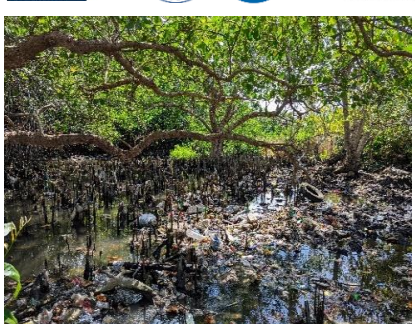
Plastics in Indonesian Societies (PISCES):

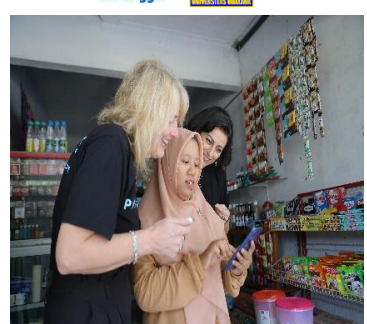
A Systems Analytics Approach to Reduce Plastic Pollution

Scientific Report for the Indonesian Government and Key Stakeholders

Authored by Scientists from The PISCES Partnership

Funded by UK Research and Innovation, Global Challenges Research Fund





Preface

Plastics dispersing into the environment via land-air pathways and leaking into the global oceans and seas represents a huge system failure of epic proportions, threatening marine food webs and causing physical and chemical contamination of every environmental compartment.

Indonesia is among the nations most impacted by plastic pollution and mismanaged waste. It currently generates around 7 million tonnes of plastic waste per year, a figure that is growing by 5 percent annually, yet its waste management sector collects only 39% of all solid waste generated and even less is recycled.

Without major intervention, plastic pollution, including ocean leakage, will increase by 30 percent by 2025 and more than double by 2040 with huge negative environmental, health, economic and social consequences.

Context

Solving the problem of plastic pollution is at the very top of the political agenda of the Indonesian Government.

Coordinated through the national coordination team for marine debris management (TKN-PSL), The National Action Plan (NAP; 2017-2025) aims to reduce marine plastic debris by 70% by 2025 and to achieve a circular economy for plastic by 2040 as an example to be adapted and implemented in other countries.

To coordinate implementation of the NAP, the National Plastic Action Partnership (NPAP) serves as a platform to bring together the most influential players across the plastics value chain, from policymakers to consumer goods giants to NGO's

The NPAP Policy RoadMap (2022) describes various legislative and voluntary measures and initiatives to reduce the consumption of single-use plastics (SUPs), and subsequently, reduce plastic waste.

Despite substantial efforts, however, progress across Indonesia's 17,000 islands is inhibited by increasing production and use of single use plastic, poor waste management, lack of education and a diversity of cultural and social, political and infrastructural challenges that are poorly understood.

Tackling this complex problem effectively requires the adoption of an interdisciplinary, multi-stakeholder and systemic approach.

INDONESIA TARGETS

- **By 2025, reduce ocean plastic by 70%[1]**
- **70% handling rate for all waste + 30% reduction of waste at source[2]**
- **By 2025 double waste collection to 80%[3]**
- **By 2040, achieve plastic pollution free Indonesia that embodies principles of circular economy**

1 Indonesia Presidential decree No. 97 year 2017
2 Indonesia's plan of action on marine plastic debris under Presidential decree No. 83 year 2018
3 Article for World Economic Forum Meeting by Luhut B. Pandjaitan, Coordinating Minister for Maritime Affairs and Investment, Coordinating Ministry for Maritime Affairs of Indonesia

The PISCES Partnership

To help accelerate efforts to meet the 2025 target and support the government's total ban on single use plastic waste by 2030, working in close collaboration with Indonesia's Coordinating Ministry of Maritime Affairs and Investment, **the Plastics in Indonesian Societies (PISCES) public-private-academic Partnership** was formed.

PISCES brings political, environmental, economic, technical and social academic experts and multi-sectoral action delivery partners together to co-develop and deliver a comprehensive and coordinated scientific research and action programme to understand and address the root causes of plastic pollution.

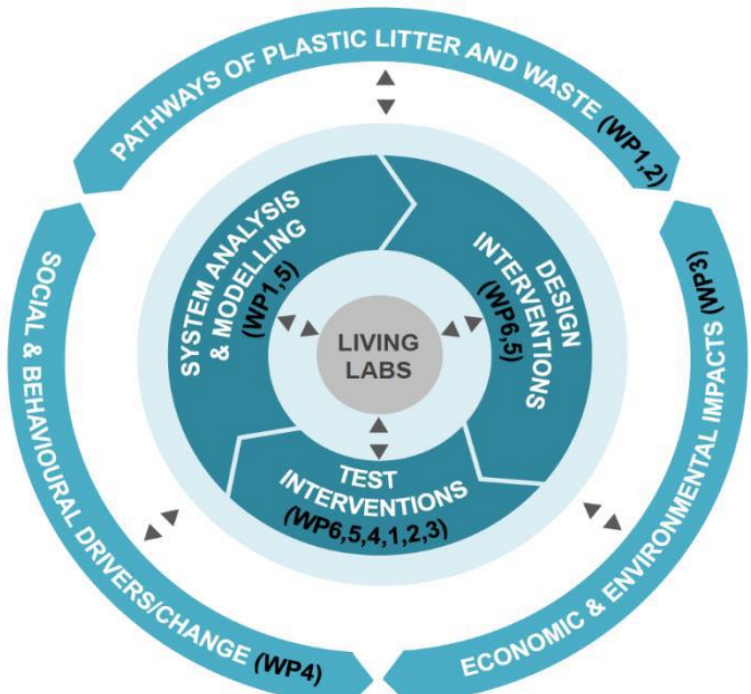
By leveraging interdisciplinary research, innovative solutions, and community engagement, ultimately the PISCES Partnership aims to help create an enabling environment to empower local communities to become agents of positive change in reducing plastic pollution and promoting sustainable development, addressing the Sustainable Development Goals (SDGs) 3, 4 11,12 and 14.

PISCES Research Programme

Funded by UK Research and Innovation, the PISCES Research Programme (2021-2024) applied a structured systems analytical approach to develop a deep interdisciplinary understanding of the nature of the complexity underpinning the failure of plastic waste management systems, together with a programme of research to trial and test combinations of solutions.

Here we present the results of our PISCES research programme, consisting of a framework of 6 interconnected work packages (WPs 1-6; chapters 1-6 of this report), together aiming to provide the core elements of a systems-based toolbox with which to understand the sources and drivers of plastic pollution, assess impacts, and co-design and test interventions, mitigations and adaptations.

Ultimately our toolbox is designed to enable policymakers and practitioners to make evidence-based decisions and other actions aimed at reducing and eliminating plastic pollution.



Susan Jobling
Director, PISCES Partnership and Program

Outline

Chapter 1.
Modelling Causes, Sources, Pathways and Accumulation of Plastic Waste to Identify Hotspots, Informing interventions

Costas Velis[a], Emenda Sembiring[b], Joshua Cottom[a], Ed Cook[a], Attar Ramadan[b], Susan Jobling[c]

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Contents

WP1 Team (left to right): Dr Costas Velis (*University of Leeds*), Dr Emenda Sembiring (*ITB*), Attar Ramadan (*ITB*), Dr Joshua Cottom (*University of Leeds*).

Context

Plastic pollution has many detrimental impacts once released in the environment. This relates not only to the harm it causes on ecosystems, and particularly the marine environment, but also to infrastructure (blocked drains), public health (air quality from open burning) and the economy (damage to tourism).

Once in the environment, plastic breaks down into innumerable microplastics making clean-up even more challenging. Instead, we need to act at source, before the flow of plastic waste into the environment becomes uncontrolled.

Moreover, because the source of this pollution stems from uncollected waste and open burning of waste there is need to understand the solid waste management system and behaviours of individuals self-managing their waste in much greater detail to understand where and how to intervene .

Current estimations of plastic emissions are highly uncertain, mainly due to a lack of field data to drive modelling efforts. The work of our team, in collaboration with the wider PISCES Partnership, is therefore focused on addressing the fundamental requirement to develop more accurate and comprehensive models of waste generation and management and the uncontrolled release and movement of plastic into and across the environment from land-based sources across Indonesia.

PISCES

Open burning of waste in concrete storage container (*Photo credit: Josh Cottom*)

Context

National modelling of sources, pathways and fate of plastic wastes, identifying plastic pollution hotspots to prioritise for intervention is a key requirement for mitigating plastic pollution because it helps us to answer the following questions:

How can we tackle plastic pollution over a country as big and diverse as Indonesia?

Where should we monitor or intervene?

How do we cope with the different scales (e.g. National policies, Regency waste management, local behaviours)?

How can we deal with varying data quality, scales, timeframes and units?

How can we report progress on a consistent basis?

The 'Spatio-temporal quantification of plastic pollution origins and transportation model' (SPOT) provides the basis for our national-scale modelling of hotspots (Chapter 1.1) whilst the Plastic Pollution Calculator (PPC), developed as part of the International Solid Waste Association (ISWA) Marine Litter Task Force aims to account for the local details of solid waste management, infrastructure, behaviours and environment to quantify the amount of plastic pollution emitted into the environment by all major source at key case study sites (Chapter 1.2).

7 stage approach to preventing plastic pollution. The SPOT model as applied by WP1 aims to quantify the hotspots of plastic pollution both in terms of emissions and movement in the environment. This can be periodically repeated to track progress towards targets.

1.1
Modelling Sources, Pathways and Accumulation of Plastic Waste to Identify Hotspots at the National Scale

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Executive summary

Mitigating plastic pollution over a country the size of Indonesia requires prioritisation of locations, interventions and monitoring efforts. The SPOT and ISWA Plastic Pollution Calculator (PPC) models, developed by the University of Leeds, include toolkits designed to aid in the identification of plastic pollution hotspots and to conduct more comprehensive multi-disciplinary assessments at a local scale so that evidence-based action plans developed, accounting for local practices and infrastructure.

In Chapter 1.1, we describe use of the SPOT model by our waste characterisation and modelling teams to predict hotspot locations of plastic pollution across Indonesia and to quantify emissions to the environment from all major sources. Further insight is also provided on crucial aspects such as the amount of plastic emitted as debris compared to that openly burned, as well as quantification of municipal solid waste flows within the solid waste management system for all Regencies.

Three research findings are highlighted in this synthesis study:

1. The SPOT model is introduced with explanation provided on how this can form the basis for on-going prioritisation of locations and sources of plastic pollution in Indonesia.

2. Material flow analysis results are presented at a national, provincial and regency level, showing flows of plastic waste and quantifying emissions into the environment by major sources.

3. Modelling is performed to determine where plastic in the environment moves to, and what the hotspot locations of plastic pollution are.

1.1 Methodology

The SPOT model is made up of two parts:

Part A: Emissions inventory

An R-based model that quantifies plastic emissions and sources at a Regency level across Indonesia to determine hotspot locations. Result can be aggregated to national scale.

Part B: Environmental movement

Uses R and GIS data to predict the overland and riverine (transboundary) movement of plastic emitted into the environment to quantify at risk locations, and link waste found in the environment to its source location and activity.

Part A: Emissions Inventory

Part B: Environmental movement

1.1 Methodology

SPOT Part A method: Regency data for the year 2020 was collected from the Sistem Informasi Pengelolaan Sampah Nasional (SIPSN) and Badan Purat Statistik (BPS) databases. Data was cleaned to remove erroneous values (e.g. implausible rates of waste generation or based on mass balance plausibility checks) whilst any data gaps were filled using provincial averages. Data collected from each dataset for the 502 Indonesian Regencies included:

SIPSN

- Waste generation rate
- Waste composition
- Recovery at TPS3R
- Recovery at waste banks
- Waste disposed at TPA
- Control status of TPA
- Informal sector recovery
- Collection coverage*

BADAN PUSAT STATISTIK

- Population
- Open burning behaviour (urban & rural)
- Itinerant buyers (urban & rural)

**estimated from mass collected / mass generated*

Regencies of Indonesia over which the SPOT model was applied

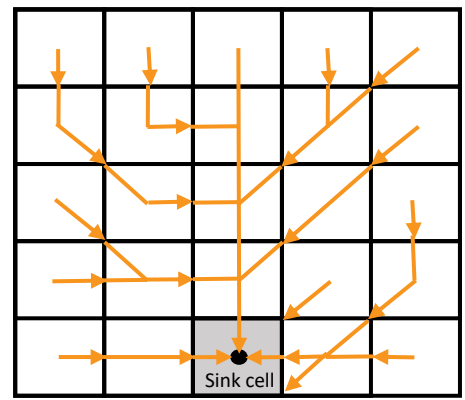
All inputs were allocated uncertainty according to a data pedigree approach (e.g. based on the reliability of the source data) and were used in SPOT to run probabilistic material flow analysis (MFA) for every Regency. The MFA quantified flows of waste in the solid waste management system, as well as flows of plastic waste emitted into the environment from 5 sources: (1) littering, (2) uncollected waste, (3) collection system, (4) disposal system, (5) formal / informal recycling systems. Emissions were further distributed based on if they were solid items (debris) or were openly burnt. Finally, emissions at the Regency level were aggregated to higher scales such as National level.

PISCES

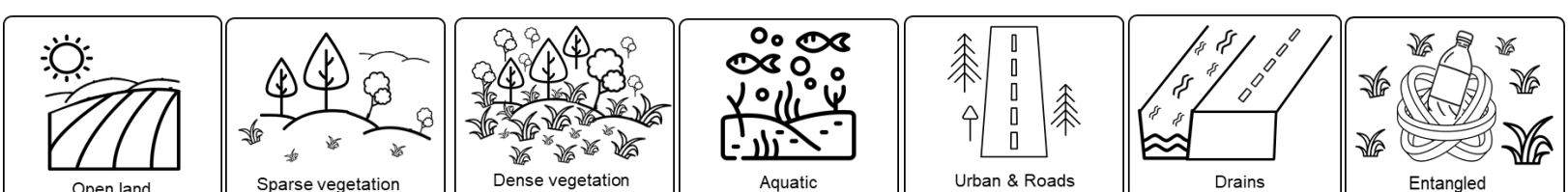
1.1 Methodology

SPOT Part B method: The plastic emissions for each Regency from SPOT Part A are spatially distributed to ~450m x 450m cells according to population density. The movement of plastic between cells is then dynamically predicted accounting for the geographical and meteorological conditions of the cell for the given time-step (month), as well as the material conditions of the plastic item (e.g. propensity for movement by wind or surface runoff). Flows are propagated according to digital elevation maps (DEMs) and between a series of domains (land uses).

The method is unique in that allows the pathways of plastic movement to be quantified at an unrivalled spatial resolution and accounts for both stocks (accumulations) and flows (movement). This details enables us to arrive at estimates for final sink location; e.g. the amount entering the ocean from a river, or the amount accumulating on land.



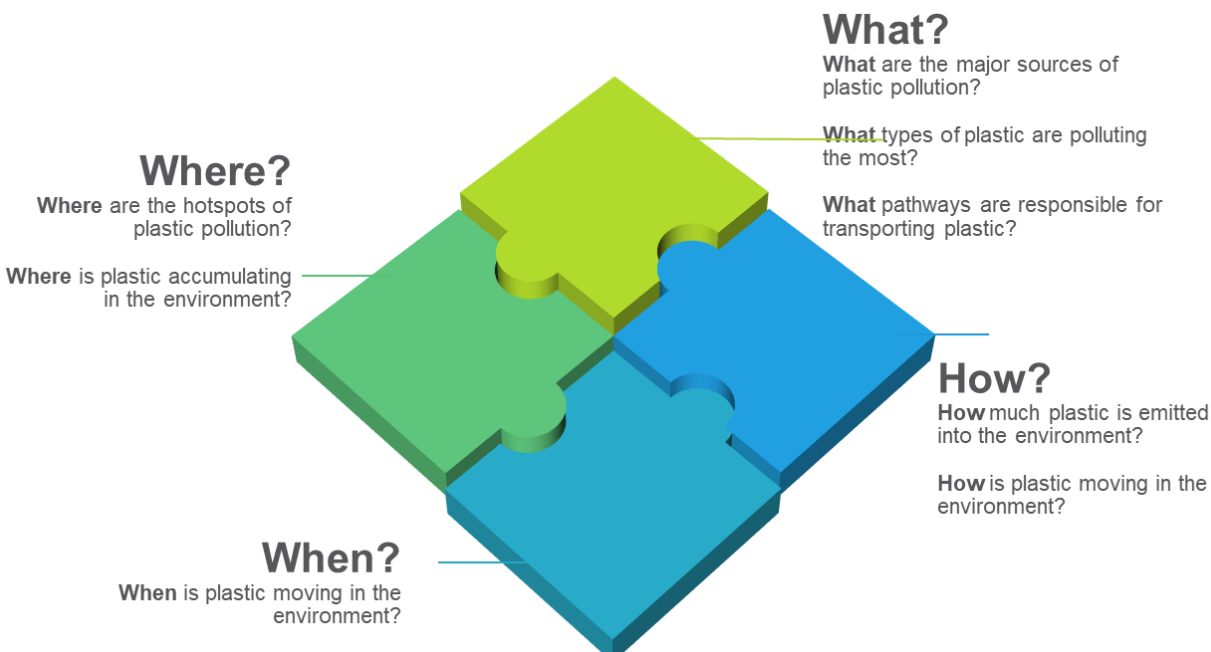
Example flow propagation according to a DEM



Domains through which plastic is propagated as part of SPOT Part B

1.1 Methodology

Together, SPOT Part A & B allow us to piece together different pieces of the puzzle and answer many important questions:



1.1 Methodology

Nationwide Sampling for Validation: Validation of SPOT requires understanding of the reliability of the solid waste management data that forms its input. This was performed by a rapid nationwide sampling approach undertaken by ITB. The sampling was conducted for household waste over four consecutive days across a number of hotspot and coldspot sites of Indonesia.

Three solid waste sampling methods were reviewed: Solid and Hazardous Waste Lab, ITB; Waste Wise Cities Tools (WACT) (UN-Habitat, 2021) and Indonesian standard (SNI 19-3964-1994) (Standar Nasional Indonesia, 1994). The number of samples collected was chosen based on the Indonesian Standard method, while the remaining methodology follows the Solid and Hazardous Waste Lab, ITB method and WACT.

The general procedures for sampling were:

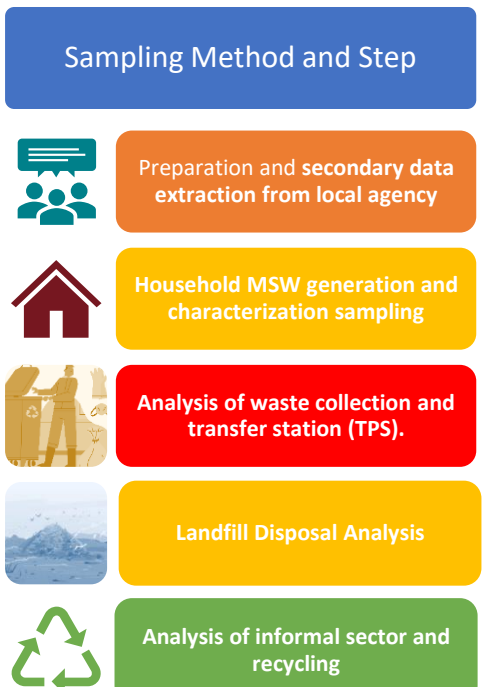
(1) Sampling preparation and secondary data extraction from local government agencies responsible for SWM

(2) Analysis of household MSW generation and characterization

(3) Analysis of waste collection and transfer stations (TPS)

(4) Analysis of waste transport and final disposal

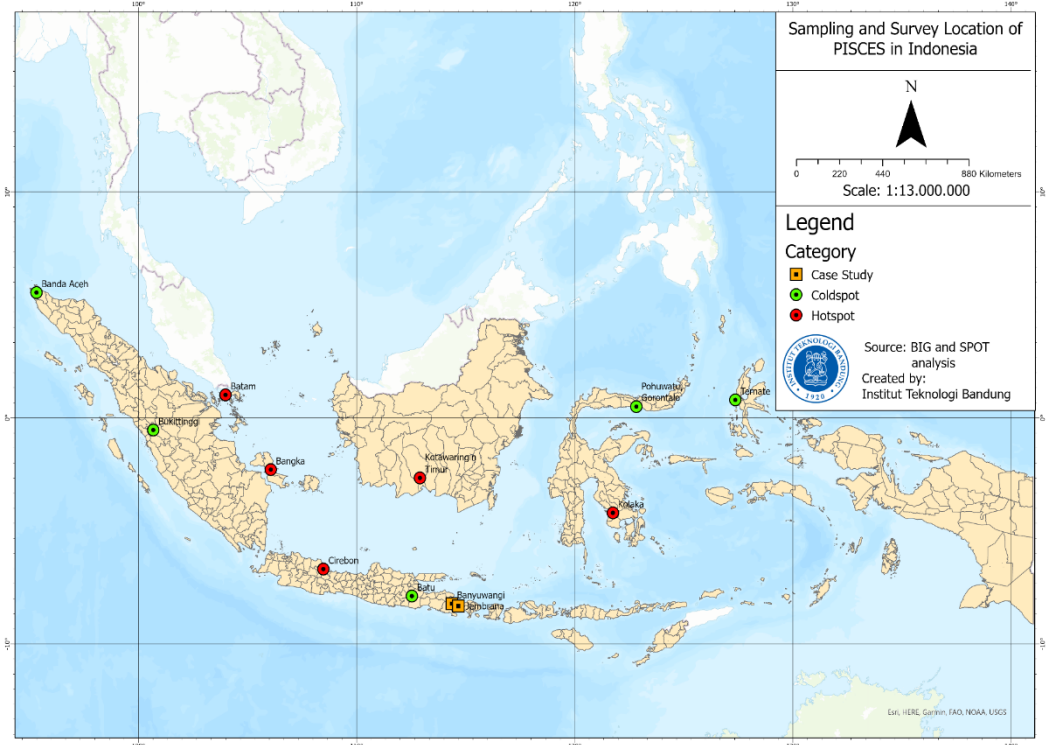
(5) Analysis of informal sector and recycling.



1.1 Methodology

Sites selected for nationwide sampling / validation were selected based on:

- Ranks in hotspot and coldspot analysis by SPOT model
- Anticipated reliability of SIPSN data (e.g. whether provincial averaging was used to fill data gaps).
- Solid waste facilities (i.e. Landfill)
- Special conditions (e.g. floating village of Pohuwatu, Gorontalo)

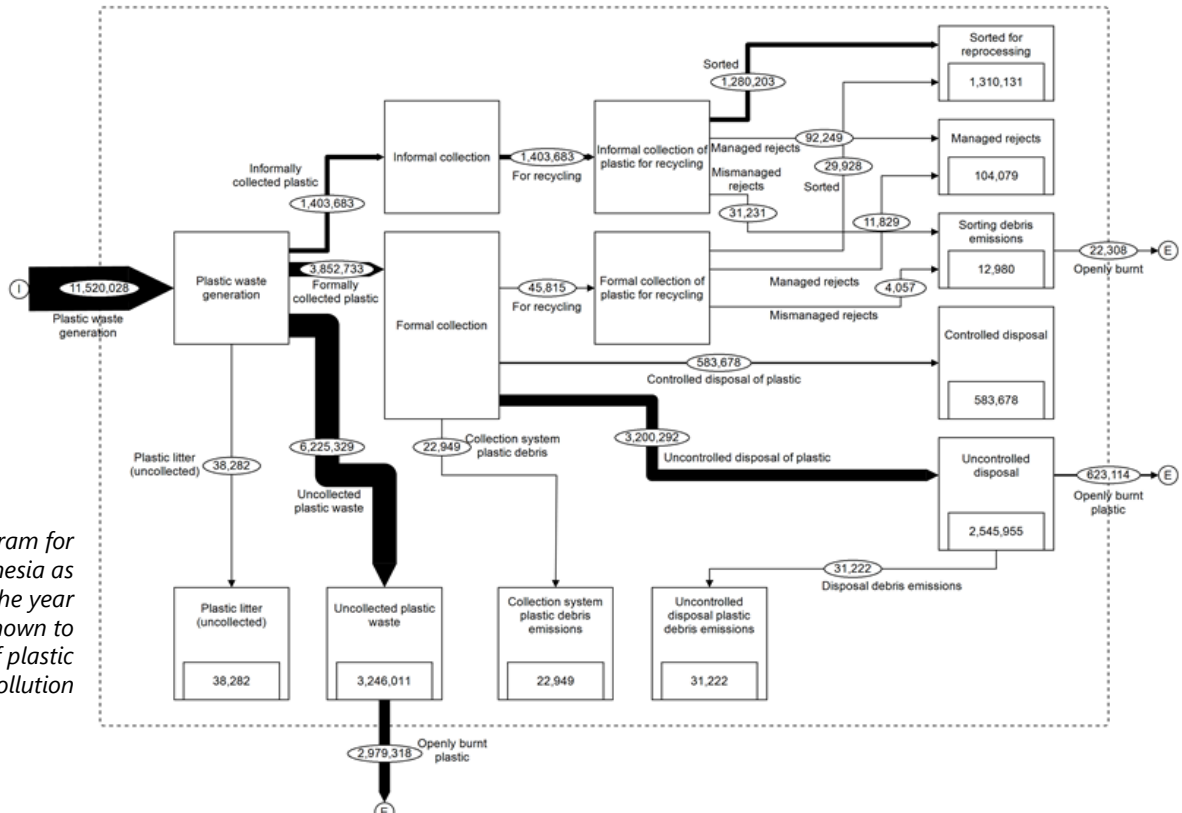


1.1 Results

National Material Flow Analysis

- An estimated 65 $Mt.y^{-1}$ of MSW is generated in Indonesia, equivalent to a per capita generation rate of 0.66 $kg.cap^{-1}.d^{-1}$.
- 18% of this MSW generated is plastic, leading to 11.5 $Mt.y^{-1}$ of plastic waste generation.
- ~46% of plastic waste is collected, either by the formal (3.8 $Mt.y^{-1}$) or informal sector (1.4 $Mt.y^{-1}$). Of this, 1.3 $Mt.y^{-1}$ is sorted for reprocessing, giving an overall plastic recycling rate of 11% w.r.t plastic generation.
- The remaining 54% of plastic waste (6.2 $Mt.y^{-1}$) remains uncollected and enters the environment either as debris (3.2 $Mt.y^{-1}$) or via open burning (3.0 $Mt.y^{-1}$).
- In total, 7.0 $Mt.y^{-1}$ of plastic waste is emitted into the environment in Indonesia, of which 42% is physical debris and 52% is openly burnt.
- Uncollected plastic waste accounts for 89% of plastic emissions, with emissions from uncontrolled disposal accounting for 9.4% (almost entirely from open burning), littering 0.6%, mismanaged sorting rejects 0.5% and collection system emissions 0.3% make up the remaining.

1.1 Results



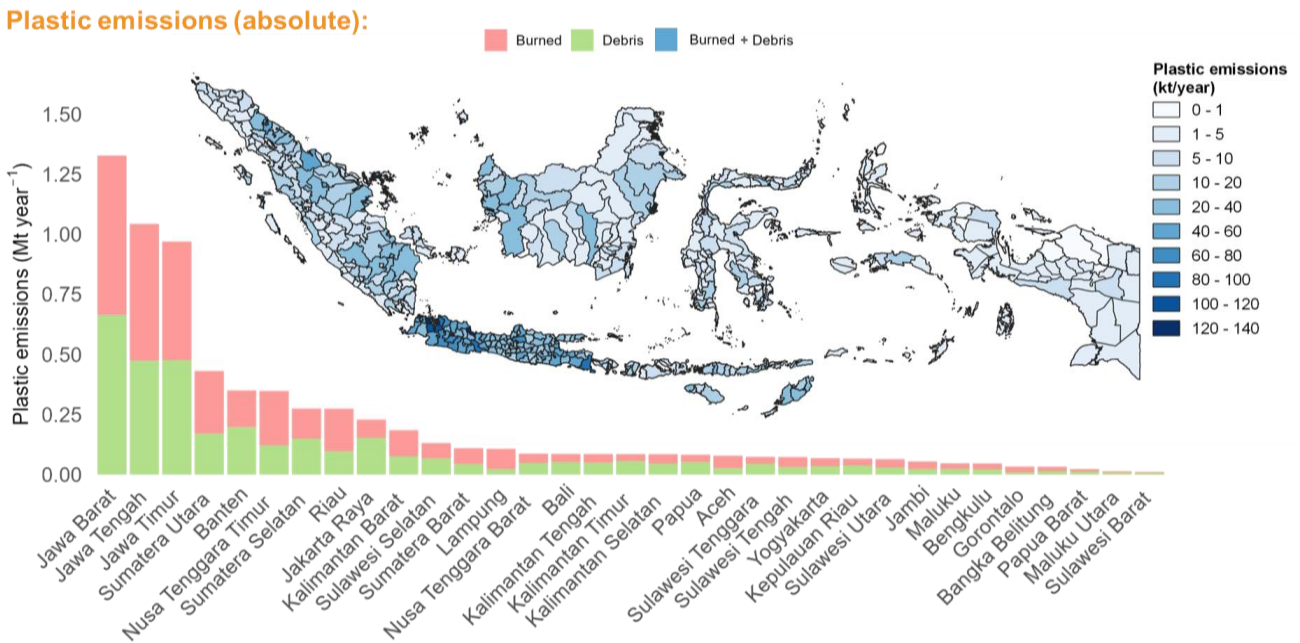
Material flow analysis diagram for plastic waste in Indonesia as quantified by SPOT for the year 2020. Uncollected waste is shown to be by far the largest source of plastic pollution

1.1 Results

Sub-national Material Flow Analysis Results

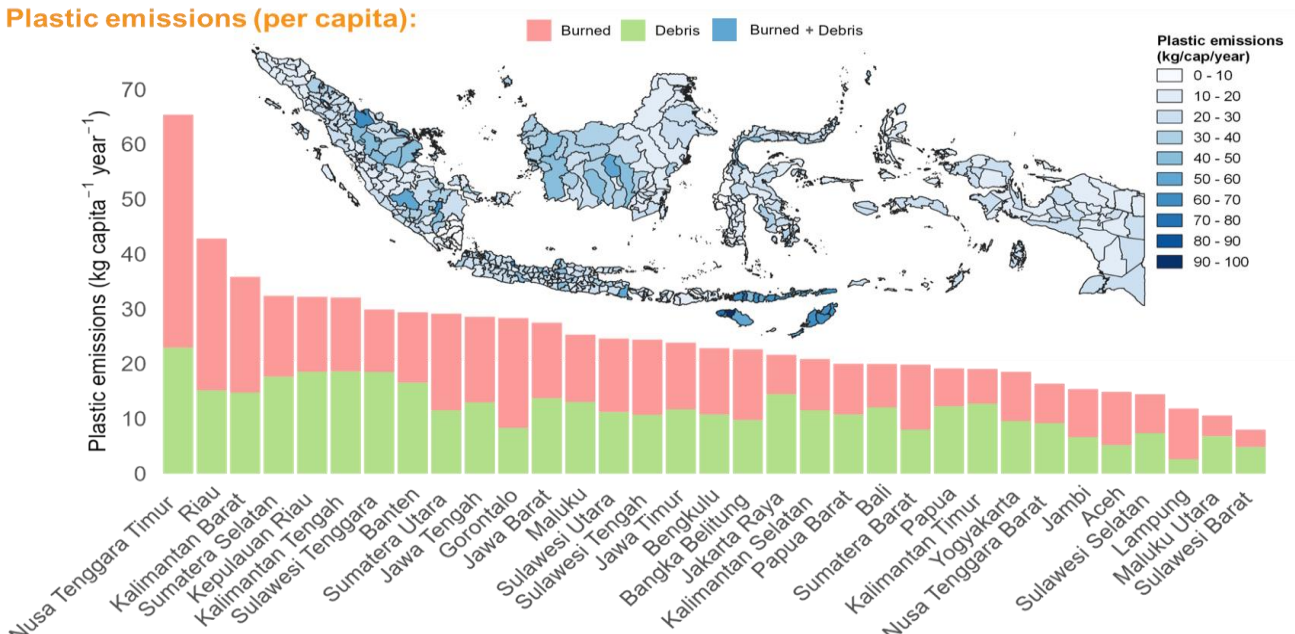
- In addition to the national MFA, waste flows are also quantified for each Regency in Indonesia allowing us to identify hotspot locations for plastic pollution.
- In terms of absolute mass, the largest emissions unsurprisingly come from the highly populated Provinces such as those of Java.
- However, Jakarta has relatively few emissions given its population due to its improved solid waste management.
- Per-capita emissions instead provide insight into the priority locations where solid waste management requires improving.
- Nusa Tenggara Timur was found to have the highest emissions per capita, largely as a result of its very low waste collection coverage.

1.1 Results



Regency and Provincial-level plastic emissions on an (a) absolute basis

1.1 Results



Regency and Provincial-level plastic emissions on a per-capita basis.

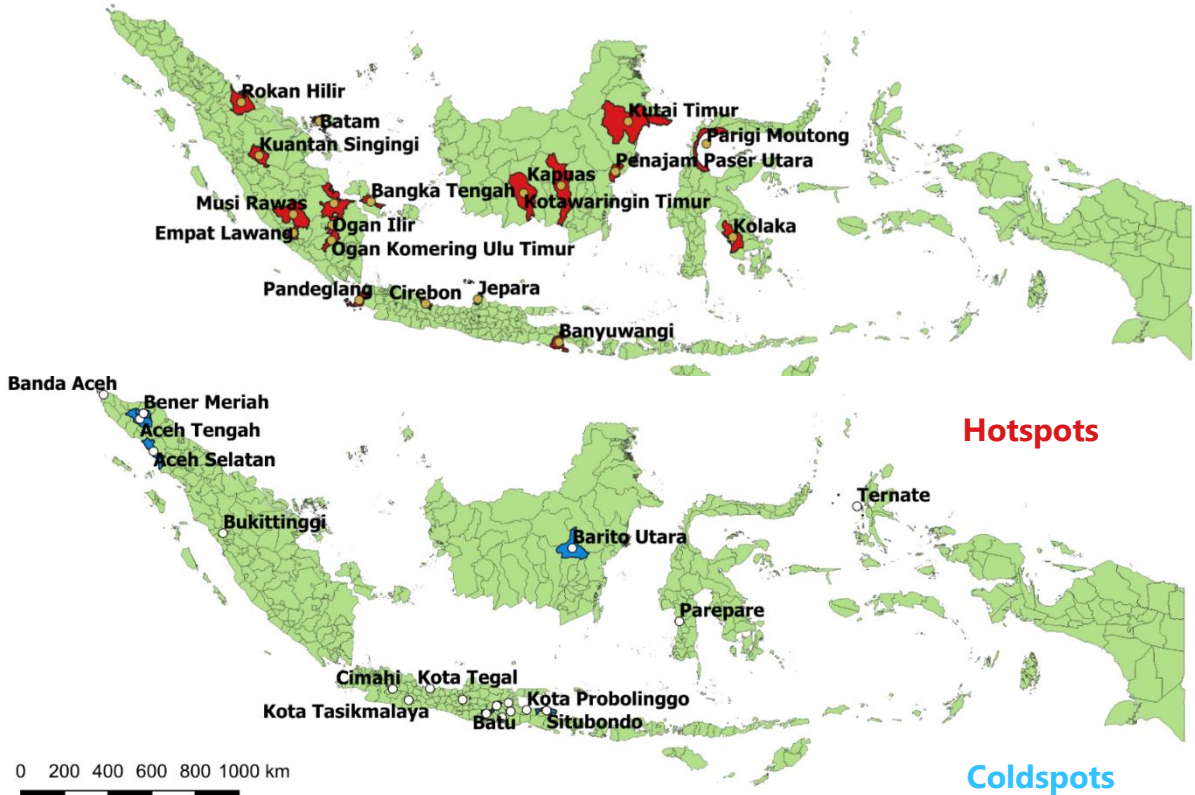
1.1 Results

Hotspot / coldspot identification

- SPOT results were also used to identify hotspot locations where more detailed assessments could be conducted and actions on mitigating plastic pollution formulated.
- Hotspot/coldspot locations were also used as areas where the modelling predictions were validated using the environmental sampling performed in WP2.
- To arrive at these hotspots and coldspots for Indonesia, we ranked Regencies according to their per capita plastic emissions. Specific regencies where then chosen which had high emissions (hotspots) and low emissions (coldspots), and which satisfied practical criteria for the sampling such as not being too large an area, having geographical spread and where predictions were based on reliable data (e.g. rather than ones which had data gaps interpolated).
- Preliminary results from the environmental sampling appear to validate the results from SPOT.

1.1 Results

Hotspot and coldspot locations of Indonesia as determined based on the per-capita plastic emissions

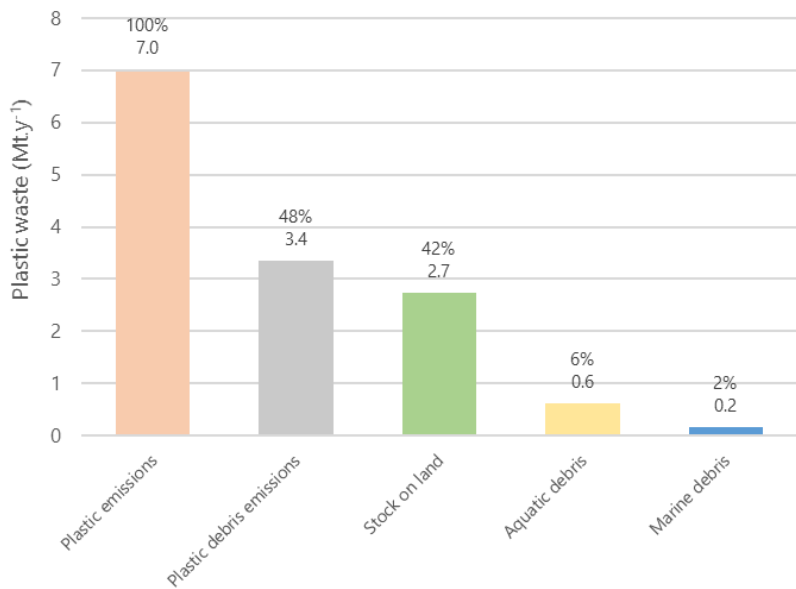


1.1 Results

Plastic movement in the environment

- SPOT part B results show the predicted movement of plastic debris waste once released in the environment.
- Of the 7.0 Mt.y^{-1} of plastic emissions, 3.4 Mt.y^{-1} (48%) is in the form of physical debris items.
- The majority (82%) of this plastic debris is predicted to remain as stock on land after one year, becoming either entangled in vegetation or accumulating in other terrestrial environments. Some of this plastic may move in subsequent years, or it may break down into microplastics.
- 0.6 Mt.y^{-1} of plastic debris is predicted to end up entering aquatic (riverine + marine) environments, with 0.2 Mt.y^{-1} reaching the oceans representing just 2% of plastic emissions.
- Despite this relatively small likelihood of emitted plastic reaching the marine environment, it still represents over 11 million plastic items entering Indonesian oceans each year*.

**assuming an average mass of 15g per item.*

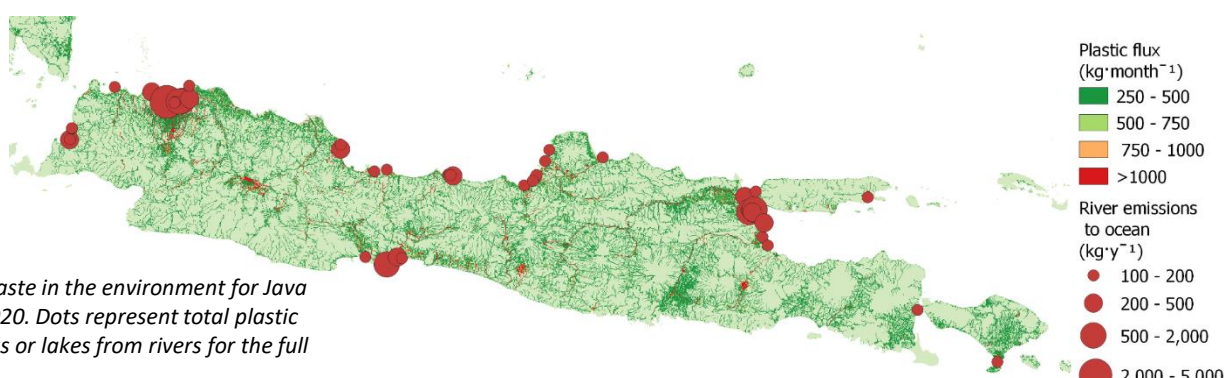


Fate of plastic emissions in the environment after one year.

1.1 Results

Plastic movement in the environment

- The high resolution with which plastic waste is mapped in the environment allows key areas for predicted plastic movement (flux) to be identified, such as the rivers that contribute the most towards marine litter.
- Rivers in Jakarta and Surbaya are shown as most likely to emit some of the largest amounts of plastic into the oceans. This is due to a combination of these locations having high absolute plastic emissions, and due to their proximity to the coast.
- Emissions occurring from inland cities (e.g. Bandung) were found to have a low likelihood of transferring to oceans, largely as a result of the plastic becoming entangled within rivers or due to obstruction from man-made barriers such as dams.
- Open drains were found to be a key pathway for the movement of plastic to rivers from their initial location of emission.



Flux of flexible plastic waste in the environment for Java and Bali in December 2020. Dots represent total plastic emission entering oceans or lakes from rivers for the full year.

1.2
Local Modelling and Mapping of Plastic Waste Sources, Pathways and Sinks in Two Case Study Sites

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[a]University of Leeds, [b]Institut Teknologi Bandung

Executive summary

Successful mitigation of plastic pollution requires interventions that account for local practices and infrastructure. The ISWA Plastic Pollution Calculator (PPC) is a model developed to operate at this local scale and aims determine the sources and pathways of plastic pollution. We applied the PPC to four Kecamaten, Banyuwangi, Muncar, Jembrana and Negara, using detailed primary data collected from each of these sites.

We found particularly high waste generation rates in Jembrana and Negara, double those measured in Banyuwangi and Muncar. All sites had a high plastic composition at between 20-30 wt.%, with plastic bags and films the most common items. By far the largest source of plastic pollution in each Kecamaten was uncollected waste, signalling further efforts need to be made to expand collection services to all. Much of this uncollected waste is either dumped into river-banks, where it has a high chance of moving to oceans, or is openly burnt resulting in potentially serious damage to air quality.

Three research findings are highlighted in this synthesis study:

1. Plastic waste generation rates are particularly high in the Kecamaten of Jembrana and Negara in Bali compared with Banyuwangi, East Java. Work is underway to establish whether this may differ between the rainy and dry season.

2. Plastic compositions are high in all studied Kecamaten at between 20-30 wt%., with plastic bags and films generated in the largest amounts.

3. Uncollected waste is by far the largest source of plastic in all Kecamaten studied. Much of this is dumped on riverbanks and/or openly burned.

1.2 Methodology

The Plastic Pollution Calculator is a toolkit developed by the University of Leeds for the International Solid Waste Association (ISWA). It performs a detailed characterisation of the flows of plastic waste in local solid waste management systems at daily temporal resolution, facilitating identification of specific and targeted engineering interventions. It includes:

1. Waste characterisation studies to determine amount and composition of plastic waste generated by households, businesses and institutions.
2. Solid waste management data is used to quantify the flows of plastic in the waste management system. The PPC automatically applies corrections where necessary to account for unmeasured flows (uncollected waste, informal sector collection etc.)
3. Observational surveys and questionnaires assess the quality of infrastructure and behaviour of individuals to inform conceptual models of the PPC.

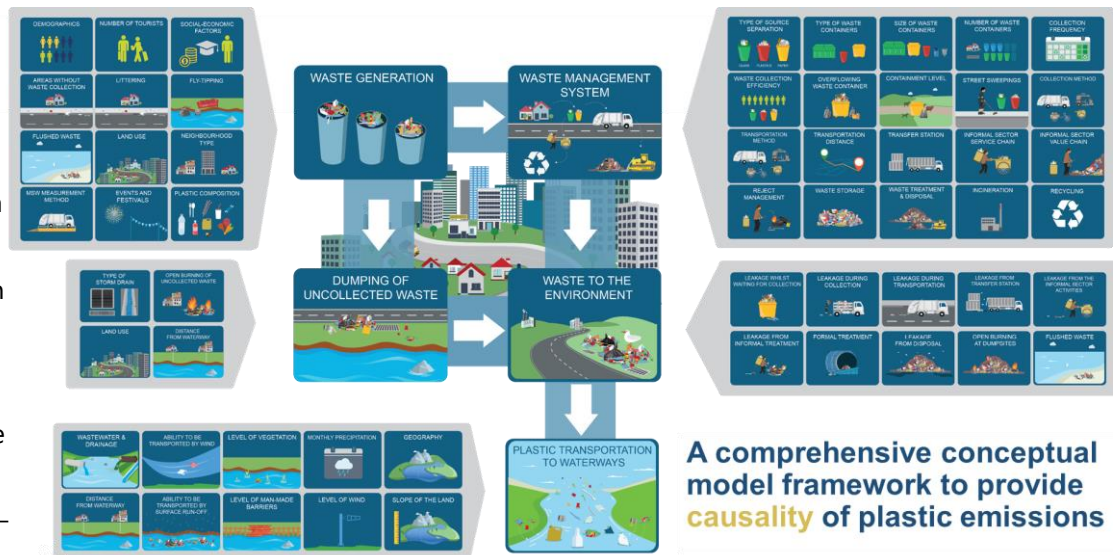
ISWA PLASTIC POLLUTION CALCULATOR

Accounting for all realities of solid waste management in a city, from downtown districts to informal settlements

The PPC works across several archetypes to account for a city's heterogeneity with respect to its solid waste management or individual behaviours by different areas or settlement types.

1.2 Methodology

PPC conceptual models were developed to account for aspects crucial to the origin of plastic pollution that are often overlooked due to being hard-to-measure. For example, one such conceptual model estimates plastic leakage from a collection container whilst waiting for collection. The model combines information on plastic composition, the likelihood of items moving by wind / rain depending on its material properties (size, density, format etc.), how secure the container is, the typical weather conditions and the length of time that It is waiting – all of which are key to understanding plastic leakage to the environment. Conceptual models not only allow these important factors to be accounted for in plastic pollution estimates; they also provide a means of incorporating potential causality, enabling us to assess how changes to infrastructure or behaviours may impact plastic pollution.

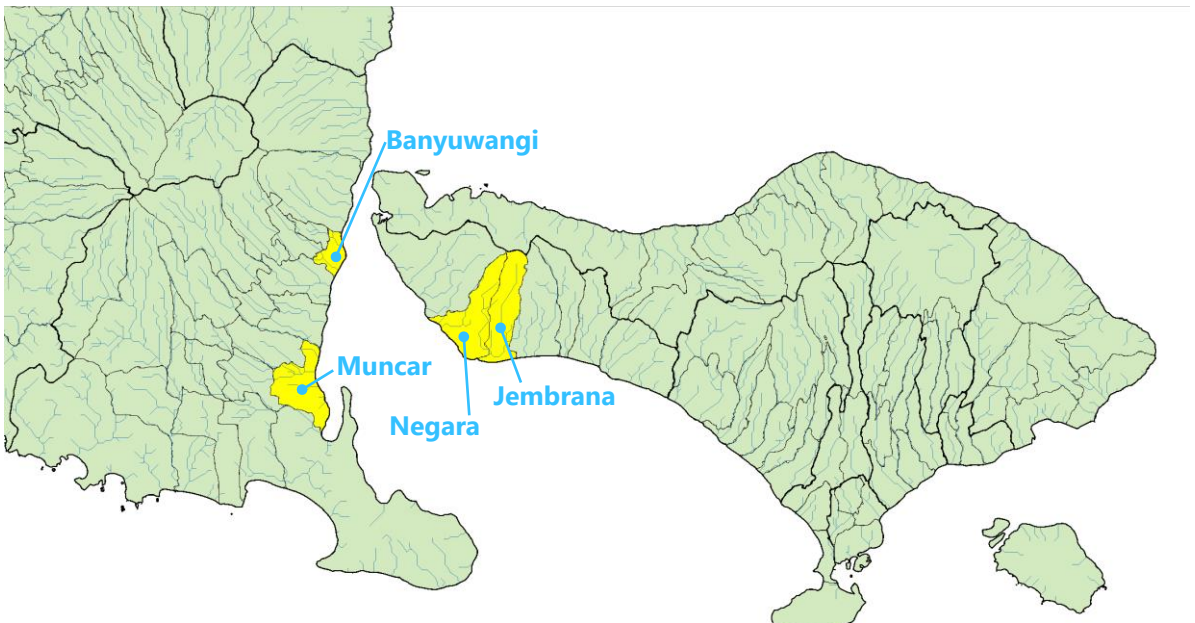


1.2 Methodology

Four case study sites were chosen in Jembrana, Bali and Banyuwangi, East Java according to their contrasting socioeconomics and opportunity to build on preliminary research and current and planned waste collection and waste management programmes conducted by our partners SYSTEMIQ and InSWA. These are:

- Banyuwangi Kecamaten
- Muncar Kecamaten
- Jembrana Kecamaten
- Negara Kecamaten

For each site, extensive data collection efforts were carried out and assessments made using the Plastic Pollution Calculator.



Case study Kecamaten for which the ISWA Plastic Pollution Calculator was applied.

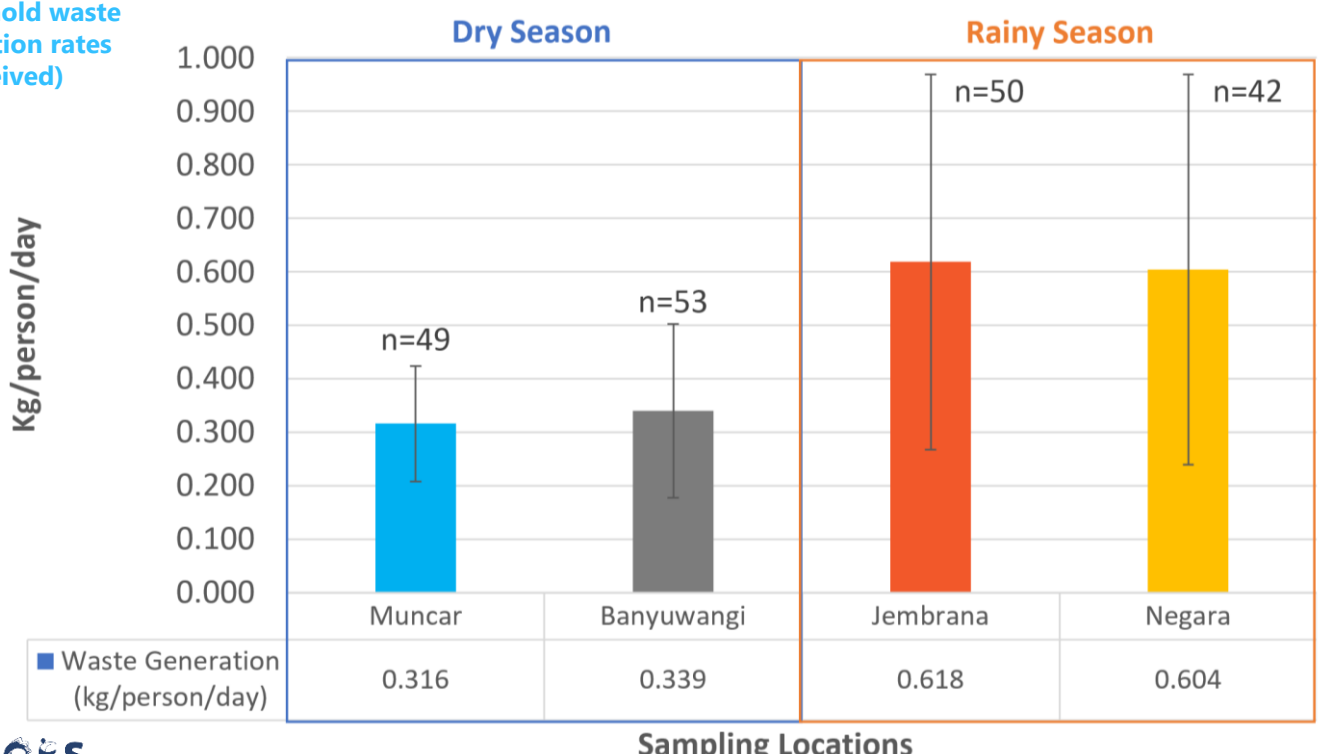
1.2 Methodology

1. **Solid waste sampling and characterization:** The waste characterisation sampling process was conducted for eight days; the initial three days used for the training, preliminary survey, and sampling preparation, and the remaining five days used for sampling. The income groups of all participating households (n=40-50 per kecamaten) were divided into high-income, middle-income, and low-income housing in the preparation process. On each sampling day, samples were collected from each household, business or institution. The weight and volume of each sample from the household and non-household waste was measured. Furthermore, we characterized the waste based on the general waste composition (e.g., food waste, paper, metal, plastic) and plastic waste composition according to 23 types of plastic. This information was used to feed into the Plastic Pollution Calculator.
2. **Waste collection and transfer:** Data was collected on the waste collection period, collection method and facilities, fees and collection site. For analysis of transfer stations, we collected data on the capacity, working hours, facilities, waste treatment, workers, informal recycling sector present, and time of transport to final disposal.
3. **Transport and Final Disposal Analysis:** We collected data regarding the specification of transport vehicle, period, and capacity. At final disposal sites, we collected data from local agencies regarding the final disposal type, planning, time-series data, report, capacity, work hours, facilities, waste treatment, workers, and the informal recycling sector. We additionally checked masses entering disposal facilities via weighbridges and/or daily counting of arriving dump trucks.
4. **Questionnaire:** For fulfilling the Plastic Pollution Calculator, we employ the questionnaire regarding the respondent profile in household and non-household. We are also have the questionnaire on sampled informal sector regarding the recycled plastic.

Solid Waste Sampling in Kecamatan Baynuwangi (*Photo credit: ITB*)

1.2 Results

Household waste generation rates (as received)



1.2 Results

Non-household waste generation rates

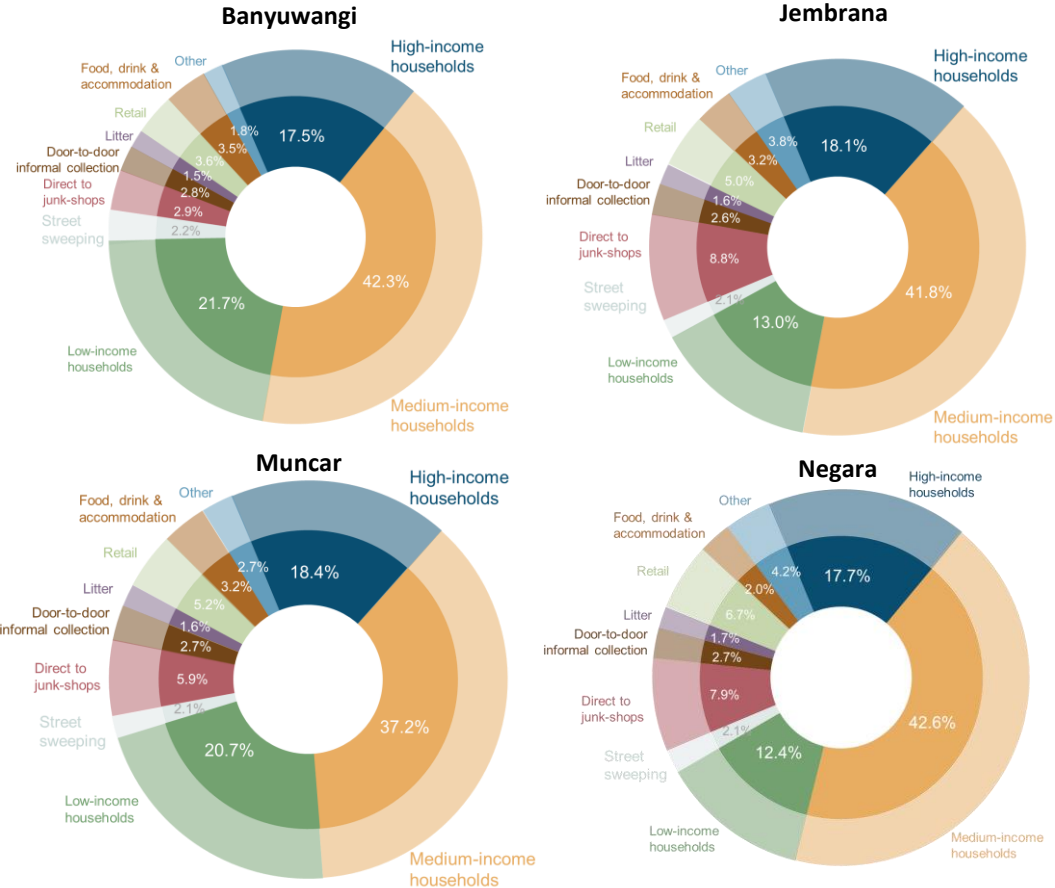
Sources	Kecamatan Banyuwangi		Kecamatan Muncar		Kecamatan Negara		Kecamatan Jembrana		Units
Office	0.100	n=7	0.329	n=5	1.713	n=4	-	n=1	kg/employee/day
School	0.020	n=7	0.086	n=6	0.101	n=5	0.194	n=4	kg/student/day
Restaurant	0.232	n=2	-	-	0.370	n=3	-		kg/chair/day
Road	0.024	n=2	-	-	0.023	n=2	-		kg/m^2/day
Shop	0.021	n=7	1.595	n=6	0.022	n=5	0.015	n=7	kg/employee/day
Ruko	1.025	n=2	-	-	-	-	-		kg/employee/day
Market	-	-	0.007	N=1	0.283	n=1	0.75	n=1	kg/m^2/day
Hospital	-	-	-	-	0.157	n=1	0.165	n=1	kg/bed/day
Hotel	0.116	n=2	-	-	0.253	n=2	0.443	n=1	kg/bed/day
Generation Equivalent	**0.382 kg/person/day**		**0.371 kg/person/day**		**0.735 kg/person/day**		**0.735 kg/person/day**		

1.2 Results

Sources of waste generation

The ISWA Plastic Pollution Calculator assesses municipal solid waste generation by household type and according to multiple commercial and institutional activities. This assessment includes an estimate of waste generated that is rarely captured in official numbers, such as that dropped as litter, or sold to the informal recycling sector; both of these were found to be non-negligible and therefore merit inclusion in the PPC.

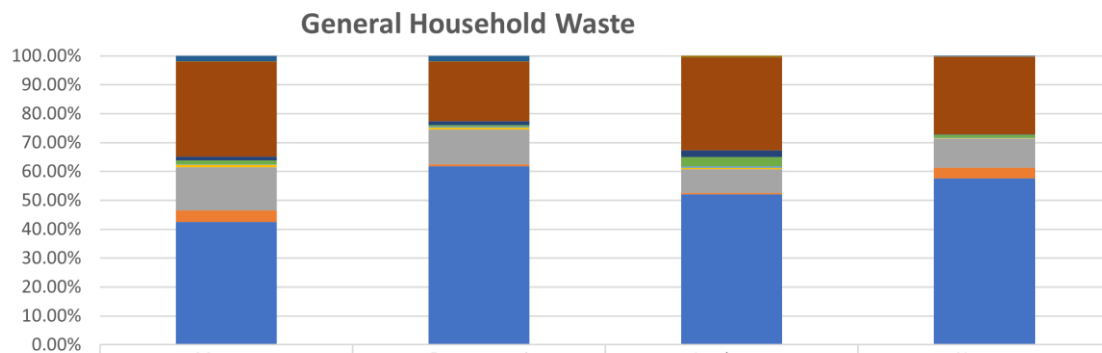
Over 70-80% of MSW generation originated from households in all case study sites, with medium-income households representing the largest share of this. On the other hand, for commercial and institutional waste, retail and food, drink and accommodation generated the largest amount of MSW.



1.2 Results

Waste characterisation

The graph illustrates types of waste generated by 40-50 households in each of the kecamatens surveyed according to the major waste fractions. Plastic forms the second largest proportion of waste, after garden and food waste at between 20-33%* by weight. This signifies that plastic waste is being generated in extremely large quantities across all case study sites.



	Muncar	Banyuwangi	Jembrana	Negara
Others	1.83%	1.75%	0.00%	0.10%
Electronic Waste	0.10%	0.20%	0.42%	0.10%
Hazardous Waste	0.05%	0.06%	0.12%	0.02%
Plastic	32.88%	20.55%	32.09%	26.83%
Glass	1.25%	1.36%	2.36%	0.17%
Textile	1.44%	0.47%	3.14%	0.99%
Rubber	0.11%	0.36%	0.50%	0.19%
Metal	0.89%	0.70%	0.50%	0.20%
Paper	14.98%	12.04%	8.22%	10.01%
Wood	3.91%	0.69%	0.62%	3.75%
Garden Waste + Food Waste	42.58%	61.80%	52.02%	57.64%

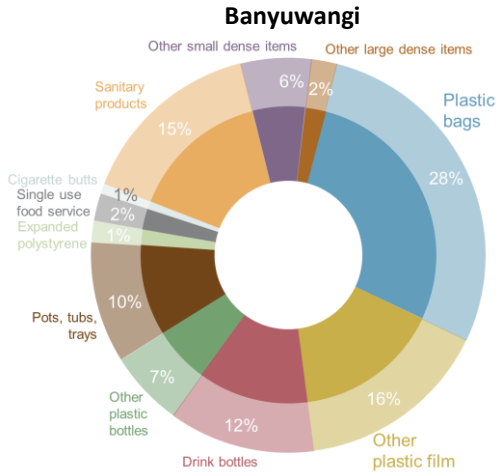
1.2 Results

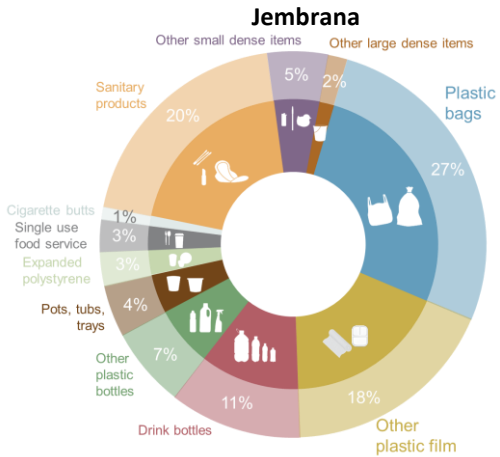
Plastic composition

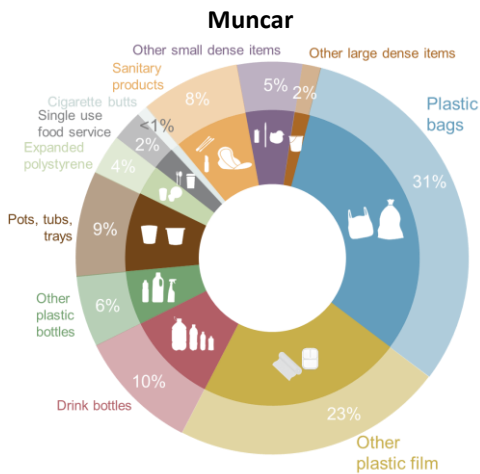
The overall composition of plastic waste according to eleven categories of items. Flexible plastics, such as plastic bags and other plastic film (e.g. sachets, film lids, wrappers and pouches) comprise the largest category in all case study sites. This poses a worry given the propensity for these items to move in the environment, as well as their relative low value and challenges associated with recycling.

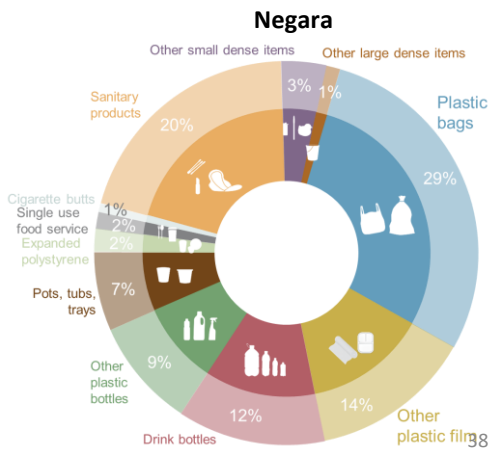
Sanitary products (e.g. diapers, hygiene products) are another major contributor to plastic waste generation, particularly in Jembrana and Negara where they represent 20% of all plastic waste generation.

High-value rigid plastics such as drink bottles and pots, tubs and trays, whilst generated in lesser quantities than plastic films, generally make up ~1/4 of plastic waste, signifying strong potential for recycling.







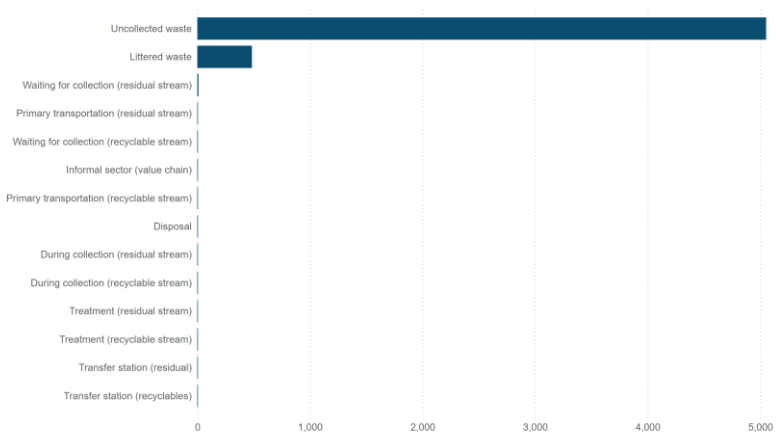


1.2 Results

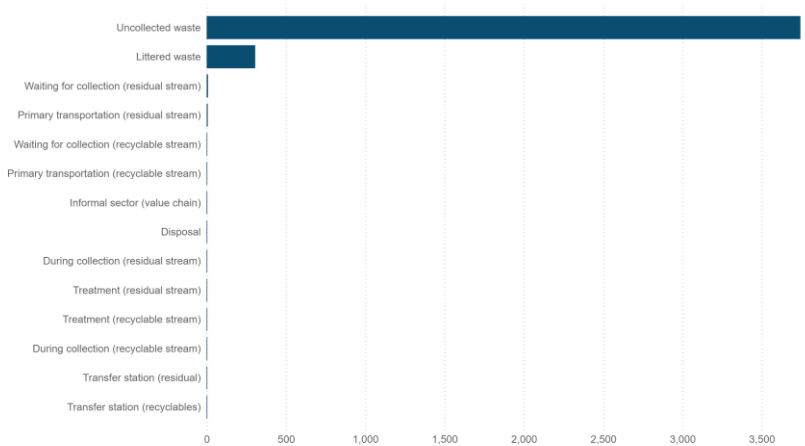
Source of plastic pollution

These results show the source activity that led to the emission (leakage) of plastic waste into the environment. It is clear that un-collected waste is by far the largest source of plastic pollution in the Bali Kecamaten of Negara and Jembrana, multiple times higher than the next highest source of littering. The second largest source in all areas is that of littering.

Negara



Jembrana

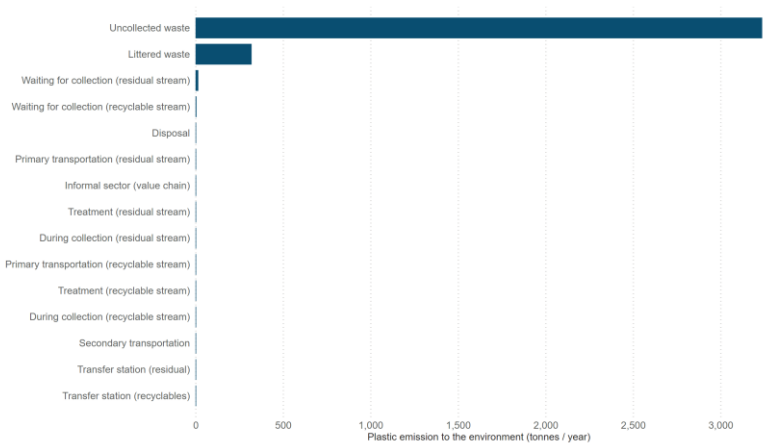


1.2 Results

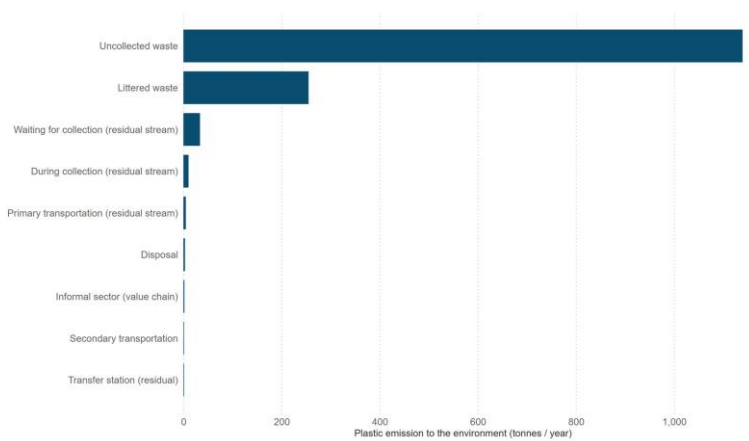
Source of plastic pollution

Results for both Banyuwangi Kecamaten (Muncar and Banyuwangi) also show that uncollected waste is by far the largest source of plastic pollution followed by littering. These results signify that uncollected waste is a widespread problem and requires significant attention given its magnitude in comparison to other sources. As such, efforts to reduce plastic pollution have to tackle the lack of collection services as a priority.

Muncar



Banyuwangi

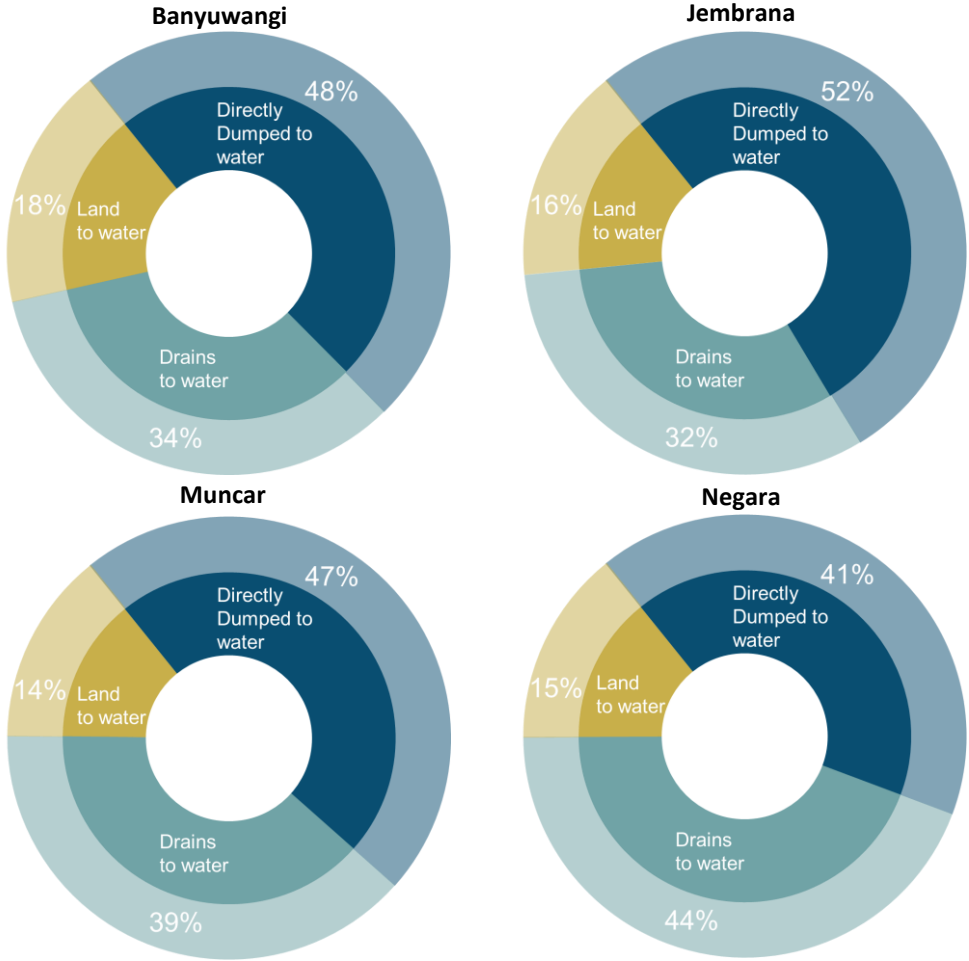


1.2 Results

Plastic pathways to water

These results examine the ways in which plastic may enter the aquatic environment (rivers and ocean). This relates only to plastic debris. However, it is important to note that a further large amount of plastic is openly burned, resulting in direct emissions to the atmosphere and a high likelihood of severe consequences to air pollution and resulting public health.

Given that uncollected waste is the major source in all sites, direct dumping is the most common way for plastic to enter the aquatic environment due to people using the rivers to dispose of their waste. Drains are also shown to be important mechanisms for moving plastic to water during periods of heavy rain given their open nature, allowing waste to be blown in or dumped in by residents.

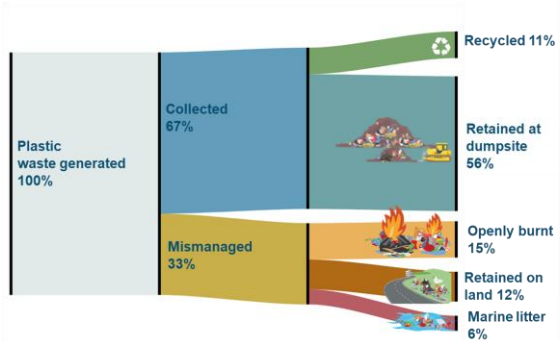


1.2 Results

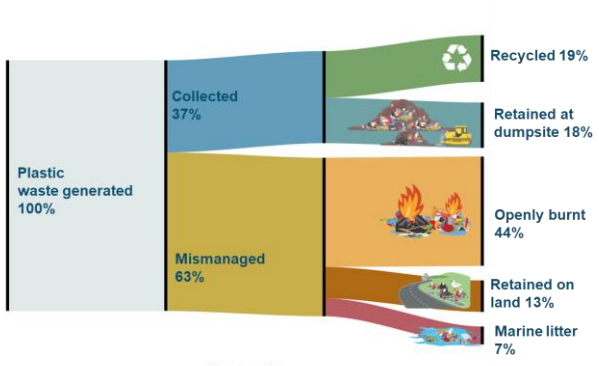
Plastic composition

These Sankey diagrams show a high-level overview of plastic waste fates in each case study site. In all sites, except Banyuwangi, the majority of waste is uncollected. Most of this waste is openly burned in all Kecamaten, although a considerable amount still enters the aquatic environment or is retained on land (becoming entangled in vegetation or deposited in informal dumpsites). Of the collected waste, between 10-20% is recycled, largely by the informal recycling sector, with the remainder going to dumpsites.

Banyuwangi



Jembrana



Muncar

Negara

2. Key Messages

The SPOT model used locally measured data from the SIPSN database to map the flows of municipal solid waste at a Regency level across Indonesia. 7 million tonnes of plastic escapes into the environment each year in Indonesia, with uncollected waste the main source. Open burning of waste is prevalent, accounting for 52% of all plastic emissions. As such, plastic pollution cannot be stopped without tackling *both* uncollected waste and open burning.

Although the majority of plastic in the environment has low mobility, almost 200,000 tonnes of plastic is predicted to enter oceans surrounding Indonesia each year. Hotspot locations of plastic pollution were identified in order to prioritise the areas for which more comprehensive multi-disciplinary assessments should be undertaken.

Key Results:

1. 7 million tonnes of plastic waste escapes into the Indonesian environment (land, water and air); 52% of which enters the atmosphere via open burning.

2. Uncollected waste accounts for the greatest percentage (89%) of this plastic waste leakage followed by open burning at uncontrolled disposal sites (9%).

3. The majority (82%) of physical plastic debris is predicted to remain on land after one year; 2% (almost 200,000 tonnes) of plastic, equivalent to at least 11 million plastic items*, is predicted to enter Indonesian seas each year via rivers and drains, with key hotspots in major coastal cities.

2. Key Messages

These more detailed results generated by the empirical data collection activities and the **PPC** modelling exercise provided much-needed scientific evidence on the sources and pathways of plastic pollution in the case study Kecamatens of Jembrana, Negara, Banyuwangi and Muncar. Plastic waste generation is high across all sites, with plastic bags and plastic films the major contributors

Whilst some of the plastic generated is recycled or transferred to dumpsites for disposal, much of the plastic remains uncollected and is either dumped into the environment or openly burnt.

Actions to mitigate plastic pollution must prioritise improving access and use of waste collection services.

Key Results:

1. The amount of plastic waste generated in all Kecamaten studied is very high (20-33% of all household MSW by weight). Low value films and flexible plastics represent the largest share of plastic waste.

2. Uncollected waste is by far the largest emission source in all studied Kecamaten. Efforts to reduce plastic pollution must therefore focus on improving access to and use of waste collection services.

3. Open burning is the main disposal method used by residents without access to collection services. In Jembrana and Negara, more plastic is openly burnt than collected for disposal. Major implications for air quality and public health are likely.

3. Frequently Asked Questions

How can these results help Indonesia mitigate plastic pollution?

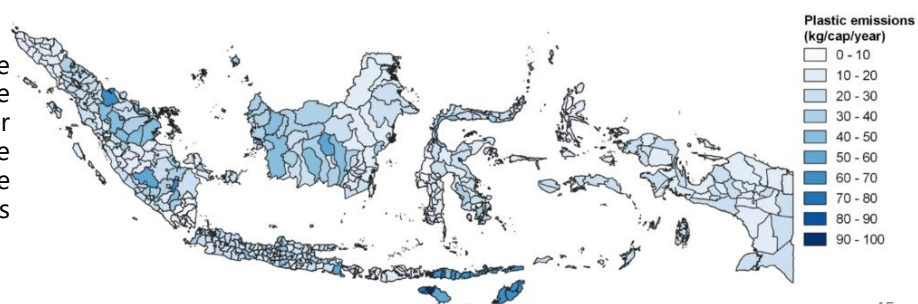
SPOT results allow us to work across different scales; e.g., monitoring plastic pollution at a national-level whilst prioritising locations and sources at a local level. Results give insight into the flows of waste in the solid waste management system allowing us to understand the parts of the system operating well or in need of improvement. By predicting the movement of plastic in the environment, SPOT results highlight transboundary movement or at-risk ecosystems, whilst enabling us to link what we find in the environment to its source. The PPC model results provide a detailed picture of how plastic waste is generated, managed and emitted into the environment within the case study Kecamatens. Only with this information can interventions to reduce plastic pollution be targeted at the sources where greatest impact can occur.

What kind of investment is required in solid waste management?

The biggest sources of plastic pollution both across Indonesia and at the case study sites come from uncollected waste and open burning at uncontrolled disposal sites. Investment should be prioritised to mitigate these sources to ensure maximum impact. If waste collection services are not available or affordable, residents are forced to self-manage their waste, for example by openly burning it, burying it, or dumping it on land or into rivers. Investment is required to extend collection services to the entire population to drastically reduce the levels of plastic pollution. Whilst open dumpsites are an obvious eyesore and source of plastic pollution, the results show that only minimal amounts of plastic debris escape from these facilities, largely due to a) much of the waste being buried under other waste, thereby restricting the likelihood of further movement onto surrounding land and into drainage channels and rivers, and b) due to there being no evidence of widespread open burning at these dumpsites.

What locations should action be prioritized for?

SPOT results highlight several hotspot locations. These hotspots can be defined using several criteria. Those illustrated in our report are based on absolute or per capita plastic emissions to highlight Regencies where improvements to solid waste management should be prioritised. These include our two PISCES case study sites of Banyuwangi and Jembrana.



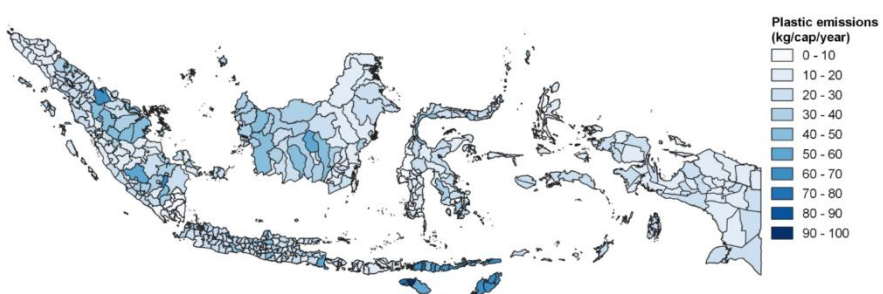
3. Frequently Asked Questions

How certain can we be of the modelling results?

All modelling results approximate real-life and have a degree of uncertainty. SPOT accounts for uncertainty in underlying input data by performing probabilistic material flow analysis, therefore, all outputs have an associated prediction interval that should be considered alongside the central estimate. Validation of SPOT is on-going through the environmental sampling described in Chapter 2, with preliminary results confirming the hotspot and coldspot predictions of SPOT.

Given the detailed nature of the assessment and data collection, we can be reasonably confident that the PPC model generates an accurate depiction of plastic waste flows and leakages within the case study Kecamatens. That said, all models are approximations of real life and therefore uncertainty does exist. Given the volume of uncollected waste in each Kecamaten, however, it is clear that, this is the dominant source of plastic pollution and should be addressed as a priority.

To improve the reliability of modelling results, calibration and validation exercises are on-going, both to characterize the nature and quantity of plastic litter in the environment and to assess movement and leakage experimentally.



4. Future Research Agenda

Validation of SPOT model

SPOT predictions are currently being validated by the nationwide environmental sampling described in Chapter 2. Although preliminary results show the model is accurate in its predictions, this additional data will also be used to aid in calibration of the model to improve its predictive capability.

Assess quality and reliability of existing SWM data

Input data used for SPOT comes from the SIPSN and BPS datasets. There are data gaps in these databases, leading to uncertainty in some of the predictions made. ITB are currently performing waste characterisation and sampling exercises at selected hotspot and coldspot locations to cross-check the reliability of input data and produce recommendations for how future data collection efforts can be improved.

Improve model capabilities to predict the upstream interventions.

At present, SPOT quantifies waste flows starting at the point of waste generation. We plan to expand its capabilities to focus on how upstream interventions (e.g. policies) may impact the downstream flows of waste such as plastic emissions.

Sampling at a TPA site (P*hoto credit: ITB*)

4. Future Research Agenda

Expand plastic item categorisation

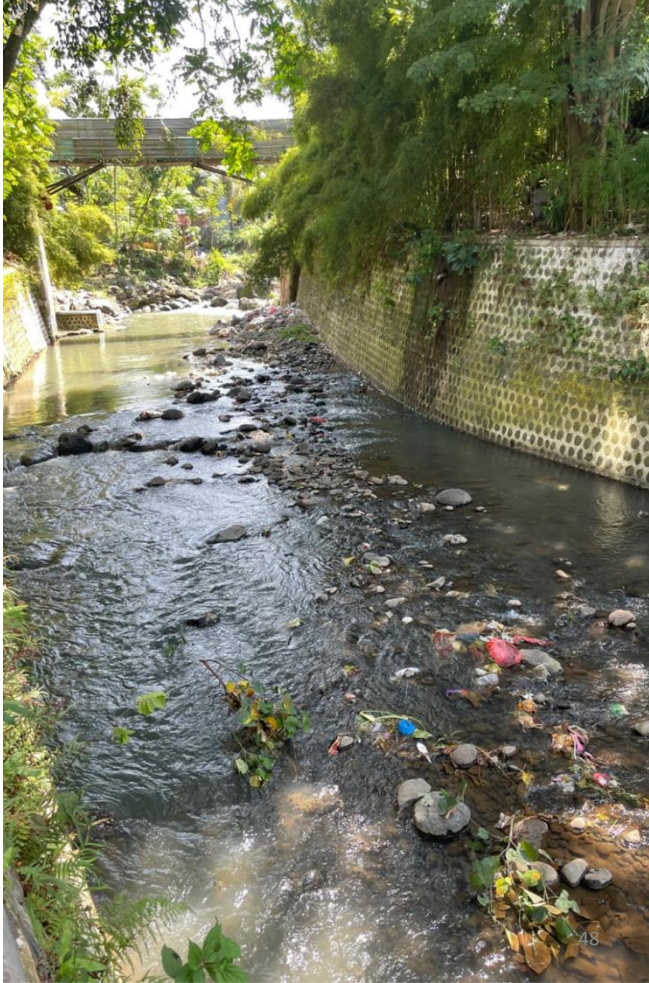
We are in the process of expanding the Plastic Pollution Calculator to account for 23 plastic item types rather than the current 11. This will enable results to better reflect how different plastic item types are generated and managed within the waste management system and predict how they may move once in the environment.

Include other key non-MSW sectors

The Plastic Pollution Calculator already includes a detailed breakdown of household and other municipal sources (e.g. commercial and institutional generators). However, we plan on expanding the capabilities to also include crucial non-MSW sources such as the fishing industry and agriculture.

Improve data collection structure and methods

Work is ongoing to improve the data collection methods used for the Plastic Pollution Calculator. This will be based on the lessons learnt by the already completed data collection exercises undertaken by ITB. It is envisaged that improvements to the data collection structure and methods will allow future application of the PPC with reduced effort and greater certainty around key inputs.



4. Future Research Agenda

Improve modelling of movement of plastic waste

The tropical climate of Indonesia, with heavy monsoon rains, means plastic in the environment is likely to undergo significant movement. However, at present it is unclear what levels of wind or rain will cause plastic to move, and how far they will travel once mobile. Although our SPOT model gives a first approximation of how plastic leaks and then moves in the environment, there is a lack of empirical data for calibration or validation of such models.

Our team aims to fill this knowledge gap by performing a series of experiments to test for the first time the conditions by which plastic moves, incorporating forces required by wind, surface runoff and gravity to move plastic items, enabling current modelling assumptions to be improved. Learnings from these experiments will allow us to develop field-tests for plastic movement in real-life conditions and enable long-term monitoring.

Understanding how plastic moves once released into the environment is fundamental in linking environmental concentrations of plastic with its initial source. Furthermore, effective modelling of the movement of plastic enables hotspot locations for plastic accumulation or emission to oceans to be identified, therefore allowing interventions to be targeted to areas of greatest impact.

Chapter 2.
Establishing Robust Approaches to Understand and Monitor Sources, Distribution and Fate of Plastic Waste Generation and Littering in Indonesia.

Max Kelly[a], Richard Thompson[a], Reza Cordova[b], Panji Pamungkasd[c], Gede Hendrawan[c] ,SusanJobling[d]

[a]University of Plymouth, [b]Research Center for Oceanography, National Research and Innovation Agency (BRIN), [c]Universitas Udayana, [d]Brunel University of London

Contents

Context

Indonesia is the world's largest archipelago nation with 17,508 islands and 270 million people. PISCES mass flow analysis Chapter 1.1 estimates approximately 65 Mt.y-1 of municipal solid waste is generated, of which 11.5 Mt.y-1 is plastic, exceeding earlier estimates of 42 Mt.y-1 and 7.8 Mt.y-1 (KLHK; NPAP, 2020; World-Bank, 2021). Approximately, 46% of plastic waste is collected, 3.2 MT.y-1 is predicted to enter the Indonesian environment as litter. Approximately 0.2Mt.y-1 are estimated to leak into the marine environment.

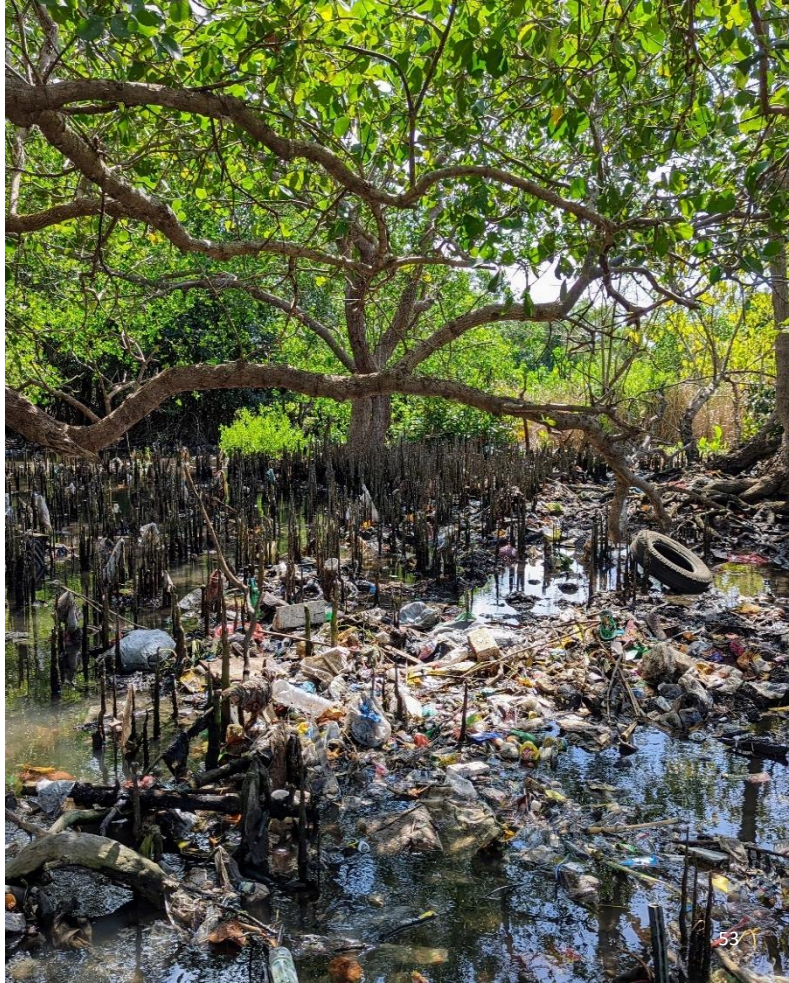
Whilst there are numerous reports of plastic contamination in the marine environment, detailed estimates of sources and quantities are lacking. At a very broad scale, our modelled predictions (Chapter 1.1), based only on waste management data, indicate potential hotspots for waste to escape to the environment. To ensure these modelled predictions are robust, however, there is a need to collate existing secondary data and to gather primary data, both to understand the distribution and abundance of plastic litter and to identify prevalent and problematic waste items to indicate potential interventions. Chapter 2 describes our research conducted to address these needs.

Context

In Chapter 2.1, we review all existing datasets to establish which secondary data could be used for model validation and to identify data needs.

Given the absence of data from land-based studies, and the need for internationally recognised protocols designed to characterise and quantify plastic pollution on land, we developed a novel rapid litter survey methodology to address this need. In Chapter 2.2, we describe this methodology and present the results of its use to conduct detailed surveys of the abundance and nature of plastic litter, assessing spatial and temporal trends in both anthropogenic and natural systems, at a national scale. These studies incorporated an assessment of plastic litter/packaging types including their function to enable identification of the most prevalent litter types to help prioritise plastic items for our intervention program (Chapter 6).

Building on this research, in Chapters 2.3 and 2.4, we applied and expanded our rapid litter survey methodology at a local scale, at each of our case study sites, in Banyuwangi, East Java and Jembrana Bali. This approach included surveys on land, in both upstream and coastal communities, across beaches, and in rivers, in order to compare the nature and abundance of plastic waste in these different types of environments.



Plastics in Indonesian Societies (PISCES):
Systems Analytics Approach to Reduce Plastic Pollution

Natural Environment Research Council

2.1
Review of Existing Data on Plastic Litter: Trends and Research Priorities

Max Kelly[a], Richard Thompson[a], Reza Cordova[b], Panji Pamungkasd[c], Gede Hendrawan[c]

[a]University of Plymouth, [b]Research Center for Oceanography, National Research and Innovation Agency (BRIN), [c]Universitas Udayana

Executive summary

This chapter provides a summary of existing data on the spatial distribution of plastic litter throughout Indonesia to identify trends, knowledge gaps and associated research priorities. This was achieved through an online workshop, comprehensive literature searches, and a novel data analysis approach to harmonise existing datasets. Across 35 studies, 55 field locations, and 224 individual study sites between 1986-2022, plastic bags (64%), plastic bottles (50%), and plastic food packaging (33%) were the most prevalent macro-debris types reported in the literature. The study revealed that 85% of studies relating to plastic pollution in Indonesia are focused on beach and riverine litter, and identified a complete lack of data relating to plastic pollution on land. This finding informed the design and implementation of a novel litter survey (described in Chapter 2.2)

Three research findings are highlighted in this synthesis study:

1. Development of a novel ranking approach to extract robust trends from diverse marine litter datasets.

2. From the existing literature (n= 35 studies), the most prevalent items of litter in Indonesia are plastic bags, plastic food packaging, and plastic bottles.

3. The majority of studies (85%) are beach focused and situated in Java, whereas there is a complete lack of data describing litter on land and the source of that litter.

2.1 Methodology

We conducted a comprehensive literature search for research articles describing marine litter in Indonesia from the peer reviewed literature with additional contributions from the grey and secondary literature. This revealed 35 studies between 1986-2022 containing data on the relative abundance of the most common types of macro-debris in Indonesia. While individual papers used consistent 'within' study methods, both the methods and units of measurements varied 'between' studies. To overcome the issue, we adopted a novel approach to evaluate trends across studies.

Online workshop. We conducted an online workshop with over fifty delegates and follow up consultations with six research groups and NGOs who routinely collect data on plastic macro-debris, including the Ministry of Marine affairs and Fisheries (Kementerian Kelautan dan Perkanan, Indonesia) and the Indonesian Waste Platform, to ensure the collation of all available data.

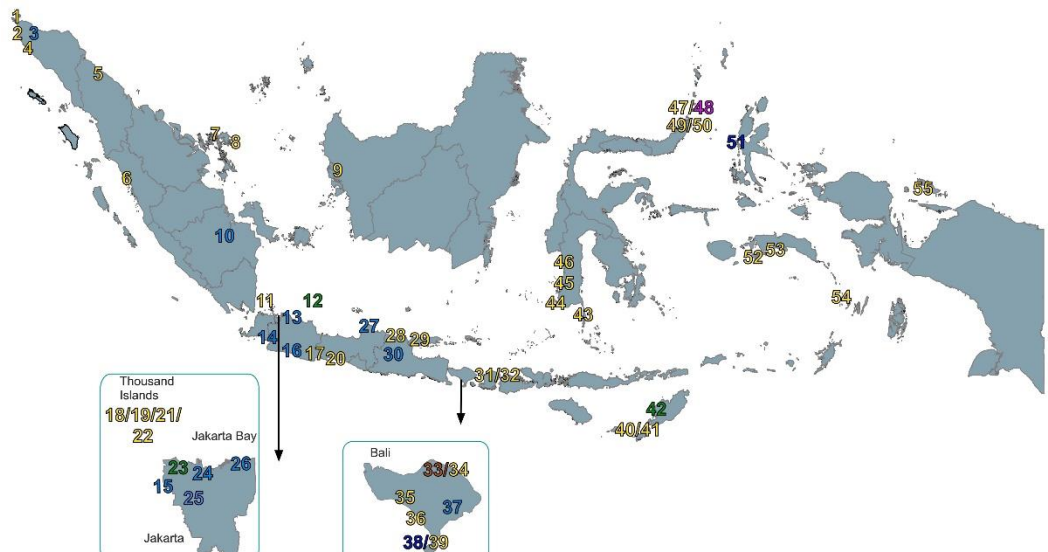
2.1 Results: Literature search

35 studies were identified encompassing 55 field locations (224 study sites) and mapped across 19 of the possible 34 Indonesian provinces, accounting for six different environment types: beach (n=36, yellow); river (n=12, blue); mangrove (n=3, green); seabed (n=2, dark blue); coral reef (n=1, pink); and land (n=1, brown).

85% of field locations were either beach or riverine and often in areas with high population densities, such as Java, Jakarta, and Bali.

The Java region, including Banten, West Java, Central Java, West Java and Jakarta accounted for 20 (36%) of the field locations studied.

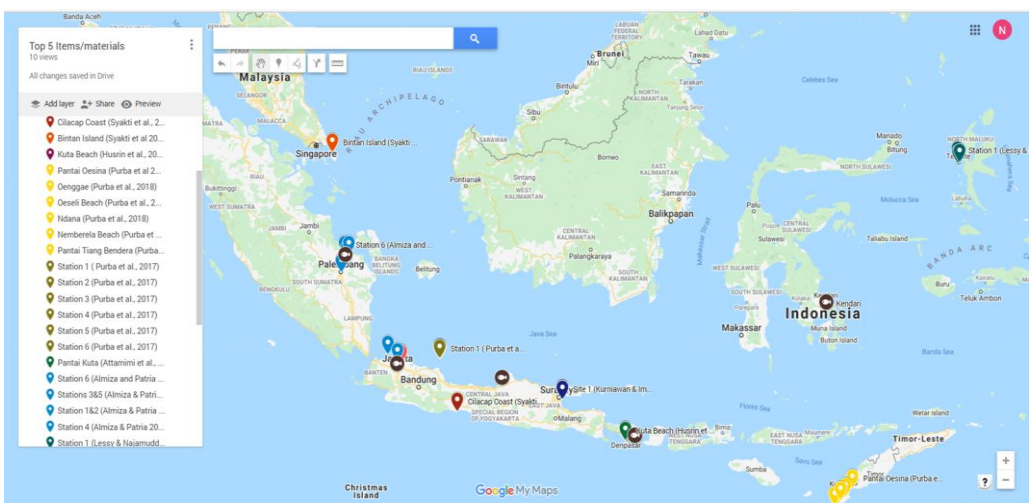
Most prevalent items included plastic bags.

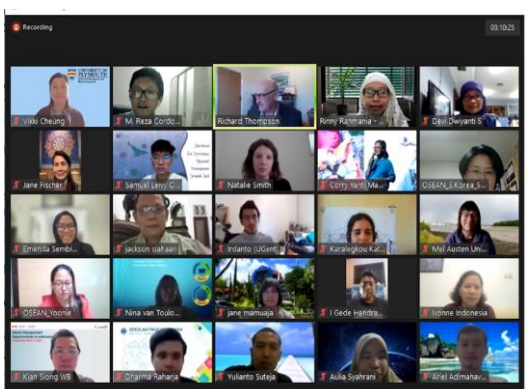


2.1 Results: Online workshop

The online workshop helped map Indonesia's research landscape (as shown below). Follow up consultations with particular groups, including the Indonesian Waste Platform and Sungai Watch, allowed insights to future research plans including an early examination of data before it was published.

These partnerships have remained strong throughout the PISCES programme and have helped to inform and align our research to build upon what is already known. The practical help we received regarding developing trash booms and implementing litter surveys in small island communities was invaluable.





2.2
Plastic Litter Abundance at Regency Scale

Max Kelly[a], Richard Thompson[a], Reza Cordova[b], Panji Pamungkasd[c], Gede Hederwan[c]

[a]University of Plymouth, [b]Research Center for Oceanography, National Research and Innovation Agency (BRIN), [c]Universitas Udayana




Executive summary

The development of a novel rapid litter survey methodology has allowed PISCES to quantify and characterise plastic pollution across 20 kecamatan and 14 provinces of Indonesia, covering a total distance of 25,500 km^2.

Our approach includes an innovative grading approach to rapidly assess the abundance of plastic pollution throughout land-based environments. Using this methodology, we were able to conduct the most comprehensive assessment of plastic litter in Indonesia to date.

Larger aggregations of litter were characterised through dump typologies and the quantities of litter were linked to the surrounding land, waste management, and commercial infrastructure. The highest proportion of litter was found on riverbanks and the most prevalent litter types include plastic food and beverage packaging and sachets.

Three research findings are highlighted in this synthesis study:

1. Development of a comprehensive rapid litter survey to quantify and characterise plastic pollution.
2. Highest proportion of litter is found on riverbanks which is correlated to a high frequency of diffuse and informal dumps.
3. Small food service plastics and sachets are the most prevalent litter types.

2.2 Methodology

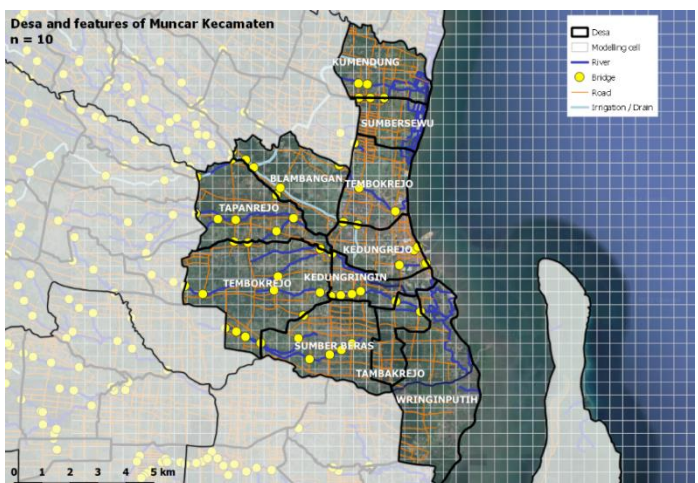
1. Rapid litter survey

The method was designed to quantify and characterise litter over large spatial scales and can be used to support the identification and verification of plastic pollution hotspots as predicted in the SPOT and PPC models in Chapter 1.

Eight of the highest and lowest predicted plastic polluting regencies were selected for field survey at the national level to ensure model predictions were accurate. Within each Regency, Kecamatans were selected for survey through a systematic process based on specific stepwise criteria including the size, population density, presence of a river, and number of individual desa.

The 4 case study site kecamatan were also surveyed to ensure our 'on the ground' findings (empirical data) could help support all of the PISCES teams and action delivery partners also working in East Java and Bali).

ArcGIS was used to map each kecamatan and the six desa to be surveyed, highlighting land features such as roads, rivers, and the land boundaries (example in figure). For each desa, a 450 x 450m area was surveyed to enable data collection that could be applied to the same spatial scales as model predictions in Chapter 1.



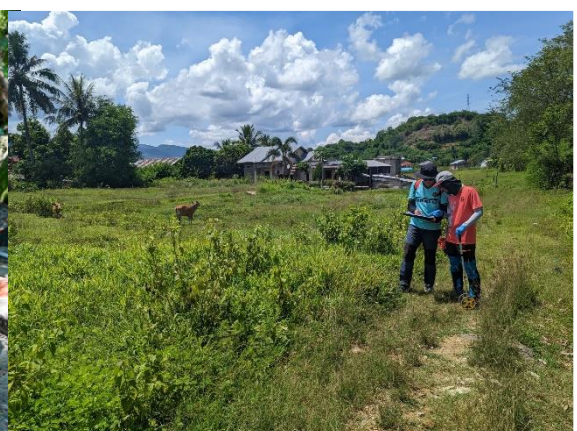
Example of ArcGIS map highlighting land features with 450x450 m grid spacing overlaid to select individual raster cells to survey.

2.2 Methodology

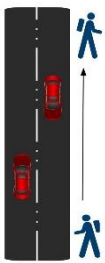
1. Rapid litter survey

The development of a novel rapid litter survey methodology has allowed PISCES to quantify and characterise plastic pollution across 20 kecamatan and 14 provinces of Indonesia, covering a total distance of >26,000 km^2. Our survey includes an innovative grading approach to rapidly assess the abundance of plastic pollution throughout land-based environments. Using this methodology, we were able to conduct the most comprehensive assessment of plastic litter in Indonesia to date.

We also identified (by count and mass) 25 categories of litter and 22 additional sub-categories for sachets (across >1000 sub-sampling events) to determine specific intervetnions within PISCES; aimed at the most prevalent litter types in Indoneisa.



2.2 Methodology



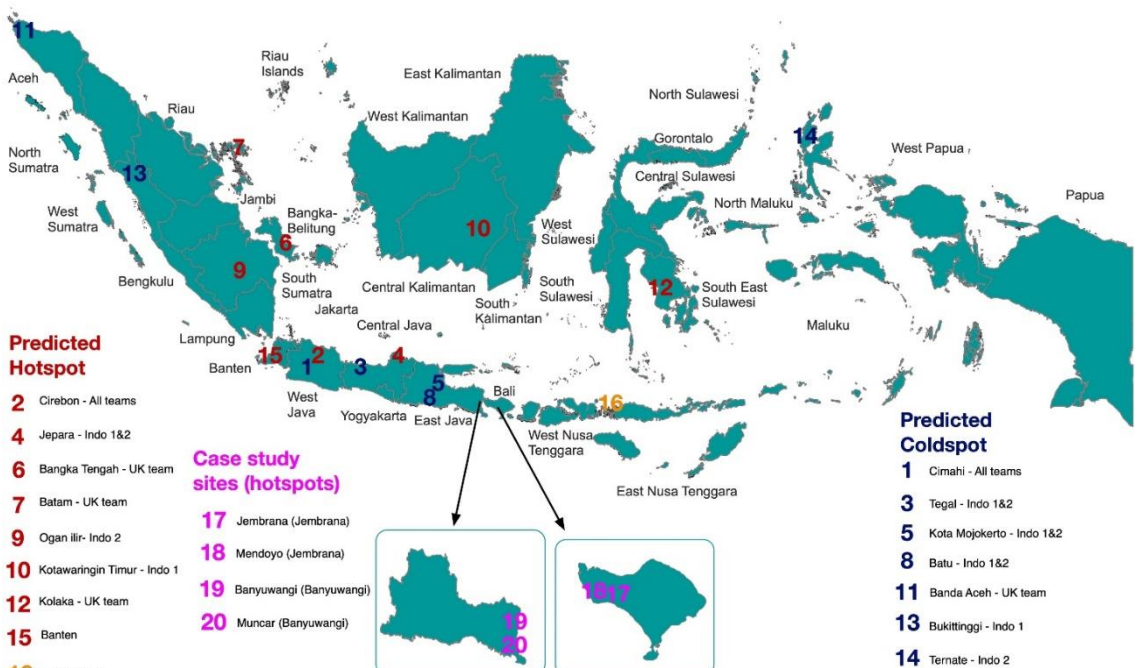
Within communities, down rivers and along beaches

Recording quantities and types of litter

Identifying local infrastructure

2.2 Results

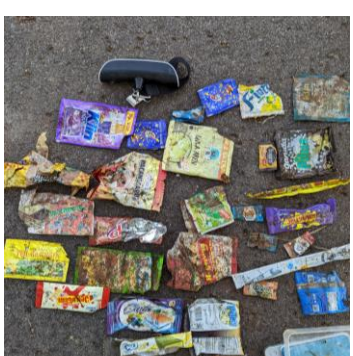
- 20 kecamatan were surveyed across Indonesia on 3 occasions before and after the monsoon.
- Surveyed kecamatan were identified from predicted hot and cold-spots described in Chapter 1.

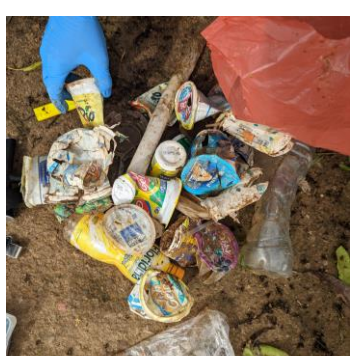


2.2 Results

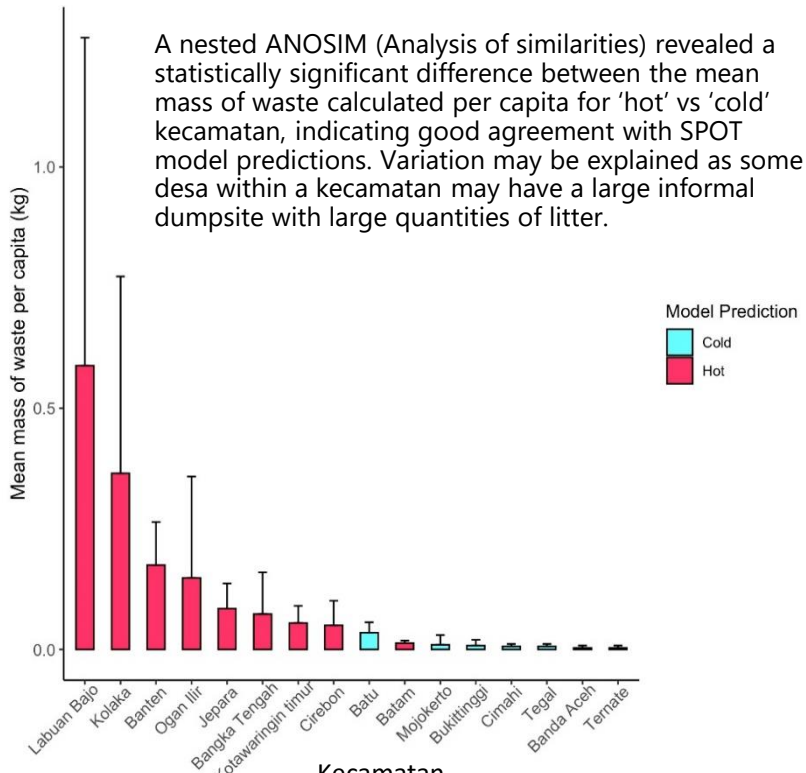
Small food service plastics and sachets were the most common items across the nationwide survey. Sachet snacks were the most common type of sachet and beverage packaging were one of the most common types of small food service plastics.

The large abundances of sachets may be attributed to their lower economic value in recycling and coupled with the high processing costs for multi-layer sachets, estimated at 72$ (US dollars) per tonne (Project STOP MRF (TPS3R) performance data, SYSTEMIQ).





A nested ANOSIM (Analysis of similarities) revealed a statistically significant difference between the mean mass of waste calculated per capita for 'hot' vs 'cold' kecamatan, indicating good agreement with SPOT model predictions. Variation may be explained as some desa within a kecamatan may have a large informal dumpsite with large quantities of litter.

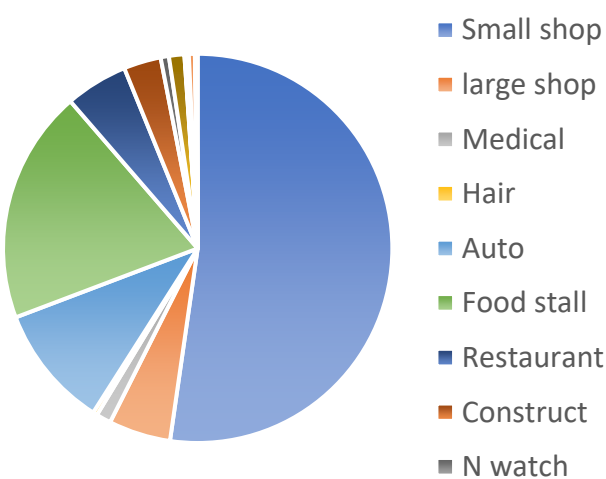


Field campaign 1 data (May 2022)

2.2 Results

The highest proportion of plastic litter was often found on riverbanks. This is due to the highest frequency of diffuse and informal dump sites also located on riverbanks. Anecdotally, we also find the same concentrated litter piles between sampling periods indicating people are repeatedly dumping waste in the same locations in the environment.

The most common commercial establishment recorded were warungs ('small shops') which sell every day household items such as plastic sachets which accounted for >50% of commercial establishments.



Plastics in Indonesian Societies (PISCES):
Systems Analytics Approach to Reduce Plastic Pollution

Natural Environment Research Council

2.3
Litter Abundance Report for Case Study Sites in Banyuwangi and Jembrana and Justification of Litter Types for Intervention

Max Kelly[a], Richard Thompson[a], Reza Cordova[b], Panji Pamungkasd[c], Gede Hendrawan[c]

[a]University of Plymouth, [b]Research Center for Oceanography, National Research and Innovation Agency (BRIN), [c]Universitas Udayana

Executive summary

The novel rapid litter survey method described in Chapter 2.2 was also used within the case study site surveys carried out in the Banyuwangi and Jembrana regencies to determine the most prevalent litter types and the overall quantities of plastic in the environment. The approach was utilised on land in upstream and coastal communities, and across beaches. The results were compared with these obtained from sampling of riverine plastic debris (Chapter 2.4) as the same litter categories were consistently adopted. Whilst the rank order may change between kecamatan and environments, the most prevalent litter types overall were consistently found. These included sachets, small food service plastics, and plastic bags. Thus, these dominant and problematic litter types should be the focus of future targeted interventions, requiring different strategies to reduce their prevalence in the environment.

Three research findings are highlighted in this synthesis study:

1. The use of the PISCES novel rapid litter survey enables comparison of the most prevalent litter types across Indonesia and within the case study sites including land, beach, and river environments.

2. The most prevalent litter types to prioritise for intervention include sachets (mainly food snacks), small food service plastics (including plastic cups), and plastic bags (including shopping and smaller food/beverage storage bags).

3. There are localised differences in litter distribution. For example, plastic bags are more often found in larger aggregations within concentrated litter piles where they are used as receptacles for smaller waste items.

2.3 Methodology

A: Case study sites: litter survey and training

The rapid litter survey applied across Indonesia was also used to characterise plastic litter in four case study site kecamatan in Banyuwangi, East Java and Jembrana, Bali.

However, the frequency of sub-sampling events was doubled, relative to the national survey, to provide a more detailed understanding of the most prevalent litter types within the case study sites.

Three teams were trained with the rapid litter survey, and sampling took place before and after the monsoon seasons:

- Training: June 10-13th 2022
- FC1: July 15-18th 2022
- FC2: October 27-1st 2022
- FC3: May 10-13th 2023
- FC4: July 7-10th 2023

2.3 Methodology

B: Case study sites: beach litter survey

Within each of the case study site kecamatan, beach surveys were also conducted using the same litter survey, during the same survey period.

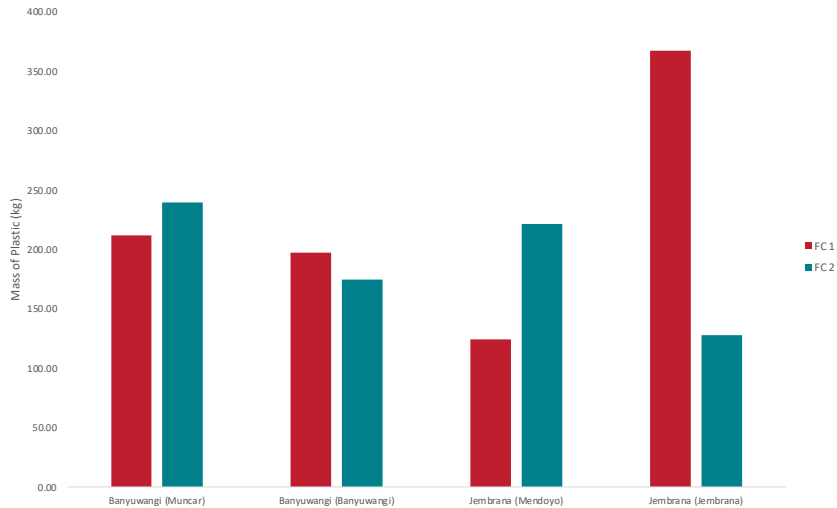
Each of the four beaches surveyed were located near the mouths of four rivers in the case study sites that were also surveyed using 'trash booms' to capture the litter (see Chapter 2.7).

This was undertaken to explore how patterns in litter may change from source to sea. Beach surveys took place in FC2 (November 2022) and FC3 (May 2023).

2.3 Results: Total plastic

Across all sampling, sachets, small food service plastics, plastic shopping bags and food wrappers were the most prevalent litter types by count, whereas contaminated items of any type were the most dominant litter type by mass.

Contaminated items were recorded to highlight litter types that are less likely to be transported from natural processes, such as surface water or wind, to inform model predictions that might otherwise be overestimated.



Overall, the mass of plastic was similar across the four-case study kecamatan during the 'dry' season sampling period (between July and October 2022). However, flooding events which occurred in Jembrana kecamatan before the FC2 survey may contribute to the large decrease in the overall mass of plastic recorded.

Comparatively across all the kecamatan surveyed throughout Indonesia (n=20), Jembrana was the 4th most polluted kecamatan, Muncar was 6th Banyuwangi was the 9th and Mendoyo was 10th over two sampling periods (FC1 and FC2).

2.3 Results: Beach plastic

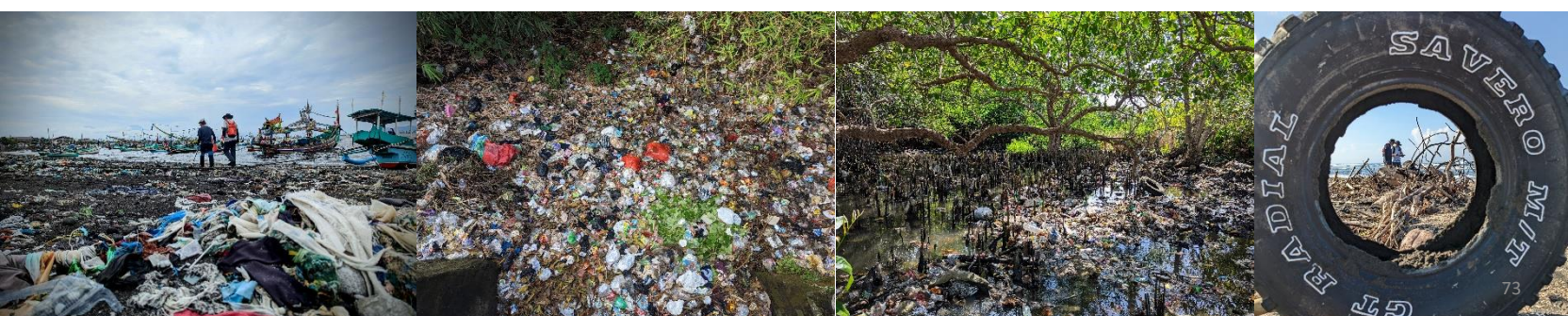
- Diapers were the most dominant litter type by mass found on the four case study site beaches and in similar quantities within the two regencies.
- Expanded polystyrene (EPS) packaging was also more prevalent on beaches compared to land-based studies. This buoyant plastic might arise from surrounding fishing communities (such as Muncar) or deposited on shorelines from ocean currents. The items were often fragmented and difficult to assign to a specific product.
- The most prevalent litter type found on the Kali lo river (captured by trash booms) in Banyuwangi kecamatan was also EPS, highlighting this litter type may also be transported in higher abundances than other litter types within Banyuwangi from upstream environments (Chapter 2.7).

Natural Environment Research Council

2.4
Riverine Plastic Leakage

Panji Pamungkasd[a], Gede Hendrawan[a], Max Kelly[b], Richard Thompson[b], Reza Cordova[c]

[a]*Universitas Udayana,* [b]*University of Plymouth,* [c]*Research Center for Oceanography, National Research and Innovation Agency (BRIN),*



Executive summary

Plastic contamination in marine environments primarily stems from terrestrial sources, including via direct discharge from coastal regions and via the transportation in rivers. There are a lack of studies informing riverine plastic leakage rates in Indonesia. Our research examines plastic leakage rates and seasonal variations in four rivers within the Bali and Banyuwangi case study areas, using trash booms to capture and subsequently characterise the most prevalent litter types. Our results revealed that the Banyuwangi rivers (Lo and Setail rivers) released more plastic litter than the Jembrana rivers (Ijo Gading and Yeh Embang rivers) and that plastic leakage was higher during the west monsoon (rainy season) across all study sites. Sachets, plastic shopping bags, plastic fragments, and other plastic bags were the most consistently abundant litter types. By elucidating the pathways and seasonal variations of plastic litter, we can help improve waste management practices and public awareness campaigns, contributing to a sustainable and healthier environment for both marine life and local communities

Three research findings are highlighted in this synthesis study:

1. An estimated 150 kg of plastic enters the Bali Strait daily, with the Lo River in Banyuwangi being the largest contributor.

2. There is a greater plastic leakage rate in Banyuwangi rivers compared to Jembrana rivers.

3. The most dominant litter types varied among rivers, for example, Lo River, Banyuwangi, had the largest proportion of expanded polystyrene (EPS) takeaway food containers. However, common items were consistently prevalent across all four rivers, including sachets, plastic shopping bags, plastic fragments, and other plastic bags.

2.4 Methodology

1. Site selection

After a comprehensive pre-survey across Banyuwangi and Bali, we meticulously chose four rivers to serve as focal points for our analysis. In Banyuwangi, we examined the Lo River and the Setail River, while in Jembrana, our focus was on the Ijo Gading River and the Yeh Embang River.

The rivers were selected due to the varied geographical locations and differing population densities that encircled them. This would allow us to gain a nuanced understanding of the intricate interplay between environmental factors and human settlements in these diverse regions.

2.4 Methodology

2. Litter trap net

Trash booms and roll nets were utilized to capture litter. Roll nets were employed in cases of extreme weather conditions, where there was potential for significant flooding events. The trash boom dimensions were 1 x 0.6 meters for each segment, while the roll was adjusted to match the width of the river x 2 meters. Both litter traps had a mesh size of 1.27 centimeters.

3. Time and period

To capture seasonal variation, our survey represented rainy and dry seasons in the East Monsoon and West Monsoon periods. For the East Monsoon period, we conducted a survey in June, July, and August 2022. For the west monsoon period, we conducted the survey in December 2022, January and February 2023. In each month, trash booms were placed for 8 days and the trapped litter was collected and characterised every day across 25 categories of litter as used throughout all litter surveys within PISCES.

2.4 Methodology

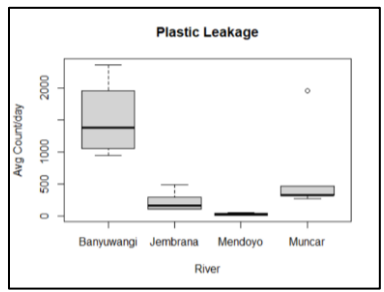
3. Characterization

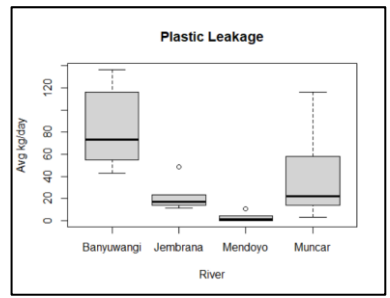
Trapped plastic litter was categorised using the PISCES's 25 plastic litter types. The amount, weight, and volume of each plastic type and intact bags were counted and measured.

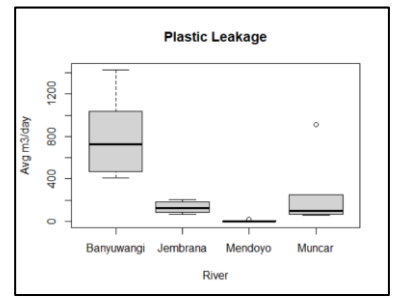
Additional data collected during the surveys included trapping time, river flow rate, and weather condition to help describe patterns in the subsequent findings.

2.4 Results: Plastic leakage

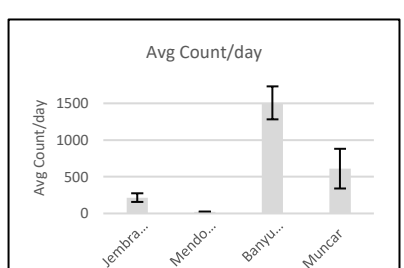
- There was a greater quantity of litter within the Lo river (Banyuwangi) compared to the rivers surveyed in Jembrana (Ijo Gading River and the Yeh Embang River).

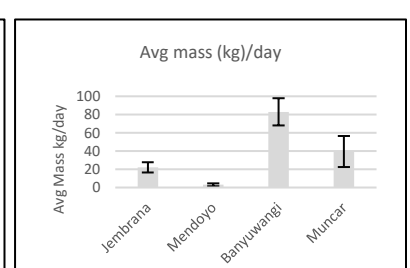


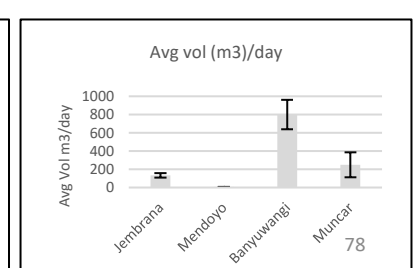




- The average rate of plastic leakage varied between rivers (weight, volume & no. of items):
  - Lo River Banyuwangi : 1500 items/day, 83 kg/day, 799 m^3/day
  - Setail River Muncar: 609 items/day, 39 kg/day, 247 m^3/day
  - Ijo Gading Jembrana: 214 items/day, 22 kg/day, 133 m^3/day
  - Yeh Embang Mendoyo: 20 items/day, 3 kg/day, 5m^3/day

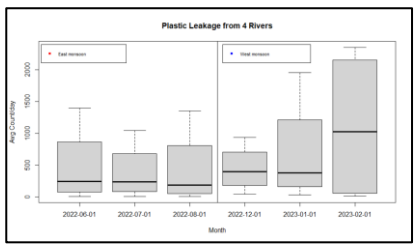


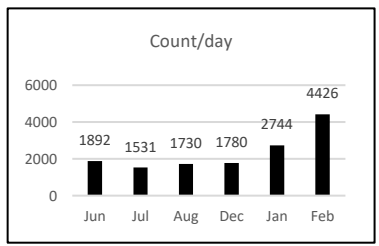


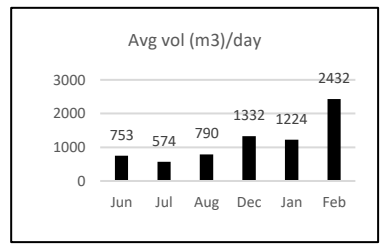


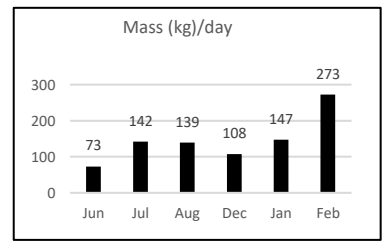
2.4 Results: Seasonal plastic leakage

- Plastic leakage is relatively higher in the west monsoon (rainy season).

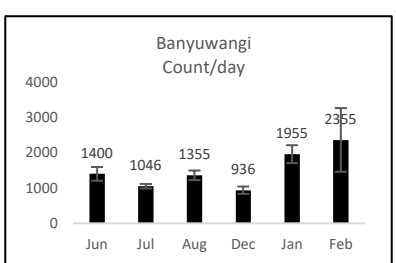


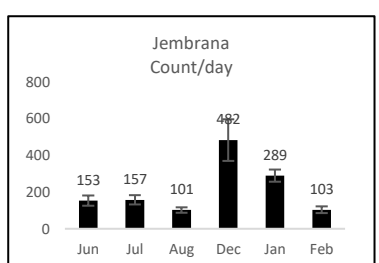


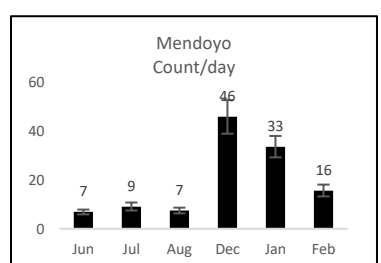


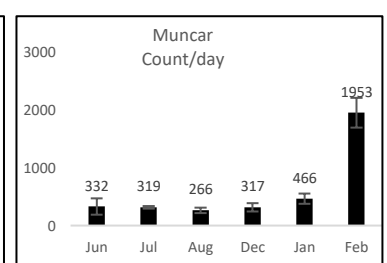


- The peak of plastic leakage in Banyuwangi is in February, while in Jembrana is in December.









- Correlation analysis shows a positive relationship between plastic leakage and total precipitation.

2.4 Results: Plastic leakage relating to the population density

- There was a significant difference ($p<0.05$) between rivers with different average population densities (Kruskal-Wallis test & Wilcoxon Rank-Sum Test)
- High average population density: Banyuwangi & Muncar, Moderate: Jembrana, Low: Mendoyo

	Banyuwangi		Jembrana	
River	**Kali Lo**	**Kali Setail**	**Ijo Gading**	**Yeh Embang**
Average population density/km2	**806**	**777**	**570**	**249**
	High	**High**	**Moderate**	**Low**

2.4 Results: Most prevalence items

•Plastic composition was similar between the rainy and dry season although the most dominant litter types varied between rivers.

•The most common items found across all rivers were: sachets, plastic shopping bags, plastic fragments, and other plastic bags.

•For the Lo River Banyuwangi, Expanded polystyrene items were the most prevalent which consisted of mainly takeaway food containers

3. Key Messages

Mapping the Indonesian literature identified knowledge holders and key data gaps that have subsequently been addressed within PISCES WP2, including the development of a novel rapid litter survey focusing on characterising and monitoring litter near the source of environmental leakage.

Recording litter across 20 kecamatan during 3 field campaigns (around the monsoon) within communities, along rivers and on beaches, covering >26,00 km^2, revealed plastic food and beverage items, including plastic sachets, are a priority for targeted interventions. The largest accumulations of litter were often recorded at informal dumpsites on river banks with items discarded in plastic bags, highlighting the need for additional waste management infrastructure and collection services.

Future monitoring of such interventions also needs to focus on quantifying the pollutant near the source, adopting the approaches developed here, for the most accurate understanding of the efficacy of subsequent legislative provisions and industry focused solutions.

Key Results:

1. Novel rapid litter survey focusing on understanding leakage near source addresses a major gap in monitoring plastic pollution in Indonesia and across the world.

2. Key items for intervention include sachets (particularly food snacks), food and beverage packaging (food wrappers and plastic cups), and plastic bags, which are consistently found across multiple environments and provinces in Indonesia.

3. Plastic leakage from rivers correlates to seasonal variability and population density as there was a greater quantity of plastic recorded on rivers during the rainy season.

4. Frequently Asked Questions

How can these results help Indonesia reduce plastic pollution?

To tackle plastic pollution, interventions need to be targeted to the specific problem, as the ‘solutions' will not be 'one size fits all’. The novel rapid litter survey developed here, allows us to understand the most prevalent litter types over large spatial scales from source to sea to inform local and national level interventions.

For example, sachets have low economic value and high processing costs in recycling so alternative materials or different food/product delivery systems (e.g. re-use) might be required; whereas, plastic bags are frequently found in concentrated litter piles containing waste, indicating their use as waste receptacles within homes before being discarded into the environment in the absence of formal disposal routes.

The approach also provides a fine resolution in detecting differences between individual commercial establishments, road types, dump and land-use types, to highlight the specific locations where interventions can be most effective.

Whilst the predominant focus in the global effort to study plastic pollution has been directed towards coastal environments, often over small spatial scales (individual transects), we provide the most comprehensive assessment of litter in Indonesia to date. We identify sachets and small food service items as key litter types for intervention.

Understanding the problem at the source of litter leakage by providing on-the-ground empirical data is crucial to ensure effective monitoring and interventions to stem the tide of plastic pollution.

5. Future Research Agenda

The next step in the analysis is to provide a greater understanding of how each of the observed auxiliary factors (waste management, land use, domain and amenities) affect the overall quantity and types of plastic litter found. This analysis will draw on the data obtained from our field surveys but also from insights provided in across PISCES.

For example, exploring **why** we see these types of litter as most prevalent in the environment from the data obtained in PISCES behavioral surveys (Chapter 4).

The latest series of data collection during the post monsoon period will help answer the question of how the monsoon season affects the quantities of litter near leakage source on land.

Finally, our approach will be built upon to enable long term monitoring of plastic pollution to determine the efficacy of new interventions that are brought forward to track future progress.

Chapter 3.
Understanding Environmental, Social, Economic and Related Health and Wellbeing Impacts of Plastic Pollution and Benefits of Reducing Plastic Contamination in Indonesia

[1]University of Plymouth, Plymouth, UK; [2]Universitas Esa Unggul, Jakarta, Indonesia; [3]Udayana University, Jimbaran, Indonesia; [4]Asian Institute of Technology, Bangkok, Thailand; [4]Brunel University of London, UK

Contents

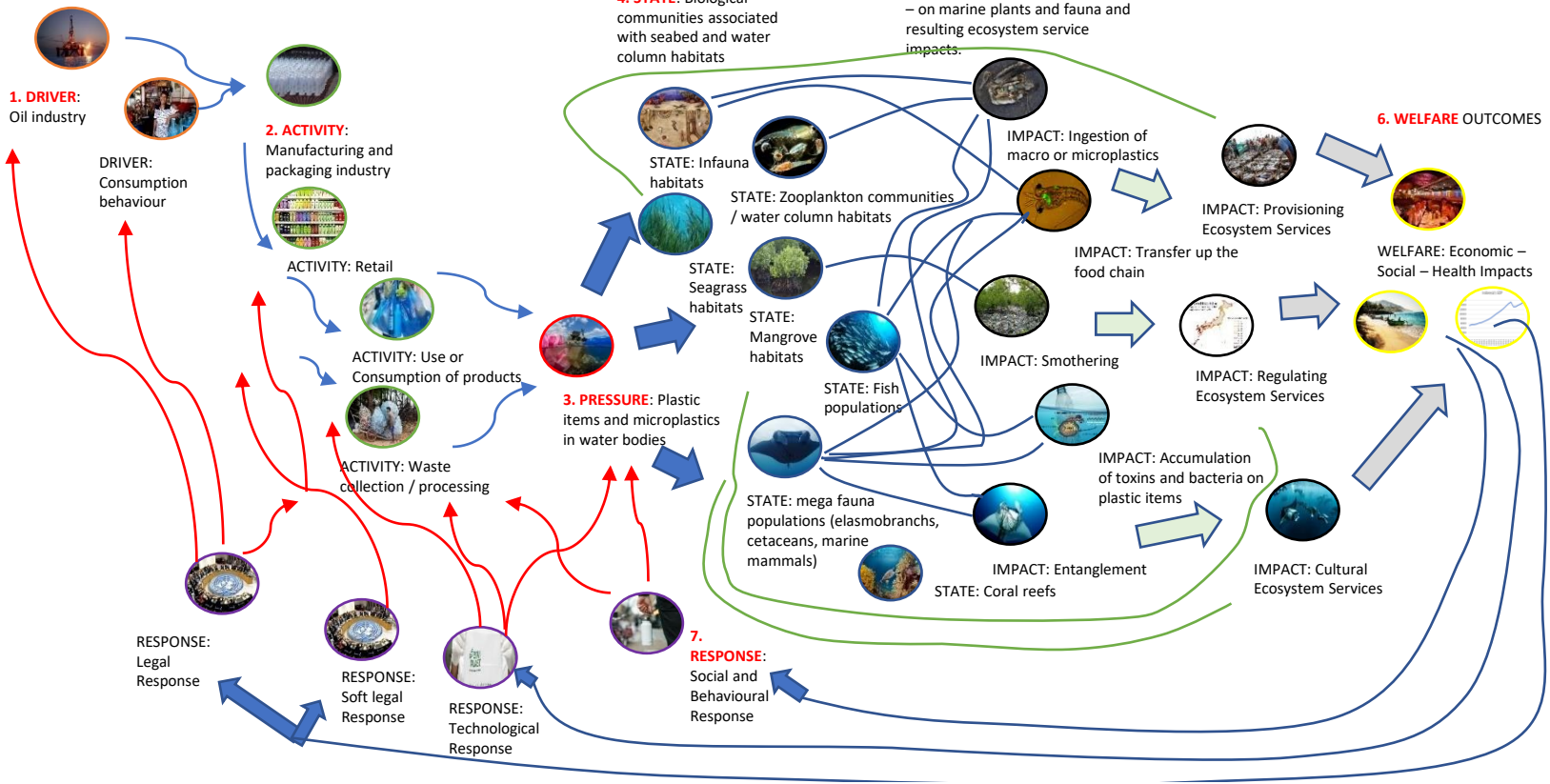
Context

The impacts of plastic contamination on the marine environment, human health and wellbeing are uncertain, but are likely to be multiple. A key priority for Indonesia is to identify habitats, biota, communities and economic and social sectors that are most vulnerable to marine plastic pollution. The PISCES work-package three team has used state-of-the-art methods for determining the ecosystem service impacts of plastic pollution, integrated to identify the costs of no action and to predict the efficacy of interventions.

Our specific aims are to :

- Identify the spread and distribution of plastic debris in the Bali Strait between East Java and Bali (3.1).
- Assess the spatial interaction of this plastic pollution with the natural environment in Indonesia and map the potential ecosystem service contribution from habitats (3.2)
- Assess habitat and species sensitivity to marine plastic pollution and assess and map the implications and risks for potential ecosystem service contribution, human health and well-being (3.3 and 3.4)
- Estimate the economic costs of impact on and damage to engineered infrastructure waste plastic debris (3.4).

Based on findings to date, there is now an opportunity to tailor spatial evidence and tools to the needs of policy development and management.



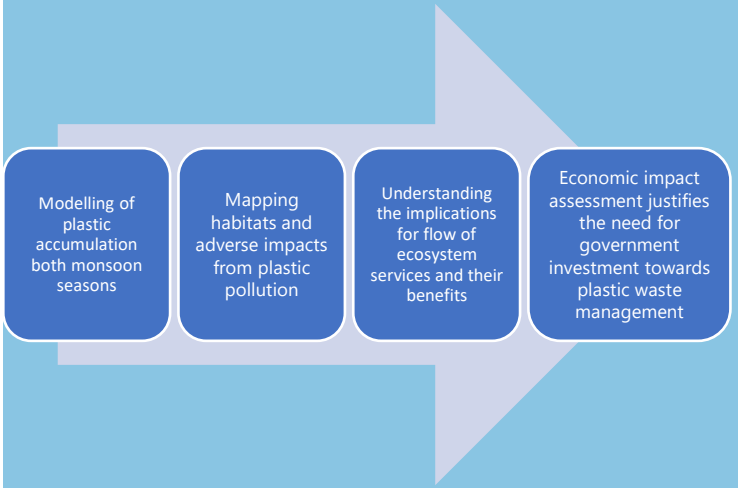
Drivers (1), activities (2) and pressures (3) related to plastic pollution on the state of the environment (4) to assess impacts and implications for ecosystem services (5) and human welfare (6) and identify the costs of inaction and the costs and benefits of interventions/responses (7).

Executive summary

Four research findings are highlighted in this synthesis study:

1. Plastic marine debris accumulation hotspots can be modelled for each monsoon season.
2. Our work enables low-cost benthic habitat mapping for coastal and marine environment in Indonesia.
3. Both literature review and Delphi study highlight key ecosystems and their services in Indonesia that are most impacted by plastic pollution.
4. Economic impact assessment, based on statistical and econometric analysis, reflects the attribution of flood damage to unmanaged plastics in the environment and justifies the need for government investment towards plastic waste management to reduce recurring annual fiscal burden through public infrastructure damages

The four research findings build our understanding of distribution and accumulation of plastic pollution and the implications for ecosystem service availability and economic costs of inaction



3.1
Modelling Plastic Marine Debris Accumulation Hotspots

Gede Hendrawan, Putu Ranu Fajar Maharta, I Made Dharma Raharja,

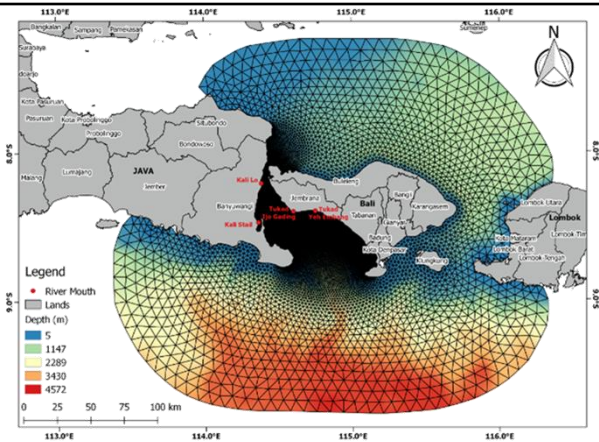
Udayana University, Jimbaran, Indonesia



3.1 Methodology

Monitoring marine debris accumulation zones in coastal areas poses numerous challenges. We conducted a case study in the Bali Strait, which features extensive coastal regions, complex coastline shapes, and dominant oceanographic dynamics as the primary factors driving debris towards coastal areas. Numerical models that explain these phenomena emerge as one of the best choices available for projecting where marine debris will accumulate.

The adoption and active enhancement of the Finite Volume Community Ocean Model (FVCOM) (Chen et al. 2003) has enabled the incorporation of a Lagrangian particle tracking system for monitoring marine debris. The marine debris tracking system focuses on comprehending the mechanisms of marine debris movement, commencing from its sources such as rivers and coastal activities, as well as its movement patterns in the sea. Furthermore, this system can also identify accumulation zones of litter on coastal shores. A high-resolution triangular grid supported by FVCOM enhances the accuracy of modeling marine litter movement along the coast. Additionally, weather, wave, and ocean observation data are integrated to improve the model's capacity to portray marine environmental conditions that impact marine debris movement and improve accuracy in tracking it.



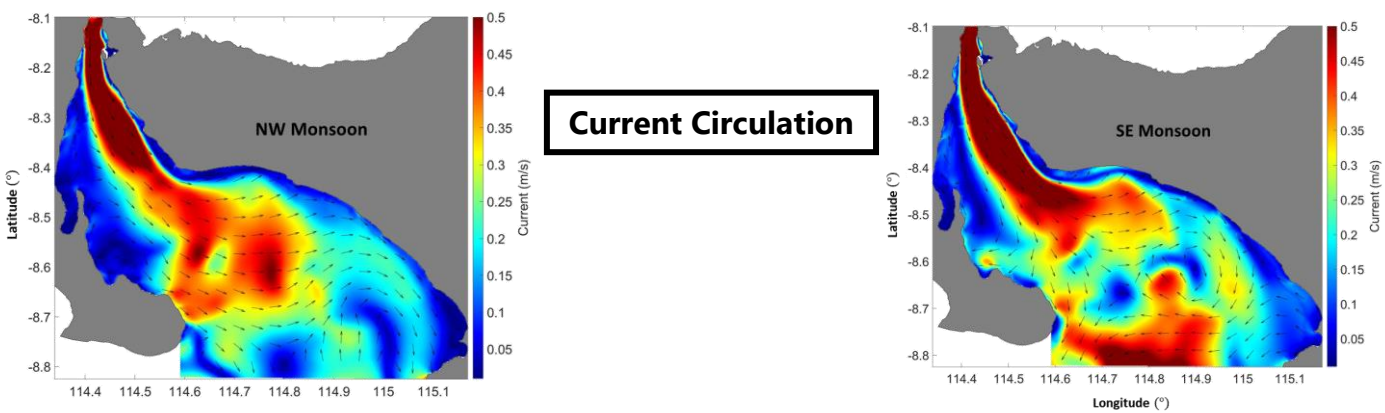
Item		Information	
Grid		Unstructured triangular grid with resolution 100 – 10 km.	
Layer		20 sigma layers.	
Bathymetry		Bathymetry data from Nasional Bathymetry Indonesia – Information Geospatial Agency	
Open boundary		Tide elevation (M2, S2, N2, K2, K1, O1, P1, Q1, MM, MF, M4, MS4, 2N2, S1, 2Q1, J1, L2, M3, MU2, Nu2, dan OO1)	Tide elevation from Tide Model Driver (TMD) - TPXO-9
Meteorological condition		- Wind - Air pressure - Heat flux - Precipitation - Evaporation	Meteorological condition from ECMWF Reanalysis v5 (ERA-5)
Particles Release from River		- Kali Lo - Kali Stail - Tukad Ijo Gading - Tukad Yeh Embang	Continue every 6 hours
Time simulation	Southeast Season	1 June - 31 August 2022	
	Northwest Season	1 December 2022 – 28 February 2023	
Time step (external mode)		1 seconds	
Time step (internal mode)		5 seconds	

3.1 Results

Task 3.1 Marine Debris Accumulation Hotspots

The current circulation patterns in the Bali Strait are significantly influenced by two seasons, namely the North-West Monsoon/Rainy season (December-January-February) and the South-East Monsoon/Dry season (June-July-August).

During the **North-West Monsoon**, the **currents** tend to move **eastward towards Bali Island**, during the **South-East Monsoon** season, the **currents** generally flow **westward towards Java Island**.



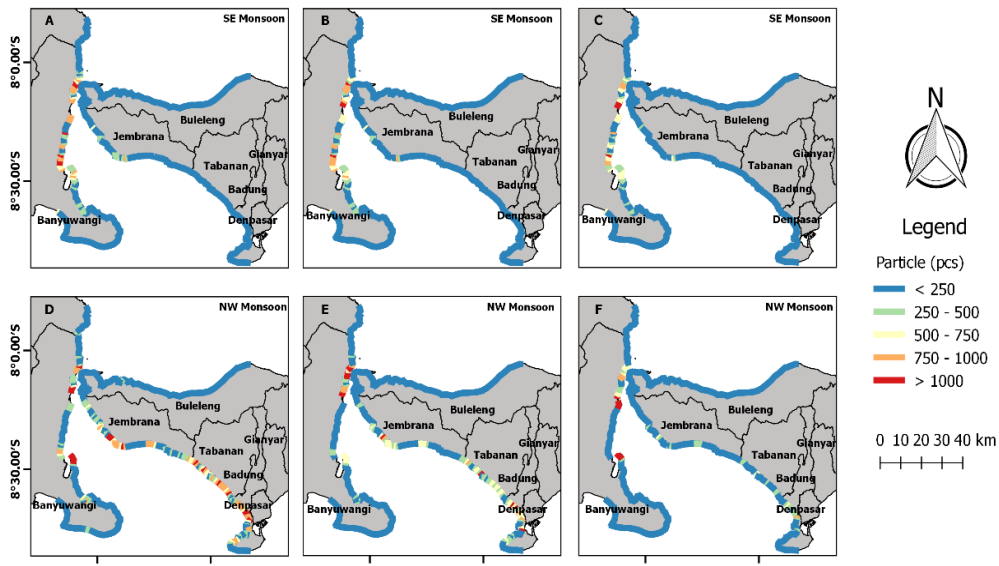
Current Circulation

3.1 Results

Marine Debris Accumulation Hotspots.

During the **North-West Monsoon**, marine debris **accumulates** along the coastlines of both **Java and Bali** Islands. In the case of Java Island, the **source** of marine debris is solely **from Java** Island itself, while the marine debris **accumulating** on **Bali** Island originates **from both Java and Bali** Islands. This phenomenon occurs due to the dominant sea currents moving towards Bali Island and the **increased volume of marine debris** entering the sea during the **rainy season**.

During the **South-East Monsoon**, marine **debris** tends to **accumulate** on the coast of **Java Island**. The **primary sources** are predominantly **from Java** Island itself and to a smaller extent from Bali Island. This occurrence is caused by the dominant sea currents moving towards Java Island.



A and D = Max Scenario, B and E = Mean Scenario, C and F = Min Scenario

Natural Environment Research Council

3.2
Benthic Habitat Mapping For Coastal and Marine Environments in Indonesia

Dr Radisti Praptiwi, Prawesti Wulandari, Ahmad Baddruzaman, Sainal, Carya Maharja

Universitas Esa Unggul, Jakarta, Indonesia

3.2 Methodology

Benthic habitat mapping for coastal and marine environments in Indonesia.

Machine learning was used to characterise benthic cover in coastal ecosystems both at case study (Bali Strait) and at national scales. The strength of this method is it enables monitoring of a large area with comparatively lower costs than in-situ techniques, especially as it relies on the use publicly available satellite images. A total of 6,472 sampling polygons, lines and points from 7 types of benthic habitats were collected from 6 locations in Indonesia to develop benthic habitat maps. All of these were possible due to the support of our local collaborators in Bali, Kepulauan Seribu, Kepulauan Selayar, Balikpapan, Nunukan, Baubau and Takalar.

Mapping Potential Ecosystem Service Contribution

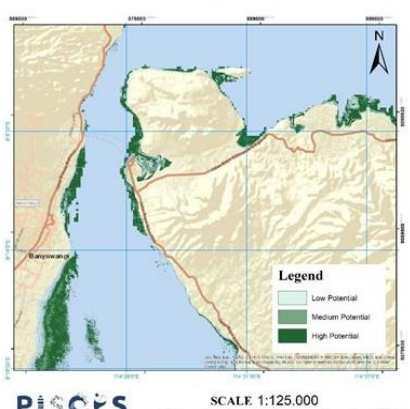
The identification of key benthic habitats will enable us to map the ecosystem services potential through integration with our previous work in Blue Communities (Hattam et al. 2021 and Broszeit et al. 2022). These habitats and ecosystem services maps will then be further integrated with our current PISCES work undertaking a systematic evidence review of the impacts of plastic on the species and habitats supporting marine ecosystems.

3.2 Results

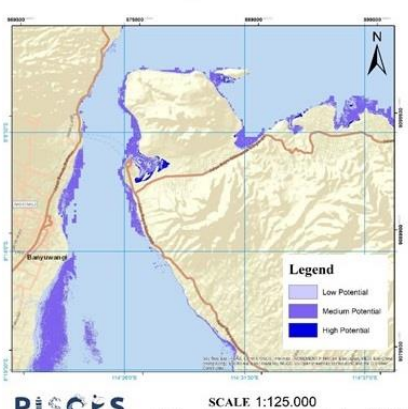
Mapping of Extent of Benthic Habitats and Ecosystem Service Potential

Benthic habitat maps are produced both at case study (Bali Strait) and national scales. The maps show distribution of 7 key habitats relevant to coastal and marine environment in Indonesia, those are: mangrove, coral reefs, seagrass, macroalgae, intertidal sand, subtidal sand, and sandy beach.

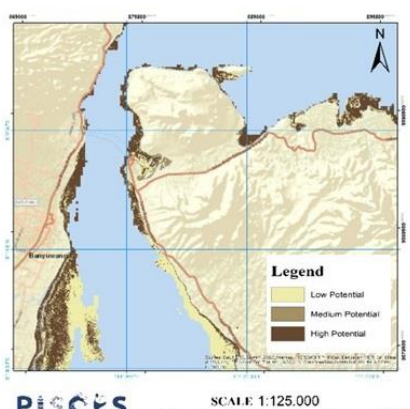
Provisioning Service:
Food Provisioning



Regulating Service:
Water Flow Regulation



Cultural Service:
Recreation

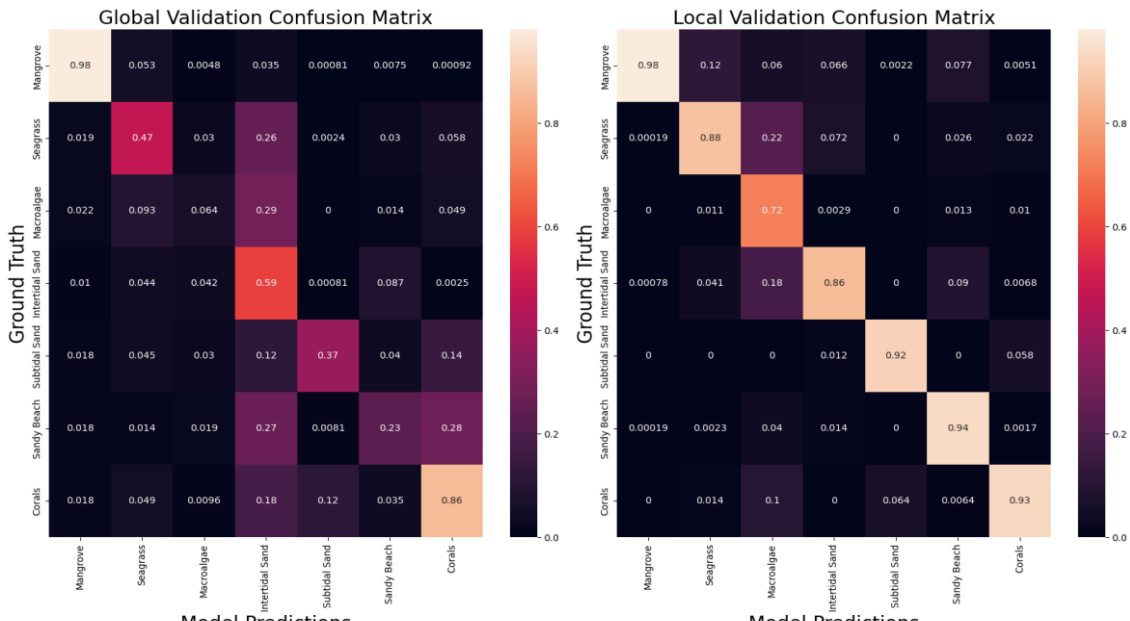


3.2 Results

Validation of the Mapping

The accuracy of the model developed to map these habitats was evaluated using validation data sets. Accuracy testing showed good fit of the model with ground-truth data, with overall accuracy of 95.8% at local level, and 70.85% at global level.

The map will support governance actors at various levels in the management of coastal areas in the region. As an illustration, the habitat map can be integrated with the result of ecosystem services assessment to produce a map of potential ecosystem services.



3.3
Assessing Habitat and Species Sensitivity to Marine Plastic Pollution and Implications for Flow of Ecosystem Services

Dr Matthew Ashley[1], Dr Radisti Praptiwi[2], Carya Maharja[2], Prawesti Wulandari[2], Ahmad Baddruzaman[2], Sainal[2], Dr Fiona Culhane[1], Professor Mel Austen[1]

[1]University of Plymouth, Plymouth, UK; [2]Universitas Esa Unggul, Jakarta, Indonesia

3.3 Methodology

Systematic Review:

Our evidence review specifically focused on two main questions:

(1) What are the effects of marine plastic pollution on the health of marine and coastal habitats in south-east Asia and their related species and ecological communities?; and (2) What are the implications for provision of ecosystem services if these habitats and related species are negatively impacted by marine plastic pollution?

From the evidence identified in the review, the team assigned categories of habitat sensitivity to plastic pollution, based on the 'resistance' and 'resilience' of each habitat type to the pressures related to plastic types (e.g. sensitivity to smothering or entanglement from exposure to large plastics, or plastic sheets; or ingestion of bacterial contamination related to very small 'microplastic' particles). Sensitivity assessment was based on 'Marine Evidence-based Sensitivity Assessment (MarESA)' guidance provided by Tyler-Walters et al., (2023).

Ecosystem Services are the contributions that ecosystems make to human well-being and quality of life, such as food from animals and plants, and healthy environments that maintain the climate and provide opportunities for recreation.

3.3 Methodology

Synthesis

The implications for availability of ecosystem services from habitats and species impacted by plastic accumulation were then assessed based on the potential contribution of each habitat and species to individual ecosystem services. Level of potential contribution was attributed from evidence provided in 'A Matrix Approach to Tropical Marine Ecosystem Service Assessment in South-east Asia' by Hattam et al. (2021).

By combining the benthic habitat mapping and evidence review work the team mapped the sensitivity of coastal waters to marine plastic pollution. Where there are hotspots identified for accumulation of plastic pollution, the risk of loss of ecosystem services in those locations can be assessed. The results will help inform policymakers by identifying priority areas for plastic management interventions.

3.3 Methodology

Sensitivity Assessment

We assessed areas at risk of loss of ecosystem services based on habitat or species sensitivity to exposure to plastic litter (via ingestion, entanglement, smothering, contamination). Sensitivity assessment was based on the assessment of a combination of initial disease or mortality (resistance) and recovery time (resilience).

	Resistance			
Resilience	**None**	**Low**	**Medium**	**High**
Very Low	**High**	**High**	**Medium**	**Low**
Low	**High**	**High**	**Medium**	**Low**
Medium	**Medium**	**Medium**	**Medium**	**Low**
High	**Medium**	**Low**	**Low**	**Not sensitive**

Sensitivity matrix combines resistance and resilience. Sensitivity increases diagonally from the lower right to the upper left of the matrix

Resistance	Description
None	Key functional, structural, characterizing species severely decline and/or physicochemical parameters are also affected e.g. removal of habitats causing a change in habitat type. A severe decline/reduction relates to the loss of 75% of the extent, density or abundance of the selected species or habitat component e.g. loss of 75% substratum (where this can be sensibly applied).
Low	Significant mortality of key and characterizing species with some effects on the physicochemical character of habitat. A significant decline/reduction relates to the loss of 25-75% of the extent, density, or abundance of the selected species or habitat component e.g. loss of 25-75% of the substratum.
Medium	Some mortality of species (can be significant where these are not keystone structural/functional and characterizing species) without change to habitats relates to the loss of <25% of the species or habitat component.
High	No significant effects on the physicochemical character of the habitat and no effect on the population viability of key/characterizing species but may affect feeding, respiration and reproduction rates.

Table 4. Assessment scale for resilience (recovery)

Resilience	Description
Very Low	Negligible or prolonged recovery possible; at least 25 years to recover structure and function
Low	Full recovery within 10-25 years
Medium	Full recovery within 2-10 years
High	Full recovery within 2 years

3.3 Results

Highest Sensitivity was assessed for:

Mangrove: Impacts of smothering (young shoots and leaves).

Coral reef: Impacts of bacterial contamination and smothering from entanglement and coverage from larger plastics and contamination from microplastics.

Cetaceans: Impacts from ingestion of microplastics and larger plastic debris (also medium sensitivity related to entanglement).

Turtle species: Impacts from ingestion of microplastics and larger plastic debris and from entanglement in larger plastic items.

Manta ray and whale shark: Ingest high quantities of macro and micro plastics when filter feeding. There is limited evidence of mortality effects, but existing research suggests sensitivity may be high, especially as they are species that are slow to mature and display low fecundity.

Moderate Sensitivity was assessed for:

Fish: Impacts from ingestion of microplastics.

Seagrass: Smothering or covering from larger plastic items and attachment of microplastics to shoots and absorbing contaminates.

Mangrove: Impacts from attachment of microplastics to plants and absorbing contaminants.

Lower Sensitivity was assessed for:

Infauna within **subtidal sand and mud habitats**: Ingestion of microplastics and smothering or coverage from larger plastics.

Fish: Entanglement in lager plastic items although confidence in the assessment was low due to lack of evidence.

Macroalgae (large seaweeds): Absorption of microplastics and contaminants, although confidence in the assessment was also low.

Zooplankton: Ingestion of microplastics in pelagic water bodies, although confidence in the assessment was also low

	Resistance	Resilience	Sensitivity	Plastic type	Interaction
Habitats/Biotopes					
Mangrove – smother/coverage	L	L	H	Macro-plastic	Cover/smother
Mangrove – absorb	M	M	M	Micro-plastic	Entrap/absorb
Seagrass – smother/coverage	M	M	M	Macro plastic	Cover/smother
Seagrass - absorb	No Ev.	No Ev.	No Ev.	micro-plastic	Entrap/absorb
Coral – cover/entangle/contaminate	L	L	H	Macro-plastic	Cover/smother/contaminat
Intertidal sand	M	H	L	Micro-plastic	ingestion
Subtidal sand	M	H	L	Micro-plastic	ingestion
Intertidal mud	M	H	L	Micro-plastic	ingestion
Subtidal mud	M	H	L	Micro-plastic	ingestion
Infauna - ingestion	M	H	L	Micro-plastic	ingestion
Infauna - coverage	M	H	L	Macro-plastic	coverage
epifauna	No Ev.	No Ev.	No Ev.	Macro-plastic	coverage
Pelagic water body - zooplankton	M	H	L	Micro-plastic	ingestion
Rock/macroalgae - coverage	M	H	L		
Macroalgae - absorption	M	H	L	Micro-plastic	Ingest/absorption
Species supporting fisheries					
Fish - entanglement	M	H	L	Macro-plastic	entanglement
Fish - ingestion	M	M	M	Micro-plastic	ingestion
Crustaceans					
Megafauna					
Shark	No Ev.	L	No Ev. (H)	Both	ingestion
Ray	No Ev.	L	No Ev. (H)	Both	ingestion
Cetacean - entangle	M	M	M	Macro-plastic	Entanglement
Cetacean - ingestion	L	L	H	Micro-plastic	ingestion
Turtle - entanglement	L	L	H	Macro-plastic	Entanglement
Turtle - ingestion	L	L	H	Micro-plastic	ingestion
Mammal - manatee	M	H	L	Macro-plastic	Entanglement

3.4.
Expert Elicitation Study of Key Ecosystems and Their Services That Are Most Impacted By Plastic Pollution

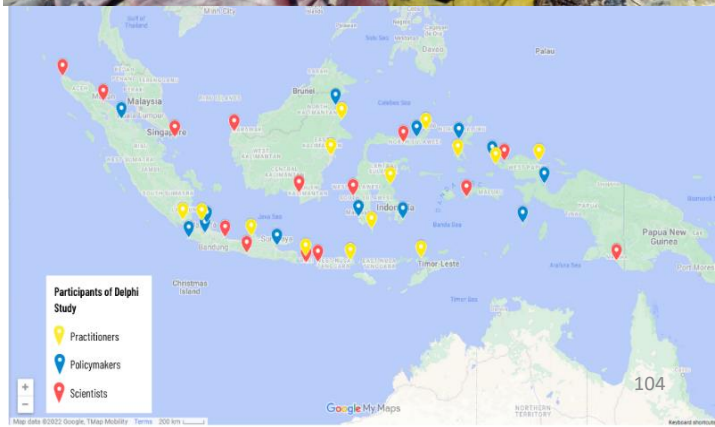
Carya Maharja2, Dr Radisti Praptiwi2, Prawesti Wulandari2, Sainal2, Dr Matthew Ashley[1], Dr Kayleigh Wyles[1], Professor Mel Austen2

[1]University of Plymouth, Plymouth, UK; [2]Universitas Esa Unggul, Jakarta, Indonesia

3.4 Methodology

To augment the findings gathered from systematic evidence review (3.3), we have conducted a two-round Delphi survey. This is a method based on expert elicitation, to understand how plastic accumulation in various coastal ecosystems affects the supply of ecosystem services and impacts on human health and well-being. For this work, we collected questionnaire responses from 42 experts consisting of Indonesian policymakers, practitioners and scientists. The final round of the Delphi survey was completed in April 2023.

The experts we consulted were distributed across various regions in Indonesia. The data is currently being analyzed and a publication will be released soon. The findings will indicate the experts' perception of which ecosystems and ecosystem services are most vulnerable to plastic accumulation in Indonesia. Furthermore, the Delphi survey will also provide an indication of how the decline in ecosystem services supply due to plastic accumulation will affect the related human health and well-being dimensions. These will inform policymaking, monitoring and management efforts, especially by providing priority areas and significant knowledge gaps.



3.4 Results

The expert panel was in agreement that, over the next 10 years, the island of **Java** will see the highest amount of plastic accumulation in its coastal environment.

The plastics were perceived to accumulate mainly in **mangrove, sandy beach**, and **coral reef** ecosystems.

The accumulated plastics were perceived to adversely impact the ecosystem services of **food provisioning** (supplied by seagrass and coral ecosystems)**, flood control** (supplied by mangrove ecosystem), **erosion control** (supplied by seagrass and coral reef ecosystem), and **recreation** (supplied by mangrove and coral reef ecosystems).

Plastics accumulated in coral reef ecosystem were consistently perceived to have higher risk of adverse impacts on the well-being dimensions of **physical health, mental health and household income.**

3.4
Economic impact assessment of flood damage related to unmanaged plastics in the environment and justification of the need for government investment towards plastic waste management to reduce recurring annual fiscal burden through public infrastructure damages

Professor Joyashree Roy, Dr Satabdi Datta , Dr Shreya Some , Jeeten Kumar, Angga Hendi Prabowo

Asian Institute of Technology, Bangkok, Thailand

3.4 Methodology

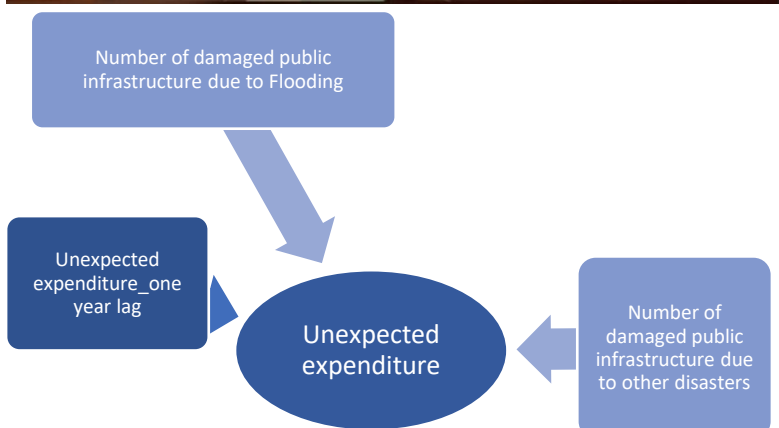
A greater qualitative understanding of attribution of flooding to unmanaged plastic waste in the environment was reviewed using multiple sources of evidence.

To determine a quantitative assessment of attribution of flooding to unmanaged plastics in the environment, we applied statistical tests to both primary and secondary data collected a) as part of our plastic litter surveys at a national scale (chapter 2) and b) secondary data obtained from official government sources (n=34 provinces) on the number of public facilities damaged due to flood events between 2012- 2021.

Using these data, we examined the correlation and strength of the relationship between unmanaged plastics in the environment (inaction) and flood related damages to public infrastructure .

An econometric model was constructed for estimating economic costs of damages to public infrastructure due to flooding in terms of per capita costs of actions and inactions.

An expert consultation workshop was carried out to validate some of our model assumptions



3.4 Results

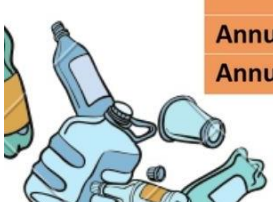
Multiple lines of evidence on Indonesia show

Unmanaged Plastics in the environment are **highly correlated** with Flood Induced Damage to Public Infrastructure

1% increase in **flood induced damage** to public infrastructure causes **0.34%** increase in Unexpected Expenditure, while **other disasters cause 0.24% increase**

Cost of action for building state of the art plastic management infrastructure is way less than the cost burden on annual budgetary expenditure from **damage to public infrastructure from flooding (cost of inaction)**

Costs	Per capita cost	
	in IDR	in USD
Annual cost of action	6,776.09	0.45
Annual cost of inaction	1,01,712.30	6.72



Cost of inaction is 15 times more than cost of action

4. Key Messages

Marine plastic and its ecosystem service impacts

Models show where marine plastics come from and where they accumulate. The overall impact of exposure to plastic litter scenarios on the ecosystem service potential within case study areas can be assessed.

These mapped results are automated within a Geographical Information System for application outside case study sites.

Maps can be used in combination with mapped locations of importance to residents and visitors, e.g. tourism businesses or dive sites may be impacted.

Expert perceptions can be integrated with evidence from literature review and sensitivity assessments to prioritise sites and communities where actions to address plastic pollution sources can be targeted. Expert perceptions support evidence that greatest impacts were to coral, mangrove and seagrass habitats & associated species. Working with our wider PISCES team, we can identify the source of plastic pollution that creates adverse impacts and the best location for potential solutions and then map the benefits from maintaining ecosystem service contributions.

Key Results:

Economic costs related to inaction.. or action

Investment in infrastructure for plastic management is net national/ provincial/ regency level welfare enhancing.

Fiscal burden of flooding due to unmanaged plastics in the environment makes the flood impact worse due to blockages and damages to public engineered infrastructure system.

Data management for identification of the costs of actions and inactions can help in planned minimization of fiscal burden on already strained budgetary situations in developing countries like Indonesia.

5. Frequently Asked Questions

What are the fiscal and monetary reasons for the government to focus on unmanaged plastics in the environment?

The study findings show that inactions of the government regarding waste management lead to higher monetary costs to the government in terms of compensation/ rehabilitation/ reconstruction after hazards caused by unmanaged plastics in the environment, compared to the costs of waste management related action of the government. Governmental revenue can also be negatively impacted due to these losses to various economic sectors.

How are ecosystem-based economic activities getting impacted due to unmanaged plastics in the environment?

Unmanaged plastics in the environment create multiple hazards, e.g. littering of beaches/ natural places of recreation, limiting drainage water run-off, aggravated impact of flooding leading to damage to public and private infrastructure, health hazards, increased governmental unexpected expenditure, losses to households, economic losses to tourism and fisheries sectors.

5. Frequently Asked Questions

How can we prioritise monitoring and management actions?

By combining: mapping of extent of habitats, understanding of where plastic accumulation occurs, sensitivity of habitats and species to plastic pollution pressures, and associated impacts on potential ecosystem services you can see which habitats (mangrove, coral reef, seagrass) and biodiversity (cetacean, turtle and ray) will be most at risk from where they interact with plastic accumulation. You can also see which ecosystem services and benefits might be impacted (food provisioning, regulating services including climate regulation, and recreation and tourism opportunities). This can guide monitoring efforts and management interventions. Litter on beaches is also a concern for its impact on tourism and recreation benefits and should be monitored.

Based on the Indonesian experts' opinion, which coastal ecosystems and ecosystem services would have to be prioritised for monitoring and management efforts?

PISCES analysis indicates that mangroves, sandy beaches and coral reefs, and the ecosystem services of food provisioning, nursery habitat and recreation would be most vulnerable to plastic pollution. Hence these are likely to be suitable for targeted management and monitoring efforts.

The economic assessment of inaction provides answers to decision makers questions on how to effectively use budget and on which economic activities will benefit from action: How can the government utilize the budget more effectively towards national/ provincial/ regency level economic growth and human well-being?

Through identification of the costs of actions and inactions, governments can plan minimization of fiscal burden due to unexpected expenditure caused by inactions and invest in infrastructure and actions for plastic management.

6. Future Research Agenda

Over the coming months, our team will work to synthesize the gathered data to provide a comprehensive picture of the impacts of plastic pollution on the marine and coastal environment. We will aim to produce maps of plastic accumulation and assess the risk to the health of marine and coastal ecosystems in the case study site.

More widely, a national scale map showing habitat sensitivity towards plastic pollution will also be produced. These maps will be disseminated to governance actors, both at the case study sites and in other locations in Indonesia to inform regional planning regarding marine plastic pollution. In addition, the results from the Delphi survey will also provide inputs both for policy making and practice in the effort to allocate resources for focused monitoring and mitigation efforts. Our work will contribute towards ensuring that management efforts for plastic pollution in the marine environment can be performed effectively and at appropriate scales, so that these crucial environments can provide the ecosystem services essential for human health and well-being now, and in the future.

On economic cost-benefit/ welfare assessment the team will focus on welfare loss to infrastructures other than public infrastructure, ecosystem service based economic activities, livelihood, stakeholders, sectors. This study will provide guidance for economic policy and instruments.

(Photo credit: Prawesti Wulandari) Indonesia has incredible marine and coastal environments that if kept healthy support local communities and visitors. For instance providing food and opportunities for recreational activities that support people's income, keep people healthy and encourage social activities.

Plastics in Indonesian Societies (PISCES):
Systems Analytics Approach to Reduce Plastic Pollution

Natural Environment Research Council

Chapter 4.
Identifying Social and Behavioural Changes Needed to Reduce Plastic Pollution

Wyles K[a], Voronkova A[a], Sudarso[b], Soedjono E[c], Syamsiah N[b], Henderson L[d], Susan Jobling[e], Kulsum Nm[e], Pahl S[f]

[a]University of Plymouth, [b]Universitas Airlangga, [c]Sepuluh Nopember Institute of Technology, [d]University of Strathclyde, [e]Brunel University of London, [f]University of Vienna




Contents

Context

Human behaviour and our decisions are both the ultimate cause *and* solution to plastic pollution. Concentrating on households within Indonesia, the PISCES team looks at understanding the role of human behaviour in contributing to plastic pollution, from the downstream (i.e., how and why people manage their waste in certain ways) to the upstream (e.g., understanding how and why certain products are purchased).

In order to co-create solutions, we aimed to understand the lived experiences of diverse people regarding plastic and plastic leakage, the motivations, habits, attitudes and emotions associated with current practices around plastics and identity processes underlying the plastic systems. Our studies attempt to represent the voices of people most affected by the current situation and by potential changes. Insights from our work will inform and facilitate circular economy solutions by identifying strategies to elicit and motivate changes in attitudes, perceptions and behavioural practices.

Context

Our objectives were:

1) To understand the level of understanding of sources, pathways, impacts of plastic pollution in different groups of residents in Indonesia.

2) To examine whether the current system of waste management and its implications are different for different groups of people (e.g., for men and women).

3) To understand the drivers and barriers of particular behaviours to be able to co-create a theory of change (i.e., identify optimum intervention points to encourage behaviour change).

4) To investigate which methods of communication and which messages about plastic pollution are most suitable to motivate change.

Fig. 1: Survey enumerators

Fig. 2: Professor Henderson and Nieke Monika engaging with stakeholders

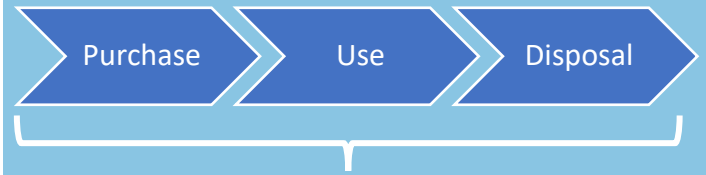
Fig. 3: WP4 members about to start a focus group discussion.

Fig. 4: A WP4 member gathering responses from a survey participant.

Executive summary

1. Human decision making is complex.
2. Not everyone manages their waste in the same way (notable differences between kecamatans and religions).
3. How people dispose of their waste depends on the product and its economic, social and cultural value.
4. Providing waste management infrastructure can help but does not fully replace other waste management behaviours (may reduce burning but regularly using dumpsites were seen to continue).
5. Community attachment, concern on the impacts on the environment and local community, and social capital (cultural values, community leaders, perceived collective responsibility) play influential roles in how people their waste.
6. Digital media is an important source of information, but this varies between groups of people and how they use it.

The six key points are based on speaking to residents of Banyuwangi, Jembrana, & Pasuruan, via focus groups, interviews, and questionnaires



Key reasons for behaviours:

social influence

socio-demographics

governance & infrastructure

attachment & concern

media & communication

Plastics in Indonesian Societies (PISCES):
Systems Analytics Approach to Reduce Plastic Pollution

Natural Environment Research Council

4.1
Identifying Social and Behavioural Changes Needed to Reduce Plastic Pollution

Wyles K[a], Voronkova A[a], Sudarso[b], Soedjono E[c], Syamsiah N[b], Pahl S[d]

[a]University of Plymouth, [b]Universitas Airlangga, [c]Sepuluh Nopember Institute of Technology, [d]University of Vienna




4.1 Insights from the literature

Aim 1: Drivers of current disposal behaviours

Waste management in Indonesia varies from municipally managed recycling, to garbage being burned or river dumped in remote and rural areas (Phelan et al., 2020; Sekito et al., 2013), to a vast informal sector built upon finding value in recyclable plastic items. As a result, people's main motivation to recycle may become **monetary** (Ulhasanah & Goto, 2018; Warmadewanthi et al., 2021) limiting willingness to put additional efforts/money to recycle items with no trading value.

Perceived **lack of knowledge/competence and lack of environmental awareness** also contribute to low waste sorting intentions (Kamil et al., 2021; Phelan et al., 2020; Sunarti et al., 2021). Limited existing evidence on what motivates people *to* separate and recycle waste suggests that social connectedness (communal activities, concern for the community, concern for the local natural environment) might be a factor (Brotosusilo et al., 2020; Schlehe & Yulianto, 2020).

4.1 Methodology

Aim 1: Drivers of current <u>disposal</u> behaviours

The lack of exploration of sociocultural aspects of **a variety of waste-related behaviours** remains to be a research gap and a limitation for the effectiveness of existing waste management awareness and implementation interventions (Phelan et al., 2020). Two studies were undertaken:

-Exploratory qualitative data collection: focus groups (N = 14, 5-10 participants per group) in Java (kecamatan Blimbingsari, Rogojampi) and Bali (kecamatan Jembrana, Mendoyo). *Format:* 5-10 people come together and discuss particular topics to gather a group consensus about certain topics. *Topics:* overall household waste management, management of plastic items, reasons behind specific behaviours, perceptions of plastic pollution impact.

-Exploratory quantitative data collection: survey (N = 506) in Java (kecamatan Blimbingsari, Rogojampi) and Bali (kecamatan Jembrana, Mendoyo). *Format:* data collectors visiting households in chosen locations and collecting responses to open and closed questions. *Topics:* overall household waste management, management of plastic items, perceptions of social norms, perceptions of plastic pollution impact, sources of information, demographics.

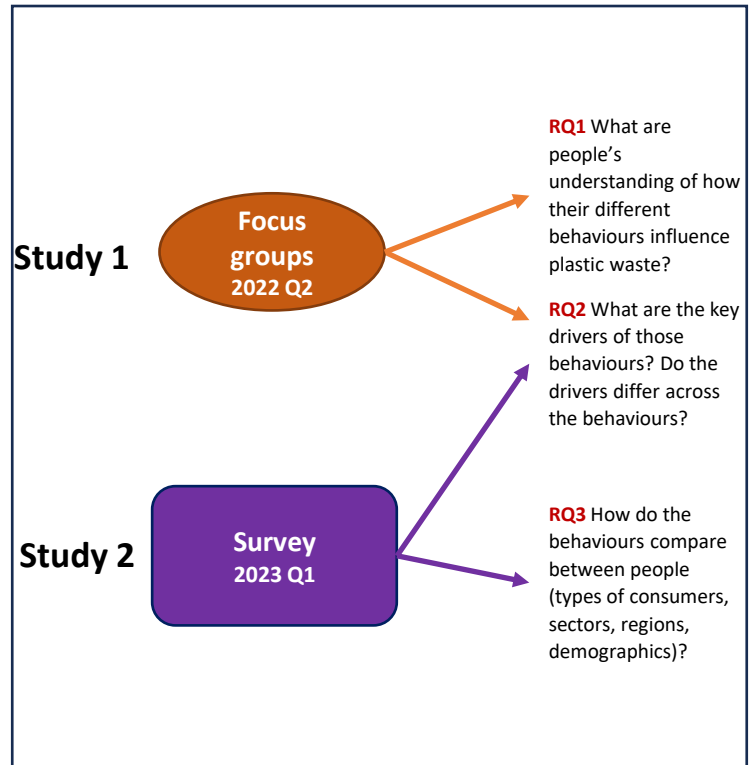


Fig. 5: Aim 1 research questions

4.1 Methodology

Aim 2: Drivers of current purchasing behaviours

Plastic sachets in Indonesia are of particular interest to this project. Sachets are incredibly popular in Indonesia, serving single-use portions of various products from coffee to laundry detergents, to facial cream, to spices. In Indonesia plastic sachets amount to 768,000 tonnes of plastic waste per year (GAIA, 2022). They are made of multi-layered thin plastic and are **not recyclable,** hence, have **no monetary value** and are of no interest to waste pickers and waste banks (Zero Waste Indonesia, 2022). As a result, there are indications that people tend to dispose of them directly in the environment, by either burning them or throwing them on the ground/into a river. The limited attempts to recover and recycle sachets have so far been **unsuccessful** (McVeigh & Cahya, 2022). To address the issue of sachet use, it is important to understand why people purchase them.

Exploratory quantitative data collection: survey (N = 500) in Java (kecamatan Blimbingsari, Rogojampi). *Format:* data collectors visiting households in chosen locations and collecting responses to open and closed questions. *Topics:* purchasing frequencies, attitudes to sachets and alternative bigger packaging, role of promotions, environmental concern, demographics.

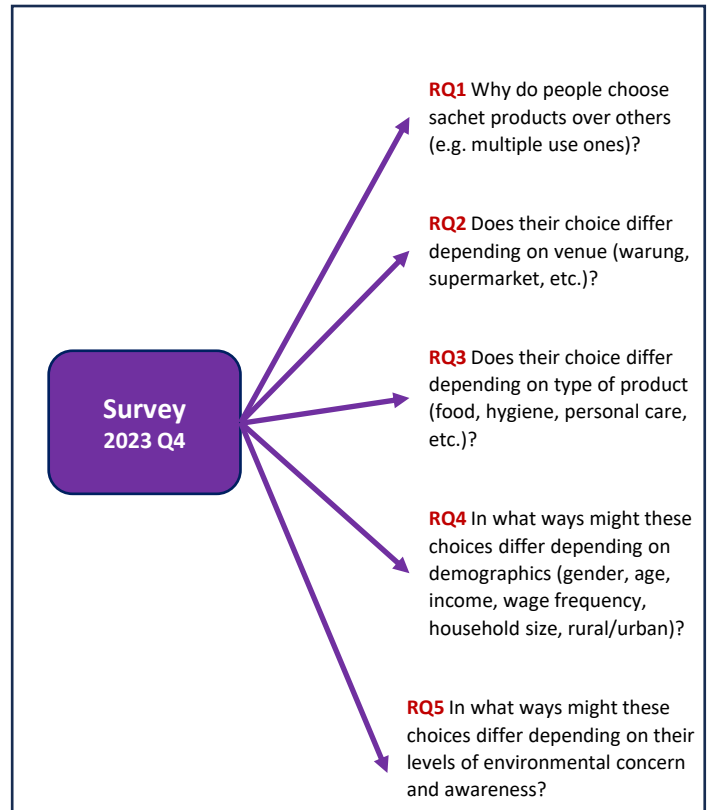


Fig. 6: Aim 2 research questions

4.1 Preliminary results

Aim 1: Drivers of current <u>disposal</u> behaviours

- Most common ways people admitted in managing their waste: **burning, using unmanaged dumpsite, using a waste collection service, river dumping, selling to waste pickers**. Less frequent: ocean dumping, selling/giving to waste banks.

Behaviours depend on:

- **Type of plastic items**. Bottles, cups, trays/tubs are significantly more likely to be sold due to their economic value, and therefore are separated. Diapers and sanitary napkins are more likely to be taken to an informal dumpsite or river dumped. And plastic bags, sachets and straws are more likely to be burned.
- **Perceived consequences for humans**. Burning often seen as harmless to people and is the default, easiest waste management option. If burning not possible (restrictions/no space), then other options like unmanaged dumpsite or waste collection service are more considered. River dumping was often seen as harmful to the community wellbeing (e.g., causing floods; but this was found to be site specific and varied between Jembrana and Banyuwangi) but acceptable for organic items and sometimes unburnable, hard to handle items like diapers. Diapers were often cleaned before placing into the river or wrapped before placing at an unmanaged dumpsite due to being associated with human waste.

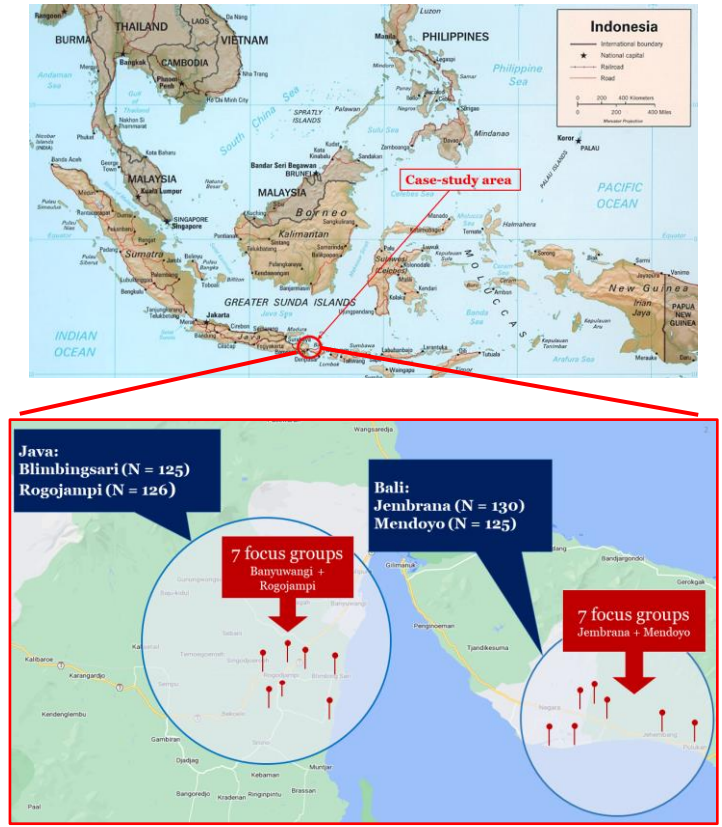


Fig. 7: The study sites across Bali and Java.

4.1 Preliminary results

Aim 1: Drivers of current disposal behaviours

- **Consequences for the environment** often seen as much less important. Perceptions that "nature will fix itself" and is not people's responsibility. However, once present, a higher level of concern about plastic pollution impact on the natural environment was associated with higher odds of using waste collection service and lower odds of burning and informal dumpsite usage.
- **Location**. Respondents in Blimbingsari reported significantly less awareness of a waste collection service (3.68%) compared to Rogojampi (40.33%), Jembrana (44.60%), and Mendoyo (41.84%). Other differences in kecamatans were recorded (see **Fig. 7**, note zero reporting of river dumping/waste bank usage in Bali). Respondents in Blimbingsari were significantly more likely to burn and less likely to use waste collection service, likely associated with waste collection service availability.

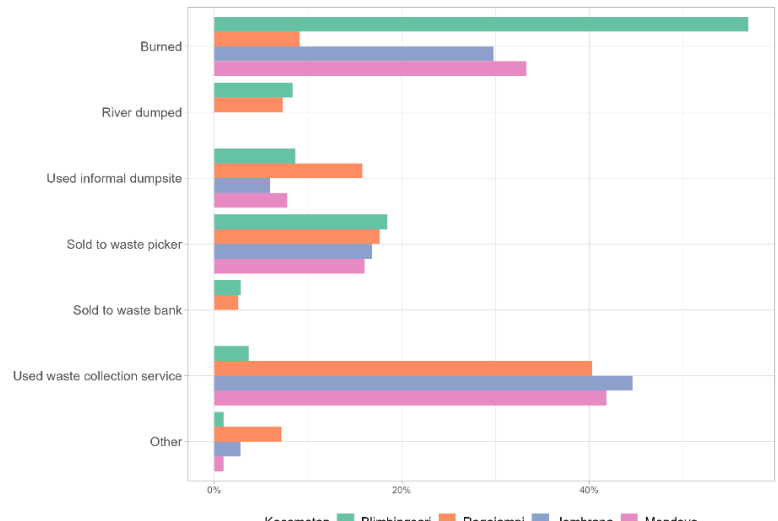


Fig. 8: Proportions of waste management behaviours divided by kecamatan.

4.1 Preliminary results

Aim 1: Drivers of current disposal behaviours

- **Social influence and community "togetherness"** often seen as important and guiding the choice of behaviours (e.g. the timing of burning, participation in waste collection service and clean-ups, etc.). People who felt a close connection to their local community were less likely to burn their plastic waste. However, people who were very worried about the impact of plastic pollution in their community were more likely to burn their plastic waste. They likely did this to prevent the plastic from spreading around their neighbourhood.
- While **waste collection service** was often described as unreliable in frequency/price in the focus groups, and therefore less desirable compared to, e.g., burning, in the questionnaire analysis presence of a collection service significantly decreased instances of burning. However, informal dumpsite usage was not affected by the waste collection service presence, signifying other factors affecting it and the need for psychological interventions to address it.

Fig. 9: Burning bins.

4.1 Preliminary results

Aim 2: Drivers of current purchasing behaviours

- The data collection in Blimbingsari and Rogojampi finished in December 2023. 501 responses were collected.
- **Targeted products**: nuts, coffee, shampoo, laundry detergent, sauce. This selection allows for a variety in food/non-food, personal/impersonal hygiene etc. items.

- Coffee was predominately purchased in sachets (only 5 respondents bought it in multi-portion packaging).
- Shampoo was the product with the highest proportion of multi-portion purchasing (20.4% of those who purchased shampoo bought it in multi-portion packaging, see **Fig. 10**).
- Overall, single-portion sachets were vastly preferred compared to multi-portion packaging in our sample.
- Sachets were significantly more likely to be purchased in warungs / toko kelontongs / meracangs, multi-portion packaging was significantly more likely to be purchased in minimarkets/supermarkets.

	Product	Multi-portion	Sachet	Total
	Coffee	5	397	**402**
	Detergent	45	405	**450**
	Sauce	84	357	**441**
	Shampoo	97	379	**476**
	Nuts	53	245	**298**
	Total	**189**	**499**	**501**

Fig. 10. Number of respondents who purchased each of the five products in sachets vs in multi-portion packaging.

4.1 Preliminary results

Aim 2: Drivers of current purchasing behaviours

- Sachets were significantly more likely to be purchased daily/every other day, whereas multi-portion packaging was significantly more likely to be purchased monthly/rarer (see **Fig. 11**).
- **Key reasons why people purchase sachets:** the only packaging size available, being affordable, trying new options/brands, and making the product easier to portion.
- **Key reasons to buy items in multi-portion packaging**: not harmful to the environment, being recyclable and being resellable.
- **Differences between products** in terms of reasons to buy it in sachets/multi-portion packaging were found to be minimal.
- **Socio-demographics:** Respondents with lower level of education/income were more likely to purchase sachets compared to the respondents with higher level of education/income.

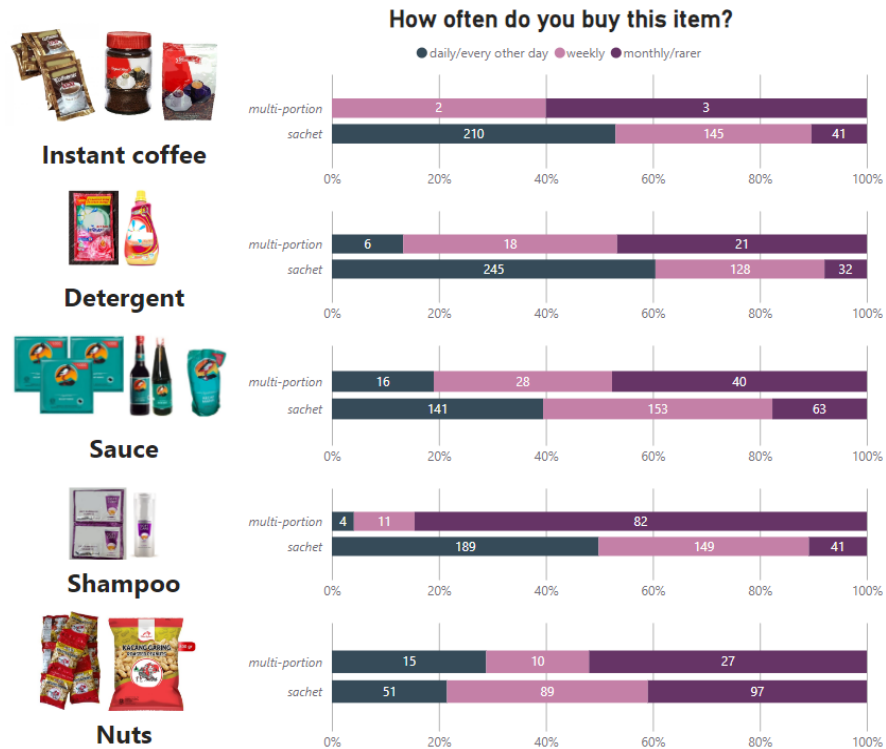


Fig. 11: Frequency of purchase of all products in sachets/multi-portion packaging.

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4.2
Exploring the Role of Media and Communications in Shaping Understandings and Behaviours with Specific Focus on Gender

Henderson La, Kulsum NMb

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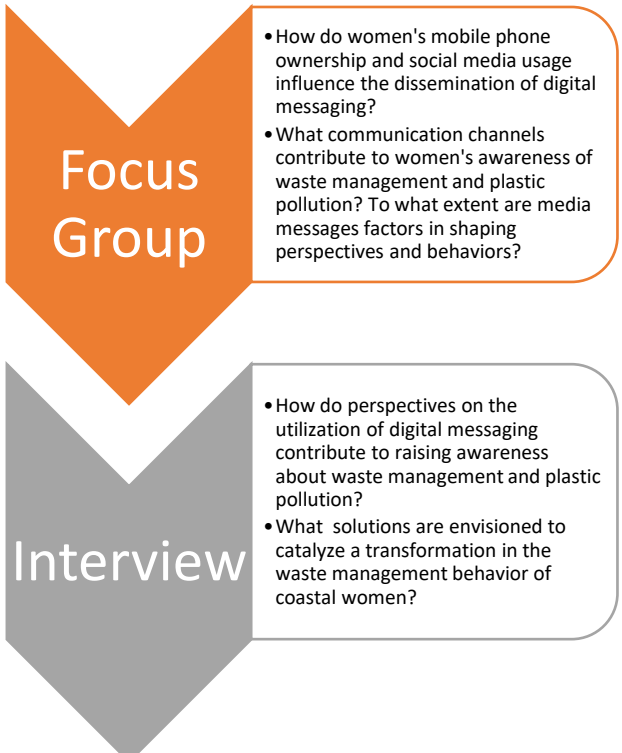
4.2 Methodology

Aim 3: Communications

This research aims to investigate whether the use of digital messaging could change plastic waste management and pollution behaviours of behaviour of women in low-income coastal communities in Indonesia. Four types of exploratory qualitative data collection were undertaken:

- Focus groups (N = 14, ~5-8 participants per group) in Java (Kecamatan Lekok and Nguling, Pasuruan). *Format*: 5-8 people come together and discuss particular topics to gather a group consensus about certain topics. *Topics*: Possession of mobile phones serves as a conduit for the dissemination of digital messaging, encompassing their habitual engagement with social media platforms. Additionally, their awareness of waste management and plastic pollution is cultivated through diverse channels of communication.

- Semi structured interviews (N = 22, Government, NGO, PKK, in Jakarta and Pasuruan, and religious leader, warung owner, women in Coastal cost of Desa Jatirejo, Kecamatan Lekok). *Format*: Conducting direct visits to the office, residence, or business premises of the interviewee.

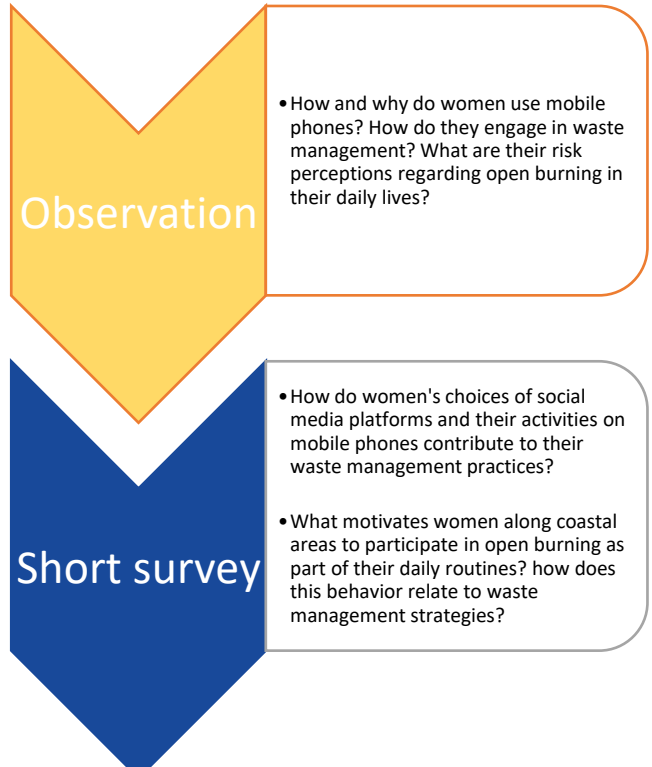


4.2 Methodology

Aim 3: Communications

- Observation: conducted non-participant observations, entailing direct visits to diverse locations, including the field, residential dwellings, businesses, and various public spaces. The primary aim was to firsthand observe the practices of coastal women in Jatijero village concerning the utilization of mobile phones, their approach to waste management, and their behaviors regarding plastic waste, sachets, and open burning.

- Short surveys: During the observation process, a variant of short surveys was executed, entailing direct interactions with women residing in the coastal areas of Jatirejo village. This encompassed direct inquiries regarding the social media platforms they employ, their engagements with mobile phones and social media, as well as their methodologies in waste management, accompanied by an exploration of the motivations underlying their involvement in open burning.



4.2 Preliminary Results

Aim 3: Communications

- Currently digital media/apps are not often used for environmental messaging and rather are used to support women's work, small business trading (*always "hustling"*) and children's education
- Waste management needs to be contextualized in a low-income culture - women in these communities are focused on economics and sorting waste is framed as laborious and taking valuable time which detracts from generating income- i.e. sorting waste is not a priority
- Where waste related messaging is communicated successfully via WhatsApp and then disseminated more widely via Facebook and Instagram or YouTube or TikTok it is organized along generational lines. Younger people are far more likely to share messaging via different social media platforms
- There is a clear digital divide in Jatijero where younger people are more likely to engage with mobile phones or have exclusive use of older family members' phones (e.g. owned by their grandmother)
- Communication breakdowns were observed between waste collection service users and authorities in Jatijero. Brief delays in waste collection and uncollected bins contribute to residents' reluctance to pay fees.

5. Key Messages

Behaviours:
Waste management behaviour choice is complex and depends on several factors:
• The type of waste and the associated benefit/risk trade-offs when handling different types of waste.

• The availability of an officially managed alternative. Waste collection service is an alternative for some (burning, river dumping) but not other (selling, dumpsite) behaviours. It is important to be aware of what motivates the actual adoption of service.

• The perceived social vs natural consequences of different behaviours. Impact of plastic pollution on themselves/other people often seen as more important than impact on the environment. However, concern for other people may lead to more burning behaviours. As a result, connection to and concern about the environment may still be more important for adoption of sustainable waste management behaviours like waste collection service usage but also need to consider different social influences when discouraging other behaviours (like burning). Communications and the involvement of community leaders have key roles to play in shaping behaviours and understandings.

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Key Results:

1. There is a great variation in the availability and quality of waste management infrastructure. Partly because of that, people often see it as inconvenient/unreliable, which needs to be fixed potentially through better infrastructure allocation of funds/monitoring.

2. People may resort to burning plastic waste because it is easier, cheaper and seen as harmless. However, this practice contributes to pollution and needs to be addressed.

3. A balance needs to be struck between the improvement of infrastructure and raised awareness/concern about plastic pollution

4. Awareness without infrastructure is found frustrating by focus group participants (no way to apply their concern/knowledge). Infrastructure without awareness/concern about plastic pollution does not become used enough.

5. Key Messages

Communication:

Digital media messaging has a role to play in communicating waste management messaging but may be hindered by various factors:

• Not all women in Jatijero have equal access to mobile phones and digital messaging.

• Women with lower education also reported being less likely to have access to a mobile phone.

• Those women who do have mobile phones predominantly use them for purposes other than engaging with environmental messaging and sorting and managing waste was not a priority ("time equals money").

•Preliminary findings suggest that diverse communications strategies in terms of messaging and tools must be considered carefully e.g. specifically targeted age groups, using family relationships to promote pro-environmental behaviours, enhancing communication and trust between communities and waste collectors, promoting the economic benefits of better management of waste (e.g. in terms of fishing).

Key Results:

1. Not all women in Jatijero have equal access to mobile phones and digital messaging, and those who do have mobile phones predominantly use them for purposes other than engaging with environmental messaging and sorting and managing waste, as it was not a priority ("time equals money"). Entertainment and "switching off" are key functions of media.

2. Preliminary findings suggest that diverse communication strategies targeting age groups and using family relationships can help promote environmentally healthy behaviors.

3. Enhancing communication and trust between communities is crucial.

4. Valuing co-creation promoting the economic benefits of better waste management (e.g., in terms of fishing) can be effective.

6. Frequently Asked Questions

Since infrastructure is important, is it enough to just provide it to change behaviours?

Just infrastructure or just raising awareness is not enough. People need to have access to sustainable waste management options, but they also need to perceive those as important/desirable to use. In our case, while presence of a waste collection service reduced instances of burning, it did not eliminate burning or other undesirable waste management behaviours, and people still perceived burning as the default option.

What information should be provided?

The information should be provided in the way that is relevant and actionable for the target population, potentially using the existing influential figures and authorities. Information about specific recommended handling for different plastic items (e.g. diapers) was seen as useful by many of the research participants.

How should key messages / communications reach the target population?

Community leaders play a crucial role in people's consumer and waste management behaviour, thus it is important to ensure influential leaders are engaged and can help promote specific targeted communications that connect with existing understandings. Perceptions of risk range from open burning of plastics causing unpleasant smells of smoke in laundry or hair to risks to human health. These included pervasive myths concerning harm of burning plastic diapers to babies. Challenging these ideas appropriately within social networks is crucial. Using media to promote healthy plastic related behaviours can draw on entertainment education principles and concepts but tailoring messages must be carefully judged to avoid sending inaccurate or anxiety inducing messages.

Will the same intervention work in all locations?

Our data shows that different locations exhibit different prevalence of waste management behaviours due to different local circumstances. As a result, the interventions need to be adapted to local circumstances and the desired behaviours to target.

7. Future Research Agenda

In the nearest future **the behavioural part of the WP4** will work on further analysing the questionnaire data on sachet purchasing behaviours, especially in terms of finding key contextual, sociodemographic and psychological factors precluding the choice of sachets as opposed to multi-portion packaging. The findings will be discussed and provided to WP5 and especially to WP6, whose planning of interventions/testing of new product design will be directly benefitted by the WP4 data on sachet preferences. The findings from both waste disposal and plastic purchasing stages will be formatted for publications in scientific journals.

The communications team of WP4 will soon engage in analysing the focus group, observation, and short survey data. The outcomes will be internally discussed with the behavioural section of WP4, contributing to the overall data of WP4 and aligning with the behavioural part to formulate effective communication strategies. These strategies aim to influence women's behaviour as agents of change, promoting a reduction in plastic usage and encouraging effective waste management practices.

Theory of Change: Synthesising the data from the previous steps (qualitative, quantitative) of the data collection and the appropriate data from other work streams of the PISCES program, we will develop a comprehensive description and illustration of how and why a desired behaviour change regarding plastic purchasing and disposal may happen in the Indonesian context.

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Plastics in Indonesian Societies (PISCES)
Systems Analytics Approach to Reduce Plastic Pollution

Natural Environment Research Council

Chapter 5.
System-wide Assessment of Plastics Production, Use and Management

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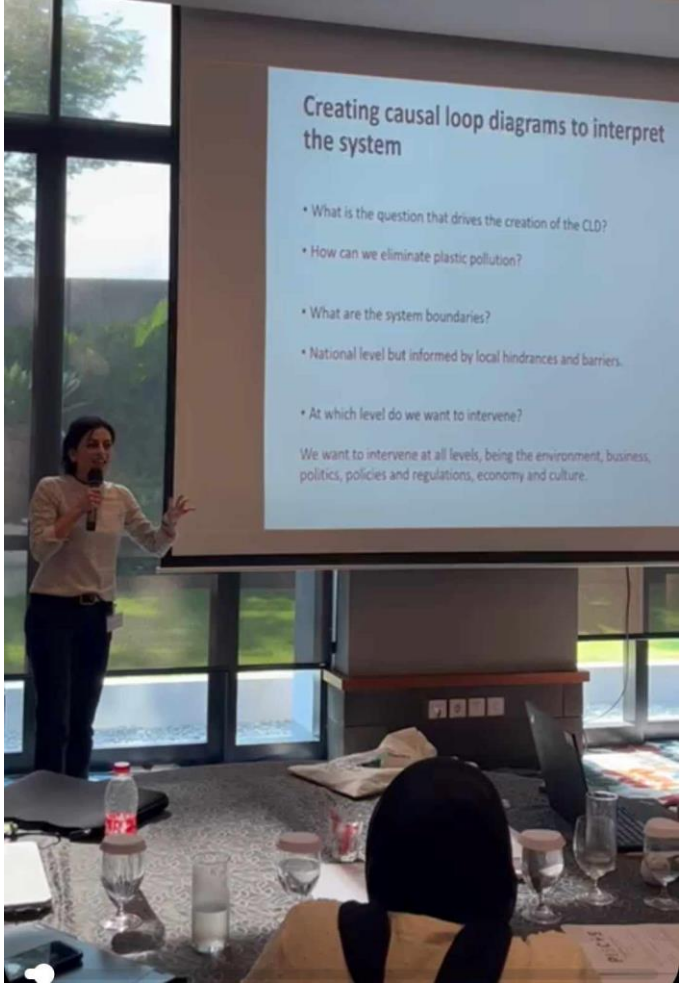
Contents



Context

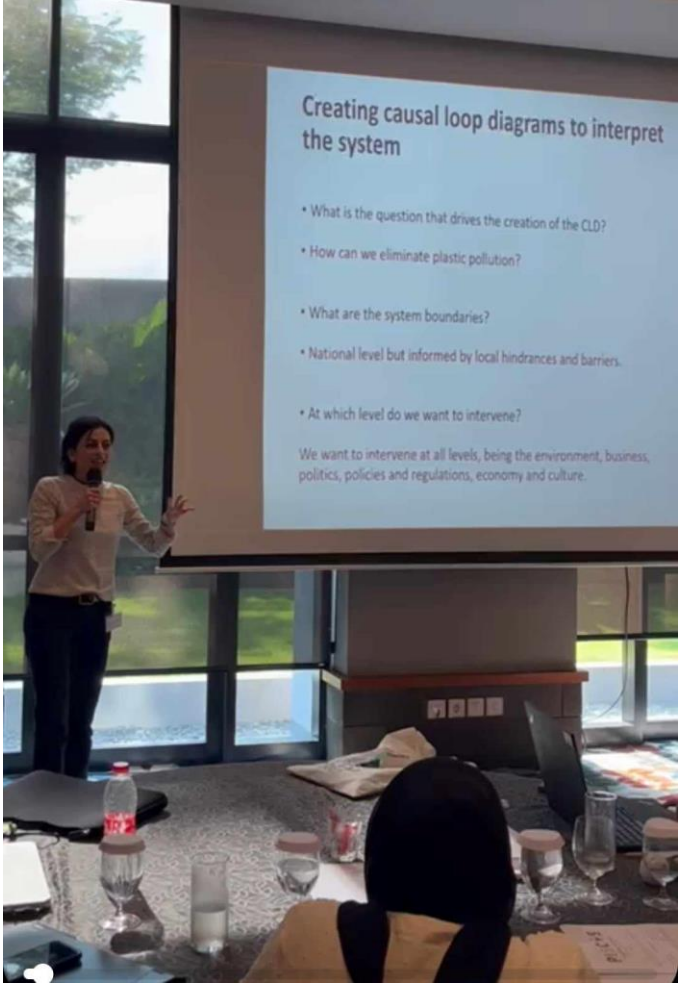
Our approach is collaborative, and transdisciplinary, fostering local, and national capacity building.

The work we carry out has two distinct strands.

1. Integration of plastics pollution quantification models upstream (supply chain) and downstream (WP1: SPOT: national level) to create an understanding of the processes and structures needed to unravel to address plastics pollution.

2. Use of the 'Complex Value Optimisation for Resource Recovery' (CVORR) systems-based approach to identify the full range of system dynamics, drivers and barriers to plastic pollution at a range of spatial contexts and scales.

This approach provides an integrative systems framework for the overall project that wraps key findings from WPs 1-4 coherently and understandably. It supports the activities carried out in WP6 and helps to point out the type of interventions needed.



Executive summary

This report presents the novel systems-based approach we developed to assess the sustainability of the plastics value chain in Indonesian society.-

The systems-based approach presented herein is instrumental in creating a holistic understanding of the plastic system processes, structures and values across national and regional levels. It addresses the sheer complexity of the plastics system and presents plastic production, use and management from multiple perspectives, key in identifying hotspots of interventions.

With this work, we ensure that the identified interventions can materialise and help form long-term strategies in the plastics system that can bring transformational change.

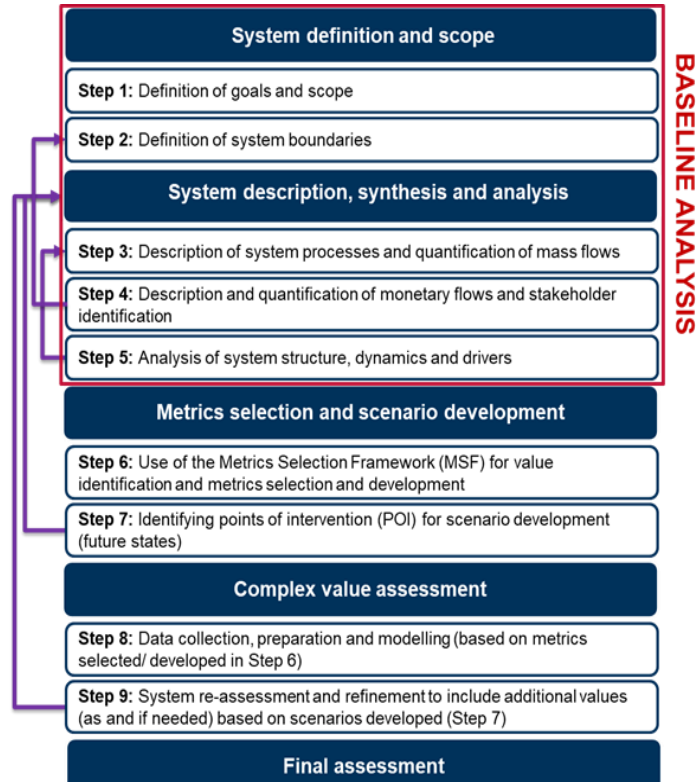
Three research findings are highlighted in this synthesis study:

1. Multiple lock-ins in the Indonesian plastics value chain currently hinder plastic pollution reduction and prevention.
2. Important dynamics upstream and downstream of the plastics value chain underline the need for cross-collaboration across the entire value chain; i.e., a cross-value chain approach.
3. Plastic pollution is highly complex and cannot be addressed through a 'one-size-fits-all' solution
4. Regional-specific indicators, such as local government commitment, infrastructure, and financial capacity, consumer behaviour are important to changing the system.

5.1 Methodology

The CVORR systems-based approach is a multiple-stage analysis. It includes the following steps:

1. Lifecycle mapping of the plastic materials, components and products (MCPs) mass flows.
2. Monetary flows (monetary flows, ownership, trading, infrastructure, investments, costs, profits) mapping and identification of the stakeholders operating in the entire system, unravelling their power dynamics.
3. Compilation of information on complex value, i.e., positive and negative environmental, economic, social and technical impacts, influenced by political regimes, using the five levels of information (5LoI) framework.
4. Causal loop diagrams (CLD) to depict the cause and effect relationships (dynamics) of diverse system variables and identifications of reinforcing and balancing feedback loops.
5. Multicriteria decision analysis of complex value and system dynamics.



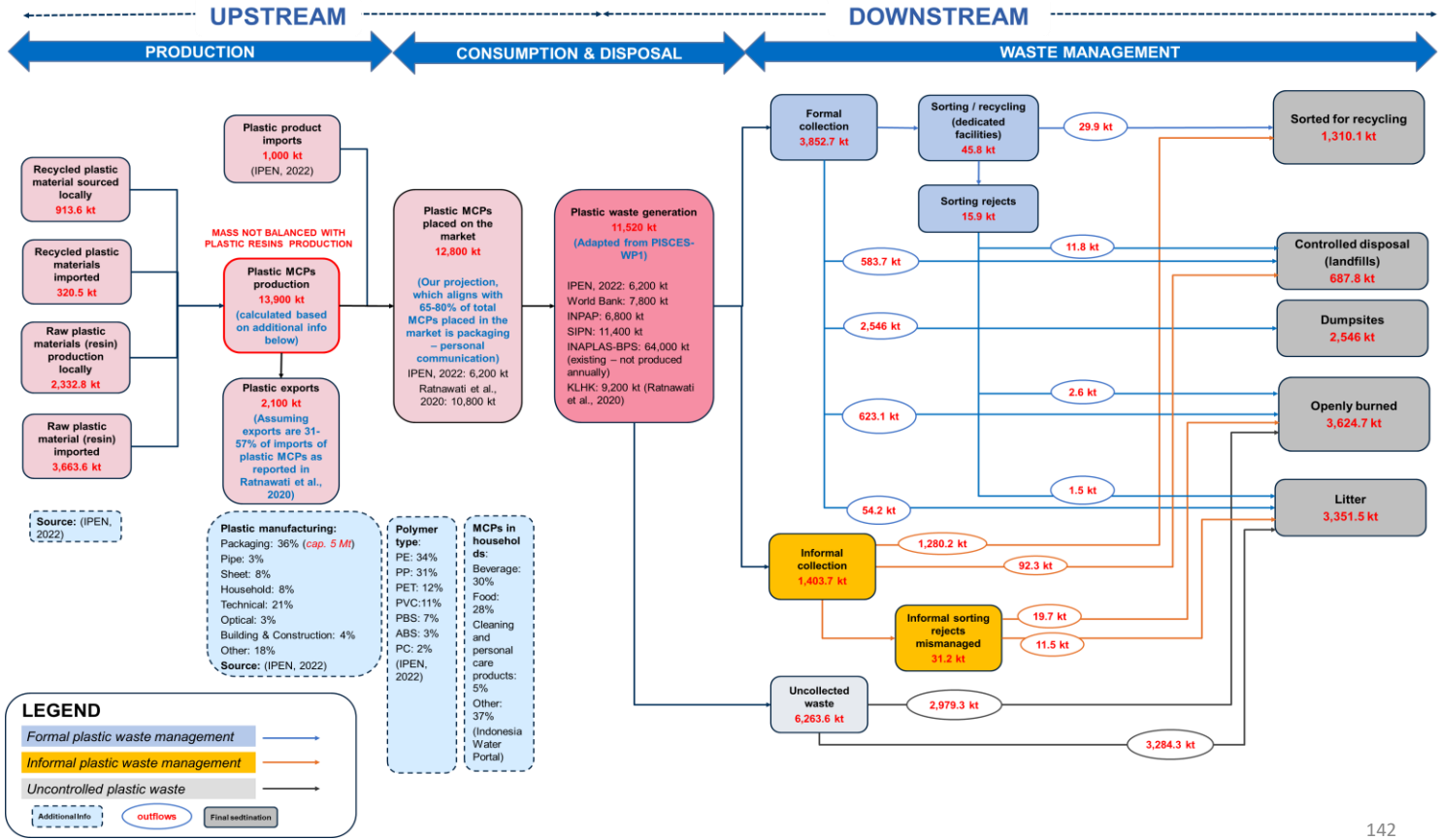
5.1 Results

On Material Flow Analysis (MFA)

The flow of plastics across the value chain within Indonesia includes the following:

- **Production**: of plastic raw materials (i.e., polymer resins), and manufacture of plastic components and products domestically, including imports and exports of both virgin and recycled polymer resins, preformed plastic components, and finished products;
- **Consumption (or use)**: of plastic MCPs placed on the market via different outlets such as retailers/wholesalers and traditional markets. It is the stage where consumers/end-users purchase plastic items based on their needs, for use in the household or on the go (i.e., outside of the household) and by the industrial, commercial and agricultural sectors;
- **Disposal**: of plastic MCPs that are no longer wanted, needed or whose nature requires disposal either in a receptacle or in other ways; it is the point at which plastic MCPs become waste.
- **Management**: of plastic waste, which includes the collection, sorting, and treatment activities, such as recycling, controlled (i.e., landfills) and uncontrolled (i.e., dumpsites) disposal, littering, and open burning.

Materials Flow Analysis(MFA) of plastic MCPs in Indonesia across the entire value chain

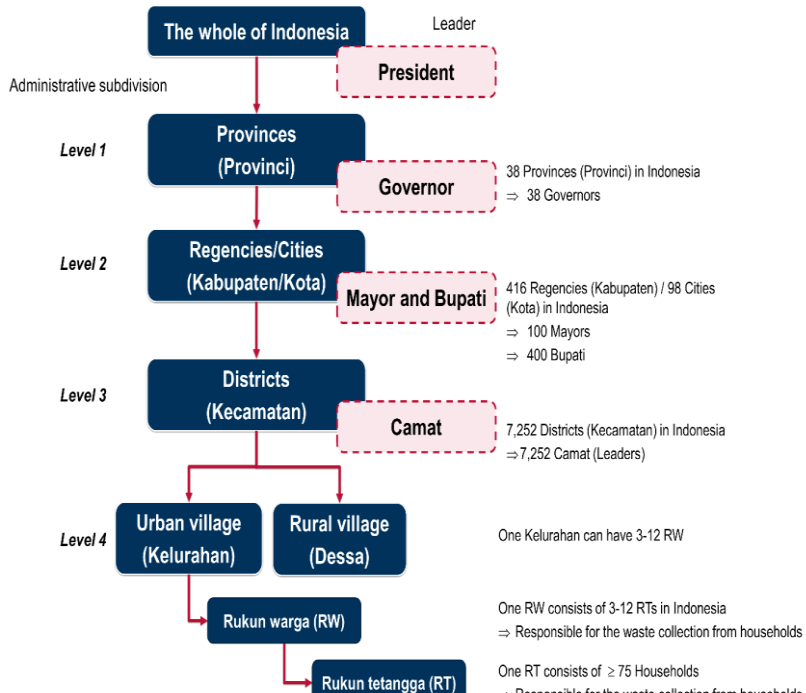


5.1 Results

On Stakeholder Mapping

The government constitutes the stakeholder group that organizes and sets the boundary conditions that could make any change possible. Therefore, understanding the government structure illuminates part of the power dynamics between key policy stakeholders.

- **National government**: is responsible for regulating and monitoring the entire supply chain of plastic (programmes and collaborations on tackling plastic pollution have developed).
- **Local government**: is responsible for implementing policies for plastic pollution and providing waste collection services (partnerships with Rukun Tetangga (RT) and Rukun Warga (RW) organisations and waste banks).



5.1 Results

On Stakeholder Mapping (cont'd)

Two main categories depending on their involvement in the system according to stakeholder theory (Freeman, 2010):

INTERNAL (primary) STAKEHOLDERS

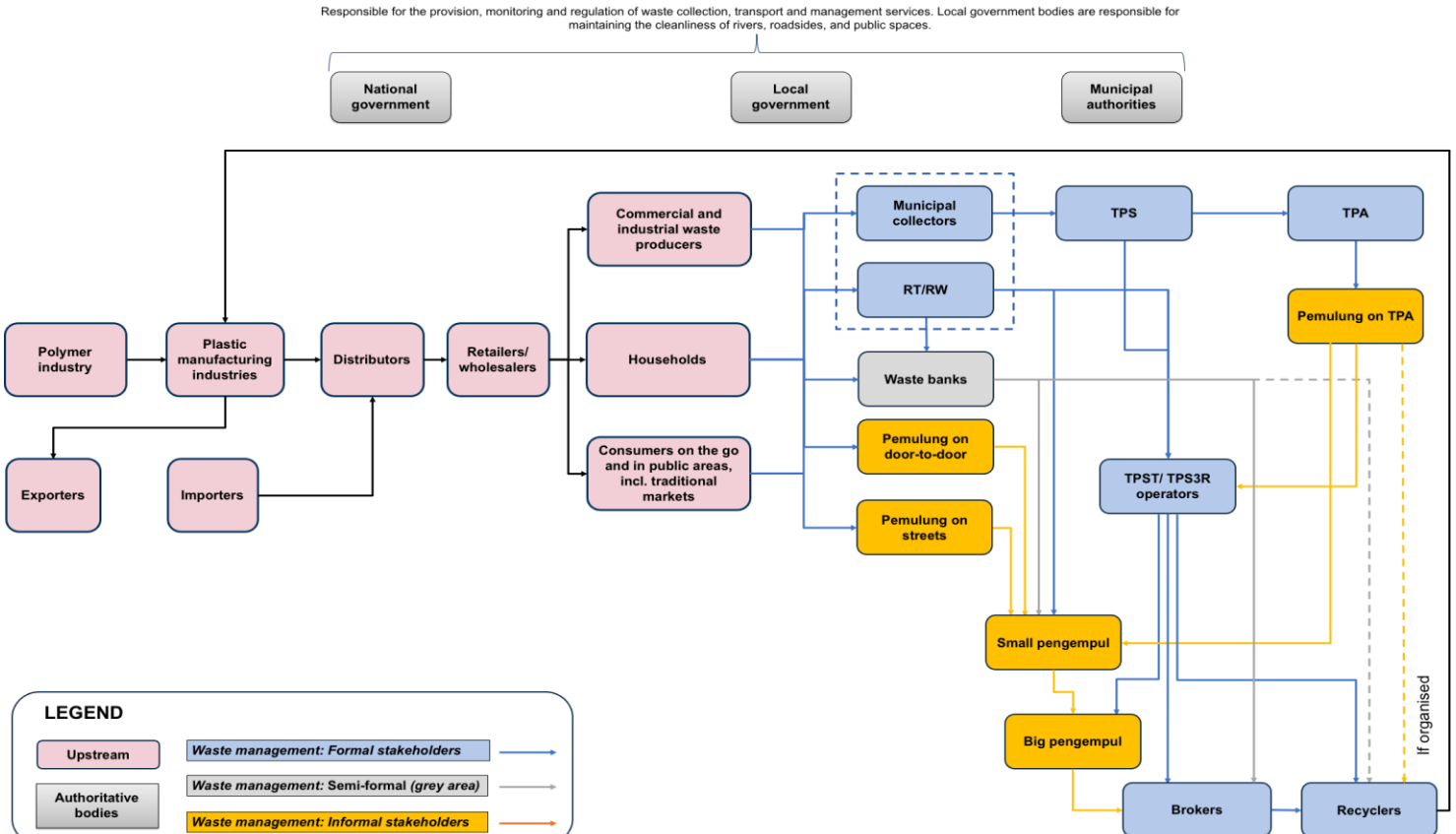
Those whose interest(s) emerge via their direct involvement (day-to-day activities) in the system and without whose support, the system would cease to be viable and are therefore parts of it:

- Producers
- Suppliers
- Consumers
- Local government
- Formal recycling sector/businesses
- Informal recycling sector
- Recyclers

EXTERNAL (secondary) STAKEHOLDERS

Those whose interest(s) emerge via their indirect involvement in the system, and their activities may affect or be affected by the system:

- Financial institutions
- Research institutions
- National government (can also be local government bodies)
- Associations
- NGOs
- Manufacturers/Brand owners
- Media


Responsible for the provision, monitoring and regulation of waste collection, transport and management services. Local government bodies are responsible for maintaining the cleanliness of rivers, roadsides, and public spaces.
National government
Local government
Municipal authorities
Polymer industry
Plastic manufacturing industries
Distributors
Retailers/ wholesalers
Exporters
Importers
Commercial and industrial waste producers
Households
Consumers on the go and in public areas, incl. traditional markets
Municipal collectors
RT/RW
Waste banks
Pemulung on door-to-door
Pemulung on streets
TPS
TPA
Pemulung on TPA
TPST/ TPS3R operators
Small pengempul
Big pengempul
Brokers
Recyclers
If organised
LEGEND
Upstream
Authoritative bodies
Waste management: Formal stakeholders
Waste management: Semi-formal (grey area)
Waste management: Informal stakeholders

5.1 Results

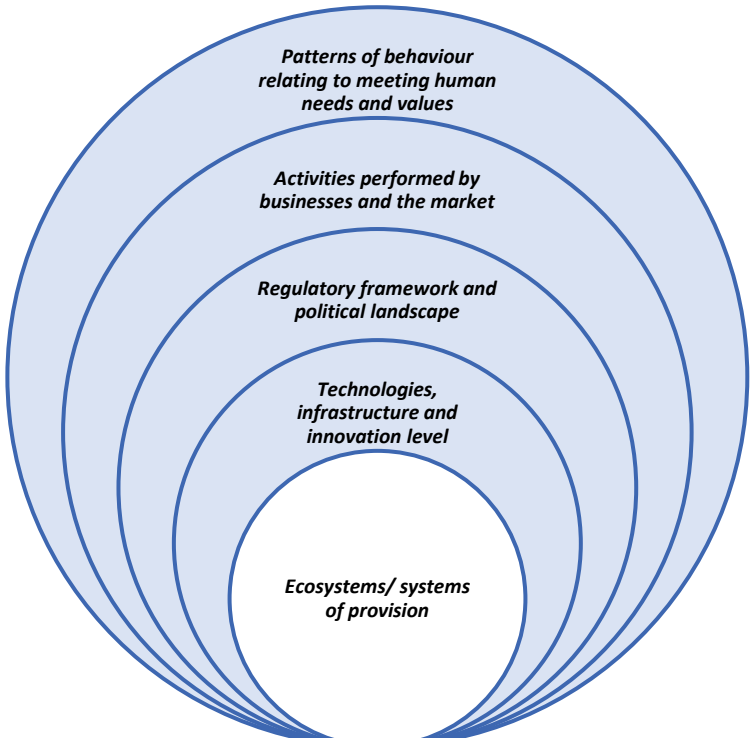
On the 5LoI Framework

Indicative impacts on the natural environment:

- Marine plastic pollution, e.g., nearly three-quarters of the plastic leakage in the environment are flexible plastics, affecting the tourist and fishery sectors.
- Flooding due to the clogging of drainage systems.
- Open burning of plastic waste that contributes to significant air pollution.

Indicative impacts on provisioning services:

- Nearly 83% of marine plastics arise from land-based sources due to a lack of waste collection and management infrastructure, the lack of enforcement of laws and regulations, illegal dumping, as well as geography and climate;
- Over 160 million Indonesians have no access to waste collection.



5.1 Results

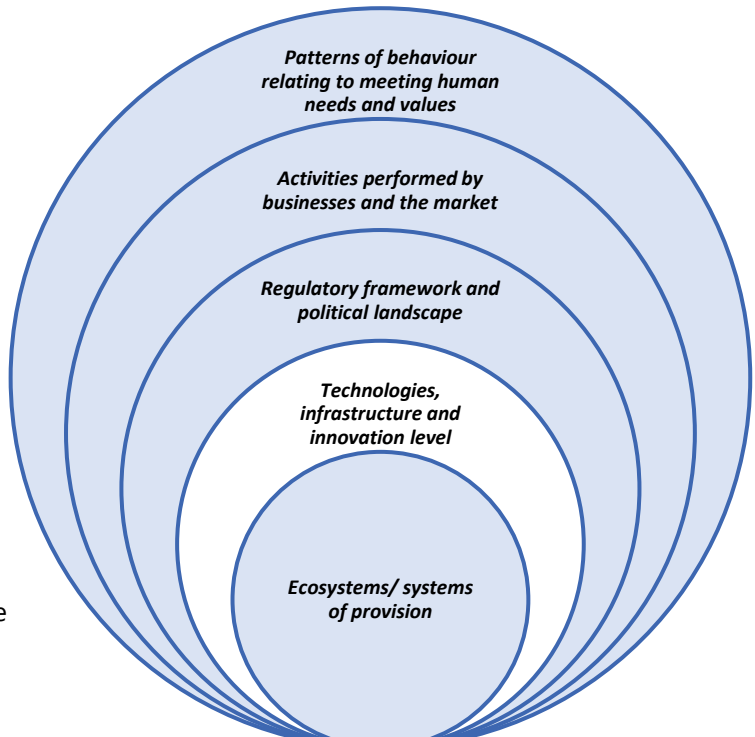
On the 5LoI Framework (cont'd)

Indicatively on urban areas and the subject of:

- **Waste disposal**: only 19 regencies/municipalities have registered landfills; many cities face landfill-space shortages or community approval.
- **Waste sorting**: nearly 45% of TPS3R and 41% of TPSTs are either not active or their status is unknown.
- **Recycling**: performance remains largely uncharted, with the majority of facilities being located in Java (87%) accessibility for those outside of this region is difficult.
- **Waste-to-energy**: a strong pipeline of WtE projects as an alternative to TPA.

Capital investments are required to:

Scale up and diversifying SWM infrastructure across the country is the greatest challenge, with the support of private investors, as these investment costs cannot be covered only by the national public sector.



5.1 Results

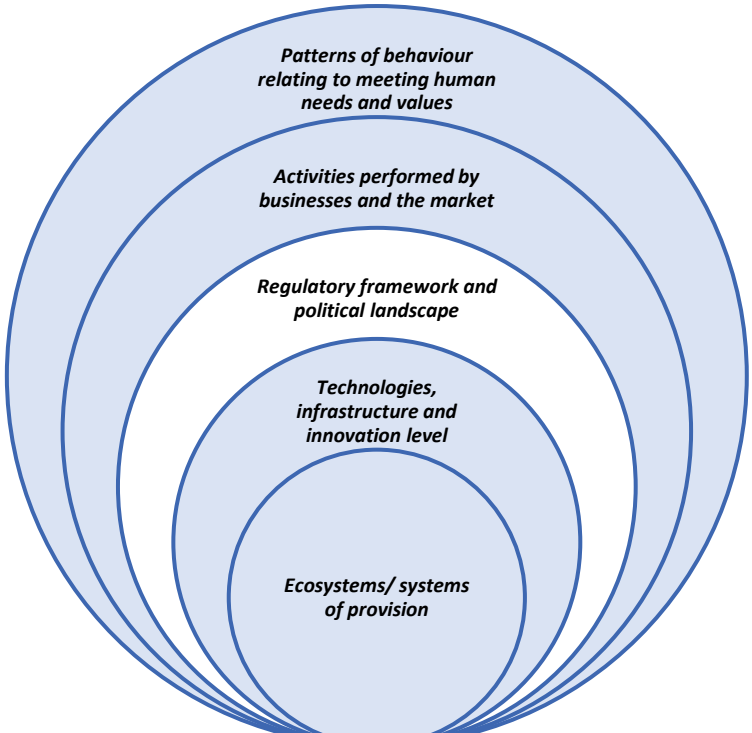
On the 5LoI Framework (cont'd)

The Government Strategies for Waste Management

- National Plastic Action Plan (NPAP)
- Indonesian National Action Plan on Marine Debris
- National Waste Management Policy and Strategy

Failure of the solid waste management (SWM) system is attributed to:

- The fragmented political landscape.
- The weak enforcement of waste management activities, monitoring measures and absence of standards related to operational health and safety.
- The restricted local government budgets (i.e., APBD), which are not specifically earmarked for waste management services, and are instead spent on operational costs.



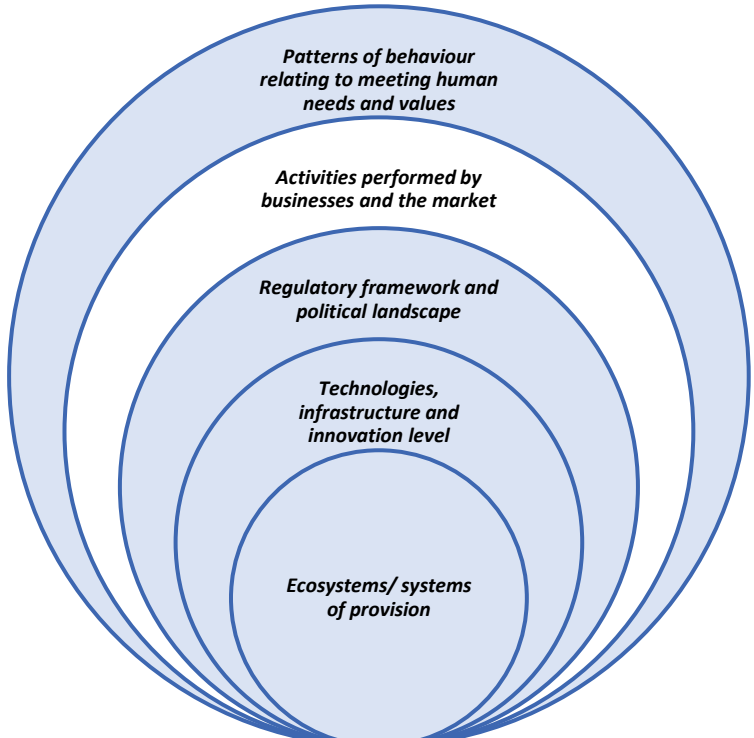
Investors are reluctant to agree on re-financing contracts due to the impending risks, processes, and potential returns.

5.1 Results

On the 5LoI Framework (cont'd)

Investments by credible businesses are prevented by:

- **Recycler activities** (feedstock for recycling is driven from the informal sector posing a risk related to compliance with social and environmental standards);
- **Plastic waste traders** (illegal waste activities and roadmap to phase down plastic waste importation);
- **Producers and manufacturers' activities** (EPR implementation and monitoring; perverse incentives in the sector);
- **Formal waste collectors and processors** (minor contribution to recycling rates, limited and inadequate personnel, operation of sorting facilities is not supported financially by local government sufficiently).



Indicative market opportunities and barriers: plastic credits, price volatility in fossil fuels and impact on both virgin and recycled plastic material, financing waste management projects with government involvement.

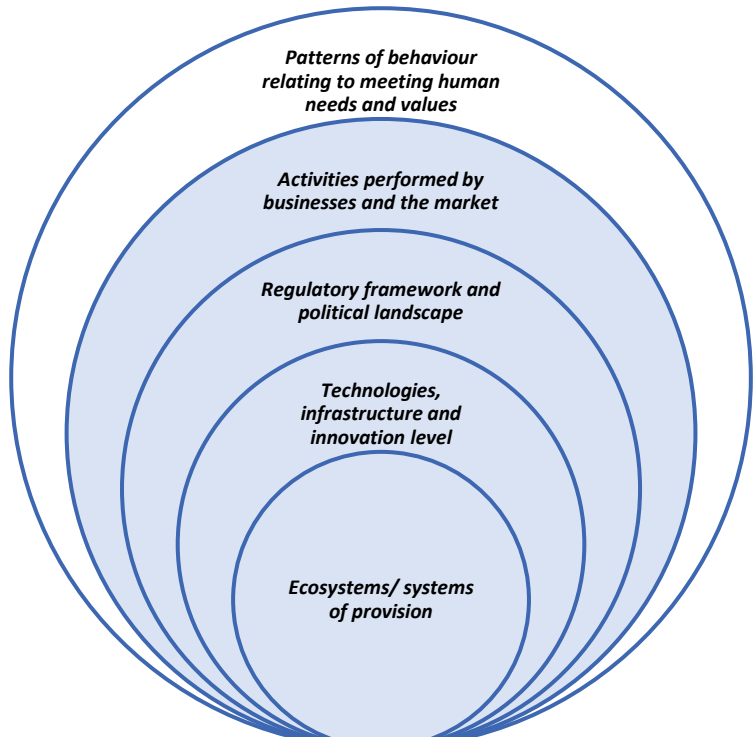
5.1 Results

On the 5LoI Framework (cont'd)

Why are there illegal waste management activities?

- Inadequacy in SWM services, e.g., no access to waste collection sites
- Cultural aspects (and habits?), e.g., low level of public awareness of waste handling and management and the impact of plastic waste in the environment.
- Socio-economic conditions, e.g., lack of employment and income opportunities
- Population growth and urbanization
- Regulations and policies are not well communicated to the public and in some cases, also not well enforced
- Lack of incentives for consumers/end-users to change their behaviours.

Action for public awareness and behavioural change campaigns



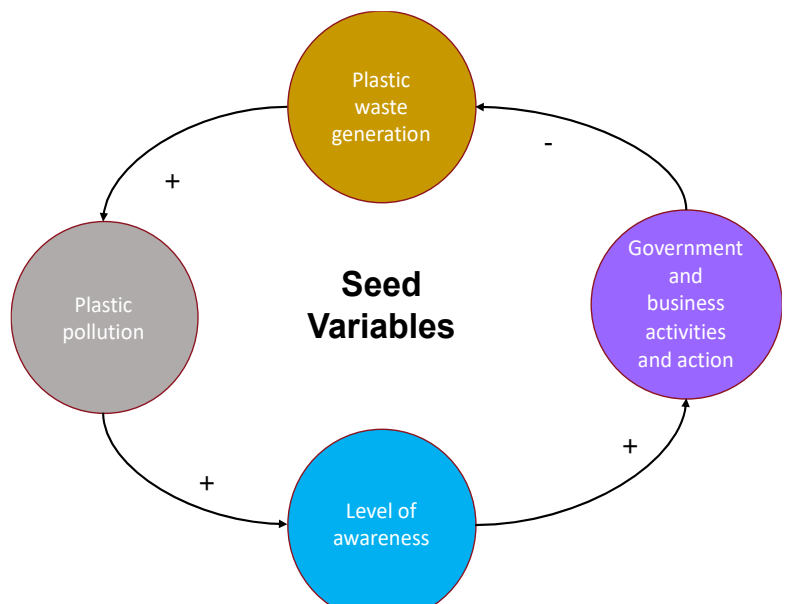
5.1 Results

On the 5LoI Framework (cont'd)

There are four seed variables in the Indonesian plastic pollution reduction CLD. The rest of the variables identified via the 5LoI Framework are connected to these.

There are two types of relationships between the variables.

- **Positive relationship (+):** a reinforcing, inextricably related, or enabling relationship where one variable supports another variable and often causes a major change in the system, the more plastic materials components and products are placed on the market, the more plastic waste will be generated.
- **Negative relationship (-):** a relationship where one variable is weakening (or constraining), counteracting, or cancelling the impact on another variable and helps in maintaining the resilience of the system, the higher the level of awareness of plastic pollution, the less plastic materials components and products are placed on the market.



6. Key Messages

A systems-based approach is the ultimate way with which we can gain a holistic understanding of the roots of the plastic pollution problem and identify the right means to intervene to address the issue.

To this end gaining insights into the mass flows of plastics and the power dynamics between the multiple stakeholders operating across the entire plastic value chain and the way these influence the movement of plastic MCPs is the first step towards unpacking the system's complexity.

Decoding information around the realities of national and local contexts into variables for depicting systemic interactions, can reveal vicious cause-and-effect relationships that need to be tackled. This is a well-calculated means to capture the ever-complex technological, sociological, ecological, political, and economic interrelationships that drive the plastics system and can highlight points where interventions are urgently needed to enable transformative change.

Key Results:

1. Synergetic and collaborative actions could make the plastics value chain in Indonesia sustainable and circular.

2. Systems-based analysis can demonstrate the power of collaborative action in promoting transformative change.

3. Sustainability in the plastics value chain can be achieved through a synergistic effect of multiple interventions driven by several stakeholders operating across the plastics value chain.

4. Interventions that deliver positive multidimensional outcomes from economic, environmental, social, technical, and political aspects with minimum trade-offs might be hard to identify but it is feasible, and this should be our penultimate goal.

7. Frequently Asked Questions (FAQ)

1. What is the CVORR baseline analysis and why is it a prerequisite of a systems-based approach?

The CVORR baseline analysis is the backbone of depicting complex (multidimensional) values and interventions. The baseline analysis reveals systemic failures by interrogating the interrelationships and interdependencies between system processes (mass flow stages) and structures (stakeholder networks). It amasses the realities of the impacts of plastic pollution on the natural environment, the regulatory aspects, infrastructure/provisioning services, and consumer/end-user behaviour to highlight areas where, rapid, viable, and sustained changes to both governance are necessary to promote change towards a sustainable circularity of resources.

2. How can data collected for each level of information be decoded into variables?

This is a critical and conceptual process. Information and data can be collected from numerous sources to capture contextual realities associated with plastics production, consumption/use and management at each level of information. This information is converted into variables that describe causes, effects, and consequences, depicted in model dynamics.

7. Frequently Asked Questions (FAQ)

3. How can the findings from this system-based analysis contribute to the broader goal of reducing plastic pollution globally?

The approach is a step-wise, streamlined tool that cuts through the complexity of resource and waste management systems, which can be critical in identifying where interventions are needed and highlighting pathways of transition to resource efficiency and sustainability. It can be applied in different regional contexts and systems, generating valuable insights, identifying key interventions, and informing effective strategies. It. It generates the evidence needed by stakeholders to develop targeted and evidence-based strategies that have a meaningful impact on reducing plastic pollution on a global scale.

4. What are the main challenges and limitations of this system-wide assessment?

Main challenge: there is a high variability of resources and waste characteristics at different spatial levels including institutional, political and governance elements which requires a tailor-based approach that is constantly monitored and updated with the regional-specific operational and logistical characteristics.

Key limitation: limited information, and a lack of publicly available data (e.g., financial flows) make it difficult to obtain insights into important aspects that influence the system dynamics.

8. Future Research Agenda

Our future research agenda revolves around the lifecycle sustainability assessment of interventions and potential scenarios concerning plastics production, use and end-of-life management. This will be achieved via the following steps:

- Identify/develop metrics that describe the prevailing issues in the plastics systems, as identified from the system-wide depiction of plastic pollution (CLD) to perform a comparative multi-criteria decision-making (MCDM) analysis to assess the environmental, social, technical, and economic performance of the BAU and proposed interventions (via scenario analysis). Data from WP1, WP2, WP3, and WP4 will be used to support the analysis stage.

- Integrate the potential design interventions (as alternatives to single-use plastics) with the policy, infrastructural and fiscal interventions that are locally relevant, explicitly linking the pollution hotspots. We will use the PEW/ SYSTEMIC zero pollution model applied in Indonesia by SYSTEMIQ and expand to provide a dynamic mathematical system that identifies and prioritises key preventive options, building relevant scenarios, each with a suite of interventions at the local level, enabling the targeting of the most effective areas to intervene.

- Develop a list of potential trade-offs (links with the SDGs) and cause-effect impacts on upstream and downstream value chains revealing the extent of plastic leakage reduction gained with the proposed/applied interventions.

- Establish a set of key performance indicators (KPIs) considering technological, environmental, economic, policy, regulatory, and social aspects that will be analysed via the living lab activities.

Natural Environment Research Council

Chapter 6.
Design and Test Innovations to Prevent and Reduce Plastic Leakage into the Environment and Drive a Sustainable Plastic Economy

Fabrizio Ceschin[a], Anouk Zeeuw van der Laan[a], Susan Jobling [a], Eleni Iacovidou[a], Spyridoula Gerassimidou[a], Yueyen Fan[a], Nazlı Terzioğlu[a], Yulianti Pratama[b], Fenitra Maminirina[b], Emenda Sembiring[b], Karnik Tarverdi[a], Gatot Yudoko

[a]Brunel University of London, [b]Bandung Institute of Technology



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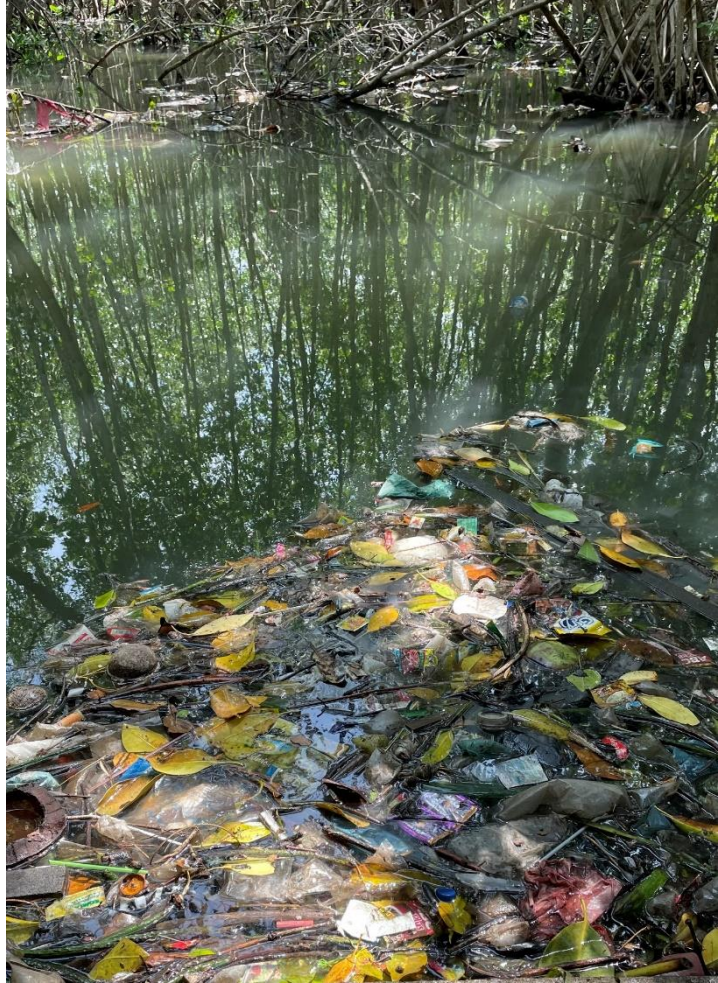


Context

The overarching aim of WP6 is to design and test solutions to prevent and reduce plastic packaging waste and pollution. The WP is structured around eight key tasks:

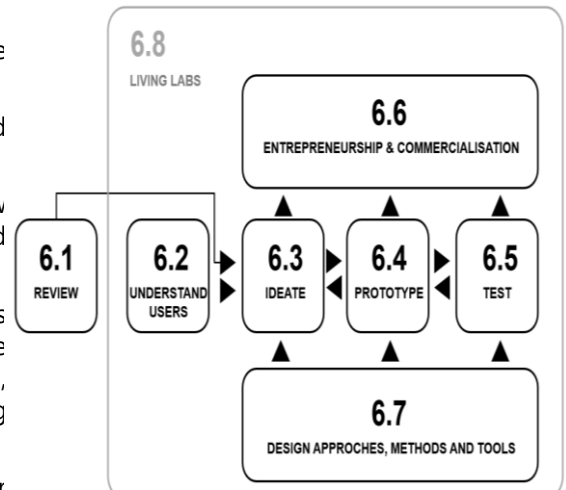
In 6.1 we reviewed existing solutions to plastic packaging waste and assessed (through expert workshops) their applicability to Indonesian contexts.

In 6.2 we enaged with Indonesian people (throuigh focus groups) to understand how they interact with existing packaging and waste management solutions, and identified key adoption barries.

Building upon 6.1 and 6.2, in 6.3 we organised a codesign workshops (with academics and stakeholders) to ideate upstream and downstream concepts tailored to the Banyuwangi context. In synergy with WP5, these initial concepts were refined, combined and detailed. A second codesign workshop focused on integrating concepts into coherent cross value chain solutions.

In 6.4 and 6.5 we prototyped the most promising concepts and assessed their user adoption potential in the PISCES living lab. Two rounds of testing took place, which helped to improve the concepts. Additionally, sustainability assessment (in sinergy with WP5) was performed).In 6.6 we are currenlty exploring how the living lab could become an economically sustainable initiative.

In 6.7 we are reflecting on the overall design approach to develop design methods and tools. Finally, 6.8 focused on designing, implementing and managing the PISCES living lab.



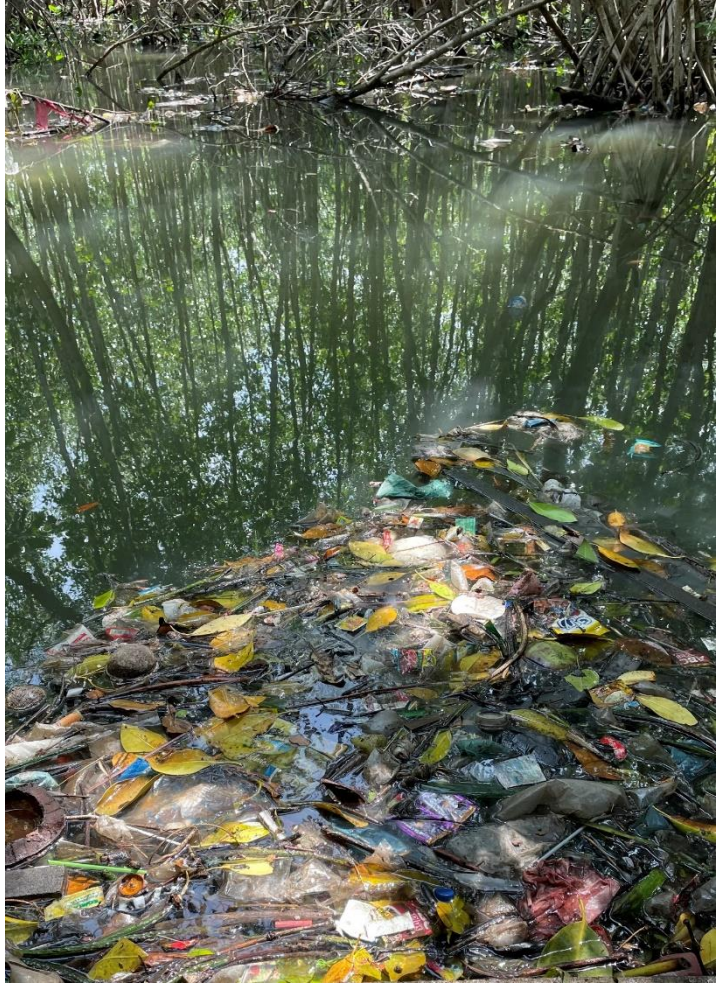
Context

Currently, there are several potentially promising initiatives that aim to tackle the problems associated with plastics. However, they are fragmented, uncoordinated, and in most of the cases only incremental, since they address only one part of the problem and thus focus only on a portion of the complex plastic/packaging value chain, with limited impact.

In PISCES we adopt a systemic and cross-value chain design approach, in order to research coordinated changes throughout the whole value chain, from packaging manufacturers to retailers, logistic providers, waste management actors etc.

These will include interventions at a product level (e.g. avoiding small packaging formats such as sachets, lids, tear-offs), service and business model level (e.g. by exploring solutions to shift from single use to reusable-refillable-returnable packaging), waste management level (e.g. to identify appropriate, effective and efficient waste collection, sorting and processing systems, from a technical, organisational and wellbeing perspectives).

We adopt a living lab approach to carry out research and innovation processes in real life environments, engaging users and all key stakeholders in co- creating, prototyping, testing, observing and refining new solutions and organisational structures.



6.1
Reviewing Existing Solutions to Plastic Waste and Assessing their Applicability to Indonesian Contexts

Nazlı Terzioğlu[a], Yulianti Pratama[b], Fabrizio Ceschin[a], Emenda Sembiring[b], Karnik Tarverdi[a], Gatot Yudoko

[a]*Brunel University of London*, [b]*Bandung Institute of Technology*



Executive summary

The aim of this research is to assess the applicability/adaptability of the existing solutions to the plastic packaging waste problem to Indonesian contexts. This report presents the literature and business practice reviews, case studies, and case study assessment workshops with the experts. Literature and business practice reviews were conducted to discover and collate existing solutions. 200 solutions were selected and categorised. Finally, 10 archetypes and 18 sub-archetypes were introduced to describe the groupings of the solutions. These archetypes are: refill stations, mobile refill stations, refill at home solutions, prefilled packaging systems, reusable takeaway and delivery solutions, B2B reusable packages, packaging solutions led by elimination, compostable and biodegradable packaging, substitution to a non-plastic material and plastic recycling.
After identifying these archetypes, we created 17 case studies to understand the archetypes for comparison and information. Finally, workshops were conducted with experts in the social, economic, contextual and regulatory aspects of Indonesia. The aim of these workshops was to assess the applicability/adaptability of the existing plastic packaging solutions to Indonesian contexts through identifying the social and economic barriers to implementing or adapting the archetypes.

Three research findings are highlighted in this synthesis study:

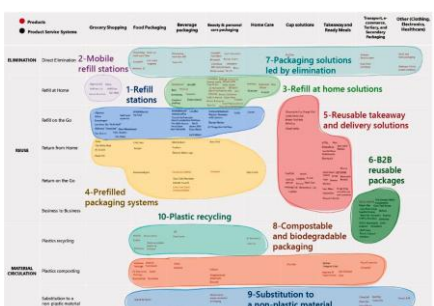
1. 200 existing solutions to plastic packaging waste problem were selected and categorised.
2. 10 archetypes and 18 sub-archetypes were identified to describe the categories.
3. Literature review, case studies, and workshops with experts were conducted to explore the adoption barriers of the existing solutions to plastic packaging waste problem.

6.1 Methodology: Key activities

1. Review of packaging solutions

Exploration of 200 packaging solutions found in literature and practice.

Categorisation against product sectors and the packaging upstream strategies (EMF, 2020).



2. Develop packaging archetypes

Consolidation of the solutions in 10 packaging archetypes (and 17 sub-archetypes) of the solutions to the plastic packaging waste problem. Each archetype describes a group of cases that share similar key characteristics such as the product category, business models, and reuse models.

3. Case study development and assessment

We created 17 case studies to understand the archetypes for comparison and information. For each case, a system was developed, that shows different actors involved in the service delivery and clarifies how they and their roles are connected.

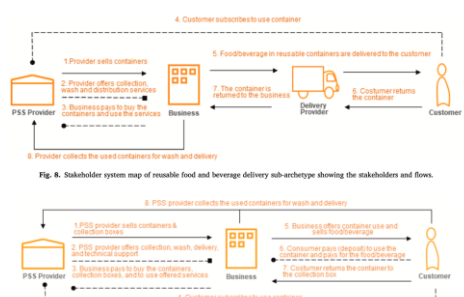


Fig. 8. Stakeholder system map of reusable food and beverage delivery sub-archetype showing the stakeholders and flows.

6.1 Overview of case studies

Packaging archetypes

The case study review led to the development of an upstream packaging strategies framework.

Terzioglu, N., Ceschin, F., Jobling, S. and Tarverdi, K., 2024. Archetypes to categorise upstream packaging strategies for a circular economy. *Resources, Conservation & Recycling Advances* https://doi.org/10.1016/j.rcradv.2024.200211

1) Refill stations

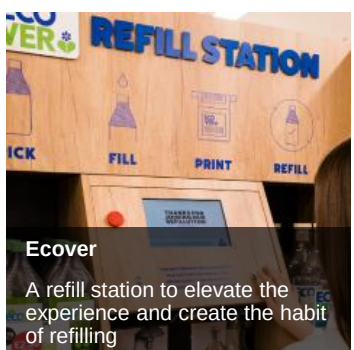
Manual or automated dispensers let customers pay to fill their own or a provided reusable container. Three types:
1) Grocery for household items
2) Beverage for soft drinks and water
3) Home and personal care products

Algramo

Refill stations to sell products in small quantities in reusable containers

Water ATM

A water vending machine that makes drinking water equitable



Ecover

A refill station to elevate the experience and create the habit of refilling

6.1 Overview of case studies

2) Mobile refill stations (and delivery)

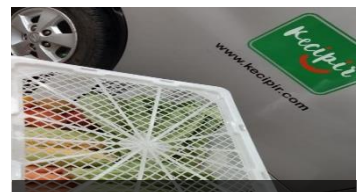
Products are delivered to customers in reusable containers. Customers pay the products, a delivery fee, and a deposit on the containers. This includes the milkman model, refill vans and grocery delivery.

Ecopure

Door to door water delivery

LOOP

A reusable packaging service offering products in premium packaging

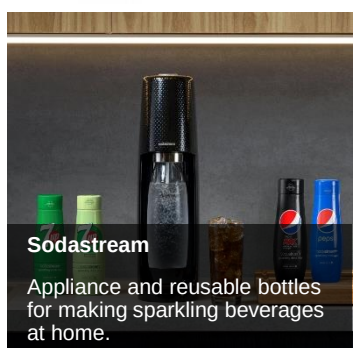


Kecipir

An e-commerce business serving fresh and organic produce from local farmers

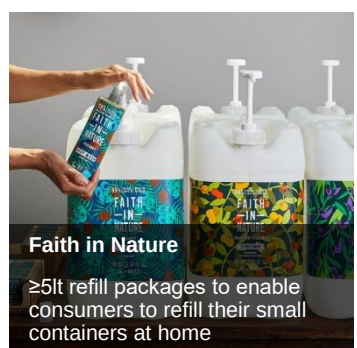
3) Refill at home

These solutions offer the convenience of refilling reusable containers at home. Customers pay for the content and, in some cases for the containers, dispensers, and delivery. It includes concentrated products in refill packages, bulk refill and recyclable packaging.



Sodastream

Appliance and reusable bottles for making sparkling beverages at home.



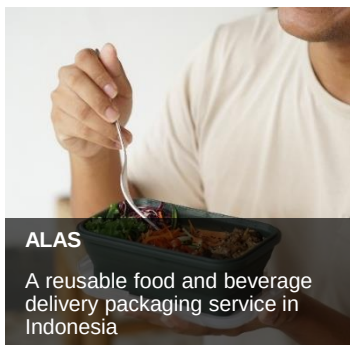
Faith in Nature

≥5lt refill packages to enable consumers to refill their small containers at home

6.1 Overview of case studies

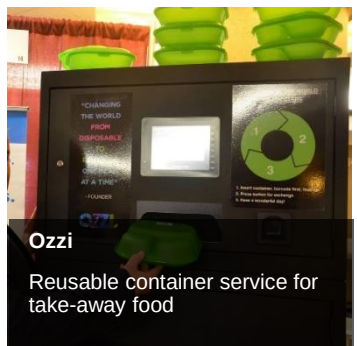
5) Reusable takeaway & delivery

Food or drinks are packaged and sold in reusable containers. Customers pay a deposit, the food/drink. Customers must return the packaging through drop-off or collection (when delivered).



ALAS

A reusable food and beverage delivery packaging service in Indonesia



Ozzi

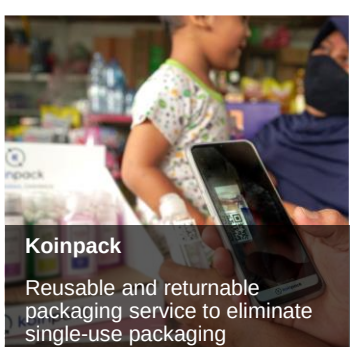
Reusable container service for take-away food

Club Zero

Reusable takeaway beverage packaging service for brands and retailers

4) Prefilled packaging systems

The reusable packaging is already filled with the product. Customers must return the packaging but does not have to refill it themselves. It includes the milkman model and a return-on-the-go system.

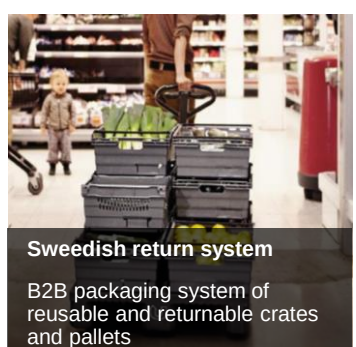


Koinpack

Reusable and returnable packaging service to eliminate single-use packaging

6) B2B Reusable packaging

The B2B reusable packaging archetype involves reusable packaging and services used between businesses, not consumers. This eliminates single-use transport packaging, providing environmental benefits. It also offers businesses cost savings on materials and transportation.



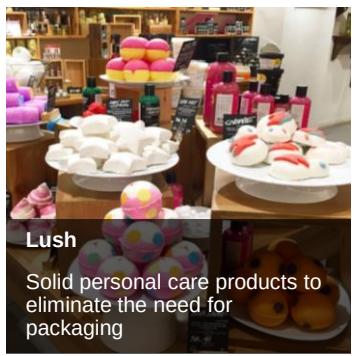
Sweedish return system

B2B packaging system of reusable and returnable crates and pallets

6.1 Overview of case studies

7) Solutions led by elimination

This archetype involves removing or redesigning packaging to eliminate unnecessary components. This includes directly eliminating non-essential packaging and converting products to solid forms to reduce packaging needs.



Lush

Solid personal care products to eliminate the need for packaging

8) Compostable and biodegradable

Compostable packaging is designed to break down through composting, converting it into CO2, water, and biomass. However, the collection system for this packaging requires careful consideration, as leaks could contaminate recycling or be mistaken for food by animals.

BioFreshPak

Bio-based, compostable, and breathable film to reduce food waste

9) Substitution to a non-plastic material

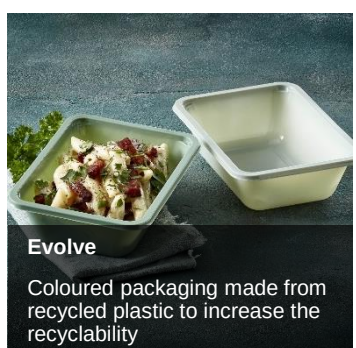
Replacing plastic packaging with non-plastic alternatives like paper, aluminium, and seaweed requires a lifecycle analysis to ensure it is more environmentally friendly than the initial solution

Keepclip™:

Cardboard fastener to replace single use plastics used to wrap multipacks

10) Plastic recycling

Covering two key aspects. 1) *Design for recycling* which reflects the entire lifecycle, from user waste separation to collection and sorting, to enable easy recyclability. And 2) *Using recycled content* which increases demand for recyclable materials and can improve overall recycling rates.



Evolve

Coloured packaging made from recycled plastic to increase the recyclability

6.1 Results

Barriers to implementing the existing plastic packaging solutions in Indonesia

Case study assessment workshops

Workshops with Indonesian social, economic, contextual and regulatory experts were conducted to assess the applicability of existing plastic packaging solutions. The archetypes and cases studies were presented and discussed with the aim to identify barriers to implementing or adapting these archetypes in the Indonesian context.

1. Sociocultural barriers: Sociocultural barriers are related to the different groups of people in Indonesian society and their habits, traditions, and beliefs. These barriers can include but are not limited to factors such as user acceptance, social roles, norms, and the lifestyle in Indonesia that could affect the applicability/adaptability of the existing plastic packaging solutions to Indonesian contexts. We have grouped four types of sociocultural barriers: *convenience*, *behaviour change*, *hygiene*, *environmental awareness*.

2. Economic barriers: Economic barriers are related to the economic aspects of implementing the packaging solutions pertaining to organisation of money, income, wealth, etc. These barriers can include factors such as average price of the packaging, income, affordability, potential demand in Indonesia that could affect the applicability/adaptability of the existing plastic packaging solutions to Indonesian contexts.

3. Contextual barriers: Contextual barriers depend on or relate to the circumstances that form the setting of a packaging solution such as infrastructural, technological, technical, and environmental factors that can affect the applicability/adaptability of these solutions to Indonesian contexts. We have identified three types of contextual barriers in this study as infrastructural barriers, technical barriers, and barriers related to environmental conditions.

4. Regulatory barriers: Regulatory barriers include laws and regulations that could affect the applicability/adaptability of the plastic packaging solutions to Indonesian contexts. Several countries, regions and cities have introduced regulations and legislations focused on plastic. These are primarily aimed at use and disposal to reduce consumption and improve waste management. Eg. bans and levies on plastic packaging and single-use products.

Plastics in Indonesian Societies (PISCES):
Systems Analytics Approach to Reduce Plastic Pollution

Natural Environment Research Council

6.2
Understanding Users and their Current Interactions with Packaging and Waste Management Solutions in Indonesia

Nazlı Terzioğlu[a], Yulianti Pratama[b], Fabrizio Ceschin[a], Emenda Sembiring[b], Karnik Tarverdi[a], Gatot Yudoko[b]

[a]Brunel University of London, [b]Bandung Institute of Technology



Executive summary

This report is about understanding users and their current interactions with packaging and waste management solutions in Indonesia. It is based on focus group discussions conducted in Indonesia and outlines key user adoption barriers to implementing selected upstream and downstream solutions in Indonesia. 3 types of barriers to implementing the existing plastic packaging solutions to Indonesian contexts identified were sociocultural, economic, and technological barriers.

Three research findings are highlighted in this synthesis study:

1. Convenience, behaviour change, habits and traditions, hygiene, and environmental awareness were identified as sociocultural barriers to implementing the existing plastic packaging solutions to Indonesian contexts.

2. Some of the technological barriers to implementing the existing plastic packaging solutions to Indonesian contexts were related to not having smart phones, problems related to cellular signal and older people's finding technology hard to navigate.

6.2 Context

Key activities:

1. Select solutions

Five upstream and five downstream solutions that can potentially tackle the plastic packaging problem were selected.

The solutions vary in their business models, user journeys, and service design. Cases were developed based on existing services although they may differ for simplification purposes. Solutions were selected for their potential to address plastic packaging waste in Indonesia by targeting a diverse consumer base, including low and middle-income individuals in rural and peri-urban areas, across a range of different sectors.

2. Develop user journeys

Storyboards were prepared to present the user journey's of these solutions from purchase to disposal stages.

3. Focus group discussions

Focus group sessions were conducted to let users in Indonesia to experience these user journeys and to provide feedback on the user adoption issues of selected solutions.

6.2 Methodology

Upstream	**Algramo 0.1** - Home care products - Own container or deposit - Vending machine in warung	**Algramo 0.2** - Home care products - App - Deposit container - Mobile vending machine	**Koinpack** - Home care products - Deposit container - Purchase in-store - Return in store or through collection	**Alas** - Dry food - App - Deposit (app) or own container - Pay through app	**MIWA** - Food delivery - App - Return through drop-off or collection
Downstream	**Storage** - Multiple bins - Coloured bins	**Sorting** - 4 types	**Collecting** - 4 types	**Octopus** - App to request collection	**Waste bank** - Drop off at waste bank

Presentation of solutions

Focus group sessions with 30 participants in Banyuwangi, Indonesia were conducted to understand the user adoption potential of the selected upstream and downstream solutions. For each solution, a user journey poster was presented, and participants were asked questions about the different stages of the user journey to identify adoption issues.

6.2 Results

Barriers to implementation/adoption

Focus group discussions with 30 participants in five sessions, potential barriers to the implementation and adoption of the cases.

Focus group

Participants were adults (8 male, 22 female) aged between 18-43, with an active role in the household purchases and waste management. They were from low- to middle-income backgrounds, living in peri-urban and rural areas in Banyuwangi, some had access to waste management infrastructure and some had no access.

Barriers	Algramo 0.1	Algramo 0.2
Sociocultural	**Convenience** - Some do not want to carry their container - It is easier to buy directly from warung, solution perceived as too complicated **Behaviour change** - Education needed on how to use this service **Habits and traditions** - Some want to be served, for the warung to serve them **Environmental awareness** - Some do not care about the environmental problems	**Convenience** - Some do not want to wait for the van to come **Behaviour change** - Some are not bothered to use it **Habits and traditions** - Some said they want to be served
Economic	- Some participants do not want to pay the deposit	- Some want to use plastic packaging because they sell it after use
Technological		**Connectivity** - Some do not have smart phones - Cellular signal is not good in rural areas - Touch screens are too complicated - Elderly do not know how to use technology

6.2 Results

Barriers to implementation/adoption

Barriers	Koinpack-inspired	ALAS-inspired	MIWA-inspired
Sociocultural	**Behaviour change** - Brand loyalty	**Convenience** - Want to return the container just after the food is delivered **Hygiene** - Discomfort around eating out of shared containers (used by others)	**Convenience** - Mobile apps are complicated - Online shopping is easier than using MIWA service **Habits and traditions** - Want to pay in cash **Environmental awareness** - Some do not care about the environmental problems
Economic			
Technological			**Connectivity** - Reluctant to download and use the mobile app

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6.3
Ideate and develop cross-value chain solutions

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Executive summary

Building upon the insights from 6.1 and 6.2, as well as the contribution from the other WPs, two codesign workshops were organised in Indonesia in 2022 and 2023. These workshops brought together researchers with multidisciplinary backgrounds, users and representatives from key stakeholders of the plastic-packaging value chain. The first workshop aimed at generating ideas to tackle the problem of plastic packaging waste and pollution, focusing on material/packaging solutions, reusable packaging system solutions, waste management solutions, and behavioural change solutions. The second workshop focused on combining the most promising ideas into a set of cross-value chain proposals. As a result, 11 promising concepts were selected to be prototyped and tested with users.

Two research findings are highlighted in this synthesis study:

1. Seven promising upstream concepts to tackle the problem of plastic packaging waste and pollution were co-developed. These include three reusable packaging solutions and four single use packaging solutions. Four of these concepts address the problems associated with sachets for dry food and three address the problems associated with food delivery and take away.

2. Four promising downstream concepts were co-developed. These included two concepts focused on the sorting of household waste and three focused on the collection of sorted waste from households. They address the infrastructural challenges faced by participants and explore different incentives to engage people in household recycling.

6.3 Context

1. Codesign Workshop 1

27 Nov - 2 Dec 2022

Codesign WS 1

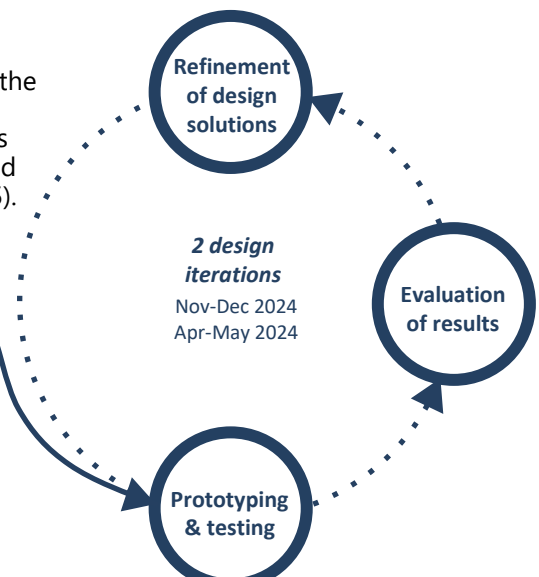
2. Codesign Workshop 2

22-23 May 2023

Codesign WS 2

3. Concept development

Based on the codesign workshops, the most promising solutions were selected and refined to fit the Indonesian market. A final selection of these concepts will later be prototyped and tested with users (WP6.4-5).



WP6.3

WP6.4-5

The packaging items/functions addressed

Building upon insights from WP2, and in synergy with WP5, two packaging items/functions:

1) Sachets used for dry food:

- snacks (e.g., crisps and nuts),

- other dry food (noodles, powdered coffee creamer, and instant coffee)

2) Packaging used for food delivery and food takeaway

The selection of these areas of interventions was based on insights from WP2 (i.e. these packaging items are amongst the most abundant litter items found in the targeted areas), and discussions with some of our key action delivery partners (in particular Enviu and Systemic).

Sachets for dry food (greasy and non-greasy)

- greasy food (e.g., crisps and nuts),
- Non-greasy dry food (e.g., noodles, instant coffee)

Food delivery and takeaway packaging

- polystyrene packaging, cups and lids, cutlery, plastic bags

6.3 Methodology: Codesign workshops

Codesign WS 1

Dates: 27 Nov - 2 Dec 2022

Aim: to generate ideas on how to tackle the problem of plastic packaging waste and pollution building upon the insights from all project WPs

The workshop lasted 1 week and focused on generating concepts of new materials and packaging design (day 2), reusable packaging systems (day 3), waste management (day 4) and behavioural change solutions (day 5). Each session involved idea generation, concept development and critical assessment. The proposed concepts were, after the workshop, were analysed regarding their feasibility and viability for adoption in the local context. The most promising were selected.

Codesign WS 2

Dates: 22-23 May 2023

Aim: to combine the selected concepts into coherent cross-value chain proposals

The workshop lasted 2 days. For each of the addressed challenges (see next page) three cross-value chain solutions were proposed (short-, medium- and long-term). Each cross-value chain proposal includes a combination of concepts spanning new materials and packaging design, reusable packaging systems, waste management, and behaviour change interventions. The timescale of the implementation (short-, medium- and long-term) is linked to the types of changes (e.g. behavioural, policy, supply chain etc.) required to implement the cross-value chain solutions

6.3 Results

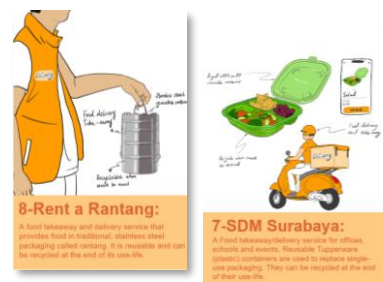
As a result of the two co-design workshops, and in synergy with WP5, a set of (upstream and downstream) concepts were defined. Among these, 11 were identified as promising and selected for prototyping and user testing (WP6.4-5)

Seven upstream concepts were selected for user testing. These include 4 single use packaging solutions and 3 reusable packaging solutions

Tackling sachets for dry food (greasy and non-greasy)

Tackling food delivery and takeaway packaging

Reusable packaging



Single use packaging

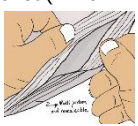
6.3 Results

Selection and specification of concepts

Intervention	**UPSTREAM*: Reusable packaging***		
	DRY FOOD (refill)	**TAKEAWAY / DELIVERY (reuse)**	
	BriOlliant • Refill station in warungs • Manual dispensers • Deposit or own container 	**Rent-A-Rantang** • Takeaway and delivery • Traditional rantang design • Pay deposit for container $ • Order through restaurant 	**SDM Surabaya** • Delivery • Reusable Tupperware • Order through App (Gojek) • Pay deposit through app $ 
Substitutes	Single-use plastic	Single-use plastic / paper with lining	Single-use plastic / paper with lining
Type of food	Dry food	Prepared meals	Prepared meals
Type of packaging	Any reusable container (deposit / own)	Stainless steel containers	Rigid plastic containers
Feedstock	Fossil fuels / Non-renewable (HD polyethylene)	Iron ore / non-renewable (stainless steel)	Fossil fuels / Non-renewable (polyethylene or polypropylene)
Shelf life	> 5 years pending maintenance	Unlimited	> 3-10 years
End-of-life	Disassembly and recycling	Recycling	Recycling
Suppliers	Enviu – Qyos by Allgramo	TBC	Allas by Enviu
Consumer acceptance	Depends on area and status (i.e. high in urban, low in rural)	Depends on area and status (i.e. high in urban, low in rural)	High
Scalability	High	Low-Medium	Low-medium
Technological readiness (TRL)	9	9	9

6.3 Results

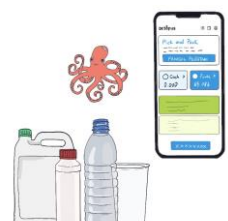
Selection and specification of concepts

Intervention	**UPSTREAM*: Single-use packaging***			
	SNACKS (recyclable)		**DRY FOOD (compostable)**	**TAKEAWAY (compostable)**
	Bottle-it-Up • Peanuts, crisps, snacks etc • Recyclable PET bottle 	**BICG & Optipak** • Crisps, peanuts, snacks etc • Single-layer sachet (PE or PP) • Resealable 	**Seashet** • Noodles, candy etc. • Single-layer sea • Biodegradable 	**PalmEatery** • Food container • Bio-based and biodegradable • Palm leave 
Substitutes	Metalised / non-metalised Multi-layer petrochemical-based sachet			Single use plastic / lined paper
Type of food	Greasy dry / semi liquid food	Greasy dry food	Non-greasy dry food	Prepared meals
Type of packaging	Rigid plastic	Flexible film-based plastic	Flexible film-based plastic	
Feedstock	Fossil fuel / non-renewable Polyethylene (PET)	Fossil fuel / non-renewable (polyethylene or poplyprop)	Red seaweed / renewable	Renewable / agricultural waste (Areca palm sheath)
Shelf life	Up to 1 year	Up to 3 years	Up to 2 years	Up to 1 year
End-of-life	Recycling	Recycling	Complete degradation soil (4-6 weeks) or marine (2-3 weeks)	Biodegradable in natural environment (100 days)
Suppliers	Koinpack by Enviu	TBC	Evoware and Biopac	Evoware
Consumer acceptance	Low-Medium	High (conditional on price)	High (conditional on price)	High
Scalability	High	High	Low-medium	Low-Medium
Technological readiness (TRL)	9	9	4-5	7-8

6.3 Results

Selection and specification of concepts

DOWNSTREAM CONCEPTS

Sorting		Collection		
Dragon e Storal	**Lave**	**Rhapsody**	**WBBD (Waste bank)**	**Octoplus**
				
Sort 2 bins (organic and inorganic) Collected to deliver to MRF (compost and recycle) Community rewards	Sort 3 types of waste using coloured bins and icons Community rewards	Collecting and Material Recovery Facility (MRF) through BUMDES	Waste Bank as a new Village Venture (selling to MRF). Save up for rewards, such as saving, rice or utensils.	App to collect recyclables (on request). Deliver it to the recycling industry.

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6.4 & 6.5
Prototype and Iteratively Test Solution for Dry Food and Food Take Away/Delivery Packaging and Waste Management in Indonesia

Yueyun Fan[a], Anouk Zeeuw Van Der Laan[a], Eleni Iacovidou[a], Spyridoula Gerassimidou[a] Yulianti Pratama[b], Aisya R Dangkua[b], Zayinatun Bila[b], Fenitra Maminirina[b], Fabrizio Ceschin[a], Emenda Sembiring[b]

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Executive summary

The user testing built upon the outcomes of the PISCES co-design workshop, aiming at testing the 11 tailored cross value chain solution from upstream (reduce reuse) and downstream solution (recycle) to avoid and address plastic waste and pollution. This report is about is about identify the main barriers that prevent target users from adopting the innovative solutions by prototpying the innovative concept and testing them by inviting participant from Banyuwangi local community. As a result, we were able to identify the adopting barriers and by integrating with the result of other work packaging research activities to tackle these barriers through several different strategies and interventions.

Two research findings are highlighted in this synthesis study:

1. The user testing invited in total 21 participants from Banyuwangi local community to test and validate the user acceptance of a range of innovative packaging and waste management solutions

2. Some of adopting barriers are identified such as (high) deposits can be off-putting at the point of purchase; reuse container may be perceived as unclean / unhygienic / unsafe / poorly preserved - which may influence their purchasing decision; preparation requirements which if not addressed impede the purchase (i.e., need to take the decision in home and plan for the purchase)

6.4 & 6.5 Context

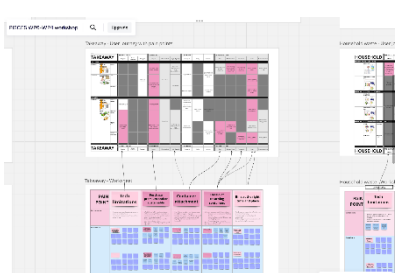
1. User testing 1

Nov 2023

The seven upstream and five downstream concepts were tested with real users in the Living Labs in Banyuwangi. The focus was to simulate the concepts and identify main barriers to adoption.

2. Concept refinement

Analysis of the data lead to emerging of pain points in each user journey that posed the key barriers to each concept. The barriers were reviewed and discussed in a workshop with WP 4 and 5. Through iterations the concepts were redesigned to offer solutions to the main barriers.



3. User testing 2

May 2024

All redesigned concepts were adapted for user testing. User testing scenarios were developed to generate feedback on the variables in each solution. User testing methodology was adapted to optimise the data collection process. Additional surveys and interviews were prepared to capture insights per participant on current behaviour as well as their preferences in each concept.

4. Concept recommendations

Analysis of the data will be used to make final recommendations for the adoption of the upstream and downstream solutions.

6.4 & 6.5 Methodology: Living lab

Objective: using living lab to tackle plastic packaging waste and pollution

INPUT

PACKAGING CONCEPT

CONCEPT EVALUATION AND REFINEMENT

The Role

Lead Researcher: Formulate an overall research activity plan, determine the activity agenda, staffing, etc.
Instructor: Key role interact with participant, giving instruction, guiding action and conducting interview, etc.
Observer: Non-interactive role, observe interactions throughout the user testing and taking note of interested data.
Participant: The targeted end user of the concepts.
Actor: Intermediary roles, as part of the simulated environment, facilitate the necessary communication and interaction.
Business Partner: Involved as Actor or Observe.

The Space – PISCES Living Lab

The PISCES living lab is located in Banyuwangi, Indonesia. The space equipped with furniture, projection, internet connection, AC to ensure researchers conducting a interaction activity with local people. The space is for creating a simulated environment to enacting and testing concepts.

The Process

Iterative process

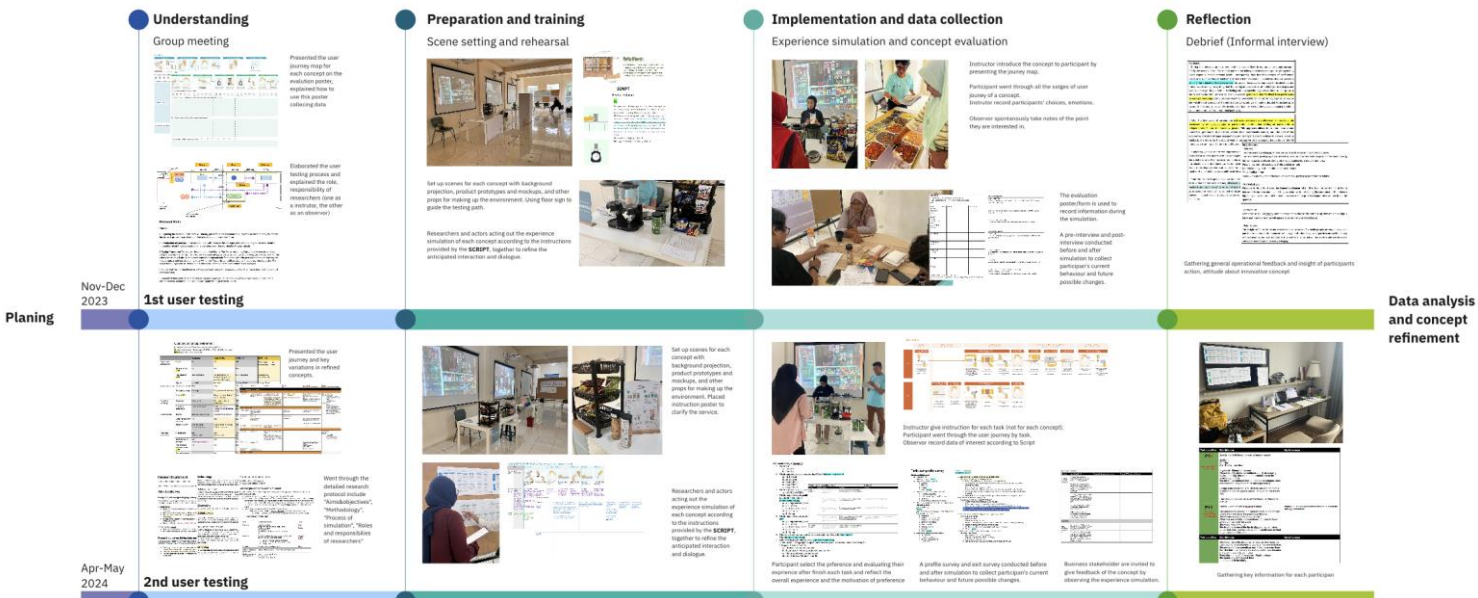
Planning → **Prototype** → **User Testing** → **Refinement**

OUTPUT

USER FEEDBACK

6.4 & 6.5 Methodology: User testing

The timeline of User Testing Activity



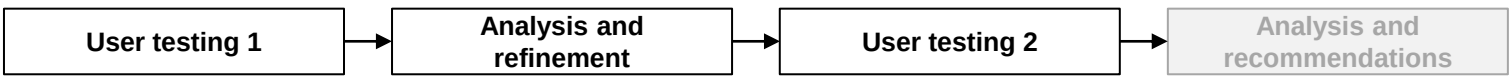
6.4 & 6.5 Reflection: User testing1 (Nov 2012) VS 2 (May 2024)

Stage	Takeaway from user testing 1	Mitigation of user testing 2
Understanding	The main objectives of the test and the details of the concepts were not synchronized and agreed upon before user testing. Small refinements to concepts during rehearsal, resulting in additional time consumption in preparation	Align on objectives and concepts ahead of user testing and avoid changes during user testing
Preparation & Training	The scripts were not well-structured, with mixed and unclear content for different roles.	Adapt the scripts based on the user journey map and dividing the content according to each role.
Implementation & Data collection	The instructor's dual roles of guiding users and recording information create excessive workload and pressure, impacting the simulation experience, while the observer's lack of clear instructions may lead to collecting unnecessary and disjointed data.	Reassign the responsibilities of instructor and observer. Instructor only guides users, including reminding their actions and asking questions. Observers record the specified interest data and participants answers.
	Participant information collection focuses only on consumption behavior.	Profile survey to gathering participant background information thoroughly including data of demographic and awareness.

6.4 & 6.5 Reflection: User testing1 (Nov 2012) VS 2 (May 2024)

Stage	Takeaway from user testing 1	Mitigation of user testing 2
Implementation & Data collection	Participants evaluate after experiencing a complete concept that comprises multiple stages, making it unlikely for them to remember the details of each stage.	Break down the concept experience into different tasks with various interventions. Shorten the process of a single simulation experience to make it easier for participant to provide timely feedback after each task.
	Time consuming to transcribe and translate after user testing	Digital surveys to record answers Note-taking in English as much as possible
	Data available per concept but not per participant	Track data per participant for triangulation and deeper understanding of barriers and drivers
Reflection (Debrief)	Debrief after each day of user testing to gather general and significant insight.	Debrief after each participant to gather detailed and specific insight.

6.4 & 6.5 Results: Concept development



Concept design and specification for user testing.

- Week 1: single-use concepts
- Week 2: reuse concepts
- Week 3: household waste

Outcome: Data on preference for concepts in each week and insight into barriers (per concept).

Identification of pain points in each set of concepts.

Workshop with WP4 and WP5 to review and address pain points.

Iteration and re-design of concepts to address main pain points.

Outcome: Identification of key variables in each concept and proposals to refine and optimise

Concept and specification re-design for user testing. Restructured user testing to align with current behaviour. Scenarios and concepts focus on key pain points.

- Week 1: purchases (dry food / snacks)
- Week 2: takeaway and delivery
- Week 3: household management

Outcome: Data on user preferences and current behaviours for specific concept variables (per participant).

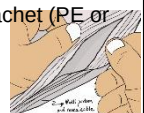
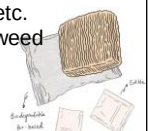
Work in progress:

- Analysis of data per concept and against current behaviour
- Review insights against concept variables

Expected outcome: Recommendations for packaging interventions in Indonesia

6.4 & 6.5 Results: Concept development

User testing 1 settings (week 1)

Intervention	**UPSTREAM*: Single-use packaging***			
	SNACKS (recyclable)		**DRY FOOD (compostable)**	**TAKEAWAY (compostable)**
	Bottle-it-Up • Peanuts, crisps, snacks etc • Recyclable PET bottle 	**BICG & Optipak** • Crisps, peanuts, snacks etc • Single-layer sachet (PE or PP) • Resealable 	**Seashet** • Noodles, candy etc. • Single-layer seaweed • Biodegradable 	**PalmEatery** • Food container • Bio-based and biodegradable • Palm leave 
Concept specification for user testing				
Food types	Peanuts (250gr)	Peanuts (250 and 500gr)	Instant noodles	Prepared meals (mock-up)
Context	Sold at warung New branding	Sold at warung New branding	Sold at warung New branding	Offered as alternative (opt in)
Incentives / price	7000 Rp 250gr	5000 Rp 250 gr 9000 Rp 500gr	3500 Rp (avg market price)	No discount No extra charge
Scenarios tested	Combined for 2 concepts 1. Select one of the new solutions to consume at home, take home to consume, consume and dispose 2. Select one of the new solutions to consume on-the-go, consume on-the-go (in a park) and dispose  		1. Purchase and consume at home, dispose 	1. Request PalmEatery container, take home to consume, dispose with compostable waste 2. Request Palmeatery container, consumer on-the-go (in a park), dispose on-the-go 

6.4 & 6.5 Results: Concept development

User testing 1 settings (week 2)

Intervention	**UPSTREAM*: Reusable packaging***		
	DRY FOOD (refill)	**TAKEAWAY / DELIVERY (reuse)**	
	BriOlliant • Refill station in warungs • Manual dispensers • Deposit or own container 	**Rent-A-Rantang** • Takeaway and delivery • Traditional rantang design • Pay deposit for container $ • Order through restaurant 	**SDM Surabaya** • Delivery • Reusable Tupperware • Order through App (Gojek) • Pay deposit through app $ 
Concept specification for user testing			
Food types	Rice and green beans	Prepared meals (mock-ups)	Prepared meals (mock-ups)
Context	Offered as an alternative At warung	Offered as an alternative (must opt in)	Use app to find participating restaurants (Gojek)
Incentives / price	10% discount on food 10.000 Rp deposit	10% discount on food 30.000 Rp deposit	10% discount on food 50.000 Rp deposit
Scenarios tested	1. Select rice and beans at restaurant, choose Briolliant contiainer, take home to use and store, return to refill or retrieve deposit. 	1. Go to restaurant and request reusable container, return at restaurant 2. Call restaurant for delivery, request reusable container, decant food and return to delivery person 	1. Receive and decant food and return to delivery person 2. Receive food, eat and clean container and request a collection for the container 3. Receive food, eat and clean container, return to restaurant  

PISCES

6.4 & 6.5 Results: Concept development

Pain points

Intervention	UPSTREAM			DOWNSTREAM
	DRY FOOD and SNACKS	**TAKEAWAY / DELIVERY**	**COMPOSTABLES**	**HOUSEHOLD WASTE**
	BriOlliant **BICG** **Bottle-it-Up**	**Rent-A-Rantang** **SDM Surabaya**	**Seashet** **PalmEatery**	
Summary of pain points				
	1. Decisions to purchase refill are made at home, ahead of shopping (planned, rather than spontaneous)/ 2. Concepts are premium offers in a saturated market, which is not always affordable, even though packaging design is a USP. 3. Peanuts, rice and green beans may constrain insights due to product preferences. 4. Refill options need to be considered together with hygiene, safety and cleanliness. 5. Container management in refill requires significant practical challenges.	1. Access to a smart phone, apps and a stable signal are not guaranteed or favourable. 2. Paying (high) deposits are off-putting and make concepts inaccessible and unaffordable to many, other incentives to be explored. 3. Packaging designs are appealing and people may be tempted to keep containers. 4. Container management in reuse requires significant practical challenges, specifically in returns, which could be better fitted to current behaviours.	1. Disposability of compostable materials is subject to availability of compost bins. 2. Identification of compostable materials requires education.	1. Lack of consistent guidance on how to sort waste, people have personal systems. 2. Lack of regulation on sorting waste and it is expensive; open burning is easier and less expensive. 3. Willingness to sort and recycle household waste strongly depends on location of collection points, volumes that can be safely stored at home, and the costs of the services.

6.4 & 6.5 Results: Concept development

User testing 2 settings (week 1)

Intervention	UPSTREAM			
	Initial settings	**SNACKS**	**Initial settings**	**DRY FOOD**
	BICG **Bottle-it-Up**	**Conventional (20 gr - $2k Rp)** **BICG Small (140gr - $7k Rp)** **BICG Large (400gr - $18k Rp)** **Bottle-it-Up (140gr - $10k Rp)**	**BriOlliant**	**BriOlliant (1L – beans $25k Rp; rice $20.5k RP)** **BriOlliant (3L – beans $65k Rp; rice $51.5k RP)**
Concept specification for user testing				
Food types	Peanuts	Peanuts	Rice and green beans	Rice and green beans
Context	Sold at warung New branding		Sold at warung Branded	Sold at warung Branded
Packaging		BICG – resealable bag (2 sizes) Bottle-it-UP – PET bottle	1L container	1L container 3L container with handle Bring own container
Incentives / price	Market prices	Multi-portion sizes Market prices for penatus Pricing to reflect premium packaging	Deposit $10k Rp 10% discount	Cashback for container – return within 14 days 1L $7k Rp and 3L $11k Rp 10% discount on food
Scenarios		Combined for 2 concepts, repeat for at home and on-the-go: 1. Purchase conventional peanuts, consume at home/on-the-go and dispose 2. Purchase one of the new peanuts solutions, consume at home/on-the-go and dispose		1. Purchase rice and beans at warung, take items home, consumer and return container 2. Choose container at home, visit warung, choose quantity, pay for product and take home.

6.4 &6.5 Results: Concept development

User testing 2 settings (week 2)

Intervention	UPSTREAM		
	Initial settings	**TAKEAWAY / DELIVERY**	
	Rent-A-Rantang / SDM Surabaya	**Klub-to-Go** • Takeaway and delivery • Membership with token • Borrow container (hand-in token) • Bring own container (show token for discount)	**SDM Surabaya** • Takeaway and delivery • Sign-up in app • Order through App (Gojek) or in restaurant (QR) • Pay penalties through app
	Concept specification for user testing		
Food types	Prepared meals (mock-up)	Prepared meals (mock-ups)	Prepared meals (mock-ups)
Context	Opt in at restaurant / use app in Gojek or WA	Offered as an alternative (must opt in) Poster with instructions	Use app to find participating restaurants (Gojek) Poster with instructions Reminders to return through app
Packaging	Rantang / tupperware	Branded tupperware	Branded tupperware
Incentives / price	10% discount on food 30k / 50k Rp deposit	10% discount on food One-off token 10.000 RP (non-refundable)	10% discount on food Time-sensitive penalties: first 7 days FREE / after 7 days 10k Rp / after 14 days 20k Rp
Scenarios		1. Purchase token, order in restaurant in borrowed container, consume and store at home, return to restaurant 2. Bring own container, get discount, consumer at home 3. Call for delivery, receive delivery in borrowed container, decant in own container and return to delivery person	1. Join through app, order food in SDM container, consumer, store and receive notification to return, reorder and return. 2. Order food in restaurant in SDM through QR code, consume, store, receive penalty, request container collection.

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6.8
Living Lab Set Up and Management

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Executive summary

A living lab can be defined a "User-centred, open innovation ecosystems based on systematic user co-creation approach, integrating research and innovation processes in real life communities and settings" [European Network of Living Labs (ENoLL), 2008].

In the PISCES project we designed and implemented a living lab specifically focused to address the problems of plastic packaging waste and pollution in Indonesia.

The PISCES living lab can be defined as a research and innovation infrastructure that, through an interdisciplinary, cross-value chain, systemic and multi-stakeholder approach, aims at: 1] co-designing and testing innovative solutions to plastic pollution, 2] providing scientific evidence of their environmental, social and economic benefits, 3] supporting local (Banyuwangi) and national (Indonesia) paradigm shift in current practices.

One research finding is highlighted in this synthesis study:

1. PISCES living lab has been established as research and innovation infrastructure that, through an interdisciplinary, cross-value chain, systemic and multi-stakeholder approach, aims at: 1] co-designing and testing innovative solutions to plastic pollution, 2] providing scientific evidence of their environmental, social and economic benefits, 3] supporting local (Banyuwangi) and national (Indonesia) paradigm shift in current practices.

6.8 Context: PISCES living lab definition

*A **research and innovation infrastructure** that, through an **interdisciplinary**, **cross-value chain**, **systemic** and **multi-stakeholder** approach, aims at: 1] **co-designing and testing** innovative solutions to plastic pollution, 2] providing **scientific evidence** of their environmental, social and economic benefits, 3] supporting local (Banyuwangi) and national (Indonesia) **paradigm shift** in current practices.*

Why

1. **Develop knowledge** on factors and drivers of **plastic pollution** in Banyuwangi
2. **Identify strategies and solutions** to avoid, reduce, reuse and recycle plastic waste
3. **Support local actors'** on-going efforts
4. **Support local and national paradigm shift** by promoting institutional, behaviour, business and regulative changes

Who

1. **PISCES project partners**
2. Representatives of the **local and national plastic-packaging value chain**, including private actors, public actors and users and communities
3. Open to collaboration and synergies

6.8 PISCES living lab key features

Where

Indonesia, East Java

Banyuwangi
Rogojampi district

6.8 PISCES living lab key features

What

1. Co-design **cross-value chain solutions**, integrating concepts at:
   - **material/product** level (e.g. new packaging design),
   - **product-service system** level (e.g. new reusable-refillable-returnable packaging systems),
   - and **waste collection and management** level
2. **Test** and improve solutions
3. Provide **scientific evidence** of their environmental, social and economic benefits

How

1. **User-centred and user-driven** approach
2. **Multi-stakeholder co-design** approach
3. **Systemic and cross-value chain** approach
4. **Interdisciplinary** approach
5. **Evidence-based** approach

6.8 PISCES living lab official launch (May 2023)

7. Key Messages

The global environmental crisis fuelled by the excessive production of single-use plastics and the mismanagement of plastic packaging waste is a pressing concern that demands immediate attention. Including social, economic, environmental, and regulatory factors various barriers affect the adoption of sustainable plastic packaging solutions in Indonesia. Through case studies and expert workshops, this report delves into these barriers.

Recognizing these barriers is the first step towards effective implementation and transition to a circular plastic economy. To succeed in this endeavour, stakeholders must work collaboratively to develop solutions that not only align with the unique characteristics of Indonesian society but also address economic disparities, contextual complexities, and regulatory aspects.

Key Results:

1. Five types of sociocultural barriers are identified: convenience, behaviour change, hygiene, and barriers related to habits and barriers related to environmental awareness.

2. To foster widespread adoption, sustainable packaging solutions must be economically viable and accessible to a broad spectrum of the Indonesian population.

3. Overcoming regulatory barriers necessitates a coordinated effort between government authorities, industry stakeholders, and environmental advocates to create a conducive regulatory environment for sustainable packaging initiatives.

7. Key Messages

Finding a solution to decrease plastic emissions in Indonesia holds immense significance not only for the nation itself but also for the global fight against plastic pollution in the oceans. Upstream packaging strategies should be explored further as they get to the source of the problem by redesigning products, materials and services rather than treating the symptoms. Understanding the barriers of implementing these solutions can facilitate their adoption in other areas of the world including Indonesia, accelerating the shift to a circular economy. Therefore, this research holds paramount importance as it explores the applicability of the upstream packaging solutions to Indonesian contexts by identifying the barriers of implementing them in Indonesia.

Key Results:

1. The focus groups with users, combined with the experts workshops, to identify user adoption barriers for a range of upstream and downstream solutions. These findings offer actionable insights to tailor packaging solutions to the unique needs and constraints of the Indonesian population, ultimately improving their adoption and effectiveness.

2. Codesign workshops enabled us to develop 11 promising solutions to tackle the problem of plastic packaging waste and pollution. These include 7 upstream concepts (single use packaging and reusable packaging systems) and 4 downstream concepts (waste collection and management).

7. Key Messages

The living lab implemented in Banyuwangi proved to be an effective research & innovation facility, by enabling multiple stakeholders in interacting in the design, development and testing of novel solutions to tackle the problems associated with plastic packaging waste and pollution.

The creation of a simulated environment (second floor of the living lab) was effective in facilitating a rapid and low-cost approach to prototype and test solutions, and in the end to gather rich insights to improve the solutions and enhance their adoption potential.

Key Results:

1. PISCES living lab has been established as research and innovation infrastructure that, through an interdisciplinary, cross-value chain, systemic and multi-stakeholder approach, aims at: 1] co-designing and testing innovative solutions to plastic pollution, 2] providing scientific evidence of their environmental, social and economic benefits, 3] supporting local (Banyuwangi) and national (Indonesia) paradigm shift in current practices.

2. The 'solution enactment' technique employed in the living lab proved to be rapid and low-cost approach to simulate the user experience (of a product, service, app, or product-service system) to identify adoption barriers and gather insights to be fed in the design process.

8. Frequently Asked Questions

What is the goal of overcoming these barriers in Indonesia's sustainable packaging journey?

The ultimate goal is to establish a circular plastic economy in Indonesia, where sustainable packaging solutions are widely adopted, reducing environmental harm and promoting a more sustainable future.

What steps can be taken to address these barriers in Indonesia's transition to circular packaging system?

Addressing these barriers involves collaboration between stakeholders such as government authorities, industry stakeholders, researchers, and environmental advocates. This collaboration can help shape favourable policies and regulations that encourage sustainable packaging practices.

What role does sociocultural acceptance play in sustainable packaging adoption?

Sociocultural acceptance is vital because packaging solutions need to resonate with the values and expectations of the local population. If they align with cultural norms and preferences, they are more likely to be adopted.

Why is understanding sociocultural, economic, and technological barriers important in the context of sustainable packaging solutions in Indonesia?

Understanding these barriers is crucial as it allows for tailored strategies to address specific challenges and increase the adoption of sustainable packaging solutions among the Indonesian population.

What were the specific sociocultural barriers identified during the focus group discussions, and how can they be mitigated?

Convenience, behaviour change, habits and traditions, hygiene, and environmental awareness were identified as sociocultural barriers to implementing the existing plastic packaging solutions to Indonesian contexts. We will conduct further research such as co-design workshops and user tests to find solutions that address these issues effectively. Some strategies may involve simplifying the user experience, launching targeted behaviour change campaigns, and ensuring the hygiene of reusable packages.

How can the findings from these focus group discussions contribute to the broader goal of reducing plastic pollution in Indonesia and globally?

The findings provide actionable insights into the barriers hindering the adoption of sustainable packaging solutions. By addressing these barriers effectively, the research contributes to the reduction of plastic pollution, not only within Indonesia but also by serving as a potential model for other regions facing similar challenges.

9. Future Research Agenda

Future research agenda involves completing the research activities as a part of:

Chapter 6.5: Analyse the results of the second user testing to then refine the concepts and develop design recommendations to improve user experience and user adoption. These recommendations will benefit both researchers in the design subject areas as well as practitioners and businesses who design/implement innovative packaging solutions.

Chapter 6.6: Complete the entrepreneurship programme to identify how to make the living lab (and related activities) and economically sustainable initiative.

Chapter 6.7: Reflect on the overall work package to develop an interdisciplinary and systemic design approach to tackle the problem of plastic packaging waste and pollution.

-Publications: 13 journal papers have been planned (1 is already published).



CHAPTER 7.
The PISCES Relay



Contents

Ambition

The PISCES Relay is an action programme designed to amplify the impacts of the PISCES project by transforming research outputs into practical outcomes within Indonesia. It facilitates the implementation of our toolkit across the Indonesian context, ensuring that the benefits of our program are accessible to various regions across the country.

The PISCES Relay is carefully adapted to accommodate Indonesia's diverse geographies, cultural richness, and communities. Its vision is to support integrated efforts to:

- Reduce plastic pollution
- Stimulate behavioural change
- Protect and preserve natural environments, such as mangroves and marine habitats, and support biodiversity and human well-being
- Strengthen governance to enable sustainable, product-based solutions and services.

The mission of the PISCES Relay is to achieve widespread implementation of the PISCES toolkit and expand the Living Lab infrastructure, ultimately building a national capability to rapidly design, test, and monitor the impacts of evidence-based solutions. This will support Indonesia in accelerating its transition towards a circular, restorative, and sustainable plastics economy – the essence of the PISCES Relay.

7.1
The PISCES Relay Reuse Pilot

Eleni Iacovidou[a], Susan Jobling[a], Fabrizio Ceschin[a], Darina Maulana[b], Firda Istania[b], Eline Leising[b], Susy Sebayang[c], Gede Hendrawan[d], Satabdi Datta[e], Joyashree Roy[e]

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Context

The PISCES Relay, Living Lab initiative, aimed at translating co-created solutions into real-world practice, generating measurable outcomes that help scale up the adoption of sustainable, cross-value-chain solutions to tackle plastic pollution in Indonesia.

From February to June 2024, we collaborated with our partner Enviu to pilot our refillable and reusable food packaging solutions aimed at reducing single-use plastic (SUP) consumption in Banyuwangi Regency, informed by insights from PISCES research.

The solutions were identified through co-design activities with stakeholders and were tailored to Banyuwangi's context, integrating elements of Enviu's existing solutions from their Jakarta-based start-up, Alner.

Together, PISCES research teams and Enviu adapted and implemented this reusable alternative to SUPs in Banyuwangi's traditional setting, marking its first introduction in the region.

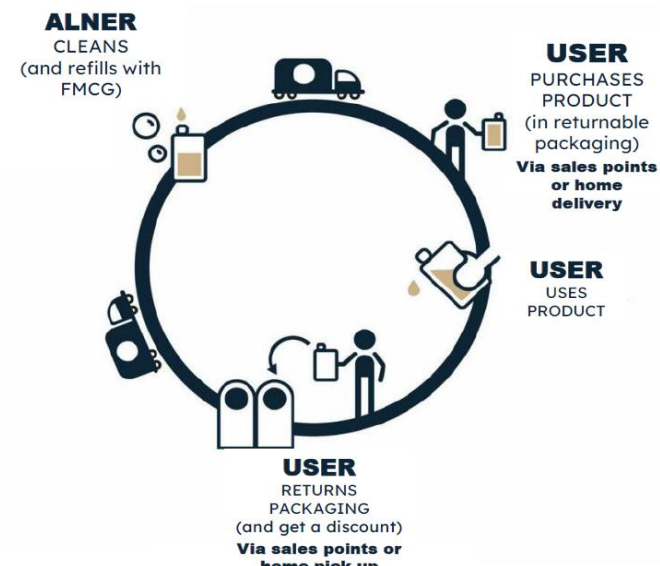
PISCES Relay products

Executive Summary

Powered by

The first ‘action’ delivery outcome of the PISCES Relay program was a small-scale pilot study to test viable alternatives to single-use food packaging (SUPs), based on insights from PISCES research.

This pilot, supported by Enviu and Alner, introduced Indonesia’s first returnable and reusable packaging system for dry food products to the Banyuwangi community. It demonstrated a proof of concept, showing that the PISCES Relay program can scale and replicate its impact to reduce single-use plastics in traditional Indonesian settings.



7.1 Approach

Set-up: Banyuwangi City and Rogojampi were used as a case study areas. Targeted B2B merchant partners were divided into: Warung (catering for middle to low-income Banyuwangi consumers), and Supermart (middle to upper-income)

Surveying consumers: Two questionnaires were structured with close-ended questions and quantitative data to elicit this information from the sellers and the consumers.

Economic evaluation: to understand if the pilot deployment has been successful in creating enabling conditions for a sustainable market in terms of motivating factors, market size and willingness of the sellers and consumers to participate.

Market data analysis: Analysis of primary data collection from 9 Warungs (sellers) and 48 consumers helped understand the consumption practices of consumers and willingness to pay

Traditional Warung Kelontong


Peronally owned semi-supermart

7.1 Outreach

E-Paper MEDIA INDONESIA

Home › Humaniora

Pisces Partnership dan Kemenko Marves Luncurkan Proyek Atasi Polusi Plastik

Deri Dahuri | Media Indonesia

21/2/2024 23:15

A- A+

Program PISCES Relay dilaksanakan di Kabupaten Banyuwangi, Jawa Timur.(Ist)

PISCES

Impresi

News Musik Sosok Leisure Didakti

Mengatasi Polusi Plastik dengan Program Pisces Relay, Simak Caranya yang Efektif

Endah Hapsari

Kamis, 22 Februari 2024 | 18:23 WIB

Kementerian Koordinator Maritim dan Investasi bersama dengan Pisces meluncurkan program “Pisces Relay” di Kantor Pisces Living Lab, Rogojampi, Banyuwangi, Jawa Timur.

Sosialiasi
kemasan
berkelanju
(DOK. PIS

8. Key Results

Selected products in reusable refillable packaging were showcased in the Banyuwangi living lab and delivered from there to the merchants on a regular basis. Returned empty packaging was collected from the merchants and cleaned and refilled in the living lab.

- >20 merchants engaged
- 75% of stores were willing to discuss reselling and more than half of these (6 stores or 30% of the total) agreed to take part in the pilot.
- 68% of the customers were repeat long-term customers
- Social recognition for being environmentally friendly was found to be the dominant factor motivating the seller to sell items packaged in reusable alternative packaging.
- Availability of subsidies for selling the items and increased sales by selling in larger packaging size were not found to be motivating the sellers.
- For all four products, consumers were found to respond primarily to price signals but were also pro-environmental.

Key Results:

1. 71% increase in the number of stores participating in the pilot in only 3 months. 36% of sellers are community-based and organically grown
2. 270 items were sold in 9 weeks of sales with a package return rate of 13.7% within that period
3. Average week on week sales growth : 33%

9. Future Agenda

TO EXPAND OUR PILOT, AND SECURE FUNDING AND FURTHER SUPPORT IN COLLABORATION WITH EXISTING PARTNERS, AS WELL AS WITH NEW ONES.

EXPAND TO INCLUDE OTHER SOLUTIONS, ADDITIONAL GEOGRAPHIES AND MORE PRODUCTS

TO FOSTER ENGAGEMENT WITH FMCGS.

TO ESTABLISH PISCES RELAY AS A RESEARCH AND ACTION ENTERPRISE TO DRIVE AND ACCELERATE TRANSFORMATIVE OUTCOMES, BUILD CAPACITY AND ENSURE THE SUSTAINABILITY OF THE LIVING LAB INITIATIVE.



Plastics in Indonesian Societies (PISCES):

Systems Analytics Approach to Reduce Plastic Pollution

Brunel University of London
UNIVERSITY OF LEEDS
Universitas Esa Unggul
UNIVERSITY OF PLYMOUTH
UNIVERSITAS AIRLANGGA
BRIN
ITS
University of Strathclyde Glasgow
AIT Asian Institute of Technology
InSWA
IWP
REPUBLIK INDONESIA
REPUBLIK INDONESIA
SYSTEMIQ
UKRI Natural Environment Research Council
GCRF Global Challenges Research Fund