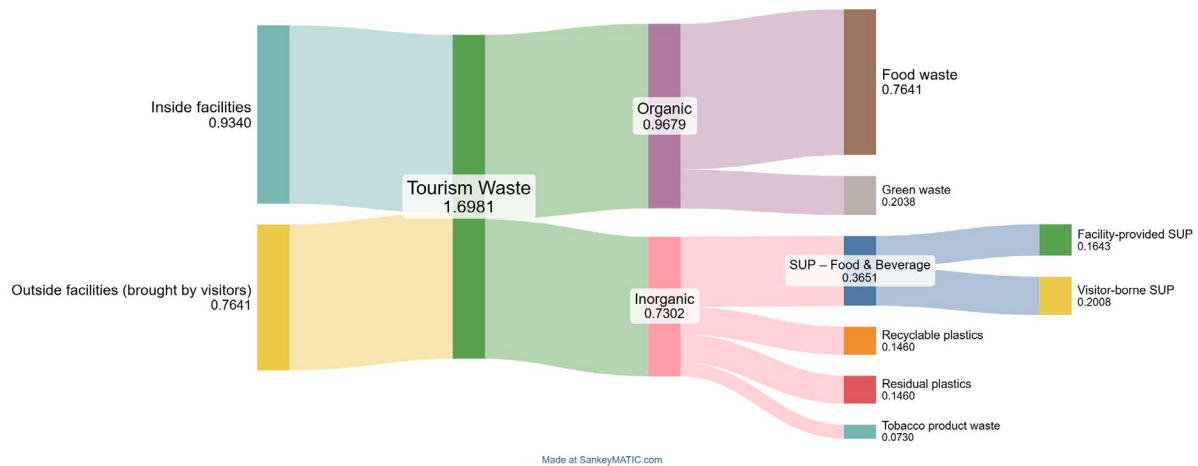


Figure 1. Composition flow of tourism waste in a mass tourism destination in Bali, Indonesia (kg/visitor/day).

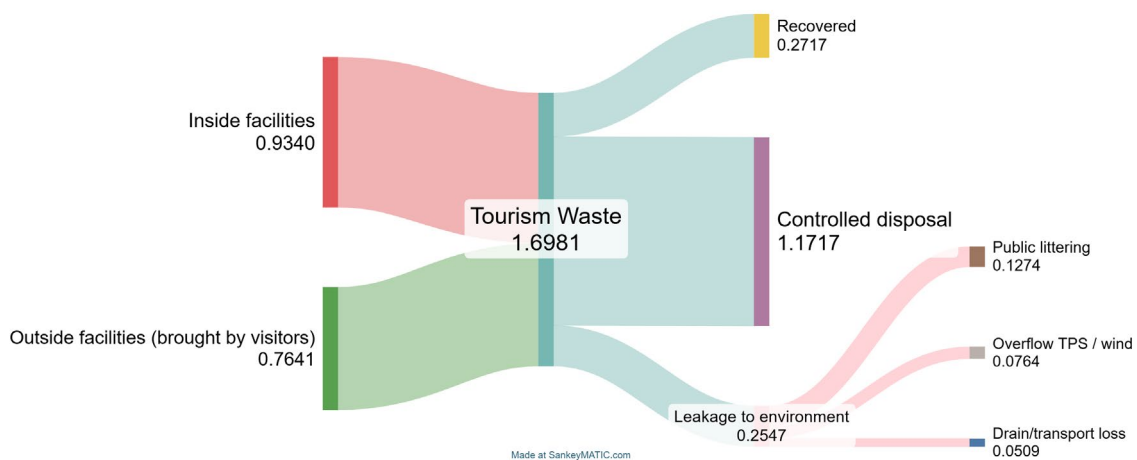


Figure 2. Management outcome flow of tourism waste in a mass tourism destination in Bali, Indonesia (kg/visitor/day).

Organic waste dominates the composition (57%), primarily food waste (45%), which is consistent with high-volume hospitality and food service operations. Inorganic waste accounts for 43%, with single-use plastics (SUP-F&B) contributing 21.5% of total waste. Notably, nearly half of SUP waste (11.8%) is visitor-borne, indicating that external purchases (takeaway items, retail packaging) remain significant

even in regulated environments. Residual plastics (8.6%) and recyclable plastics (8.6%) are balanced, suggesting moderate sorting efficiency but still substantial contamination. Tobacco product waste represents 4.3% by mass, though likely higher by item count.

From the outcome perspective (Figure 2), 69% of waste enters controlled disposal systems, while 16% is recovered and 15% leaks to the environment. leakage is mainly driven by public littering (7.5%), followed by overflow or wind dispersal. This pattern reflects relatively structured collection systems but persistent beach-related exposure risks.

Overall, Bali demonstrates a semi-structured mass tourism waste system with moderate recovery performance and non-negligible leakage linked to high visitor density and coastal dynamics.

4.2.2 Management Performance

Segregation performance varied by facility class. Higher-tier hotels showed better sorting practices. Smaller establishments and public areas exhibited lower segregation rates. The majority of waste was directed toward controlled disposal. However, leakage pathways were observed through public littering near beaches, overflow at temporary storage sites, and riverine transport during monsoon. Plastic items

collected during coastal transects accounted for 30-60% of visible debris, consistent with prior studies (Purba et al., 2019). Bali's plastic challenge is primarily driven by scale. Even moderate leakage rates translate into substantial environmental loads due to high visitor volume. This confirms the typology described in Chapter 2: Bali is a volume-dominant system.

4.3 Urban Cultural Tourism (Yogyakarta)

4.3.1 Waste Generation and Composition

Waste generation in Yogyakarta ranged from 0.7 to 2.1 kg per visitor per day, with a mid-estimate of approximately 1.47 kg per visitor per day (Figure 3). Plastics accounted for approximately 32% of total waste (around 0.47 kg per visitor per day). Packaging-intensive street food culture significantly influenced plastic composition. Takeaway containers and multilayer packaging were common.

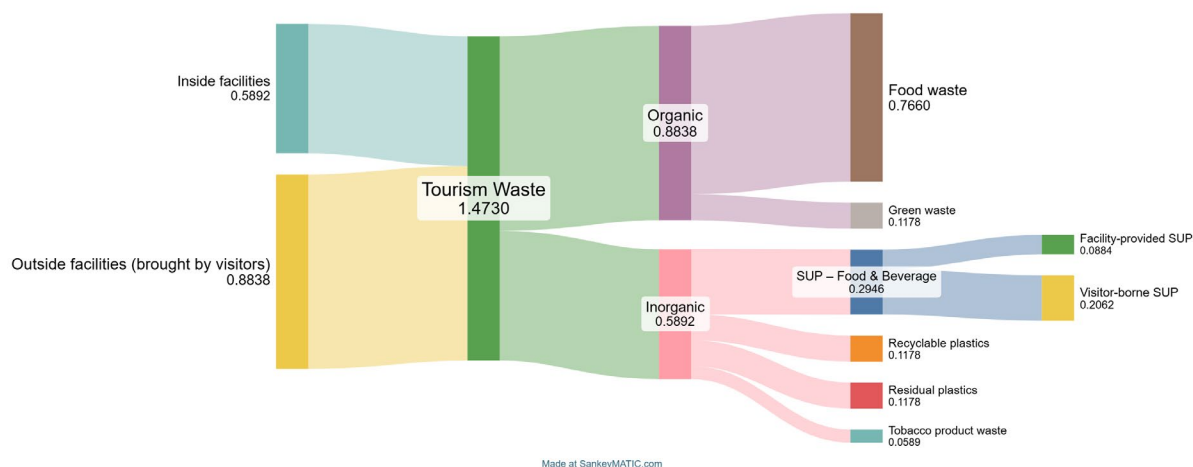


Figure 3. Composition flow of tourism waste in an urban tourism destination in Yogyakarta, Indonesia (kg/visitor/day).



Figure 4. Management outcome flow of tourism waste in an urban tourism destination in Yogyakarta, Indonesia (kg/visitor/day).

Organic waste represents 60% of total waste (Figure 4), driven primarily by food waste (52%), which aligns with the city's culinary tourism profile and high street-food density. Inorganic waste constitutes 40%, with SUP-FEB accounting for 20%. A distinctive feature is the high share of visitor-borne SUP (14%), indicating that packaging purchased outside formal facilities (retail, takeaway, delivery services) significantly contributes to the waste stream. Recyclable and residual plastics each account for 8%, suggesting moderate recovery potential but limited segregation effectiveness.

Outcome analysis shows 73% controlled disposal, 15% recovery, and 12% leakage, the lowest leakage rate among the four regions. leakage pathways are relatively balanced between public littering and urban drainage losses. This reflects a more structured urban collection network compared to island-based destinations. Yogyakarta therefore represents a relatively stable urban waste system, where leakage is lower but visitor-driven packaging consumption remains a structural challenge.

4.3.2 Management Performance

Sorting at vendor level was limited. Municipal collection systems captured a large share of total waste. However, leakage risk was associated with urban drainage during rainfall and informal dumping in peri-urban zones. Short-stay visitors contributed to

higher packaging intensity per transaction. Yogyakarta's plastic profile is shaped by urban mobility and culinary packaging. Leakage risk is structurally linked to stormwater systems rather than direct coastal disposal. This aligns with the urban tourism typology.

4.4 Small Island and Event-Based Tourism (Lombok)

4.4.1 Waste Generation and Composition

Waste generation ranged from 0.8 to 2.0 kg per visitor per day, with a mid-estimate of approximately 1.61 kg per visitor per day. Plastics accounted for approximately 37% (0.59 kg per visitor per day).



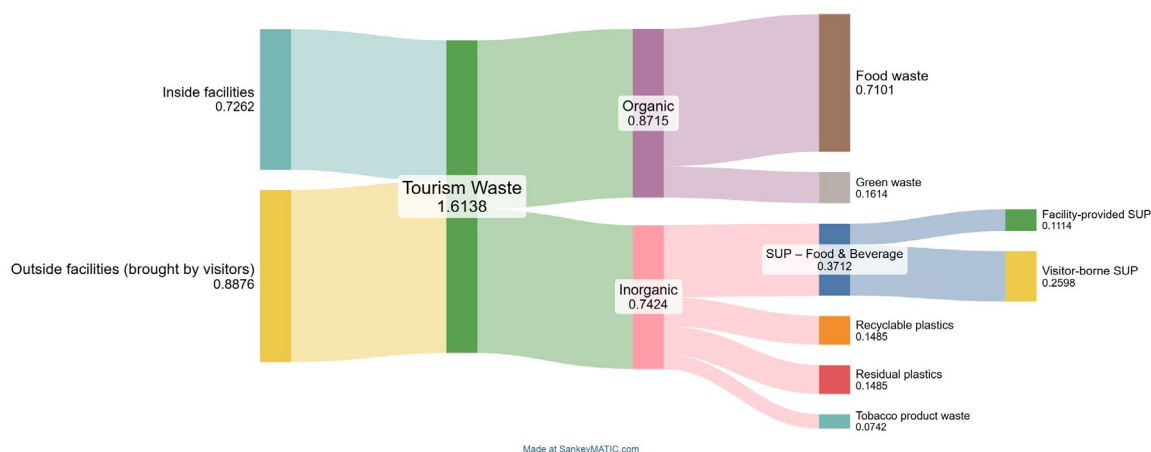


Figure 5. Composition flow of tourism waste in a small island tourism destination in Lombok, Indonesia (kg/visitor/day).



Figure 6. Management outcome flow of tourism waste in a small island tourism destination in Lombok, Indonesia (kg/visitor/day).

Organic waste accounts for 54% (Figure 5), while inorganic waste is relatively high at 46%. SUP-F&B contributes 23%, with the majority (16.1%) being visitor-borne. This indicates substantial external consumption and takeaway behavior. Residual plastics (9.2%) are elevated, suggesting limited recovery capacity for multi-layer or contaminated materials. Tobacco product waste (4.6%) is notable and consistent with coastal recreation patterns.

Outcome distribution shows 20% leakage, significantly higher than Bali and Yogyakarta. Public littering accounts for over half of leakage, reflecting open coastal areas and seasonal infrastructure stress. Recovery is modest (12%), while 68% enters controlled disposal.

Lombok thus exhibits characteristics of a semi-managed island waste system, where infrastructure capacity and seasonal tourism pressures amplify leakage risks. Moreover, event weeks were observed to significantly increase daily waste volumes. Temporary surges often exceeded routine system capacity.

4.4.2 Management Performance

Small island sub-destinations, such as Cili Islands, exhibited limited landfill space and high logistics costs for off-island transfer. Segregation rates were lower compared to Bali. leakage proxies indicated elevated risk during high-occupancy weeks and periods of insufficient transport frequency

Observed leakage pathways included open dumping and spillage at collection points. In Lombok, plastic leakage risk is strongly linked to infrastructure constraints and seasonal surges rather than daily average volume. This supports the small island typology framework.

4.5 Nature and Marine Tourism (Labuan Bajo)

4.5.1 Waste Generation and Composition

Waste generation ranged from 0.5 to 2.2 kg per visitor per day, with a mid-estimate of approximately 1.59 kg per visitor per day. Plastics constituted approximately 38% of total waste (around 0.61 kg per visitor per day), the highest fraction among the four destinations.

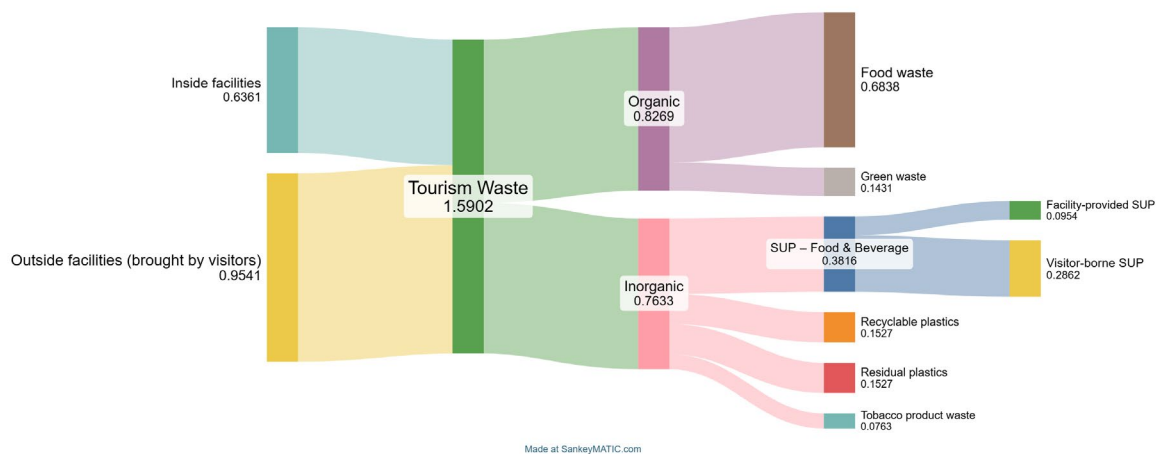


Figure 7. Composition flow of tourism waste in a nature-based tourism destination in Labuan Bajo, Indonesia (kg/visitor/day).

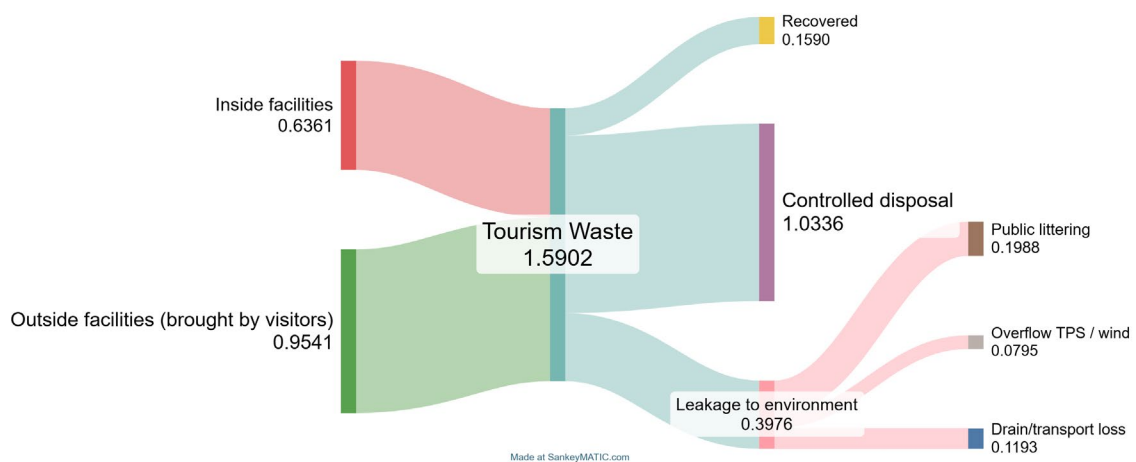


Figure 8. Management outcome flow of tourism waste in a nature-based tourism destination in Labuan Bajo, Indonesia (kg/visitor/day).

Organic waste represents 52%, while inorganic waste reaches 48%, the highest proportion among the four regions (Figure 7). SUP-FEB accounts for 24%, and most of it (18%) is visitor-borne, indicating significant dependence on packaged goods during excursions. Residual plastics (9.6%) are relatively high, suggesting limited local recycling infrastructure. Tobacco product waste (4.8%) also contributes meaningfully, particularly in open coastal environments.

Outcome analysis reveals the highest leakage rate (25%), with nearly half attributed to public littering and a substantial share linked to transport or marine dispersal. Recovery remains low (10%), while 65% reaches controlled disposal (Figure 8).

Labuan Bajo therefore represents a high-leakage nature-based tourism system, where infrastructure limitations and spatial dispersion increase environmental vulnerability. Boat-based tourism introduced decentralized waste streams. Onboard consumption of bottled water and packaged food was common.

4.5.2 Management Performance

Port inspection and municipal systems captured a substantial share of waste. However, monitoring of onboard disposal practices was inconsistent. leakage proxies were associated with improper onboard storage, limited inspection capacity, and small island transfer points.

Given the ecological sensitivity of Komodo National Park, even small leakage fractions pose significant environmental risk. Labuan Bajo represents a marine governance-sensitive system. leakage risk is amplified by ecosystem fragility rather than sheer waste volume.

4.6 Comparative Synthesis

Across the four tourism typologies, waste generation ranges from 1.47 to 1.70 kg/visitor/day, indicating relatively high consumption intensity compared to typical municipal per capita waste benchmarks in

Indonesia. A clear gradient emerges mass tourism (Bali) shows the highest waste intensity (1.70 kg), an urban tourism (Yogyakarta) shows the lowest (1.47 kg). Small island (Lombok) and nature-based tourism (Labuan Bajo) fall in between but closer to mass tourism levels. This suggests that service density and hospitality scale, rather than visitor numbers alone, strongly influence per-visitor waste generation.

Table 3. Typological distinction appears in waste origin

Typology	Inside (%)	Outside (%)
Mass tourism	55	45
Urban tourism	40	60
Small island tourism	45	55
Nature-based tourism	40	60

In this research we found a strong typological distinction appears in waste origin (Table 3). Urban and nature-based destinations show a dominance of visitor-borne waste, reflecting takeaway consumption, retail packaging, delivery services, decentralized informal vendors. Mass tourism (in Bali), in contrast, shows higher internal generation due to full-service hotels, in-house FEB, and centralized facility-based waste streams. This indicates that policy interventions must differentiate between facility-centered waste governance and visitor consumption control mechanisms.

All destinations show organic waste dominance (52-60%), largely driven by food waste. However, the environmental risk profile is shaped by the inorganic fraction (40-48%), particularly SUP-FEB (20-24%), residual plastics (8-10%), tobacco product waste (~4-5%). Nature-based and small island tourism show higher inorganic shares, which is critical because infrastructure is weaker, environmental sensitivity is higher, and leakage consequences are more severe. This creates a structural vulnerability mismatch, higher-risk materials in lower-capacity systems.

Table 4. Recovery performance and residual burden of tourism waste

Typology	Recovered (%)	Leakage (%)
Mass tourism	16	12
Urban tourism	15	15
Small island tourism	12	20
Nature-based tourism	10	25

Recovered waste remains modest across all typologies, while leakage presents the clearest typological distinction (Table 4). The relatively low recovery performance reflects contaminated plastic streams, limited segregation compliance, and dominance of residual multilayer packaging. As residual plastics increase, recovery potential structurally decreases, reinforcing a linear disposal pathway.

leakage increases with coastal exposure, spatial dispersion, infrastructure limitations, and event-driven waste surges. Nature-based tourism (Labuan Bajo) shows the highest leakage rate, driven by public lit-

tering and transport loss in marine contexts. This confirms that environmental vulnerability amplifies waste system weaknesses.

Although tobacco product waste contributes only ~4-5% by mass, field observations suggest high item density. This indicates a mismatch between mass-based quantification, visual pollution perception, and ecological microplastic risk. Future assessments should therefore integrate item-based density indicators alongside mass flow modeling.

Across typologies, three systemic patterns emerge waste intensity is linked to service scale and consumption style, visitor-borne waste dominates in decentralized tourism systems, and leakage risk increases as infrastructure stability decreases.

In short, urban systems manage waste better but face consumption pressure. Meanwhile, mass tourism generates more waste but has stronger collection systems. Moreover, island and nature-based systems face disproportionate environmental leakage risk.





5. POLICY, INSTITUTIONAL CONTEXT, AND STRATEGIC RECOMMENDATION

5.1 National Policy Alignment

Indonesia has established a comprehensive regulatory framework to address plastic pollution. The National Plan of Action on Marine Debris (2018-2025) targets a 70% reduction in marine plastic debris. Complementary regulations include Extended Producer Responsibility (EPR) under Ministerial Regulation No. 75/2019 and regional single-use plastic bans. These frameworks provide strategic direction. However, translation into tourism-specific operational mechanisms remains limited.

Findings from Chapter 4 indicate several structural gaps

1. Lack of tourism-specific waste intensity benchmarks.
2. Inconsistent enforcement of SUP bans across destinations.
3. Limited integration of hospitality sector into EPR schemes.
4. Insufficient monitoring of plastic flows at facility level.
5. Weak linkage between marine conservation governance and tourism operators.

Tourism supply chains rely heavily on beverage and FMCC products. However, producers' waste reduction roadmaps rarely integrate tourism-specific return systems. Deposit-return systems, refill infrastructure, and supplier take-back mechanisms remain underdeveloped in most destinations. Bridging EPR implementation with tourism procurement systems represents a high-impact opportunity. In small islands, infrastructure limitations further constrain regulatory effectiveness.

5.2 Institutional Coordination Challenges

The results presented in Chapters 4 and 5 demonstrate that tourism plastic pollution in Indonesia is not driven by a single factor. It is shaped by volume, infrastructure capacity, governance gaps, and consumption patterns. A transition toward plastics-reduced tourism therefore requires

systemic, multi-level interventions. Solutions must address generation intensity, supply chains, segregation and recovery, leakage prevention, and institutional coordination.

Tourism waste governance spans multiple agencies, including Ministry of Environment, Ministry of Forestry, Ministry of Tourism, Provincial and municipal governments, Port authorities (marine tourism areas), and Informal waste sector. Fragmentation reduces accountability. Destination-level coordination mechanisms remain uneven. Policy responses must reflect tourism typology. In Bali, we suggest to do supply chain reform and large-scale monitoring. In Yogyakarta, we recommend MSME packaging reform. In Lombok we suggest to infrastructure and seasonal surge planning. While in Labuan Bajo we recommend onboard waste regulation and marine inspection. One-size-fits-all policies are unlikely to be effective.

Waste management in tourism destinations operates across overlapping mandates. Responsibilities are distributed, but not always aligned. At the national level, regulatory functions sit with environmental and tourism authorities. At the local level, implementation falls on municipal governments, often with limited operational capacity. The private sector-hotels, restaurants, tour operators-controls a large share of waste generation, yet operates under uneven compliance and reporting obligations. Informal actors remain active, but rarely integrated into formal systems. This fragmentation creates three recurring issues. First, unclear responsibility at the operational level. Sorting, transport, and treatment are often assumed to be someone else's role, especially in mixed-use tourism zones. Second, weak data ownership. Multiple institutions collect data, but there is no single system that consolidates and validates it. Third, limited coordination mechanisms. Existing forums tend to be ad hoc, project-based, or donor-driven, rather than institutionalized.

A structured overview of institutional roles, formal mandates, and observed gaps in implementation within tourism waste management is provided in Table 5.

Table 5. Institutional roles, mandates, and gaps in tourism waste management

National environmental authority	Regulation, target setting, compliance oversight	Policy development, limited enforcement at local level	Weak enforcement chain to sub-national level
National tourism authority	Tourism development and standards	Promotion, limited integration of waste requirements	Waste not embedded in tourism performance indicators
Local government (municipality/district)	Waste collection and management	Collection and transport, limited sorting and treatment	Capacity constraints, budget limitations
Private sector (hotels, restaurants)	Waste handling within premises	Partial sorting, outsourced collection	No standardized reporting or obligation
Waste service providers	Collection, transport, treatment	Operate based on contract scope	Focus on collection, not reduction
Informal sector	No formal mandate	Material recovery (plastics, recyclables)	Not integrated into formal system
NGOs / projects	Support, pilot interventions	Short-term programs	Lack of continuity and scale-up

5.3 Strategic Recommendations

Findings from Chapter 4 confirm that interventions must reflect destination structure (Table 6). This sub chapter outlines a pathway structured across three time horizons, immediate (1-2 years), medium-term (3-5 years), and structural transformation (beyond 5 years).

Table 6. Typology-based policy priorities

Typology	Recovered (%)	Leakage (%)
Mass tourism	16	12
Urban tourism	15	15
Small island tourism	12	20
Nature-based tourism	10	25

5.3.1 Immediate Actions (1-2 Years)

Immediate actions should focus on low-cost, high-impact measures that can be implemented within existing governance structures. Findings from Chapter 4 indicate that plastic intensity and segregation gaps are measurable and can be addressed without large capital investments.

Tourism destinations should institutionalize reporting of kg waste per guest-night, kg plastic per visitor, and segregation rates. Mandatory simple waste log-books for hotels and restaurants can significantly improve transparency. Evidence from this study shows that intensity data are currently fragmented. Without standardized baselines, policy effectiveness cannot be evaluated.

Across all four destinations, recurring high-risk items include bottled water (PET), food wrappers, sachets, straws and lids, and cigarette butts. Focused reduction strategies for these items can yield measurable leakage reduction. Targeted interventions are more feasible than blanket plastic bans.

Hotels and restaurants should shift procurement practices toward refill water systems bulk purchasing, reusable serveware, and supplier take-back agreements. Procurement reform does not require major capital investment. It requires management commitment. Mass tourism destinations such as Bali could lead this transition due to their established supply chains.



5.3.2 Medium-Term Actions (3-5 Years)

While immediate actions focus on operational improvements at facility level, medium-term interventions must address structural integration within the tourism-waste system. Findings from Chapter 4 show that leakage risk is not only a function of generation, but also of system performance. In several destinations, recovery remains fragmented and institutional coordination uneven. Strengthening integration between tourism operators, local governments, and producer responsibility schemes is therefore essential. Over a three- to five-year horizon, interventions should prioritize system alignment, infrastructure stabilization, and formalization of recovery pathways.

Producers under Extended Producer Responsibility (EPR) schemes should integrate tourism facilities into deposit-return systems, reverse logistics, and take-back partnerships. Tourism areas concentrate beverage consumption. This creates an opportunity for efficient recovery systems.

Producers operating under EPR frameworks should align their financial contributions with the geographic distribution of product sales. Tourism destinations represent high-density consumption nodes, particularly for bottled beverages and fast-moving consumer goods. As such, EPR financing mechanisms should reflect the volume of products placed on the market within each tourism-intensive region.

5.3.3 Structural Transformation (Beyond 5 Years)

Long-term transformation requires moving beyond incremental waste reduction toward systemic circularity. The evidence presented in this report indicates that tourism plastic flows are deeply embedded in procurement patterns, supply chains, and consumption culture. Addressing leakage alone is insufficient if generation remains structurally high. A long-term transition must therefore redesign how materials enter, circulate within, and exit tourism destinations. This involves aligning environmental governance, market incentives, and tourism branding under a unified circular economy framework.

Destinations should move beyond waste management toward circularity by local material recovery hubs, supplier consolidation, and plastic footprint certification. Eco-labeling systems for hotels can incentivize performance through reputational mechanisms. Specifically in marine tourism area, such as in Labuan Bajo, marine-based tourism requires mandatory onboard waste storage standards, port-based inspection systems, and digital reporting for boat operators. Given ecosystem sensitivity, prevention is more effective than remediation.

Plastic reduction can become a competitive advantage. Research indicates that environmental quality influences tourist satisfaction and destination choice (UNEP, 2021). Indonesia can position plastics-reduced tourism as part of its sustainability narrative.

5.4 Financing and Cost Framework

The transition from baseline assessment to implementation depends on one question: who pays, and for what. Current systems rely heavily on public budgets, often focused on collection and disposal. Upstream interventions (such as reduction, reuse, and sorting) remain underfunded, despite their lower long-term cost. A disaggregated cost structure, distinguishing capital, operational, and behavioral/ system-related components, is presented in Table 7.

Table 7. Cost structure and potential financing sources

Capital cost	Infrastructure (bins, MRF, composting units)	Public funding (local government)	Public–private co-financing, grants
Operational cost	Collection, transport, sorting	Municipal budget	Service fees, tourism levy
Reduction systems	Refill stations, reusable systems	Limited pilots	Private sector investment, EPR
Monitoring & reporting	Data collection, audits	Minimal	Government + donor support
Awareness & behavior change	Campaigns, training	Project-based	Shared responsibility (public + private)
Leakage control	Coastal cleanup, interception systems	Reactive approach	Blended finance (public + CSR + tourism sector)

5.5 Monitoring, Reporting, and Verification (MRV) Framework

Implementation needs a tracking system that can actually be used on the ground. Not perfect. Not overly technical. But consistent enough that results from Bali, Yogyakarta, Lombok, and Labuan Bajo can be read in the same way. Without that consistency, comparisons become misleading, even if the numbers look precise. The framework proposed here is structured in three layers (Table 8). The separation matters, because many systems fail when everything is measured at once without distinction.

5.5.1 Input indicators

These describe whether the system is in place. It is less about performance and more about readiness. For example, how many facilities have introduced waste sorting? Are refill systems available, or still absent? Are businesses participating, or opting out? These indicators answer a simple question: is the system being adopted at all.

5.5.2 Output indicators

This is where operational discipline shows up. Waste generated per visitor becomes a useful metric here, especially when tracked over time rather than as a single value. The proportion of waste sorted at source also sits in this layer, together with collection coverage. These are not abstract indicators. They can be measured monthly with relatively simple tools.

5.5.3 Outcome indicators

This is where change becomes visible. Has residual waste decreased? Is recycling actually increasing, or just reported as such? What portion of waste is still likely to leak into the environment? These indicators require some level of aggregation and interpretation. They should not be overused at the early stage, but they remain necessary to assess whether interventions are doing what they are supposed to do.

Table 8. Proposed KPI framework for tourism waste management

Type	Indicator	Unit	Frequency	Source
Input	Facilities implementing waste sorting	% of total facilities	Quarterly	Facility reporting
Input	Availability of refill systems	Number of locations	Quarterly	Local authority / private sector
Output	Waste generated per visitor	kg/visitor/day	Monthly	Logbook and estimation
Output	Waste sorted at source	%	Monthly	Facility reporting
Output	Collection coverage	% of waste collected	Monthly	Local government
Outcome	Recycling rate	% of total waste	Quarterly	Waste flow analysis
Outcome	Residual waste reduction	% change	Annual	Aggregated data
Outcome	Leakage estimate	% or ton/year	Annual	Model-based estimation

Data collection should start from the lowest practical level. A facility-level logbook is often enough. Daily records, even if imperfect, provide a more reliable basis than occasional surveys. Digital systems can be introduced later, once routines are established. Pushing for digitalization too early often results in gaps rather than improvements.

Verification is often overdesigned. It does not need to be. Periodic audits, combined with random spot checks, are sufficient in the early phase. The point is not to eliminate all error. The point is to keep the data usable over time. Once patterns are visible, refinement can follow.

One issue tends to be overlooked. Definitions. What counts as sorted? What is classified as recycled? Does informal recovery count, or not? If these are not standardized from the start, the system produces numbers that cannot be compared across locations. Once inconsistencies are embedded, they are difficult to correct later.

Thus the MRV framework should not aim for completeness at the beginning. It should aim for stability. A small set of indicators, applied consistently, will do more work than a long list that no one maintains..

CONCLUSION

Tourism in Indonesia represents both opportunity and responsibility. It generates employment, strengthens regional economies, and shapes the country's global identity. At the same time, it intensifies material consumption and contributes significantly to local plastic waste streams. When waste systems are under strain, even small management gaps can translate into environmental leakage.

This study provides one of the first structured, typology-based baseline assessments of plastic use and waste flows within Indonesia's tourism sector. By integrating facility-level audits, stakeholder engagement, infrastructure analysis, and mass-balance Sankey modeling, it moves beyond volume estimation toward system understanding.

Across Bali, Yogyakarta, Lombok, and Labuan Bajo, several consistent patterns emerge.

First, plastic constitutes a substantial fraction of tourism-generated waste. In all destinations assessed, plastics represent a structurally significant component of total waste streams. Hotels and hospitality facilities are key nodes within these flows.

Second, leakage risk is not determined solely by visitor numbers. It is shaped by infrastructure stability, segregation performance, governance coordination, and ecosystem sensitivity. High-volume systems such as Bali face scale-driven risk. Small islands such as Lombok face capacity-driven risk. Marine-based systems such as Labuan Bajo face ecological amplification of even small leakage fractions. Urban systems such as Yogyakarta face runoff-linked pathways.

Third, previous studies across Indonesia consistently confirm that tourism intensity correlates with plastic accumulation in coastal and recreational environments. However, most existing research remains focused on volume or litter density. The present study contributes by linking generation, management, and leakage within a coherent analytical framework.

The findings demonstrate that targeted interventions can significantly reduce tourism-related plastic leakage without constraining visitor growth. Improvements in segregation, procurement reform,

EPR alignment, and small-island infrastructure could meaningfully lower mismanaged fractions.

Importantly, the transition toward plastics-reduced tourism should not be framed as a constraint on economic development. Instead, it represents an opportunity to enhance destination resilience, improve environmental quality, and strengthen international competitiveness. Clean beaches, healthy reefs, and well-managed urban spaces are not only environmental goals; they are tourism assets.

Indonesia has already established a strong regulatory foundation through its National Plan of Action on Marine Debris and Extended Producer Responsibility roadmap. The next phase requires sector-specific operationalization. Tourism provides a strategic entry point because it concentrates consumption and visibility.

A typology-based policy approach is essential. One-size-fits-all interventions will not address the structural diversity of Indonesia's tourism systems. Aligning EPR financing with territorial sales distribution, integrating cross-subsidy mechanisms for small islands, strengthening marine governance for boat-based tourism, and formalizing partnerships with the informal recycling sector are all realistic pathways identified in this report.

Finally, this baseline should be understood not as an endpoint, but as a foundation. Continued monitoring, annual intensity reporting, and iterative Sankey modeling will allow destinations to track progress and adapt interventions over time.

Indonesia stands at a pivotal moment. By integrating environmental science, tourism planning, and circular economy principles, it can position itself not only as a world-class destination, but as a global leader in sustainable tourism governance. The transformation toward plastics-reduced tourism is both necessary and achievable. The evidence presented in this report provides a roadmap for that transition.

DOCUMENTATION

Focus Group Discussion with the Environmental Agency, Tourism Office, community representatives, researchers, academia, hotel owners, restaurant owners, café owners, and tourism destination managers to gather methodological insights, conduct stakeholder mapping, and organize a kick-off meeting prior to the commencement of sampling activities at each sampling sites.



FGD in Labuan Bajo was conducted on January 27, 2026



FGD in Bali was conducted on February 5, 2026



FGD in Lombok was conducted on February 3, 2026



FGD in Yogyakarta was conducted on January 29, 2026

The data was primarily derived from primary sources at each location. Primary data were collected directly from waste generated by hotels, cafés, restaurants, and tourism destinations. Samples were collected by a team of experts in accordance with standardized research methodologies.



Waste data were systematically collected from hotel rooms across Lombok. The sampling was conducted over a six-day period, from 2 to 7 February, ensuring adequate representation of daily waste generation patterns. This approach enabled a more comprehensive assessment of waste composition, volume, and variability within hotel operations during the study period.



Waste data collected from hotel rooms were systematically compared and analyzed with waste data obtained from temporary waste storage facilities (TPS) at a three-star hotel in Lombok. This comparative analysis aimed to assess variations in waste composition, volume, and management practices between point-of-generation sources and centralized collection points, providing a more comprehensive understanding of waste generation patterns within hotel operations.



Waste data were also collected from tourism destinations. The waste depicted in the image was gathered from a cave-based tourism site located in Labuan Bajo, providing additional insights into waste generation and management practices in natural tourist attractions.



Waste data were also analyzed at beach sites in Labuan Bajo. The sampling was conducted over a six-day period, from 26 to 31 January, to capture variations in waste generation and composition in coastal tourism areas.



Meanwhile, waste data from several beaches were collected over a five-day period, from 2 to 6 February, to ensure representative coverage of waste generation patterns across multiple coastal sites.



Not only hotels, waste data were also collected from cafés. The sampling sites were consistent across all locations to ensure comparability of results. This image was taken during the analysis of waste collected from a café in Bali.



The sampling period for waste collected in Yogyakarta was conducted over six days, from 26 to 31 January 2026.



Waste data were collected in Yogyakarta at one of its historic tourism sites, providing insights into waste generation patterns within cultural heritage destinations.

REFERENCES

- Ashuri, A., and Kustiasih, T. (2020). Timbulan dan komposisi sampah aktivitas pariwisata di Pantai Pangandaran. *Jurnal Presipitasi*, 15, 1-9. <https://doi.org/10.31815/jp.2020.15.1-9>
- Astawa, P. (2022). Seasonal waste management in the southern coasts of Bali, Indonesia. *Journal of Indonesian Sustainable Development Planning*, 3, 95-100. <https://doi.org/10.46456/jisdep.v3i1.266>
- Badan Pusat Statistik. (2023). Tourism statistics of Indonesia. BPS Indonesia. Coordinating Ministry for Maritime Affairs. (2018). Indonesia's National Plan of Action on Marine Debris (2018-2025).
- Cordova, M. R., and Nurhati, I. S. (2019). Major sources and monthly variations in the release of land-derived marine debris from the Greater Jakarta area, Indonesia. *Scientific Reports*, 9, 18730. <https://doi.org/10.1038/s41598-019-55065-2>
- Cordova, M. R., and Nurhati, I. S. (2019). Major sources and monthly variations in the release of land-derived marine debris from the Greater Jakarta area, Indonesia. *Scientific Reports*, 9, 18730. <https://doi.org/10.1038/s41598-019-55065-2>
- Cordova, M. R., et al. (2022). Marine debris distribution and sources in Indonesian waters. *Marine Pollution Bulletin*.
- Cordova, M. R., Purbonegoro, T., Puspitasari, R., et al. (2021). Preliminary study of the effect of tourism activities on litter pollution: A case study on Padar Island, Komodo National Park, Indonesia. *Journal of Ecological Engineering*, 22, 131-139. <https://doi.org/10.12911/22998993/140265>
- Jambeck, J. R., Ceyer, R., Wilcox, C., Siegler, T., Perryman, M., Andrady, A., Narayan, R., and Law, K. L. (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. <https://doi.org/10.1126/science.1260352>
- Jambeck, J. R., Ceyer, R., Wilcox, C., Siegler, T., Perryman, M., Andrady, A., Narayan, R., and Law, K. I. (2015). Plastic waste inputs from land into the ocean. *Science*, 347(6223), 768-771. <https://doi.org/10.1126/science.1260352>
- Kamil, S. Y., and Kusnanto. (2018). Citizen science network: Plastics dominate the trash found in 8 Labuan Bajo beaches and Komodo National Park.
- Kaza, S., Yao, L., Bhada-Tata, P., and Van Woerden, F. (2018). What a waste 2.0: A global snapshot of solid waste management to 2050. World Bank.
- OECD. (2022). Global plastics outlook: Economic drivers, environmental impacts and policy options. OECD Publishing.
- Purba, N. P., et al. (2019). Marine debris in Indonesian beaches. *Marine Pollution Bulletin*. Sekito, T., et al. (2019). Waste generation from tourism activities in Cili Trawangan. *SN Applied Sciences*. <https://doi.org/10.1007/s42452-019-1369-4>
- Tarigan, et al. (2023). Waste generation in tourism village systems. *IOP Conference Series: Earth and Environmental Science*, 1257, 012016.
- United Nations Environment Programme. (2021). From pollution to solution: A global assessment of marine litter and plastic pollution. UNEP.
- United Nations Environment Programme. (2021). From pollution to solution: A global assessment of marine litter and plastic pollution. UNEP.
- Widiyanti, A., et al. (2023). Marine debris mitigation strategy in supporting sustainable tourism in SEZ Mandalika Lombok. *Jurnal Presipitasi*, 20, 53-66. <https://doi.org/10.14710/presipitasi.v20i1.53-66>
- Wulandari, T. J., Suripto, S., and Ernawati, E. (2025). Analysis of waste generation in the Cili Trawangan tourism area. *Journal of Biological Tropics*, 25, 1171-1179. <https://doi.org/10.29303/jbt.v25i1.9252>



United Nations Development Programme

Menara Thamrin 7-9th Floor

Jl. MH Thamrin Kav. 3

Jakarta 10250

Indonesia

<https://www.undp.org/indonesia>

©UNDP 2026