Benchmark of Plastic Hotspotting Methodologies

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Quick guide and review of existing plastic material flow and leakage methodologies

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List of abbreviations

BMUV	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and Consumer Protection
BPW	Breaking the Plastic Wave
EA	Environmental Action
GHG	Greenhouse gas
GPAP	Global Plastic Action Partnership
HDPE	High-density polyethylene
ISWA	International Solid Waste Associations
IUCN	International Union for Conservation of Nature
LDPE	Low-density polyethylene
LLDPE	Linear low-density polyethylene
M&E	(WWF) Monitoring & Evaluation Framework
MFA	Material Flow Analysis
MSW	Municipal solid waste
MSWM	Municipal Solid Waste Management
NGOs	Non-governmental organizations
OECD	Organisation for Economic Co-operation and Development
PET	Polyethylene terephthalate
PFN	Plastic Footprint Network PFN
PLP	Plastic Leak Project
POM	Plastic products put On the Market
PP	Polypropylen
SDG	Sustainable development goal
SUP	Single use plastic
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
UNITAR	United Nations Institute for Training and Research
WaCT	Waste Wise Cities Tool
WFD	Waste Flow Diagram
WWF	World Wide Fund for Nature Inc.

Glossary

Baseline	Collection and assessment of present data, with the purpose of establishing a point from which future measurements and predictions can be calculated or compared to.
Forecast/Scenarios	Process of making predictions based on past and present data. The methodology allows for forecasting when, based on present data, results include projections on the future. While by defining or selecting different scenarios, the user can compare the results if different actions were put into place, today or in the future.
Formal sector	Waste management activities which are legal and undertaken by units working within the context of the formal economy, under the local regulations related to wastes and their management. It includes public service providers and private companies. Activities carried out by generators that are related to management of their own wastes (for example, separation of recyclable materials into different types in preparation for collection) are also considered formal activities.
Hotspot	A component of the system that directly or indirectly contributes to plastic leakage and impact. In this study, hotspots can refer to polymer type, sector (e.g., packaging, textiles, automotive, etc.), application/product, waste management stream component, or geographical location.
Household waste	Any solid plastic waste derived from households, including single and multiple residences, hotels and motels, crew quarters, campgrounds, and other public recreation and public land management facilities.
Industrial waste	Plastic waste generated by industrial processes, such as mining and quarrying, manufacturing, construction, waste and water treatment services, food processing industries, etc. It is usually categorized in three forms: solids, liquids, and gases.
Informal sector	Individuals or a group of individuals who are involved in private sector recycling and waste management activities but are not formally registered or formally responsible for providing waste management services. Informal waste workers are often referred to as "waste pickers".
Leakage	A quantity of plastic that leaves the Technosphere and is released to the environment. It refers to plastics that escape from the waste management system and becomes mismanaged waste. In the case of the Waste Flow Diagram (WFD) methodology, this term is meant to exclude uncollected plastic waste, there being treated separately. In this study, when possible, we make the following distinctions: › Leakage to ocean and waterways: Potential leakage into oceans and seas caused by e.g., uncollected waste disposed close to waterways, unproperly managed landfills close to waterways, plastic waste entering wastewater and drainage systems, etc. › Leakage to other compartments: Potential leakage on land in places where no nearby water systems or water sources can be affected by the pollution. › Leakage impact on human health: Estimation of the potential harm to human health caused by potential plastic leakage hotspots, as, e.g., micro-plastics leakage into drinking water sources in places caused by nearby mismanaged waste.

Litter	Waste incorrectly disposed, such as a cigarette thrown on the ground, a crisp packet dropped, or a drinking cup tossed on the ground. The items may or may not be collected through formal waste management schemes.
Macro-plastics	Plastics particles readily visible, with dimensions greater than 5 mm, e.g., plastic packaging, plastic infrastructure, and fishing nets.
Managed waste	Plastic waste, out of collected municipal solid waste, being accepted in a recovery or disposal facility that has reached at least an intermediate level of control.
Micro-plastics	Small plastic particles of a size between 1 and 5 mm.
Mismanaged waste	Combination of improperly managed and uncollected (see definition below) plastic waste. Improperly managed waste is a fraction of waste that is disposed of in a waste management system where leakage is expected to occur, such as a dumpsite or an unsanitary landfill. A dumpsite is a particular area where large quantities of waste are deliberately disposed in an uncontrolled manner. A landfill is considered unsanitary when waste management quality standards are not met, thus entailing a potential for leakage.
Municipal Waste or Municipal Solid Waste (MSW)	Plastic waste generated by households, and waste of a similar nature generated by commercial premises, by institutions such as schools, hospitals, care homes and prisons, and from public spaces such as streets, markets, slaughterhouses, public toilets, bus stops, parks, and gardens. It also includes bulky waste (i.e., white goods, old furniture, mattresses) and waste from selected municipal services such as waste from street cleaning services (street sweepings and content of litter containers). Does not include waste from municipal sewage network and treatment, construction, demolition, or sewage treatment.
Municipal Solid Waste Management (MSWM) or System	The set of activities carried out by formal and informal economic units, both public and private, and by generators for the purpose of the prevention, collection, transportation, treatment, and disposal of waste. Waste management includes only controlled waste-related activities (both formal and informal).
Polymers	Polymers are a group of organic, semi-organic or inorganic chemical substances containing large polymer molecules.
Recycling	Process of converting plastic waste materials into feedstock for new materials or objects.
Reduction of waste	Any action that targets reduction of waste engaging in redesign of products (redesign), disincentive usage of a product (reduce) or elongating the lifetime of a product (reuse).
Storm drains (e.g., as used in WFD methodology)	Any natural or man-made channel that drains excess rain or ground water, and which does not have a continuous flow of water. This includes seasonal riverbeds, drains at sidewalks, built in canals, etc. but excludes plastics in the sewage system drains, unless they are combined (e.g., open rainwater and sewage systems). Only plastic which is removed (cleaned) from storm drains is accounted under this fate. Anything not removed is assumed to eventually reach water systems and is accounted under the water systems fate.

System map	A visual illustration of the main flows and stocks of a waste or plastic management system.
Single use plastic (SUP)	Single-use plastic products are only used once, and only for a short period of time, before being discarded. SUPs can be both packaging (e.g., beverage bottle or a plastic container for take-away consumption) as well as non-packaging items (e.g., plastic cutlery). They are more likely to end up in the environment and the oceans than reusable options.
Technosphere	Part of the environment that is made or modified by humans for use in human activities and human habitats.
Uncollected waste	Fraction of plastic waste (including littering) that is not collected by the formal sector and does not end up in either a recovery or disposal facility. It refers to the fractions of waste that are not dealt within the MSW management system, making it difficult to estimate either the size of the problem or the scale of the associated costs.
Water systems (e.g., as used in WFD methodology)	Any permanent body of water including rivers, canals, lagoon, lakes which drain into a river network or the ocean. Although not all plastic entering waterbodies may reach the ocean, there is a high chance for it to do so harming aquatic and marine life. Therefore, it is defined here as marine litter.

Context

1

Nowadays, barely any other global threat to the oceans is as visible as the pollution from plastic waste. As often portrayed in visually charged media reports, the increasing littering of the oceans has reached an alarming level. Various stakeholders recognize the need for a paradigm shift to combat plastic pollution and marine litter. Strategies focus on limiting further discharge of plastics as effectively as possible. In addition to bans and voluntary approaches, e.g. to reduce single-use plastics, discussions are also taking place on how producers, retailers and other stakeholders can be held accountable. Awareness-raising measures to trigger changes in societal behaviour regarding littering, waste separation and waste avoidance represent another important approach. However, it is difficult to assess the success of those mentioned actions. As noted at the third United Nations Environment Assembly (UNEA 3, Nairobi, 2017), there is currently no standardized way to measure the extent of the plastic problem. Although there are various methods and tools to assess plastic pollution, it is difficult amongst others to measure how much plastic is entering the oceans and thus to compare this. Only when decision-makers have credible, meaningful, and legitimate data they can estimate and analyze the current state of the issue, set measurable goals, implement effective actions, and track progress towards set goals over time to tackle the problem of plastic pollution at source.

Hence the purpose of this report is to conduct a review of the existing methodologies which assess plastic waste flows and leakage into the environment and more specifically, plastic leakage into waterways and entering oceans and seas.

By developing a comparative framework, the reader can find support in identifying the methodology which best enables monitoring projects or national programs to be assessed within their context of application and in terms of their added value for preventing plastic pollution and marine litter.

This study is part of the GIZ Global Marine Litter Project, which supports the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and Consumer Protection (BMUV) in the implementation of the funding program “Marine Debris Framework - regional hubs around the globe” (Marine: DeFRAG). The aim of the funding program is to support developing and emerging countries in improving their waste management system and to create incentives to prevent marine litter pollution.

Objectives of the study

2

The detailed objectives of this study are:

- To identify methodologies and tools allowing to assess plastic flow and leakage within the waste management chain.
- To compare them and give the reader an overview of the features of each methodology.
- To provide the reader with the context of application in which each methodology best fits and assess whether it is suitable for monitoring (regional) projects and national programs.
- To provide an estimation of the effort-related aspects for each methodology and tool.

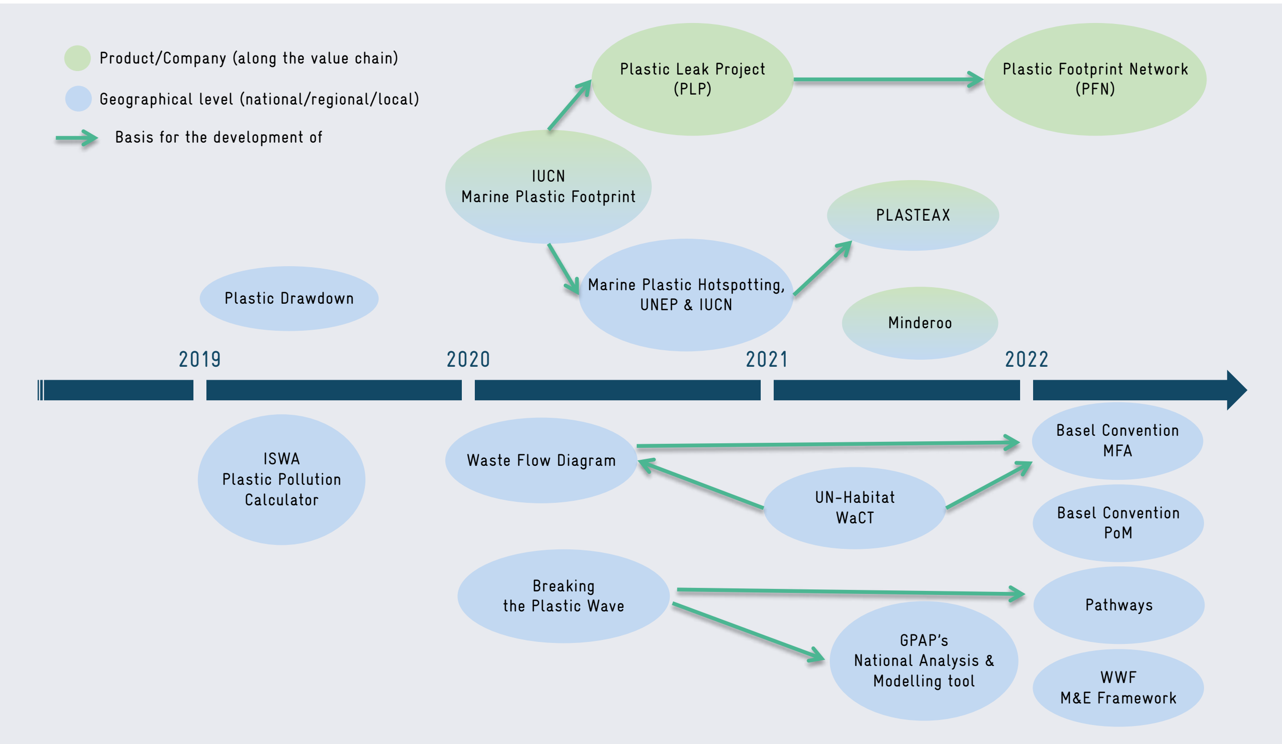
Methodologies

3

The methodologies selected for this study are listed in Table 1. The focus is on those that perform an assessment at geographical level, e.g., excluding the tools that specifically focus on the corporate level. Based on the year of their publication, they are visually represented in Figure 1 over a three-year timeline. The green arrows show how one methodology contributed as a basis for the development of a subsequent methodology and data feeding relations. Blue oval shapes represent the methodologies or tools performing the analysis at a geographical coverage level, while green oval shapes represent some of the existing methodologies or tools focusing on an analysis at product or company level, such as the Plastic Leak Project (PLP) and the more recent Plastic Footprint Network (PFN). These methodologies are included here only to show the evolution of the ICUN Marine Plastic Footprint, but they do not fall in the scope of this study.

Another selection criterion is that the methodologies are operable, i.e., that they are available to users for the assessment or monitoring of plastic leakage. For this reason, the OECD Plastic Modelling is not considered here. This model was used to elaborate the OECD Plastics Outlook report[1]. The report provides a set of coherent projections for plastics to 2060, including plastic consumption and waste, and environmental impacts. These are presented in both a business-as-usual scenario and policy scenarios that assess the environmental and economic impacts of various policies through 2060. While the report's data are available, the underlying methodology is not operable by users.

Figure 1: Timeline of the selected methodologies



1 Global Plastics Outlook: https://www.oecd.org/environment/plastics/

Table 1: Overview of analyzed methodologies

Methodology	Short name	Authors	Year of release	Online tool	Context of application	Page
Basel Convention Practical guidance for the development of inventories of plastic waste	BC Guidance	Basel Convention	2022	No	The Basel Convention elaborated an additional practical guidance for the development of inventories of plastic waste to guide the Parties to the Convention in the annual reporting. The guidance suggests three practical methodologies for the inventory of plastic waste. While two methodologies estimate plastic waste generation (the product life-time approach and survey approach) the third aims at the mapping of plastic waste flow (Material Flow Analysis). As the survey approach is based on the application of the WaCT, this review will focus in the following on the product life-time approach (BC PoM) and the Material Flow Analysis (BC MFA).	26
Breaking the Plastic Wave	BPW	Systemiq, The Pew Charitable Trust	2020	No	Modelling approach to assess global plastic pollution and to estimate the quantity of plastic pollution leaking into oceans. The baseline is computed for the year 2016 and the model forecasts plastic flows and stocks, as well as their impact, by 2030 and 2040. The baseline is generated for three plastic categories, based on eight geographical archetypes (4 income levels, with a distinction between urban and rural areas). The forecasting showcases six different scenarios (including business-as-usual 2016), which are defined based on eight possible interventions.	32
Global Plastic Action Partnership's National Analysis and Modelling tool	GPAP NAM	Systemiq	2022	Yes	Modelling approach to assess national plastic pollution and to estimate the quantity of plastic pollution leaking into oceans, based on the BPW methodology. The baseline can be adapted by the user and the model forecasts plastic waste flows and stocks, as well as their impact, in the future until 2040. It comes with preloaded data from Breaking the Plastic Waste (mapping of countries to three different income archetypes) and from PLASTEAX data, for some countries. It calculates 5 different scenarios (Business as Usual, Upstream, Downstream, System change, Custom scenario), combining different levers from the following categories: Reduce & Substitute, Redesign, Collection & Sorting, Trade control, Recycle, Disposal, Mismanaged.	36
ISWA Plastic Pollution Calculator	ISWA PPC	ISWA – International Solid Waste Associations, University of Leeds	2019	No	Modelling of item-specific plastic waste generation, and its subsequent flow throughout the waste management system and its fate into the environment. It allows each leakage route to be quantified and then ranked according to its relative importance. The tool combines data on solid waste management system, with local socioeconomic, geographical, and meteorological factors.	39
Minderoo	Minderoo	Dominic Charles et al, Minderoo Foundation	2021	No	The Minderoo global single use plastic tool was developed to identify the most relevant producers of polymer forming single use plastic and the amount that finally ends up as waste. At country level, the tool is able to assess the production and trade of polymers and SUP and SUP waste generation.	44
National Guidance for Plastic Pollution Hotspotting and Shaping Actions	UNEP&IUCN Guidance	UNEP, IUCN, Life Cycle Initiative, EA – Environmental Action, Quantis	2020	Yes	The National Guidance for Plastic Pollution Hotspotting and Shaping Action aims to provide countries with a methodology to identify plastic leakage hotspots, and to prioritize effective interventions for leakage reduction. It provides a country-level baseline assessment of micro- and macro-plastic leakage. The assessment is sector-, polymer-, and product-specific. It highlights the sectors, polymers, products, sub-national geographies, and waste management levers that are most problematic by absolute or relative leakage. Finally, it guides the user through a list of possible instruments and interventions to tackle plastic leakage to ocean and waterways.	48

Methodology	Short name	Authors	Year of release	Online tool	Context of application	Page
Breaking the Plastic Wave Plastic Pathways Tool	Pathways	The Pew Charitable Trusts Oxford University	2022	No	The Pathways tool is a freely available software application and flexible modeling framework that analyzes the movement of plastic throughout the value chain to assess plastic leakage into the environment. It can be used at local, national, regional, or global scales, and can simulate plastics flows by plastic category, polymer, or product type. Pathways enhances the "Breaking the Plastic Wave" model (above) by increasing its flexibility and analytical capabilities (e.g., allowing users to re-define system flows, allowing material to flow between model archetypes, etc.).	51
PLASTEAX	PLASTEAX	EA – Environmental Action	2021	No	The PLASTEAX tool and methodology aim to provide a baseline of plastic packaging waste management and leakage to ocean and waterways, by country. The results are polymer-specific and product-specific. PLASTEAX database contains the baseline assessment for more than 43 countries, as of July 2022.	55
Plastic Drawdown	Plastic Drawdown	Common Seas	2019	No	Plastic Drawdown assesses country specific plastic pollution challenges and identifies an optimal portfolio of policies and actions to mitigate plastic pollution into rivers and oceans, by projecting to 2030 and comparing different scenarios to the Business-as-Usual one. It includes suggestions for the most effective measures worldwide and their implementation.	58
SPOT Model	SPOT	University of Leeds	N/A	No	The SPOT (Spatio-temporal quantification of Plastic pollution Origins and Transportation) model has been developed on behalf of UN-Habitat and UNEP and is a GIS-based tool to identify plastic pollution hotspots on a regional and global level. The tool focuses on land-based solid waste sources and is designed to accept data according to SDG 11.6.1. Currently, the methodology and relative tool have not been published yet and no further information is available.	62
Waste Flow Diagram	WFD	GIZ, University of Leeds, Eawag, Wasteaware	2020	Yes	The WFD is a rapid assessment tool to estimate the amounts of municipal solid waste leaking to the environment and water from different sources. It combines a Material Flow Analysis (MFA) approach with systematic and observation based qualitative assessment which involves primary and secondary data collection, observations, and interviews along waste management stations. It visualizes quantities of municipal solid waste streams within a waste management system in standardized Waste Flow Diagram and Sankey diagram. It allows to insert data following different scenarios and compare the different assessments for waste management planning.	62
Waste Wise Cities Tool, SGD 11.6.1	UN-Habitat WaCT	UN-Habitat	2021	Yes	The core and main purpose of the methodology is to provide the user with a complete and detailed step-by-step guide for collecting data on collected, recovered, disposed and uncollected municipal solid waste to assess the actual state of the MSW system. The Excel tool helps the user to centralize and visualize the collected data. There is specific analysis on marine litter.	66
WWF Monitoring & Evaluation Framework	WWF M&E	WWF, EA – Environmental Action	2022	No	The framework is suitable for assessing the impact of direct and indirect measures at the city level (in the context of WWF's Plastic Smart Cities target of a 30% reduction in plastic pollution by 2030). It does not perform baseline evaluation, but baseline data is still needed to apply the methodology. Therefore, the framework can be seen as complementary to a more technical baseline assessment tool, to which it adds a layer of analysis on the impact of measures.	70

Benchmarking plastic hotspotting methodologies

4

4.1 About

The comparison between the different methodologies is structured along four axes. Different indicators have been identified for each axis, as illustrated in Figure 2, to give an overview of the main features of each methodology and how they might complement each another.

The first axis ("Geographical coverage", orange ray) allows a comparison of the geographical coverage of each methodology: whether the data collection, and subsequent analysis, are restricted to municipal and sub-national level, or if the analysis covers a wider geographical area, such as a country or the whole world, as in the case of Breaking the Plastic Wave methodology.

The second axis ("Waste breakdown", turquoise rays) shows which type of waste the respective method covers: e.g., municipal solid waste or industrial waste, and whether it focuses on microplastics and/or individual products, packaging, and polymers.

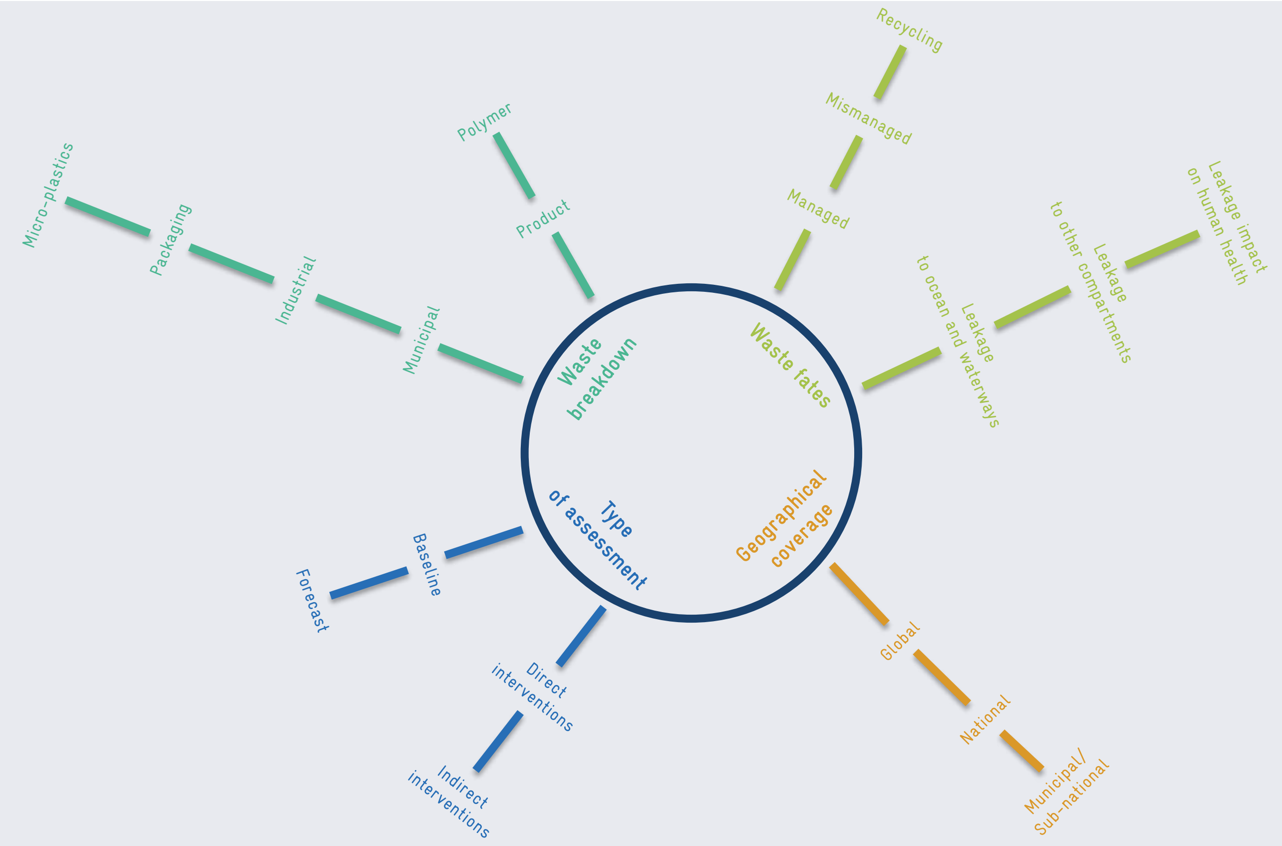
The third axis ("Waste fates", green rays) investigates the waste fates considered in each methodology on two levels. At first identifying if the methodology analyses both managed and mismanaged waste, and if it includes recycling. Then, digging a bit further in granularity, by identifying if the methodology estimates leakage to waterways and other compartments, and its impact on human health.

The fourth axis ("Type of assessment", blue rays) indicates what type of assessment the user can perform with the respective methodology: i.e., whether the methodology (or tool) can only be used to calculate the baseline situation or whether it also allows for forecasting and comparison of different scenarios. Two other indicators also show whether the methodology allows the user to assess the impact of direct and indirect interventions.

Finally, section 4.6 gives an overview the level of technicality required to apply the methodologies or to use the corresponding tool. Three indicators are defined for comparison, to differentiate between the level of granularity required for the data collection phase, the level of complexity in the analysis of the waste management system and the technical knowledge required in terms of software and programming skills. Three labels are defined for each of the three "technical" indicators: low, medium, high, as explained here under in the corresponding section.

For definition of terms please refer to the Glossary, at the beginning of the report.

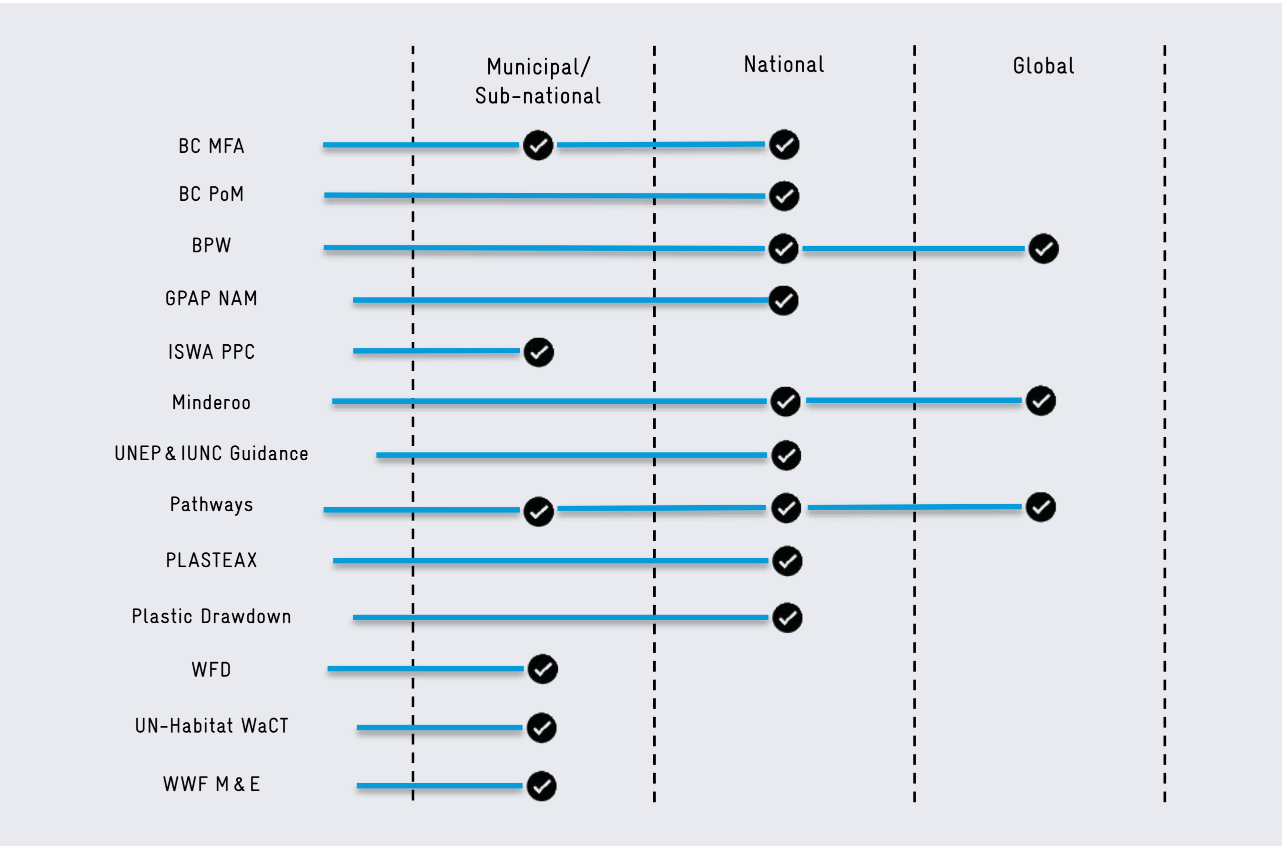
Figure 2: Indicators for benchmarking framework



4.2 Geographical Coverage

Figure 3 shows the first axis differentiation between three geographical coverage levels: municipal/sub-national, national, and/or global. The figure shows the geographic coverage targeted by the developers at the time of development and initial implementation. It should be noted that any tool that performs a city/municipality-level assessment can be used to assess multiple cities or a subnational region simultaneously, assuming that the waste management system is homogeneous within the study area. The data of the considered municipalities are entered cumulatively. For subnational regions with inhomogeneous waste management systems, one can conduct the analysis separately for multiple cities (e.g., for known hotspots) and then combine the results, e.g., possible with the WFD. In contrast, tools that provide a national assessment rely on national data, such as trade, to estimate waste generation and are therefore not well suited for subnational regional assessment.

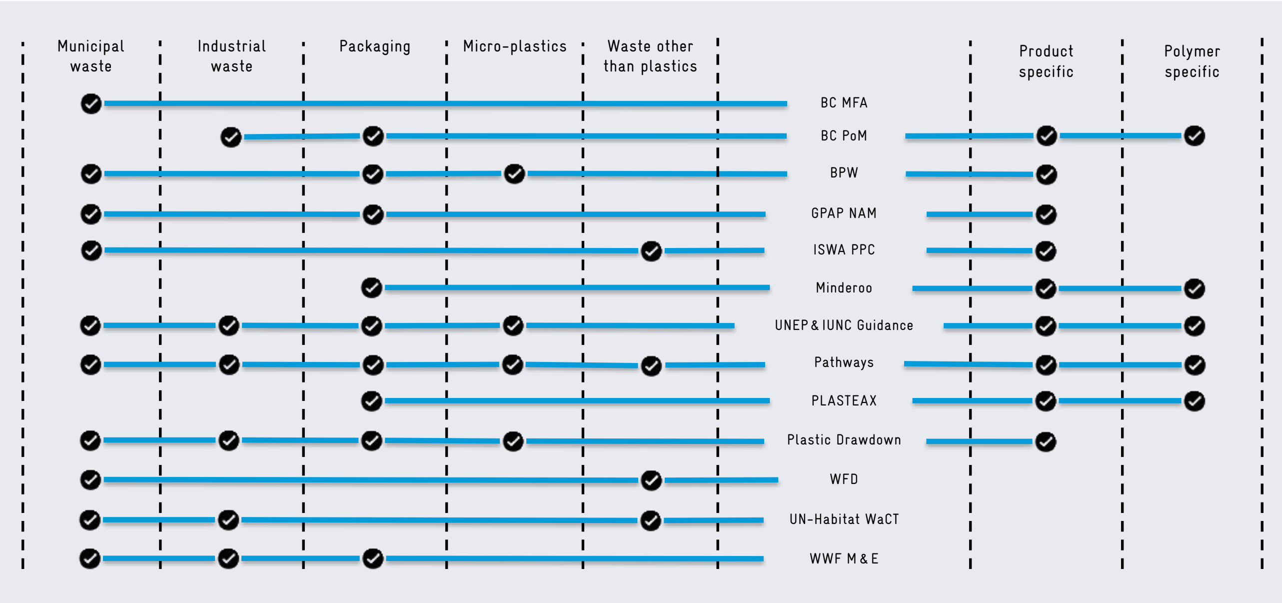
Figure 3: Comparison of the different levels of geographical coverage for each methodology



4.3 Waste breakdown

Figure 4 reports the results along the second axis indicators, illustrating the type of plastic waste that can be included in each methodology assessment.

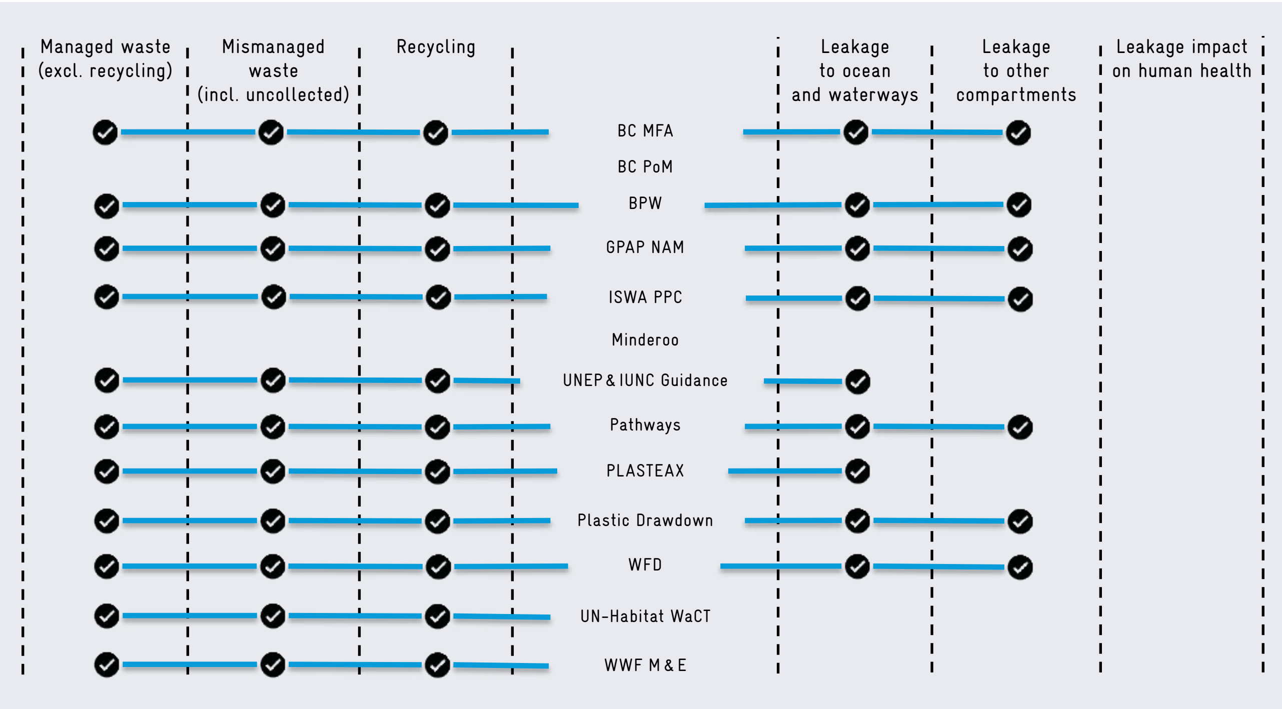
Figure 4: Comparison of the different types of plastic waste analyzed in each methodology



4.4 Waste fates

Figure 5 reports the level of plastic waste fates granularity included in each methodology.

Figure 5: Comparison of the different plastic waste fates analyzed in each methodology



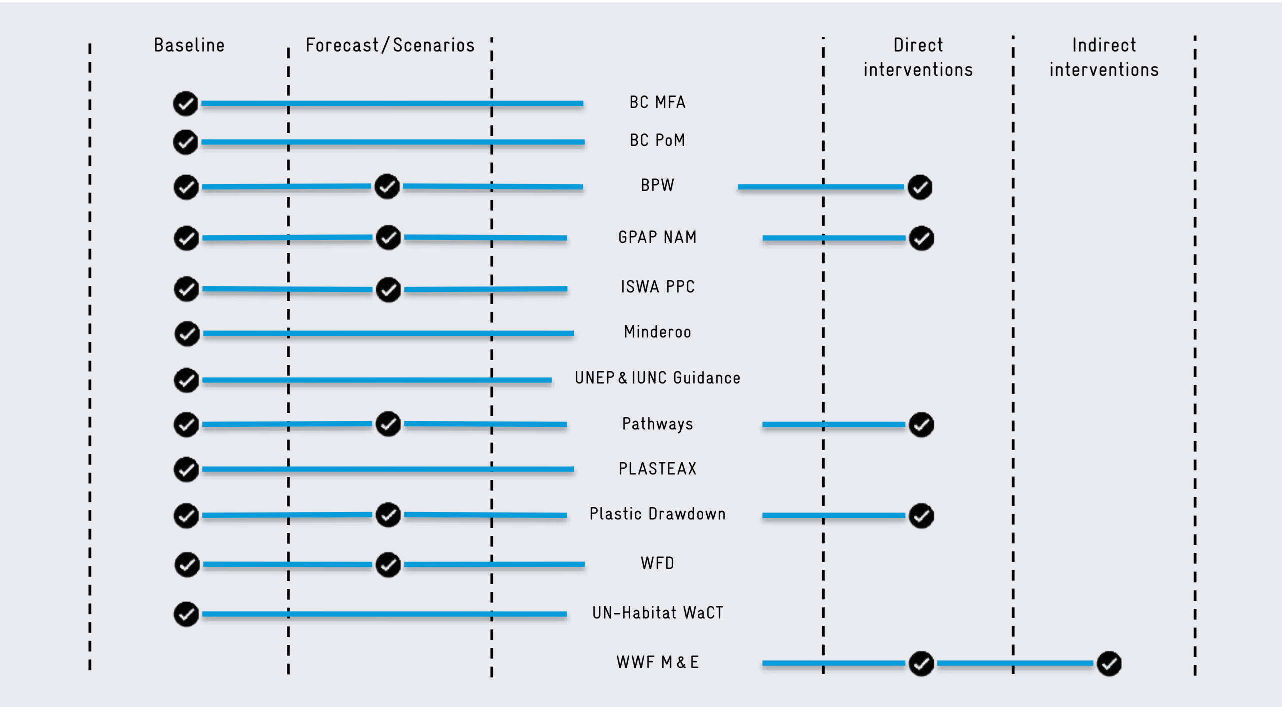
4.5 Assessment type

Figure 6 shows the type of assessment that can be performed by applying each methodology.

An intervention is defined as a tangible action taken to mitigate plastic leakage, e.g., an increase in bottle collection. Decision makers need to design and prioritize interventions that will address the most problematic hotspots. In the following, we distinguish between:

- Direct interventions are actions whose direct impact on the physical waste stream can be quantified.
- Indirect interventions (sometimes also called "instruments") are intended to influence behaviors rather than control or affect it. Their impact can be related to leakage reduction only if an evaluation scheme is in place and appropriate values are provided.

Figure 6: Comparison of the different types of assessment provided by each methodology



There are five methodologies that explicitly explore interventions to reduce plastic leakage, these are: Breaking the Plastic Wave, Plastic Drawdown, National Guidance, Pathways and WWF M&E Framework. The National Guidance supports the user to select direct and indirect interventions that are better suited to target the leakage hotspots, but it does not provide an estimate of the leakage reduction potential. Breaking the Plastic Wave explores a pre-defined set of scenarios and how they could impact the plastic leakage forecast. The derived Pathways tool allows the user to customize the plastic system map to reflect local conditions, define interventions, conduct trade-off analyses among interventions, and assess their impacts on plastic leakage. Plastic Drawdown allows the user to select between a set of 18 pre-selected interventions and then assess their impact. WWF M&E

Framework has been developed specifically to assess the leakage reduction of direct and indirect measures. The type of measure can be customized by the user and the impact assessment is performed based on indicators such as the waste generation reduction and the number of people affected by the interventions.

In principle the other methodologies can also be used to assess the impact of (direct) interventions. By changing the input values to mimic the change brought about by the intervention (e.g., collection %, recycling quantities etc.), one can see how this affects the leakage. The type of measures that can be assessed and the type of indicators that need to be monitored will then depend on the type of input parameters that the methodology requires. For insights into the input requirements of each method, see the description of each method in Section 5.

4.6 Technical requirements

Since the methodologies and tools differ in the requirements in terms of data collection, complexity of analysis of the waste management system, and technical knowledge, such as software and programming experience, three indicators were introduced to give the reader an a priori idea of the level of technicality required by each methodology. The indicators are: Data collection complexity, Waste management complexity and Technical (software) expertise. Each of these indicators were assigned to a label (low, medium, high) to allow the reader to make a comprehensive preliminary assessment of the effort required to apply a methodology. This evaluation is based on freely available information online, considering that most of the tools are not available and as such, it was not possible to evaluate them based on empirical trials.

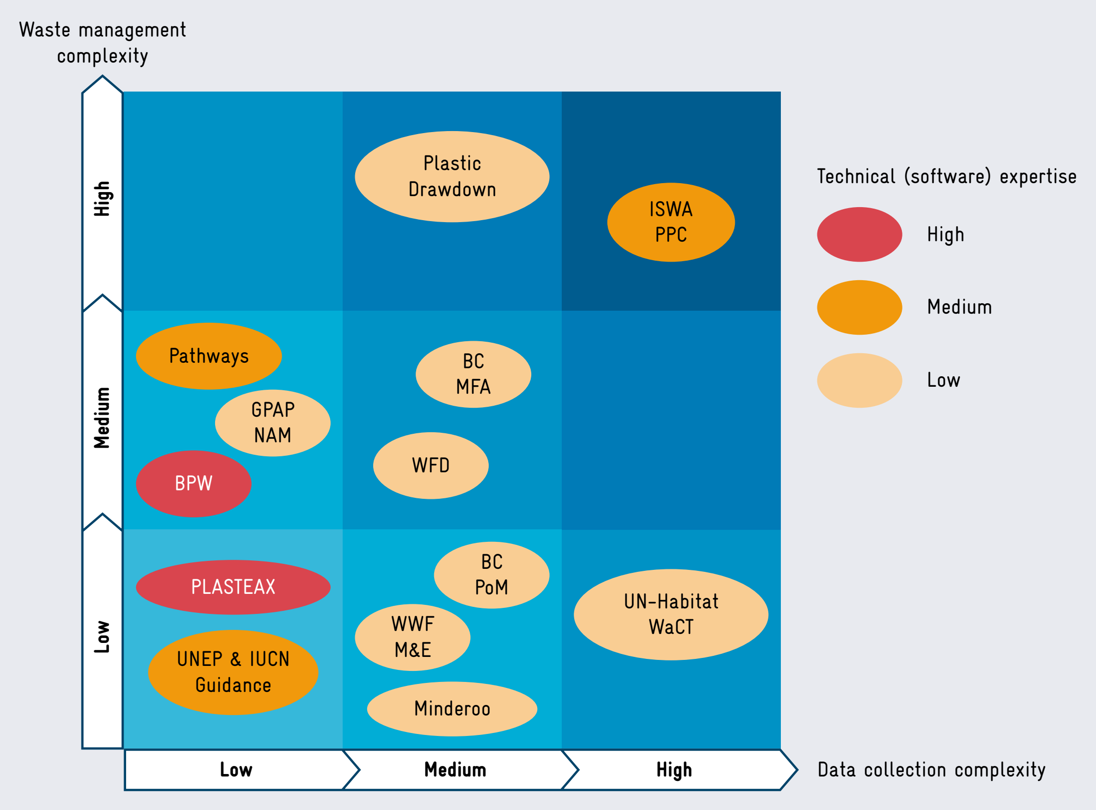
The Data collection complexity evaluates the effort required to collect data for the assessment (horizontal axis in Figure 7). The level of complexity for the analysis of the waste management system is reported on the vertical axis in Figure 7. The Technical (software) expertise evaluates requirements in terms of software and programming skills, to apply the methodology or to use the tool (represented with red-scale colors in Figure 7). For sake of uniformity, three labels are defined for each indicator: low, medium, and high, as defined in the following.

Data collection complexity:
- Low: Default values are directly available in the tool or in literature and cited sources.
- Medium: Primary data collection and surveys are required, but a low level of data granularity required, and/or default values available.
- High: Primary data collection and surveys are required, and no default values are available, or a high level of data granularity is required.

Waste management complexity:
- Low: High-level waste management system map.
- Medium: Waste management system map accounts for components such as, e.g., waste transportation, sorting losses, chemical recycling, drainage, etc.
- High: Waste management system map highly detailed, including wastewater treatment analysis.

Technical (software) expertise:
- Low: User friendly interface.
- Medium: User friendly interface, but some software skills might be required for deeper analysis.
- High: Software and/or programming experience.

Figure 7: Comparison of the technical level required by each methodology



4.7 Informal sector

The informal sector (collection and sorting) could also be considered a waste fate. As noted in the full Breaking the Plastic Wave report, which includes it in the analysis and findings, the informal sector does indeed play a critical role in reducing plastic pollution, especially in middle- and low-income level countries. In 2016, there were an estimated 11 million informal sector workers worldwide, and 59% of the plastic recycled globally was collected by informal services (about 27 million tons of plastic that might otherwise have leaked to the environment).

Therefore, the informal sector is an important component to be considered when defining policies and interventions to improve waste management. It has not been defined as an indicator for comparison, since all the methodologies do include it in the analysis (depending on the availability of the data).

As with the Basel Convention MFA, Waste Flow Diagram, the ISWA Plastic Pollution Calculator, PLASTEAX and Pathways, the user can enter data on informal collection and sorting or recycling. In the analysis of plastic runoff, waste collected by the informal sector, street sweepers or rubbish screens in waterways is considered "intercepted", and for the UNEP and IUCN national guidelines, "dumping" can be the result of both the formal and informal collection sectors. The WWF M&E framework and Pathways also provide an opportunity to include the informal value chain in the assessment, as interventions can be defined as targeting this specific sector. The data on collected and intercepted amount are inherent.

Methodologies in-depth

5

In this chapter, the methodologies are explored in detail and, where available, examples of possible results are given. For each methodology, a table summarizes the indicators from Section 4. The corresponding references and sources of information are also given.

5.1 Approaches and tools under the Basel Convention

"Parties to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal" are required by Article 13(3) of the Convention to submit annually to the Conference of the Parties a national report including inventories, i.e., information on the types and quantities of waste covered by the Convention, and description of the measures taken to implement the Convention. To facilitate the reporting, the Convention has developed a set of guidance documents for the preparation of such inventories for different waste streams. Following the amendments to the Annexes II, VIII and IX to the Convention related to the transboundary movements of plastic waste and clarification of the scope in 2021, additional practical guidance on the preparation of inventories of plastic waste was developed under the Convention. Thereby, the guidance has a focus on the development of a first-generation inventory to provide a national estimate on the generation of plastic waste and how it is managed. The information gained can be used to develop appropriate policies and measures, including for the collection and disposal of plastic waste. In addition, the development of the inventory can provide insight into the effectiveness of the system in place in a country to regulate the transboundary shipments of plastic waste. The guidance suggests three practical methodologies for the inventory of plastic waste that provide high flexibility to a wide range of Parties with varying priorities and capacities. While two methodologies estimate plastic waste generation (the product life-time approach and survey approach) the third aims at the mapping of plastic waste flow (Material Flow Analysis). As the survey approach is based on the application of the WaCT, the following sections focus on the product life-time approach and the Material Flow Analysis. The approaches vary in terms of efforts for data collection and purpose; hence these aspects need to be considered when selecting the methodology.

5.1.1 Material flow analysis approach

Context of application:

The "material flow analysis" (MFA) approach focuses on estimating plastic waste flows. Since this requires data from different stages along the waste management chain, the application of this approach might be more resource intensive. Thereby, the accuracy depends on the quality of primary data (e.g., from field studies) and/or proxy data from similar contexts. As a result, plastic waste streams are mapped from generation sources (e.g., households and businesses) through formal and informal waste collection systems to final disposal and/or recovery or leakage to the environment.

The MFA methodology adapted elements of the WaCT and the WFD which have been applied at the city or regional level in various developing countries. While data collection approach is largely based on the WaCT, the quantification of plastic leakage comes from the WFD. While the WaCT and WFD were designed to be applied at local/city level, the MFA approach provides a way to apply elements of these methodologies for various archetypes in order to obtain a picture of (mis-)managed plastic waste at the national level.

Author:

Basel Convention; UNEP

Year:

2022

Geographical coverage:

Subnational and national level[2]

Assessment type:

Baseline

Target audience:

Government/Authorities

Target user:

local and national stakeholders

Online tool:

Excel-based

Input data:

- Population statistics
- Data on municipal solid waste generation and composition from non-household sources, as hotels, markets, restaurants, schools, offices, shopping malls, public spaces (If data is not available, proxy formulae are suggested in the methodology report.)
- Data from disposal and recovery facilities (e.g., quantities of waste arriving and daily streams, waste composition, level of environmental control)

Data collection complexity:

See chap. 5.11 (WaCT)

Output data:

This methodology enables the estimation of plastic waste quantities managed within the waste management system and those that escape into the environment. Key outputs from this inventory include:

1. Regional and national estimations of plastic waste quantities:
   a. collected by formal and informal services
   b. present in mixed waste fractions sent to disposal and incineration facilities
   c. recycled
   d. left uncollected at source
2. Regional and national estimations of plastic waste leakage:
   a. During collection
   b. During sorting
   c. During transportation
   d. From disposal sites
3. A qualitative understanding of the key actors, their roles and the interdependencies of flows within the plastic waste management landscape.

Case studies:

Ghana, others ongoing

Useful links:

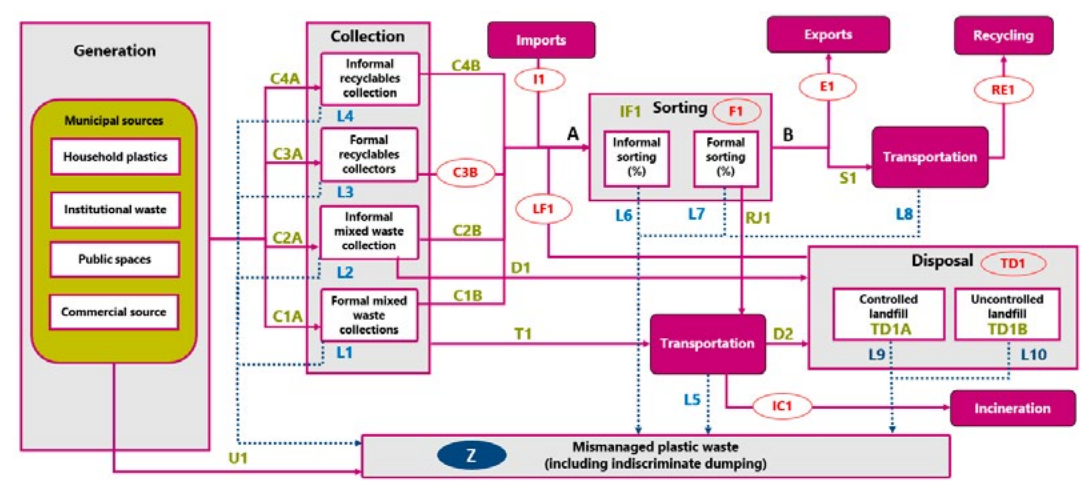
Website:
http://www.basel.int/Countries/NationalReporting/Toolkitsforwasteinventory/tabid/9043/Default.aspx

2 Toolkit for developing an inventory of plastic waste using the Material flow analysis methodology, Basel Convention

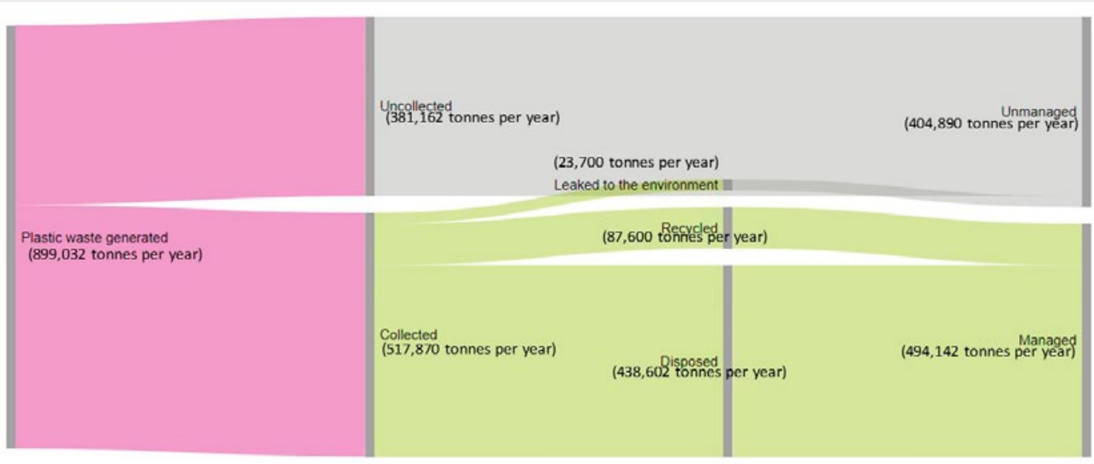
Waste breakdown	
Municipal waste	Yes
Industrial waste	No
Packaging	No
Micro-plastics	No
Product specific	No
Polymer specific	No
Waste other than plastics	No
Waste fate	
Managed waste (excl. recycling)	Yes
Mismanaged waste (incl. uncollected)	Yes
Recycling	Yes
Leakage to ocean and waterways	Yes
Leakage to other compartments	Yes
Leakage impact on human health	No
Geographical coverage	
Global	No
National	Yes
Municipal/Sub-national	Yes
Assessment type	
Baseline	Yes
Forecast/Scenarios	No
Impact monitoring through direct and measurable interventions	No
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	Medium
Waste management complexity	Medium
Technical (software) expertise	Low

Figures – BC material flow analysis (MFA)

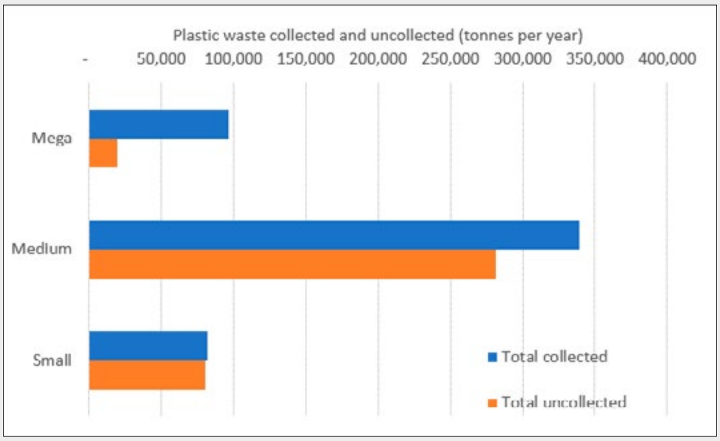
Framework for the MFA



Plastic waste fate at the national level



Plastic waste collection according to archetype



5.1.2 Plastic product life-time approach

Context of application:

The product lifetime methodology provides information on plastic waste generation by using production and trade data, e.g., from national production statistics and international trade data. By combining these data with estimated product life-time the likely plastic waste generation by sector is calculated, i.e. this requires a two steps approach:

Step 1: Estimation of plastic products put on the market (PoM) based on import/export and production statistics.

Step 2: Calculation of plastic waste generated based on the age of products (lifespan) and the probability of such products becoming waste.

Using existing trade and production data requires less time and resources, however the management of waste is not considered.

The PoM calculation tool for plastics uses the 'apparent consumption methodology' (Apparent consumption = Domestic production + Imports – Exports) to estimate the weight of plastic consumed for countries and for the desired timeframe. The calculation routines have been developed by the United Nations Institute for Training and Research (UNITAR).

Author:

Basel Convention; UNEP

Year:

2022

Geographical coverage:

National

Assessment type:

Baseline

Target audience:

National authorities

Target user:

Governmental employees

Online tool:

No/Excel-based

Input data:

The methodology to calculate the total quantity of plastic PoM in a given year for a specific country is based on:

- the amount of plastic imported (using HS codes)
- the amount of plastic exported (using HS codes)
- the amount of plastic domestically produced (using CPC codes)

Data collection complexity:

The PoM calculation tool contains 12 different sheets. All of them are essential for the proper functioning of the tool.

The Plastic Waste Generated Calculation Tool contains 18 different sheets. All of them are essential for the proper functioning of the tool.

Output data:

The plastic PoM calculation tool uses the 'apparent consumption methodology' to estimate the weight of plastic (PE, PP, PS, PET, PVC, PUR, Others) by sectors (Packaging, Transportation, Building and Construction, Electrical/ Electronic, Consumer & Institutional Products, Industrial Machinery, Textiles, Others) for the desired timeframe and calculates the generated plastic waste.

Case studies: —

Useful links:

http://www.basel.int/Countries/NationalReporting/Toolkitsforwasteinventory/tabid/9043/Default.aspx

Waste breakdown	
Municipal waste	No
Industrial waste	Yes (plastics)
Packaging	Yes
Micro-plastics	No
Product specific	Yes
Polymer specific	Yes
Waste other than plastics	No
Waste fate	
Managed waste (excl. recycling)	No
Mismanaged waste (incl. uncollected)	No
Recycling	No
Leakage to ocean and waterways	No
Leakage to other compartments	No
Leakage impact on human health	No
Geographical coverage	
Global	No
National	Yes
Municipal/Sub-national	No
Assessment type	
Baseline	Yes
Forecast/Scenarios	No
Impact monitoring through direct and measurable interventions	No
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	Medium
Waste management complexity	Low
Technical (software) expertise	Low

5.2 Breaking the Plastic Wave

Context of application:

Modelling approach to assess global plastic pollution and to estimate the quantity of plastic pollution leaking into oceans. The baseline is computed for the year 2016 and the model forecasts plastic flows and stocks, as well as their impact, by 2030 and 2040. The baseline is generated for three plastic categories, based on eight geographical archetypes (4 income levels, with a distinction between urban and rural areas). The forecasting showcases six different scenarios (including business-as-usual 2016), which are defined based on eight possible interventions.

Author:

The Pew Charitable Trusts, Systemiq

Year:

2021

Geographical coverage:

Global and National level

Assessment type:

Baseline, Forecast, Impact monitoring through direct measurable interventions

Target audience:

Decision-makers across government, business, civil society, and academia

Target user:

Technical expertise in waste management and mathematics, as well as profound technical expertise in Matlab coding required to be able to run the model simulations from Github

Online tool:

No

Input data:

It does not require input data per se as Breaking the Plastic Wave uses archetypes based on income level and rural/urban population split, to estimate waste generation and waste management practices at a global level. However, if the user wishes to adapt the BPW to a national level, it will require to manually calculate total waste input for that country, as well as to eventually change the scenario assumptions to country level.

Data collection complexity:

Variable. Default data is available in the tool for all mass flows, costs, GHG emissions and jobs impacts, for any of the eight geographic archetypes (High-income urban vs rural, Upper-middle income urban vs rural, etc.). But any updates to this, or creating country-specific data overrides, takes as much time as needed to reach the desired accuracy for the target use case. Suggested taskforce: 2 people for one month to compile and fact-check data assumptions at country level.

Output data:

The full report is a global-scale analysis of the plastic pollution situation in 2016 with projections to 2040. It compares the Business-as-Usual scenario to five other scenarios, where 8 (suggested) system change interventions are put in place, making a distinction between 3 main categories of plastics and country income regions across the world. Further output data are GHG, capex, opex and jobs, per year 2016-2040, for each of the scenarios.

Case studies:

Additional to the global study, the BPW methodology has been applied for Europe and the report “ReShaping Plastics” was published in April 2022 and available online (cf. “Useful links” here under). The methodology has been further applied to Norway and Germany, and both reports are also available.
Moreover, the GPAP’s NAM tool is based on Breaking the Plastic Wave’s methodology, and so far, it has been published for Indonesia and Ghana, as reported in the next section on the GPAP NAM tool.

Useful links:

Global study:
https://www.pewtrusts.org/-/media/assets/2020/07/breakingtheplasticwave_report.pdf

Matlab code to simulate report results:
https://github.com/richardmbailey/P20/tree/v1.0.0

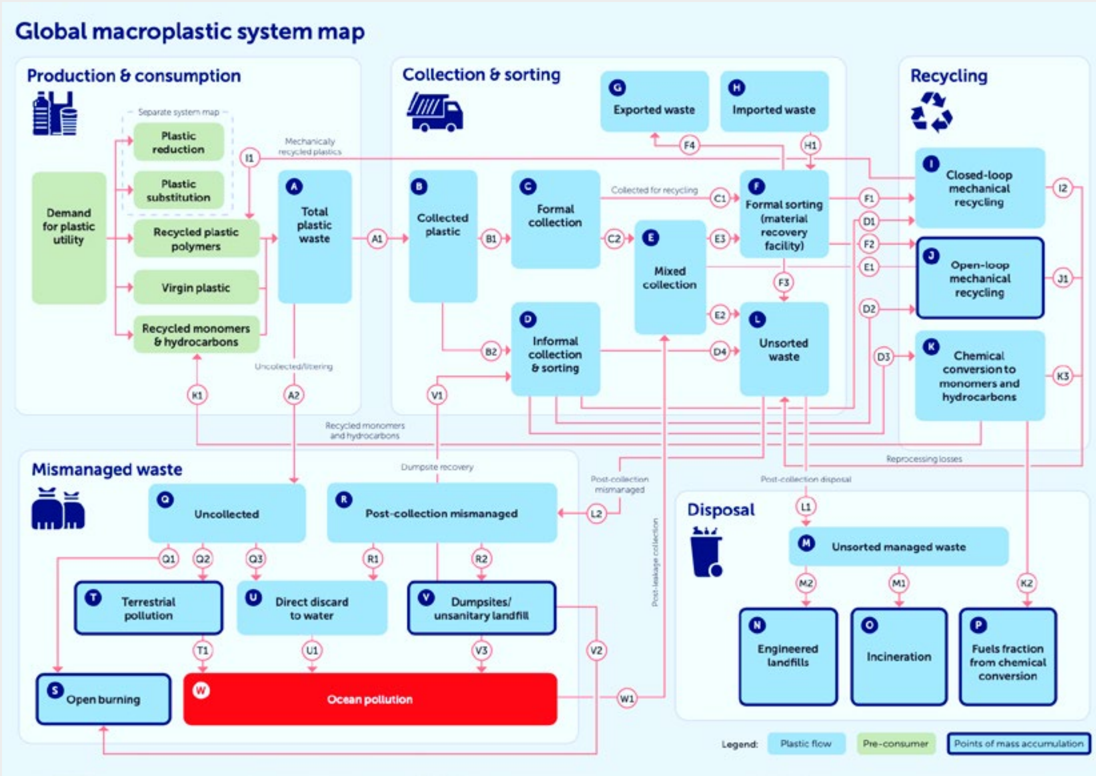
ReShaping Plastics, April 2022:
https://plasticseurope.org/wp-content/uploads/2022/04/SYSTEMIQ-ReShapingPlastics-April2022.pdf

Norway study case:
https://www.systemiq.earth/wp-content/uploads/2021/06/AchievingCircularity-MainReport-June2021.pdf

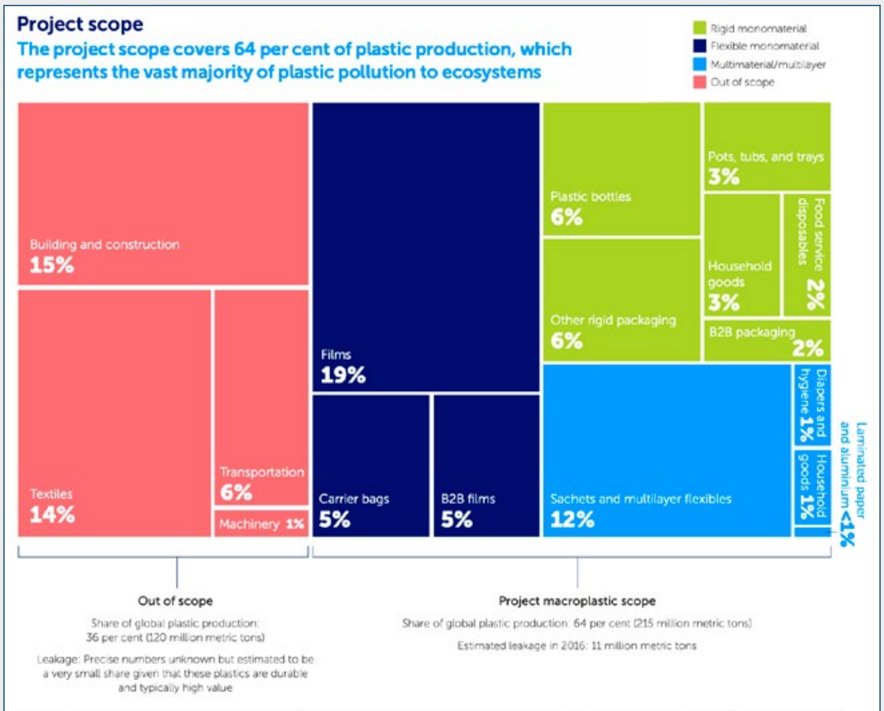
Germany study case:
https://www.systemiq.earth/wp-content/uploads/2021/08/210816_WWF_Verpackungsstudie_EN_sr.pdf

Waste breakdown	
Municipal waste	Yes
Industrial waste	No
Packaging	Yes
Micro-plastics	Yes
Product specific	Yes
Polymer specific	No
Waste other than plastics	No
Waste fate	
Managed waste (excl. recycling)	Yes
Mismanaged waste (incl. uncollected)	Yes
Recycling	Yes
Leakage to ocean and waterways	Yes
Leakage to other comparments	Yes
Leakage impact on human health	No
Geographical coverage	
Global	Yes
National	Yes
Municipal/Sub-national	No
Assessment type	
Baseline	Yes
Forecast/Scenarios	Yes
Impact monitoring through direct and measurable interventions	Yes
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	Low
Waste management complexity	Medium
Technical (software) expertise	High

Figures – Breaking the Plastic Wave



The macroplastic system map depicts the five major components of the global plastic system: production and consumption; collection and sorting; recycling; disposal; and mismanaged. The boxes labelled with letters (A to W) represent mass aggregation points in the model, and the arrows represent mass flows. Boxes outlined in solid lines represent places where plastic mass leaves the system, including where it leaks into the ocean (see Box W). The boxes to the left of Box A reflect plastic demand. See Appendix A and the technical appendix for details on the modelling methodology and parameters used.



The project scope shows the municipal solid waste macroplastic applications and their relative contribution to municipal solid waste globally. Total global plastic production in 2016 was 335 million metric tons, of which municipal solid waste represented 215 million metric tons, or 64 per cent.

Figures from Breaking the Plastic Wave, Full Report, 2020

Figures – Breaking the Plastic Wave

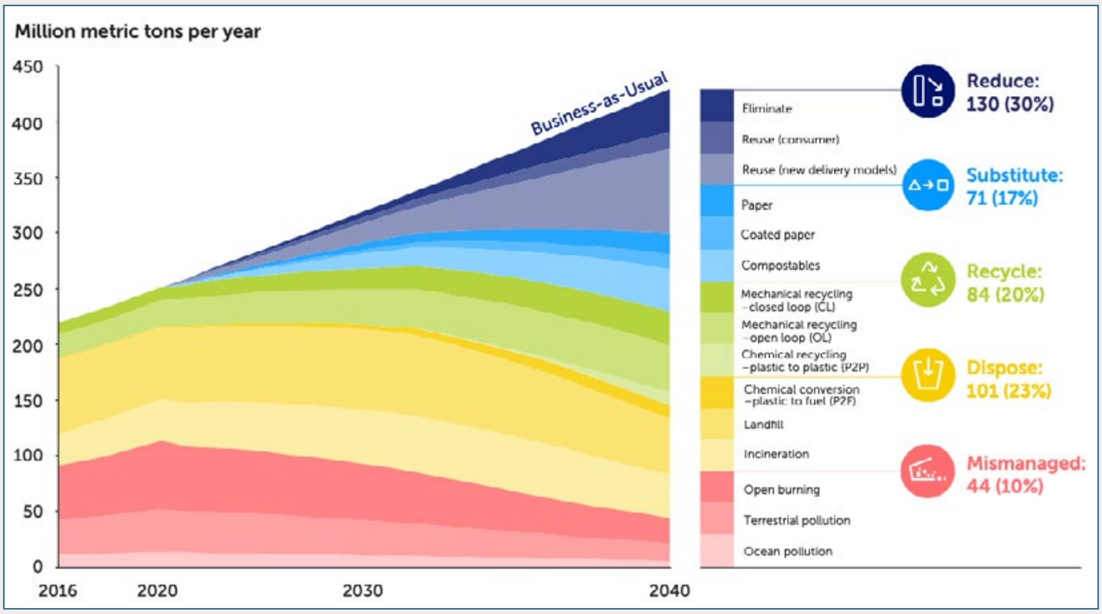


Figure from Breaking the Plastic Wave, Full Report, 2020

5.3 Global Plastic Action Partnership's National Analysis & Modelling tool

Context of application:

Modelling approach to assess national plastic pollution and to estimate the quantity of plastic pollution leaking into oceans, based on the BPW methodology. The baseline can be adapted by the user and the model forecasts plastic waste flows and stocks, as well as their impact, in the future until 2040. It comes with preloaded data from Breaking the Plastic Waste (mapping of countries to three different income archetypes) and from PLASTEAX data, for some countries. It calculates 5 different scenarios (Business as Usual, Upstream, Downstream, System change, Custom scenario), combining different levers from the following categories: Reduce & Substitute, Redesign, Collection & Sorting, Trade control, Recycle, Disposal, Mismanaged.

Author:

Systemiq

Year:

2022

Geographical coverage:

Country level

Assessment type:

Baseline, Forecast, Impact monitoring through direct measurable interventions

Target audience:

Decision-makers across government, business, civil society, and academia

Target user:

National governments

Online tool:

Yes, available when granted access

Input data:

To use the GPAP NAM tool, primary data collection is recommended, but not required. It is designed to use data from external database, such as PLASTEAX (EA – Environmental Action) data, or What a Waste (World Bank Group) combined with the results from the BPW report. The user can insert or fine tune all data displayed in dark blue and orange boxes in the Plastic System Map (page 18), as well as the system flow data represented by the arrows. After performing baseline assessment using the tool, the user is still able to play with the levers from the following categories: Reduce & Substitute, Redesign, Collection & Sorting, Trade control, Recycle, Disposal, Mismanaged.

Data collection complexity:

Variable. The tool comes with preloaded data sets from Breaking the Plastic Wave and PLASTEAX (for some countries). However, the suggestion for governments is to collect and input own data. As very likely all these data not easily available at the required granularity. This can come with certain effort in collecting and estimating data.

Output data:

- Assessment of a Business-as-Usual, Upstream, Downstream, System change and Customized scenario.
- Information about the key metrics of Plastic Pollution, Cost to government, Livelihoods supported, GHG emissions, Circularity score and Source of plastics.

Case studies:

Indonesia and Ghana (see links below)

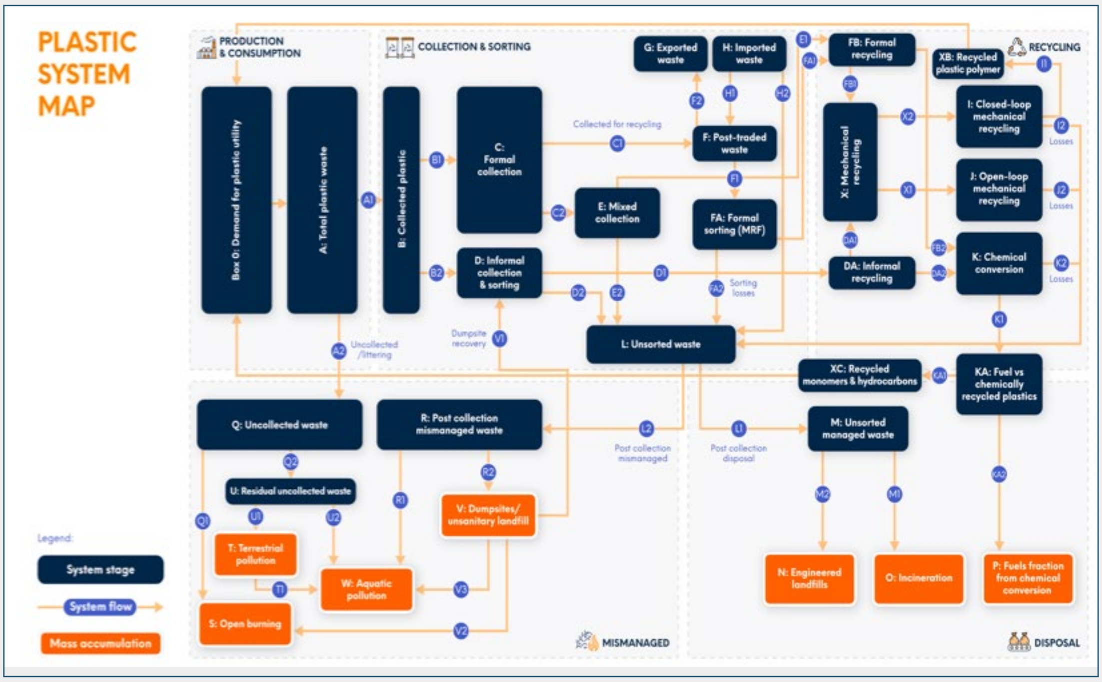
Useful links:

Indonesia case study:
https://weforum.ent.box.com/s/3dx0h6h3iyab847msnx7iw62kjtv5myu

Ghana case study:
https://weforum.ent.box.com/s/7iaf2zes5ifggzhurnysyxiu2to0fx7r

Waste breakdown	
Municipal waste	Yes
Industrial waste	No
Packaging	Yes
Micro-plastics	No
Product specific	Yes
Polymer specific	No
Waste other than plastics	No
Waste fate	
Managed waste (excl. recycling)	Yes
Mismanaged waste (incl. uncollected)	Yes
Recycling	Yes
Leakage to ocean and waterways	Yes
Leakage to other compartments	Yes
Leakage impact on human health	No
Geographical coverage	
Global	No
National	Yes
Municipal/Sub-national	No
Assessment type	
Baseline	Yes
Forecast/Scenarios	Yes
Impact monitoring through direct and measurable interventions	Yes
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	Low
Waste management complexity	Medium
Technical (software) expertise	Low

Figures – GPAP National Analysis and Modelling tool



5.4 ISWA Plastic Pollution Calculator

Context of application:

Modelling of item-specific plastic waste generation, and its subsequent flow throughout the waste management system and its fate into the environment. It allows each leakage route to be quantified and then ranked according to its relative importance. The tool combines data on solid waste management system, with local socioeconomic, geographical, and meteorological factors.

Author:

ISWA – International Solid Waste Associations, University of Leeds

Year:

2019

Geographical coverage:

Municipal/Sub-national level (The tool is designed to operate at local intra-city level due to homogeneity requirements on the solid waste management and administration, but it is capable of being aggregated across larger scales, as in the case study on Bali.)

Assessment type:

Baseline

Target audience:

Any party interested in plastic pollution and marine litter, such as municipal waste managers, NGOs, and national and international waste management organizations. It is applicable to informal settlements in developing countries, as well as city centers of developed nations.

Target user:

Solid waste management expertise and solid knowledge of the waste management situation on the ground

Online tool:

No

Input data:

Data required for modelling must cover:

- Population statistics
- Per capita waste generation
- Per capita waste composition (paper, metal, glass, plastic, hygienic product, organic, other)
- Formal/informal collection
- Formal/informal recycling
- Landfilling
- Energy recovery
- Composting
- Uncollected plastic waste

"Transmission factors" must be estimated. They are defined as numerical estimates, usually expressed as percentage of plastic waste flows, which distribute plastic waste quantities along different transmission pathways (such as, uncollected plastic waste in proximity to waterways, plastic waste entering the wastewater system, additional littering on the coastline, etc.). The estimation of non-measurable transmission factors requires the intervention of waste management experts.

Data collection complexity:

Bali study took 5 months: approximately 950 Balinese households were surveyed. 230 waste characterization studies were conducted. 50 inland and 50 river litter surveys were administered. All Bali landfills were examined and tracked. Waste master plans and data from all regencies were analyzed. In addition, numerous interviews of the environmental agencies and other government officials, non-governmental organizations, the private sector, associations, the informal recycling sector, and key individuals were conducted.

Output data:

Plastic emissions to the environment (tonnes/year) coming from:

- Uncollected waste
- Littered waste
- Residual streams waiting for collection
- Fly-tipped waste
- Primary and secondary transportation
- Residual streams during collection and transfer
- Informal sector
- Disposal
- Treatment

Composition of plastic emissions to the environment and to waterways specifically (plastic bags, plastic film, bottles, sanitary items, single use food products, expanded polystyrene, and other types of plastic items)

Quantification of key plastic pollution pathways to waterways (directly dumped to water, land to water, drains to water)

Quantification of plastic waste fates (recycled, retained at landfill, openly burnt, mismanaged, and retained on land, marine litter)

Case studies:

Kuala Lumpur, Malaysia
Bali, Indonesia
Cairo, Egypt
Additionally, the tool is currently being applied in several ongoing projects (City of Rotterdam project, ESCAP project, GRID Arendal, MSc project, ABRELPE SEPA project)

Useful links:

- Website:
  https://plasticpollution.leeds.ac.uk/toolkits/calculator/
- Closing the loop on plastic pollution in Surabaya, Indonesia (Baseline report):
  https://www.unescap.org/sites/default/d8files/event-documents/SB%20Baseline%20Report_English.pdf
- ISWA Press Release, Case study on Bali, Indonesia:
  https://marinelitter.iswa.org/media/news/detail/press-release-marine-litter-calculator
- Short PDF, ISWA Combats Plastic Pollution:
  https://plasticpollution.leeds.ac.uk/wp-content/uploads/sites/89/2020/07/Plastic-Pollution-Calculator-Summary.pdf

Waste breakdown	
Municipal waste	Yes
Industrial waste	No
Packaging	No
Micro-plastics	No
Product specific	Yes
Polymer specific	No
Waste other than plastics	Yes
Waste fate	
Managed waste (excl. recycling)	Yes
Mismanaged waste (incl. uncollected)	Yes
Recycling	Yes
Leakage to ocean and waterways	Yes
Leakage to other compartments	Yes
Leakage impact on human health	No
Geographical coverage	
Global	No
National	No
Municipal/Sub-national	Yes
Assessment type	
Baseline	Yes
Forecast/Scenarios	Yes
Impact monitoring through direct and measurable interventions	No
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	High
Waste management complexity	High
Technical (software) expertise	Medium

Figures – ISWA Plastic Pollution Calculator

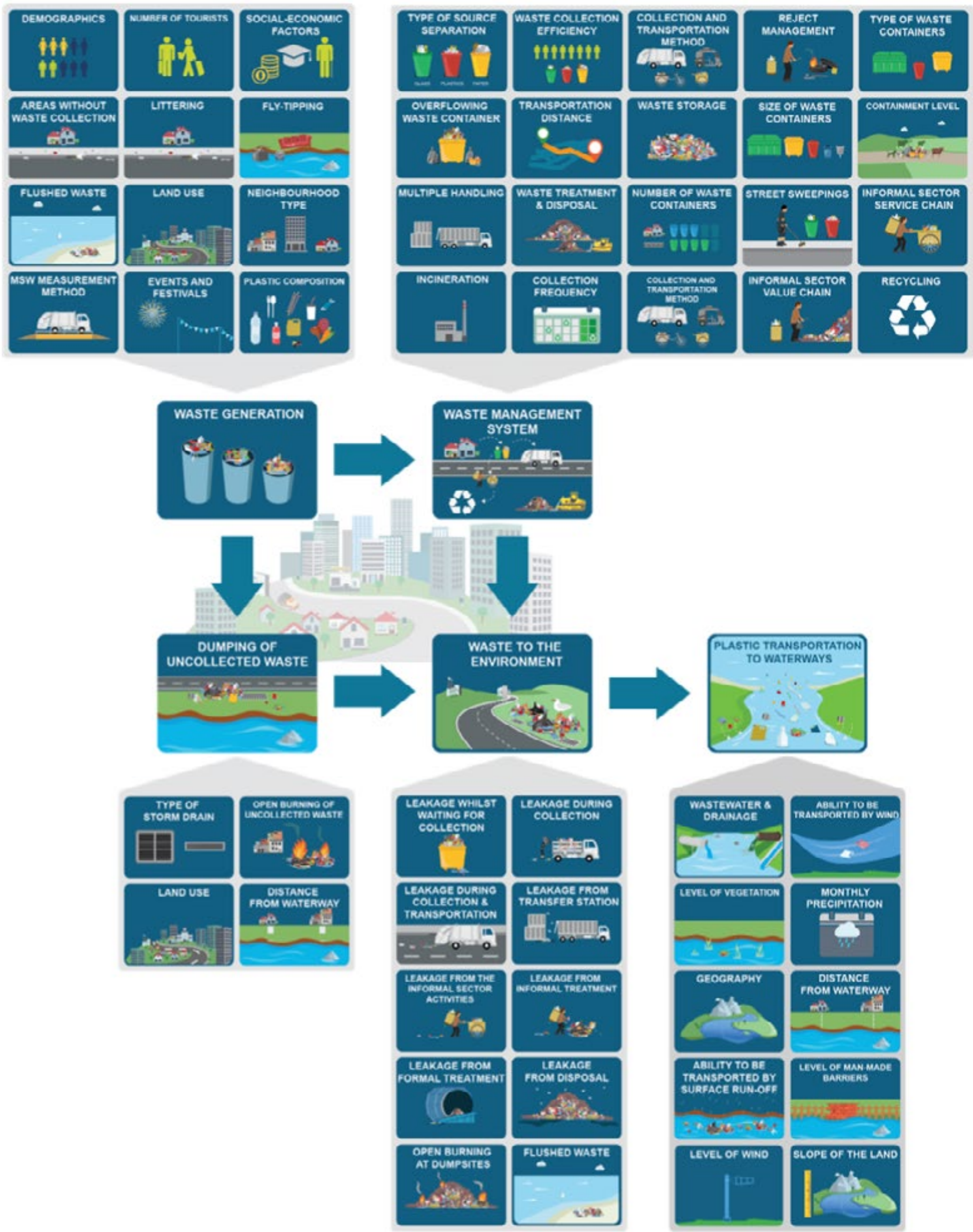
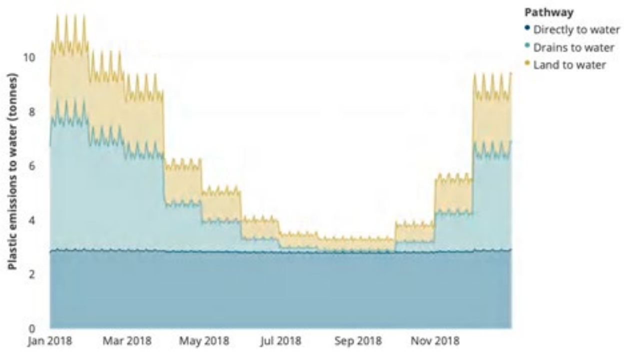


Figure 4

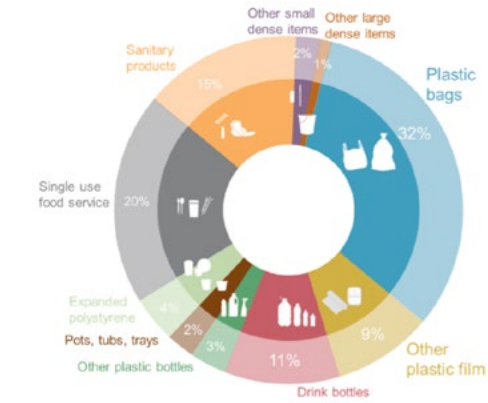
Generalized material flow analysis (MFA) approach used in the Plastic Pollution Calculator (PPC) and visualization of some important factors at each stage of the solid waste management system that are included in the conceptual models for determining transfer coefficient

Figures from Closing the loop (Surabaya, Indonesia) baseline report

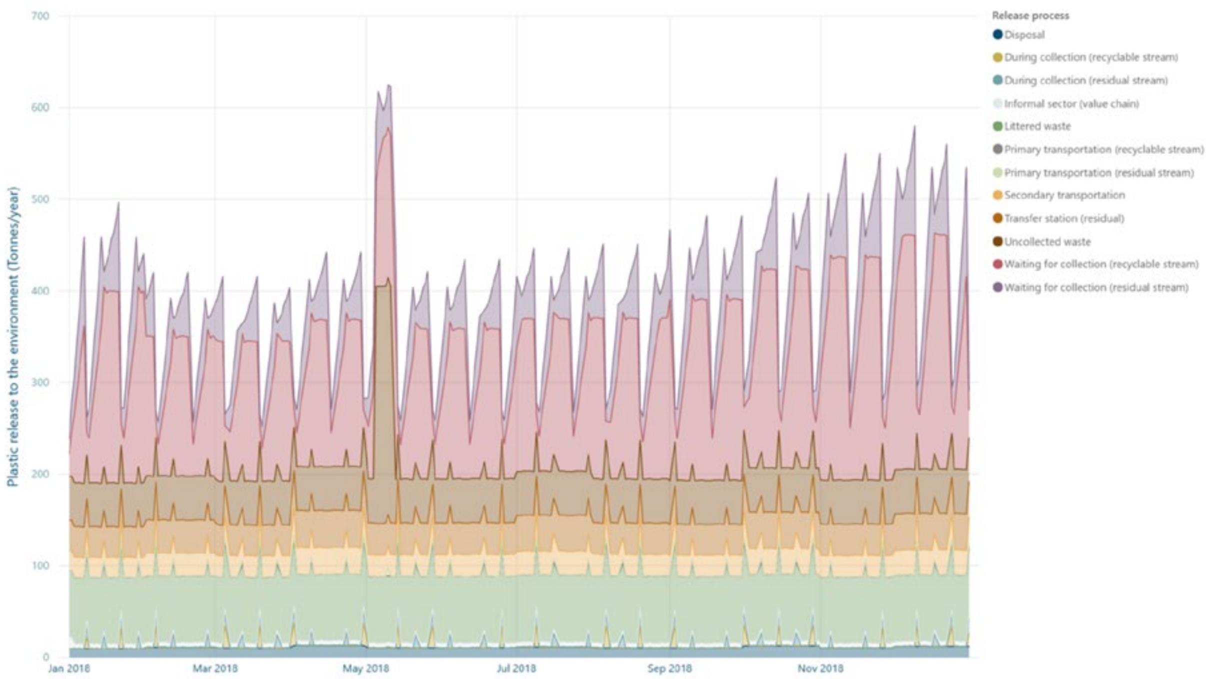
Figures – ISWA Plastic Pollution Calculator



Plastic emissions to water with time



Composition of plastic waste entering waterways



Figures from Closing the loop (Surabaya, Indonesia) baseline report, and Calculator website

5.5 Minderoo

Context of application:

The Minderoo global single use plastic tool was developed to answer the questions on the most relevant producers of polymer forming single use plastic (SUP) and the amount that finally ends up as waste. The results of the analysis were published in the Plastic Waste Makers report in 2021. Only virgin polymers were included in the analysis, as they accounted for more than 98% of total production in 2019, which is the baseline year for the data involved. The report shows the top 20 petrochemical companies that generate more than half the world's single-use plastic waste, and the global financial institutions backing them. At the national level, results are presented for more than 150 countries on the production and trade of polymers and SUP, as well as the waste generation of SUP. Apart from this high-level analysis, the tool can also be used for deeper dive analysis at country level – e.g., results by polymer, by producer, by trading partner. Currently, there is no open access for an external user to perform this kind of deep dive; however, it can be done on request. The data is continuously updated and further developed. Future editions are expected to include recycled and bio-based polymers as their production increases in scale.

Author:

Dominic Charles et al, Minderoo Foundation

Year:

2021

Geographical coverage:

Global, at national scale
(150+ countries covered)

Assessment type:

Baseline, updated annually

Target audience:

National authorities, Financial Institutions

Target user:

Policy-makers, regulators

Online tool:

No/Excel-based

Input data:

1. Identification of ~1,200 production facilities globally that produce the five main polymers that account for almost 90 per cent of all SUPs: polypropylene (PP); high-density polyethylene (HDPE); low-density polyethylene (LDPE); linear low-density polyethylene (LLDPE); and polyethylene terephthalate (PET). Following this, the volume of plastic polymer produced in 2019 at each facility (Step 1) is estimated. These facilities are owned and operated by ~300 distinct companies. Both the facilities and the production estimates were provided by Wood Mackenzie, an energy research consultancy.
2. Tracking of the trade of the polymers at global level by using data from UN Comtrade (Step 2).
3. Within each country of destination, the tool also modelled the proportion of polymers which have been converted into SUPs versus non-single use products, based on installed capacity of different conversion processors (e.g., sheet extrusion and roto-moulding), using data provided by Wood Mackenzie (Step 3).
4. By involvement of UN Comtrade and World Bank data, the volume of SUPs traded in bulk (i.e., raw/unfilled packaging materials) (Step 4), and within finished/packaged goods themselves (Step 5) are calculated. These trade flows are then simulated up to the consumption and disposal stage.
5. This gives an estimate of SUP waste in each country globally (Step 6).

Figure 8: Calculation of SUP in municipal waste and applied data

Material Flow	Polymer production	Polymer trade	Conversion	SUPs Trade in bulk	Trade of SUPs in finished goods	Single Use Plastic MSW
Key questions	Who **produces polymers that form single-use plastic**, where and how much?	What are the **trading patterns** between polymer producers and countries?	How are **polymers converted** into single use plastic product categories?	How are the relevant categories of **bulk packaging traded**?	What **volume of single-use plastic in finished goods** is traded and what are the trade patterns?	What is the **volume of single-use plastic in municipal solid waste (MSW)** and what is its source?
Key data sources	Wood Mackenzie	ExportGenius; International Trade Centre	Wood Mackenzie	International Trade Centre	McKinsey & Company; WITS World Integrated Trade Solutions	Results of this analysis
In-scope volumes, Million metric Tonnes	~200	~90	~110	~40	~25	~110

Data collection complexity:

As described above. There are 6 models each with their own data inputs, some (far) more complex than others.

Output data:

Single-use plastic waste generation by country; by polymer type; by rigid or flexible format.

Case studies:

https://www.minderoo.org/plastic-waste-makers-index/data/flows/#/sankey/global/10

Useful links:

Plastic Waste Makers Index: Revealing the source of the single-use plastics crisis
Download the full PDF of the 2021 Plastic Waste Makers Index
https://cdn.minderoo.org/content/uploads/2021/05/27094234/20211105-Plastic-Waste-Makers-Index.pdf

Basis of Preparation
Download this document outlining the steps taken to complete each analysis
https://cdn.minderoo.org/content/uploads/2021/05/15232634/20210513-pwmi-basis-of-preparation.pdf

KPMG Independent Limited Assurance
Download the Independent Limited Assurance report prepared by KPMG Australia
https://cdn.minderoo.org/content/uploads/2021/05/15232627/20210513-pwmi-kpmg-limited-assurance-opinon.pdf

Website:
https://www.minderoo.org/plastic-waste-makers-index/

Waste breakdown	
Municipal waste	No
Industrial waste	No
Packaging	Yes
Micro-plastics	No
Product specific	Yes
Polymer specific	Yes
Waste other than plastics	No
Waste fate	
Managed waste (excl. recycling)	No
Mismanaged waste (incl. uncollected)	No
Recycling	No
Leakage to ocean and waterways	No
Leakage to other compartments	No
Leakage impact on human health	No
Geographical coverage	
Global	Yes
National	Yes
Municipal/Sub-national	No
Assessment type	
Baseline	Yes
Forecast/Scenarios	No
Impact monitoring through direct and measurable interventions	No
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	Medium
Waste management complexity	n/a
Technical (software) expertise	Low

Figures – Minderoo

SUP production/trade and SUP waste generation by countries

TOP 100

Countries by per capita single-use plastic waste generation

		In-scope Polymer Production and Trade				Conversion				Single-use plastic bulk packaging trade		Trade of single-use plastic finished goods		Single-use plastic waste generation	
Rank	Country	Domestic production (MMT) +	Exports (MMT) −	Imports (MMT) =	Net polymer production (MMT) −	Volume of out-of-scope application (MMT) =	Converted single-use plastic volume (MMT): Total	Rigid format	Flexible format −	Bulk packaging trade (MMT): Exports +	Imports −	Finished goods trade (MMT): Exports +	Imports =	Net single-use plastic waste generation (MMT)	Single-use plastic waste generation per capita (kg per person)
1	Singapore	4.1	4.1	0.3	0.3	0.2	0.1	0.0	0.1	0.1	0.4	0.4	0.4	0.4	76
2	Australia	0.5	0.1	0.4	0.8	0.5	0.4	0.2	0.2	0.1	0.8	0.1	0.4	1.5	59
3	Oman	0.9	0.6	0.1	0.4	0.1	0.3	0.2	0.1	-	-	0.0	0.1	0.3	56
4	Netherlands	2.7	2.7	1.5	1.5	1.2	0.3	0.1	0.2	1.2	1.4	0.5	0.9	0.9	55
5	Belgium	3.5	3.5	3.4	3.4	2.7	0.8	0.4	0.4	1.0	1.1	0.9	0.6	0.6	55
6	Israel	0.5	0.3	0.5	0.8	0.4	0.4	0.2	0.2	0.1	0.2	0.1	0.1	0.5	55
7	Hong Kong	-	-	0.0	0.0	-	0.0	0.0	-	0.0	0.4	-	-	0.4	55
8	Switzerland	-	-	0.3	0.3	0.2	0.1	0.1	0.0	0.5	0.4	0.1	0.5	0.5	53
9	United States	28.8	10.7	4.6	22.7	9.2	13.6	7.6	5.9	2.4	4.1	2.0	4.0	17.2	53
10	United Arab Emirates	3.9	3.4	0.9	1.3	1.0	0.3	0.2	0.2	0.0	0.1	0.2	0.4	0.5	52
11	Chile	0.1	0.1	0.5	0.5	0.2	0.3	0.1	0.1	0.1	0.6	0.0	0.1	0.9	51
12	South Korea	10.4	6.6	0.5	4.3	1.9	2.4	1.1	1.3	1.1	1.2	0.7	0.5	2.3	44
13	United Kingdom	1.2	0.8	1.5	1.9	0.8	1.2	0.6	0.5	0.4	1.9	0.9	1.2	2.9	44
14	Kuwait	0.9	0.7	0.1	0.4	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.2	40
15	New Zealand	-	-	0.2	0.2	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.1	0.2	39
16	Ireland	-	-	0.1	0.1	0.1	0.1	0.0	0.0	0.1	0.2	0.2	0.2	0.2	39
17	Finland	0.5	0.4	0.3	0.4	0.2	0.2	0.1	0.2	0.1	0.0	0.1	0.1	0.2	38
18	Japan	5.3	0.8	1.7	6.1	2.6	3.6	2.1	1.5	0.6	1.8	0.9	0.9	4.7	37
19	France	2.7	2.3	2.2	2.6	1.1	1.5	0.9	0.5	1.1	1.9	1.1	1.1	2.3	36
20	Slovenia	-	-	0.2	0.2	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.1	0.1	35
21	Saudi Arabia	15.4	13.8	0.4	2.0	0.9	1.1	0.5	0.5	0.3	0.2	0.0	0.2	1.2	35
22	Czech Republic	0.5	0.4	0.8	0.8	0.5	0.3	0.2	0.1	0.4	0.6	0.4	0.2	0.4	35
23	Spain	2.3	2.0	1.7	2.0	0.8	1.2	0.6	0.6	0.8	1.2	0.7	0.6	1.6	34
24	Canada	4.0	3.6	1.5	1.8	0.9	1.0	0.4	0.6	0.9	1.1	0.7	0.8	1.3	34
25	Denmark	-	-	0.3	0.3	0.2	0.1	0.1	0.0	0.2	0.2	0.1	0.2	0.2	33
26	Sweden	0.5	0.5	0.5	0.6	0.3	0.3	0.1	0.2	0.3	0.4	0.3	0.2	0.3	32
27	Austria	0.8	0.7	0.5	0.7	0.3	0.3	0.1	0.2	0.5	0.5	0.3	0.3	0.3	32
28	Norway	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	27

5.6 National Guidance for Plastic Pollution Hotspotting and Shaping Actions

Context of application:

The National Guidance for Plastic Pollution Hotspotting and Shaping Action aims to provide countries with a methodology to identify plastic leakage hotspots, and to prioritize effective interventions for leakage reduction.
It provides a country-level baseline assessment of micro- and macro-plastic leakage. The assessment is sector-, polymer-, and product-specific. It highlights the sectors, polymers, products, sub-national geographies, and waste management levers that are most problematic by absolute or relative leakage. Finally, it guides the user through a list of possible instruments and interventions to tackle plastic leakage to ocean and waterways.

Author(s):

UNEP, IUCN, Life Cycle Initiative,
EA – Environmental Action, Quantis

Year:

2020

Geographical coverage:

Country level (with sub-national split)

Assessment type:

Baseline, Impact monitoring through direct measurable interventions, Impact monitoring through indirect interventions

Target audience:

Governments, Policymakers, Stakeholders

Target user:

Expertise in excel is required, as well as a good understanding of the waste management system. GIS is needed only if performing analysis at sub-national level

Online tool:

Yes (Excel, GIS Python optional)

Input data:

- Import and export of plastic by polymer
- Production of plastic by polymer
- Recycling of plastic by polymer
- Share of MSW uncollected, incinerated, sent to sanitary landfill, improperly disposed, collected for recycling by informal sector
- Waste management data at sub-national level
- Specific information for textile, automotive, and fishing sector
- Qualitative input required on waste management hotspots
- Prioritization of proposed intervention and instruments

Data collection complexity:

It can take an experienced user one or two week to produce the results for one country. If sub-national level analysis is required, this can take an experienced user another week to complete.

Output data:

- Sector-, Polymer- and Product- specific information on:
  - Waste generated
  - Domestic recycling
  - Informal recycling
  - Import and export of waste
  - Incineration
  - Sanitary landfill
  - Improperly disposed
  - Uncollected (incl. littering)
  - Mismanaged
  - Leaked to ocean and waterways
- Identification of hotspots at polymer, sector, product, sub-national, and waste management category level
- Maps showing waste management and leakage at sub-national level
- Charts with a prioritization of intervention and instruments

Case studies:

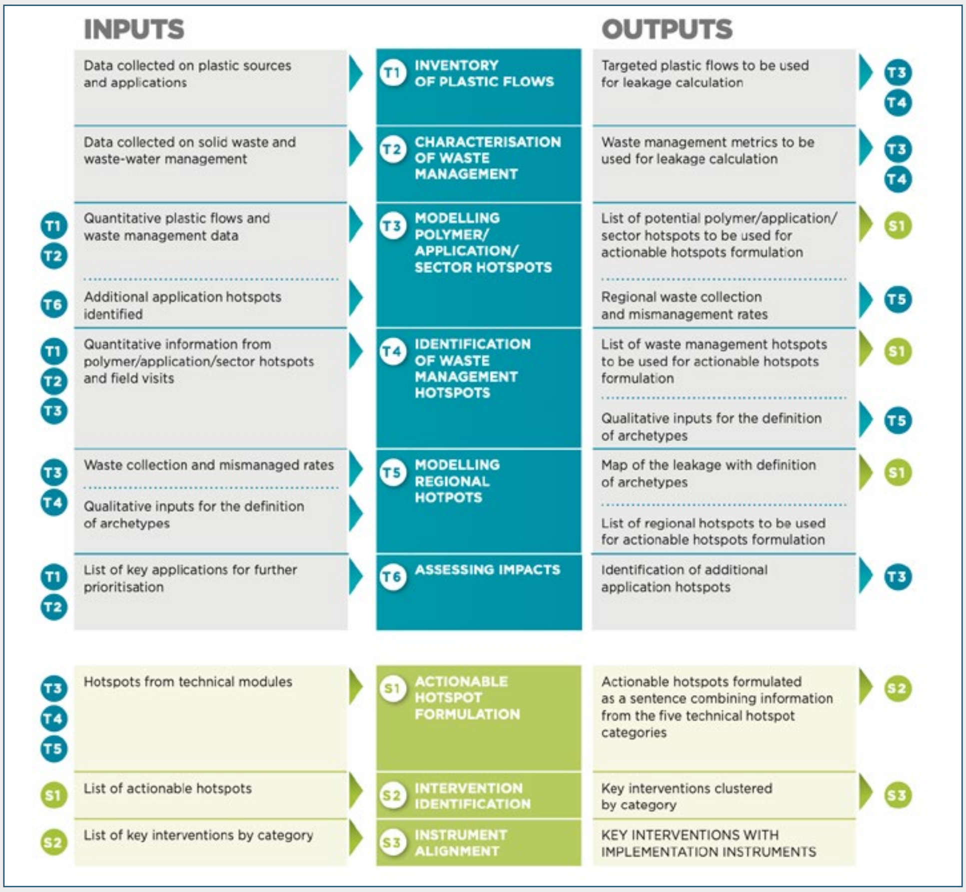
The baseline assessment for 7 countries and 1 island is available online.

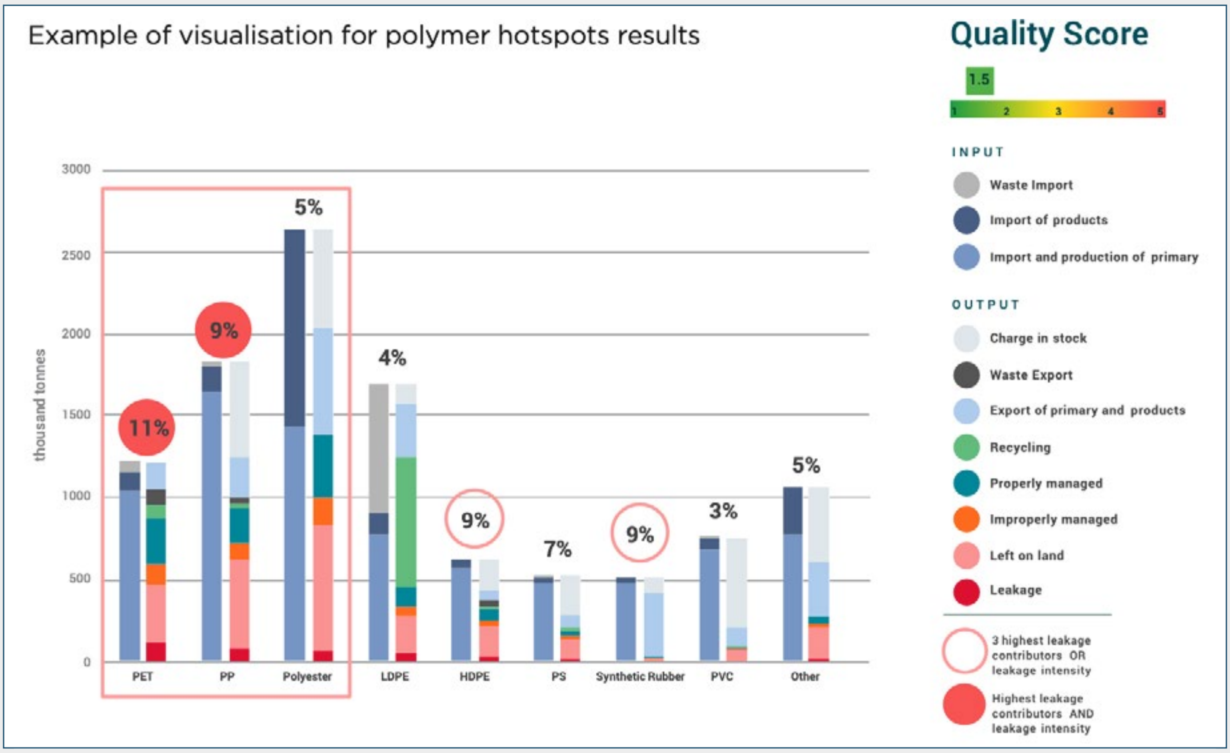
Useful links:

- National Guidance website: https://plastichotspotting.lifecycleinitiative.org
- Tool and methodology: https://plastichotspotting.lifecycleinitiative.org/modules/
- Video-tutorials: https://plastichotspotting.lifecycleinitiative.org/tutorial/
- Available pilot studies: https://plastichotspotting.lifecycleinitiative.org/pilots/

Waste breakdown	
Municipal waste	Yes
Industrial waste	Yes
Packaging	Yes
Micro-plastics	Yes
Product specific	Yes
Polymer specific	Yes
Waste other than plastics	No
Waste fate	
Managed waste (excl. recycling)	Yes
Mismanaged waste (incl. uncollected)	Yes
Recycling	Yes
Leakage to ocean and waterways	Yes
Leakage to other compartments	No
Leakage impact on human health	No
Geographical coverage	
Global	No
National	Yes
Municipal/Sub-national	No
Assessment type	
Baseline	Yes
Forecast/Scenarios	No
Impact monitoring through direct and measurable interventions	No
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	Low
Waste management complexity	Low
Technical (software) expertise	Medium

Figures – UNEP & IUCN National Guidance





Figures from Introduction to the methodology report, Boucher et al., 2020

5.7 Breaking the Plastic Wave Plastic Pathways Tool

Context of application:

The Pathways tool is a freely available software application that analyzes the movement of plastic throughout the value chain to assess policies and tradeoffs relevant to the leakage of plastic into the environment. Pathways provides a modeling framework that expands upon the "Breaking the Plastic Wave" approach by increasing flexibility and analytical capabilities, adding sensitivity analysis to help users focus data collection efforts, and implementing trade-off analyses among potentially competing policy objectives to identify optimal solutions. Users can estimate baseline plastic flows, customize interventions, and define the time scale for projections. Pathways allows governments and relevant stakeholders to drive and own the process from start to finish and retain the knowledge and data for continued assessment.

As a generalizable tool to model waste, there are no formal limitations in how it can be used, i.e., it can be used for MSW, Industrial Waste, Packaging, Micro-plastics, and wastes other than plastics. Also, it can be used in a product specific and polymer specific manner.

Author:

The Pew Charitable Trusts, Oxford University

Year:

2022

Geographical coverage:

Local, Sub-national, National, Global

Assessment type:

Baseline, Forecast and Scenario

Target audience:

Decision-makers across government, business, civil society, and academia

Target user:

Technical expertise in waste management and knowledge of excel for data entry.

Online tool:

No. Available online to download as a computer application (Windows, Mac, Linux).

Input data:

- Key stocks and flows of macroplastics such as production and consumption, collection and sorting, recycling, disposal, and mismanaged waste
- Waste management costs, which include capital expenditures and operational expenditures (optional)
- Revenue from recycling and incineration with energy recovery (optional)
- Number of people employed throughout the plastics value chain (optional)
- Key stocks and flows of microplastics such as production, collection, disposal and mismanaged waste.

The system map can be customized to reflect the local plastic value chain. The data can be split into multiple geographic regions (e.g., urban, suburban, rural) as waste generation and waste management may differ between populations. The user can use primary and secondary data and fill any gaps using data from Breaking the Plastic Wave from the appropriate archetype based on income level.

Data collection complexity:

Variable. Default data is available for all mass flows, costs, GHG emissions and jobs for any of the eight geographic archetypes (high-income urban vs rural, upper-middle income urban vs rural, etc.). But any updates to this, or creating country-specific data overrides, takes as much time as needed to reach the desired accuracy for the target use case. Suggested taskforce: 2 persons for one month to compile and fact-check data assumptions at country level.

Output data:

Users can forecast plastic flows, costs, jobs, and greenhouse gas emissions under business-as-usual and scenarios with customized interventions. Pathways enables users to assess trade-offs among potentially competing policy objectives to identify optimal solutions. Because data quality varies within the plastic system, Pathways produces uncertainty around estimates to inform stakeholders about the range of potential outcomes following policy implementation. To help users efficiently use time and resources to collect missing or highly uncertain data, sensitivity analysis identifies those parts of the plastic value chain for which improved data are most likely to impact analyses.

Case studies:

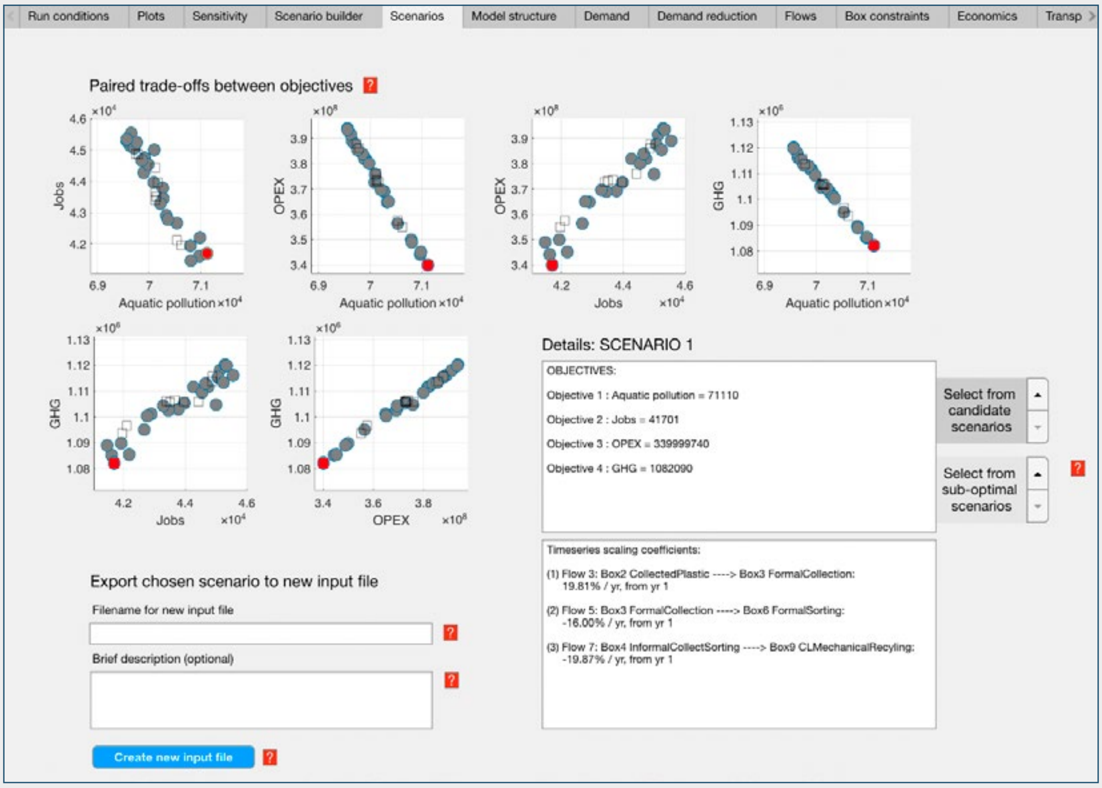
Pathways has been used in South Africa and the city of Pune, India. The South Africa analysis used data from government and industry reports; the Pune analysis used primary data and data from government reports. Results from the South Africa analysis will be published in a report by the Council for Scientific and Industrial Research and will be freely available on their website.

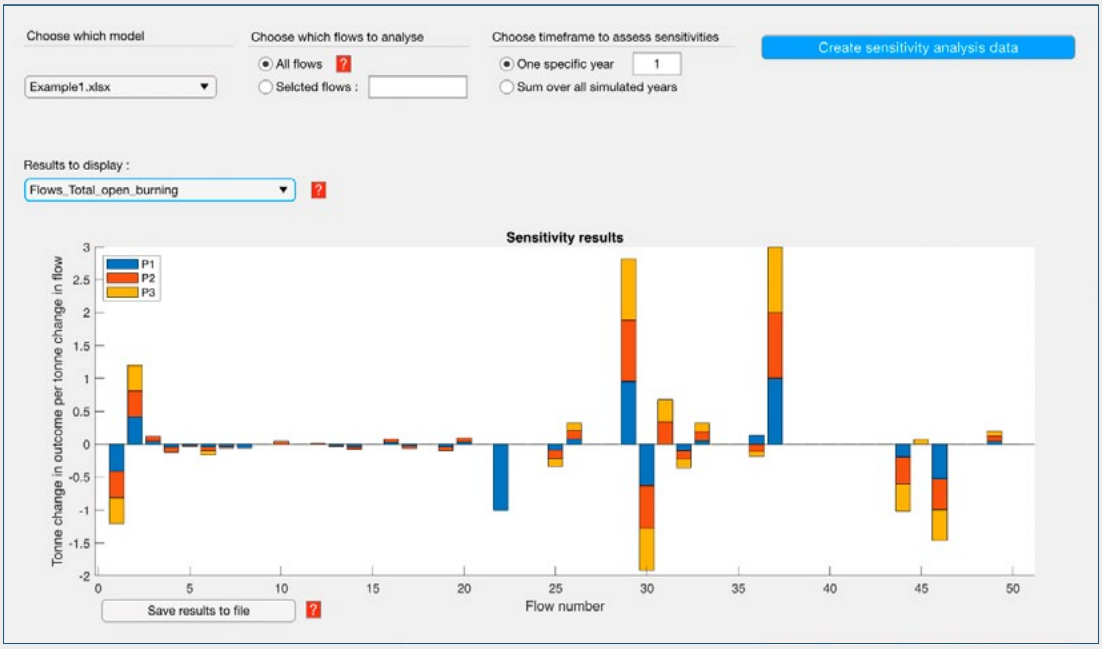
Useful links:

Pathways Factsheet – https://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2022/09/a-new-tool-can-help-address-ocean-plastic-pollution

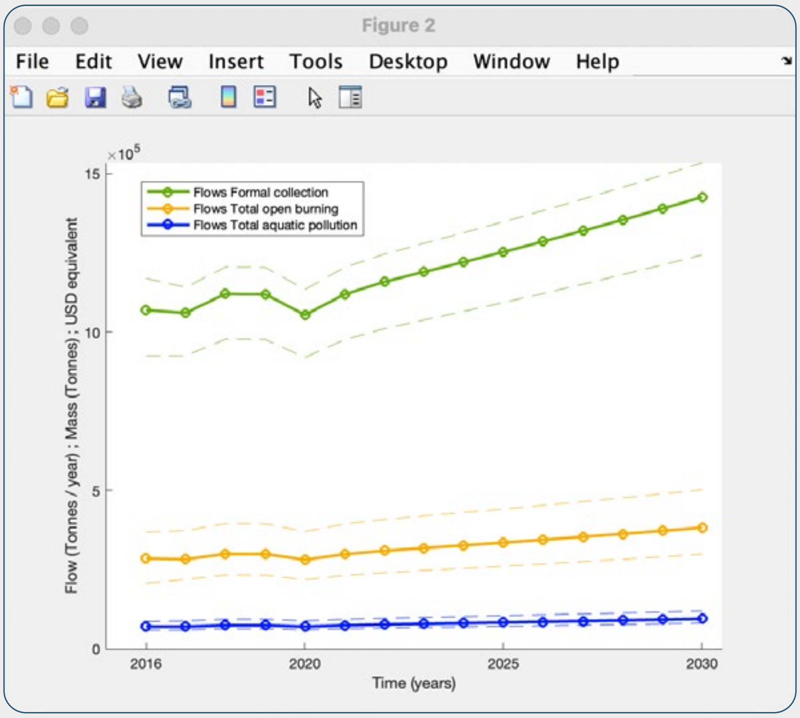
Waste breakdown	
Municipal waste	Yes
Industrial waste	Yes
Packaging	Yes
Micro-plastics	Yes
Product specific	Yes
Polymer specific	Yes
Waste other than plastics	Yes
Waste fate	
Managed waste (excl. recycling)	Yes
Mismanaged waste (incl. uncollected)	Yes
Recycling	Yes
Leakage to ocean and waterways	Yes
Leakage to other compartments	Yes
Leakage impact on human health	No
Geographical coverage	
Global	Yes
National	Yes
Municipal/Sub-national	Yes
Assessment type	
Baseline	Yes
Forecast/Scenarios	Yes
Impact monitoring through direct and measurable interventions	Yes
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	Low
Waste management complexity	Medium
Technical (software) expertise	Medium

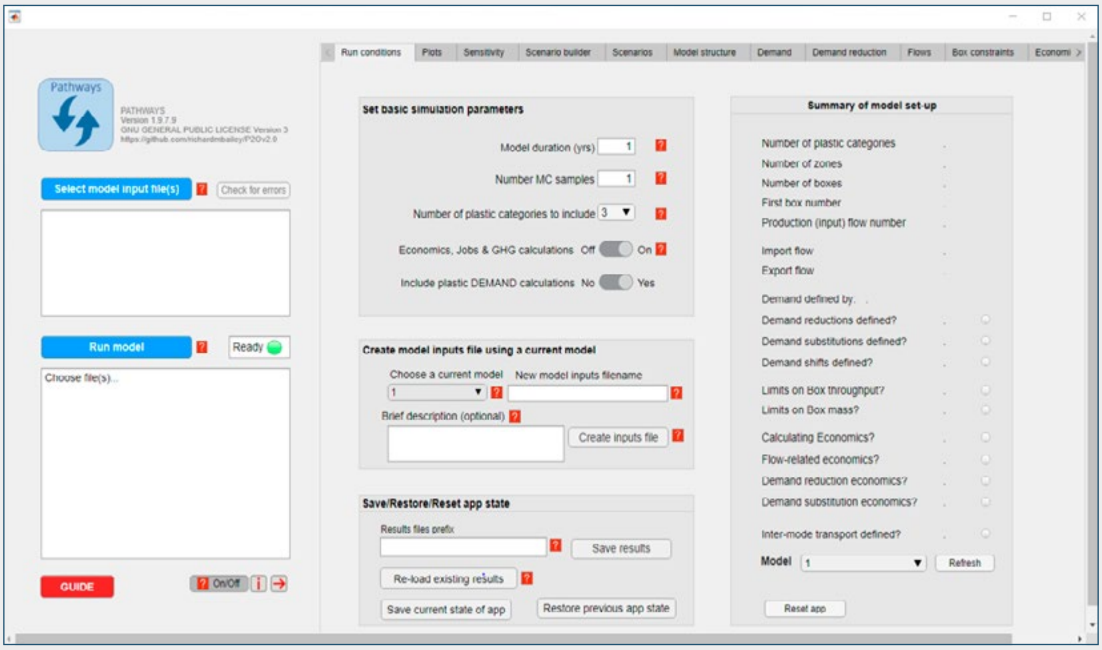
Figures – Pathways





Figures – Pathways





5.8 PLASTEAX

Context of application:
The PLASTEAX tool and methodology aim to provide a baseline of plastic packaging waste management and leakage to ocean and waterways, by country. The results are polymer-specific and product-specific. PLASTEAX database contains the baseline assessment for more than 43 countries, as of July 2022.

Author(s):
EA – Environmental Action

Year:
2021

Geographical coverage:
National level

Assessment type:
Baseline

Target audience:
Governments, Policymakers, Stakeholders, Consultant, Companies, Plastic credit issuers, General public

Target user:
Highly technical expertise in waste management systems and mathematics/modelling

Online tool:
No

Input data:
- Import and export of plastic by polymer
- Production of plastic by polymer
- Recycling of plastic by polymer
- Share of MSW uncollected, incinerated, sent to sanitary landfill, improperly disposed, collected for recycling by informal sector

Data collection complexity:
It takes an experienced user a week to produce the results for one country.

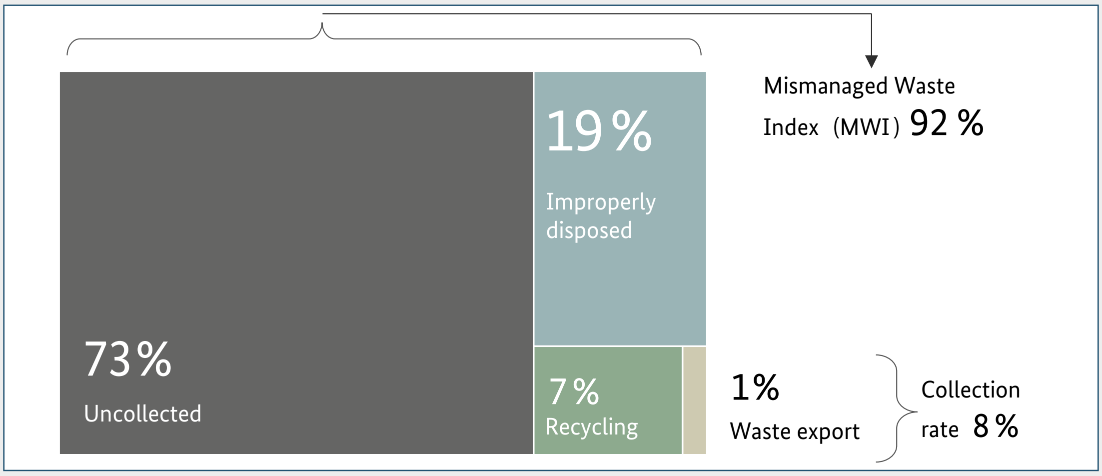
Output data:
Packaging polymer- and product-specific information on:
- Waste generated
- Domestic recycling
- Export of waste
- Incinerated
- Sent to Sanitary landfill
- Improperly disposed
- Uncollected (incl. littering)
- Mismanaged
- Leaked to ocean and waterways

Case studies:
Applied to 43 countries as of July 2022. For all these case studies the "generic data" analysis on all packaging is freely available online, while the breakdown analysis to polymers and products is on demand.

Useful links:
- Website:
  https://www.plasteax.org/
- Methodology material:
  https://www.plasteax.org/use-data
- Free generic dataset:
  https://www.plasteax.org/access-data-1
- Polymer- and product-specific dataset:
  https://www.plasteax.org/contact

Waste breakdown	
Municipal waste	No
Industrial waste	No
Packaging	Yes
Micro-plastics	No
Product specific	Yes
Polymer specific	Yes
Waste other than plastics	No
Waste fate	
Managed waste (excl. recycling)	Yes
Mismanaged waste (incl. uncollected)	Yes
Recycling	Yes
Leakage to ocean and waterways	Yes
Leakage to other compartments	No
Leakage impact on human health	No
Geographical coverage	
Global	No
National	Yes
Municipal/Sub-national	No
Assessment type	
Baseline	Yes
Forecast/Scenarios	No
Impact monitoring through direct and measurable interventions	No
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	Low
Waste management complexity	Low
Technical (software) expertise	High

Figures – PLASTEAX



Polymer Type	Waste generated (kt)	Recycling	Waste export	Properly disposed	Improperly disposed	Uncollected	Total	Collection rate	MWI
PET	44	10%	3%	0%	21%	66%	100%	34%	87%
PP	109	5%	1%	0%	19%	74%	100%	26%	94%
Polyester	112	0%	0%	0%	23%	77%	100%	23%	100%
LDPE	53	15%	2%	0%	19%	64%	100%	36%	83%
HDPE	52	19%	2%	0%	16%	63%	100%	37%	79%
PS	5	0%	0%	0%	18%	82%	100%	18%	100%
Synthetic Rubber	24	8%	0%	0%	21%	71%	100%	29%	92%
PVC	35	1%	0%	0%	13%	86%	100%	14%	99%
Other	69	4%	1%	0%	18%	77%	100%	23%	95%
All plastics	502	7%	1%	0%	19%	73%	100%	27%	92%

5.9 Plastic Drawdown

Context of application:

Plastic Drawdown assesses country specific plastic pollution challenges and identifies an optimal portfolio of policies and actions to mitigate plastic pollution into rivers and oceans, by projecting to 2030 and comparing different scenarios to the Business-as-Usual one. It includes suggestions for the most effective measures worldwide and their implementation.

Author(s):

Common Seas

Year:

2019

Geographical coverage:

National level

Assessment type:

Baseline, Forecast, Impact monitoring through direct measurable interventions

Target audience:

Governments, Policymakers, Stakeholders

Target user:

Highly technical expertise in waste management systems and mathematics/modelling

Online tool:

No

Input data:

- Country level waste and consumption data for 24 macro-plastics and five micro-plastic items
- Historical data on waste management and consumption to establish the growth factors for projections
- Baseline transmission factors, representing the relative amount of plastic waste along each pathway (They are assessed specifically to each study case, either using existing studies of relevance to the transmission factors, or consulting a group of experts, or through fields visits.)
- Timeframe and immediacy of each selected policy intervention (The 18 proposed policies are described in the PDF “Summary for policy makers”, downloadable from the official website, including information on how the policies work, where they were successful, and who they are best for.)

Data collection complexity:

As an example, the case study on Maldives required data collection on the formal waste management systems, field work, data reviewing and supplementing it with confidential data (gathered from Maldives Customs), experts’ meetings, estimation of import data, and market and literature research. It is unclear how much time the whole study required.

Output data:

- Baseline assessment of the amount of plastic from different waste sources that leaks into aquatic environments, and what drives this leakage
- Business-as-Usual projection of annual plastic emissions (leakage) between now and 2030
- Modelling and visualization of the interventions that could have the greatest potential impact on reducing plastic waste leakage, considering the plastic waste composition and leakage characteristics of the jurisdiction

Case studies:

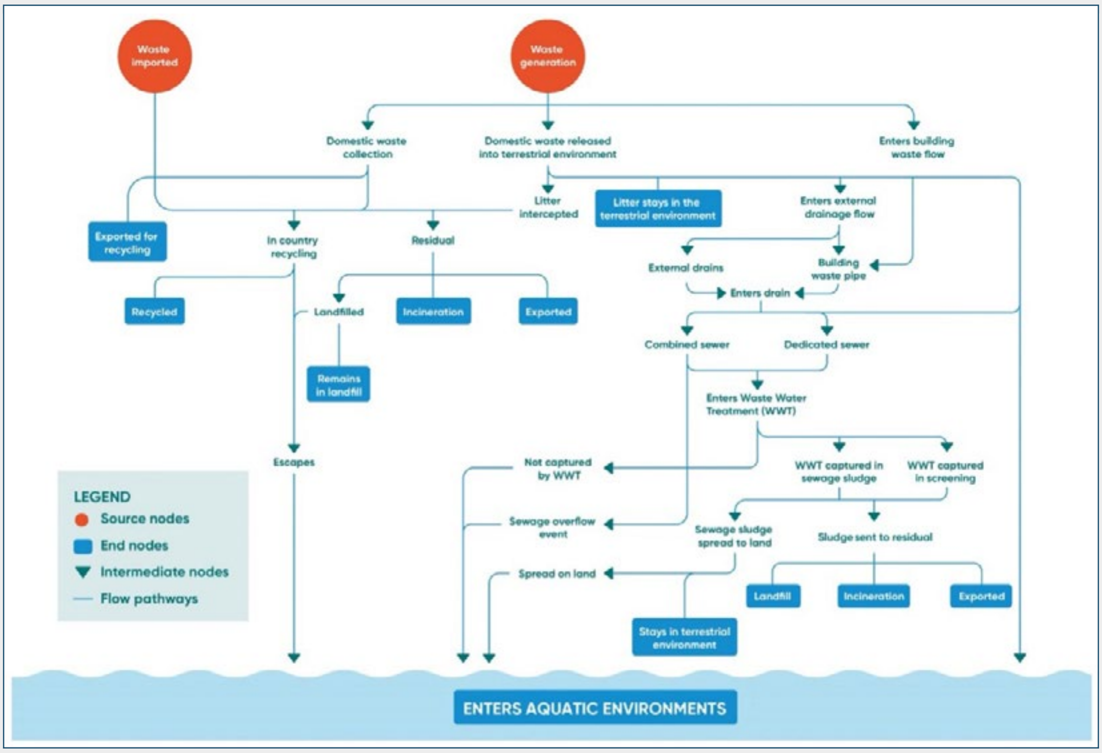
The methodology has been implemented in Indonesia, UK, Maldives and Greece, with the UK and Maldives studies are available online. The case study on Indonesia is an example of how the model can help support discussions on possible solutions to the problem of plastic pollution, which is recognized as being especially acute in this country.

Useful links:

- Website: https://commonseas.com/programmes/plastic-drawdown
- J. Royle et al., Plastic Drawdown: A rapid assessment tool for developing national responses to plastic pollution when data availability is limited, as demonstrated in the Maldives, 2022: https://www.sciencedirect.com/science/article/pii/S0959378021002211

Waste breakdown	
Municipal waste	Yes
Industrial waste	Yes
Packaging	Yes
Micro-plastics	Yes
Product specific	Yes
Polymer specific	No
Waste other than plastics	No
Waste fate	
Managed waste (excl. recycling)	Yes
Mismanaged waste (incl. uncollected)	Yes
Recycling	Yes
Leakage to ocean and waterways	Yes
Leakage to other compartments	Yes
Leakage impact on human health	No
Geographical coverage	
Global	No
National	Yes
Municipal/Sub-national	No
Assessment type	
Baseline	Yes
Forecast/Scenarios	Yes
Impact monitoring through direct and measurable interventions	Yes
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	Medium
Waste management complexity	High
Technical (software) expertise	Low

Figures – Plastic Drawdown



Intervention Matrix

Policy group	No.	Intervention	1 Grocery bags (plastic)	2 Other plastic bags	3 Beverage bottles (plastic)	4 Bottle tops (plastic)	5 Lids (plastic)	6 Other plastic bottles (oil, bleach, etc.)	7 Cigarette butts	8 Straws, stirrers	9 Food wrappers (candy, chips, etc.)	10 Single serve sachets (food)	11 Single serve sachets (non-food)	12 Take out/away containers (foam)	13 Take out/away containers (plastic)	14 Cups, plates (foam)	15 Cups, plates (plastic)	16 Forks, knives, spoons	17 Balloons	18 Wet wipes	19 Diapers	20 Condoms	21 Sanitary pods/ tampons	22 Fishing gear	23 Tyre wear	24 Brake wear	25 Clothing fibres	26 Pellets	27 Microbeads	28 Construction plastics	29 Other plastic waste	
POLICIES THAT REDUCE PLASTIC PRODUCTION	1	Item Ban	x	x						x				x		x		x											x			
	2	Taxes on Specified Items	x	x											x		x		x	x												
	3	Deposit Return scheme for Beverage containers			x	x		x																								
	4	Provision of Potable Water Supply			x	x																										
	5	Water refill scheme			x	x																										
POLICIES THAT REDUCE WASTE GENERATION	6	Pre-production plastic pellet handling standards and regulations																										x				
	7	Fibre-release threshold standards and clothing labelling regulation																									x					
	8	Regulation and labelling of tyres																							x							
	9	Deposit refund scheme for fishing gear with extended producer responsibility																						x								
	10	Gear zoning of fishing areas																						x								
POLICIES THAT IMPROVE WASTE MANAGEMENT	11	Provision of solid waste collection, with or without Extended Producer Responsibility	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x								x	
	12	Standards for storage and management of collected waste	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x					x		x	x	
	13	On-the-go waste collection system	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x		x										x	
	14	Litter and fly-tipping regulations	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x										x	
POLICIES THAT IMPROVE WASTE MANAGEMENT	15	Waste Water Treatment (WWT) infra-structure																		x		x	x		x	x						
	16	Sewerage and stormwater catchment systems																		x		x	x		x	x	x	x	x			
	17	Track and trace systems for fishing gear																						x								
	18	Implementing flat fees for waste disposal in port facilities																						x								
		# Interventions per Item	5	5	7	7	4	3	4	5	4	4	4	5	5	5	5	5	5	6	4	4	4	4	3	2	2	3	2	1	4	150

Figures from Plastic Drawdown, Summary for policy makers

Figures – Plastic Drawdown

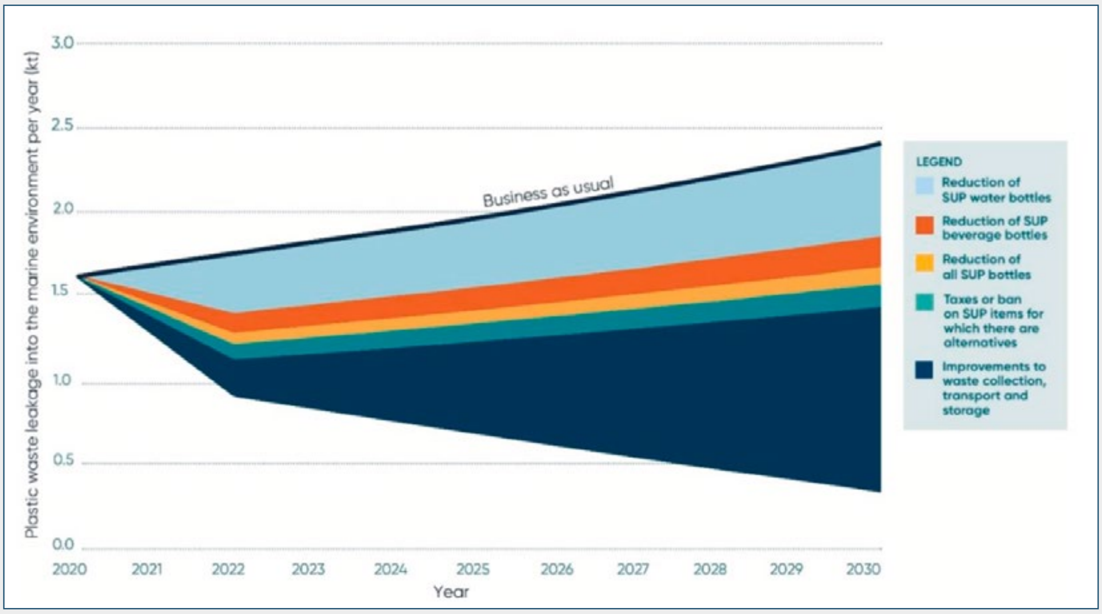


Figure from study case Maldives, 2020

5.10 SPOT Model

The SPOT (Spatio-temporal quantification of Plastic pollution Origins and Transportation) model has been developed on behalf of UN-Habitat and UNEP and is a GIS-based tool to identify plastic pollution hotspots on a regional and global level. The tool focuses on land-based solid waste sources and is designed to accept data according to the SDG 11.6.1. Currently, the methodology and the relative tool have not been published yet and no further information is available.

Useful links:

- Main web page: https://plasticpollution.leeds.ac.uk/toolkits/spot/
- GPML Data Hub, Marine Litter Hotspots (MLHS ULUH MW), September 2021: https://datahub.gpmarinelitter.org/maps/gpml-community::marine-litter-hotspots-mlhs-uluh-wm/explore?location=15.110506%2C27.013472%2C4.00

5.11 Waste Flow Diagram

Context of application:
The WFD is a rapid assessment tool to estimate the amounts of municipal solid waste leaking to the environment and water from different sources. It combines a Material Flow Analysis (MFA) approach with systematic and observation based qualitative assessment which involves primary and secondary data collection, observations, and interviews along waste management stations. It visualizes quantities of municipal solid waste streams within a waste management system in standardized Waste Flow Diagram and Sankey diagram. It allows insert data following different scenarios and compare the different assessments for waste management planning.

Author:
GIZ, University of Leeds, Eawag, Wasteaware

Year:
2020

Geographical coverage:
Municipal level

Assessment type:
Baseline

Target audience:
Local authorities, NGOs, Civil society organizations, Donor agencies, Private investors, Entrepreneurs

Target user:
Substantial waste management experience and basic mathematical knowledge are required. There is a User Manual on how to use the tool, as well as online training videos and courses.

Online tool:
Yes (also works offline with Excel)

Input data:

- Population statistics
- Per capita MSW generation
- Per capita MSW composition (paper, plastics, glass, metals, organic, other)
- Data from disposal facilities
- Data on recovered MSW and rejects from sorting facilities
- Formal/informal waste collection and recovery
- Data on amounts and composition of disposed waste
- Data on energy recovery
- Manual assessment of leakage influencers (such as, collection services, transportation, formal and informal sorting, storm drains
- Manual assessment of potential plastic pollution fates (such as, plastic openly burnt, dumping on land, dumping on drains, dumping in water systems)

Guidance on assessing the factors influencing leakage and plastic pollution fates is provided to the user in the User manual and in the tool itself.

The data collection process is supported via integration with the SDG 11.6.1 methodology.

The tool contains columns for checking the calculations and pop-up cells with information on input data. There is clear guidance on how to proceed for primary data collection and for missing data. Moreover, the user is asked to self-assess reliability of the inserted data, and the related score is then processed and reported in the results.

Data collection complexity:

Estimated 2 to 4 weeks of work with a team of 2 to 6 people, depending on complexity of the municipal waste system and on primary data available. The User Manual gives clear guidance on data collection requirements and with reference to SGDs data collection methodology.

Output data:

The user can generate a waste flow diagram per baseline or scenario and per material (paper, metal, glass, plastic, organic, other). The second graphical representation available is under the form of a Sankey diagram, while the online version creates the Sankey in the portal, the offline tool generates the corresponding code that the user can copy into sankeymatic.com to generate the Sankey diagram. Finally, two summary tables are generated: the first focuses on waste management flows for both plastics only and general MSW, while the second focuses on sources, pathways, and fates of unmanaged plastics pollution, and includes results on plastics marine litter.

Case studies:

In total about 100 case studies conducted, from small to large urban areas and mega cities, including e.g.:

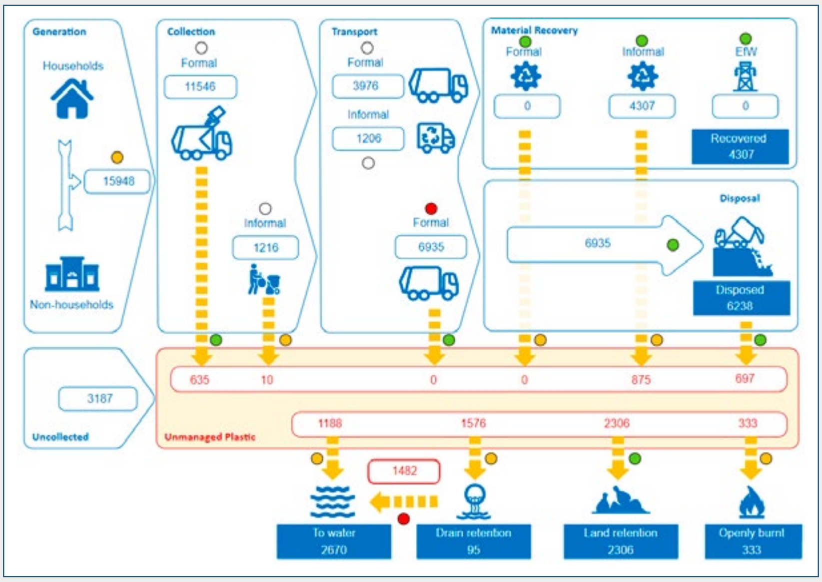
- Sidoarjo, Indonesia
- Annaba, Algeria
- Tulum, Mexico
- Mombasa, Kenya
- Fnideq, Morocco

Useful links:

- Marine Litter Prevention full report, GIZ (contains case studies for Sidorajo, Indonesia and Annaba, Algeria): https://www.giz.de/de/downloads/giz2018_marine-litter-prevention_web.pdf
- University of Leeds webpage on WFD: https://plasticpollution.leeds.ac.uk/toolkits/wfd/
- GIZ webpage on WFD: https://www.giz.de/expertise/html/62153.html
- Description and link to the Excel tool (for download): https://www.giz.de/expertise/html/62153.html
- User manual: https://www.giz.de/expertise/downloads/giz-waste-flow-diagram-user-manual.pdf
- Introductory video: https://www.youtube.com/watch?v=g_jLS2lMpqc

Waste breakdown	
Municipal waste	Yes
Industrial waste	No
Packaging	No
Micro-plastics	No
Product specific	No
Polymer specific	No
Waste other than plastics	Yes
Waste fate	
Managed waste (excl. recycling)	Yes
Mismanaged waste (incl. uncollected)	Yes
Recycling	Yes
Leakage to ocean and waterways	Yes
Leakage to other compartments	Yes
Leakage impact on human health	No
Geographical coverage	
Global	No
National	No
Municipal/Sub-national	Yes
Assessment type	
Baseline	Yes
Forecast/Scenarios	Yes
Impact monitoring through direct and measurable interventions	No
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	Medium
Waste management complexity	Medium
Technical (software) expertise	Low

Figures – Waste Flow Diagram



	Plastic waste				Municipal Solid Waste				
	Baseline	Scenario 1	Scenario 2	Scenario 3	Baseline	Scenario 1	Scenario 2	Scenario 3	Unit
Municipal solid waste generation	20,696	20,696	20,696	20,696	229,950	229,950	229,950	229,950	Tonnes/year
Municipal solid waste generation	57	57	57	57	630	630	630	630	Tonnes/day
Collected waste	12,969	15,805	17,875	19,944	123,929	149,081	172,076	195,071	Tonnes/year
Collected waste	63%	76%	86%	96%	54%	65%	75%	85%	% of waste generation
Uncollected waste	7,727	4,890	2,821	751	106,021	80,869	57,874	34,879	Tonnes/year
Uncollected waste	37%	24%	14%	4%	46%	35%	25%	15%	% of waste generation
Waste sorted for recovery *(excludes energy from waste)*	5,110	5,352	5,680	6,008	17,520	18,172	19,350	20,527	Tonnes/year
Waste sorted for recovery *(excludes energy from waste)*	25%	26%	27%	29%	8%	8%	8%	9%	% of waste generation
Waste sorted for recovery by formal sector *(excludes energy from waste)*	7%	9%	10%	11%	2%	3%	3%	4%	% of waste generation
Waste sorted for recovery by informal sector *(excludes energy from waste)*	18%	17%	17%	18%	5%	5%	5%	5%	% of waste generation
Energy from waste	365	497	579	662	3,650	4,561	5,321	6,081	Tonnes/year
Energy from waste	2%	2%	3%	3%	2%	2%	2%	3%	% of waste generation
Disposal in disposal facilities	7,300	9,924	11,578	13,232	102,565	126,315	147,368	168,420	Tonnes/year
Disposal in disposal facilities	35%	48%	56%	64%	45%	55%	64%	73%	% of waste generation
Managed in controlled facilities	0	0	8,919	19,902	0	0	86,019	195,028	Tonnes/year
Managed in controlled facilities	0%	0%	43%	96%	0%	0%	37%	85%	% of waste generation

	Plastic waste				
	Baseline	Scenario 1	Scenario 2	Scenario 3	Unit
Unmanaged plastic waste	7,931	4,937	2,875	812	Tonnes/year
Unmanaged plastic waste	38%	24%	14%	4%	% of plastic waste generation
Contribution from uncollected waste	97.43%	99.06%	98.13%	92.49%	% of mismanaged plastic waste
Contribution from collection service	1.81%	0.25%	0.50%	2.04%	% of mismanaged plastic waste
Contribution from informal value-chain collection	0.38%	0.07%	0.12%	0.42%	% of mismanaged plastic waste
Contribution from formal sorting	0.09%	0.18%	0.36%	1.47%	% of mismanaged plastic waste
Contribution from informal sorting	0.15%	0.16%	0.32%	1.30%	% of mismanaged plastic waste
Contribution from transportation	0.00%	0.00%	0.00%	0.00%	% of mismanaged plastic waste
Contribution from disposal facilities	0.13%	0.28%	0.56%	2.28%	% of mismanaged plastic waste
Plastic waste retained on land	3,394	2,084	1,216	351	Tonnes/year
Plastic waste retained on land	43%	42%	42%	43%	% of mismanaged plastic waste
Plastic waste openly burnt	2,042	1,296	753	210	Tonnes/year
Plastic waste openly burnt	26%	26%	26%	26%	% of mismanaged plastic waste
Plastic waste cleaned from drains	334	207	120	34	Tonnes/year
Plastic waste cleaned from drains	4%	4%	4%	4%	% of mismanaged plastic waste
Plastic waste to water systems	2,160	1,350	785	218	Tonnes/year
Plastic waste to water systems	27%	27%	27%	27%	% of mismanaged plastic waste
Plastic waste to water systems	10%	7%	4%	1%	% of plastic waste generation
Contribution directly entering water systems	38%	39%	39%	39%	% of plastic in water systems
Contribution entering via storm drains	62%	61%	61%	61%	% of plastic in water systems
Plastic to water systems per person	2.2	1.3	0.8	0.2	kg per person/year
Plastic to water systems per person	72	45	26	7	no. PET bottles per person/year*
Plastic to water systems	25	16	9	3	no. of olympic swimming pools/year**
Plastic to water systems	3,177	1,985	1,155	321	no. of waste trucks/year***

*Mass of 1.5 litre PET bottle: 30 g

**Pool volume: 2,500 m^3, Density mixed plastic waste: 34 kg/m^3

***Volume truck: 20 m^3, Density mixed plastic waste: 34 kg/m^3

Figures from Waste Flow Diagram User Manual, 2020

5.12 Waste Wise Cities tool, SDG 11.6.1

Context of application:

The core and main purpose of the methodology is to provide the user with a complete and detailed step-by-step guide for collecting data on collected, recovered, disposed and uncollected municipal solid waste to assess the actual state of the MSW system. The Excel tool helps the user to centralize and visualize the collected data. There is specific analysis on marine litter.

Author:

UN-Habitat

Year:

2021

Geographical coverage:

Municipal/City level

Assessment type:

Baseline

Target audience:

Local authorities and government, Local task forces, NGOs willing to assess MSW at city level

Target user:

Good understanding of the waste management system on the ground and ability to organize sites visits

Online tool:

Yes (Excel)

Input data:

- Population statistics by income levels (low, medium, high)
- Household waste composition (if possible, broken down to wood, glass, metals, plastic film, plastic dense, paper, garden, kitchen, textiles, special wastes, compost, other)
- Data on municipal solid waste generation from non-household sources, as hotels, markets, restaurants, schools, offices, shopping malls, public spaces (If data is not available, proxy formulae are suggested in the methodology report.)
- Data from disposal facilities (e.g., quantities of waste arriving and daily streams, waste composition, level of environmental control)
- Data from recovery facilities (e.g., quantities of daily streams and received materials, quantities of recycled or recovered material, quantities of rejects)

Data collection complexity:

UN-Habitat estimates 40 days of work with following human resources and costs setup: expert team for a total period of approximately 6 working weeks, personnel cost for 20-30 people for an 8-10 day field survey, plus related logistical costs.

The tool is provided with:

- step-by-step guide for the data collection
- a household survey guide for total MSW generation
- a questionnaire to identify the MSW recovery chain
- criteria to check the environmental control level of waste management facilities in a city

Output data:

- A “performance dashboard”, in the form of gauges (see pictures below), showing the waste collection performance and the waste generation factors compared to high and low values from the World Bank’s “What a Waste 2” database
- Summary table for household waste generation (quantities and composition)
- Summary table for non-household waste (generation)
- Summary table for recovered waste (quantities recovered and potential recoverable quantities)
- Summary table for MSW disposal (quantities and composition at disposal)
- Flow diagram summarizing the data collected and relative flows in tones/day

Case studies:

23 worldwide cities
(source: https://unh.rwm.global/Map):

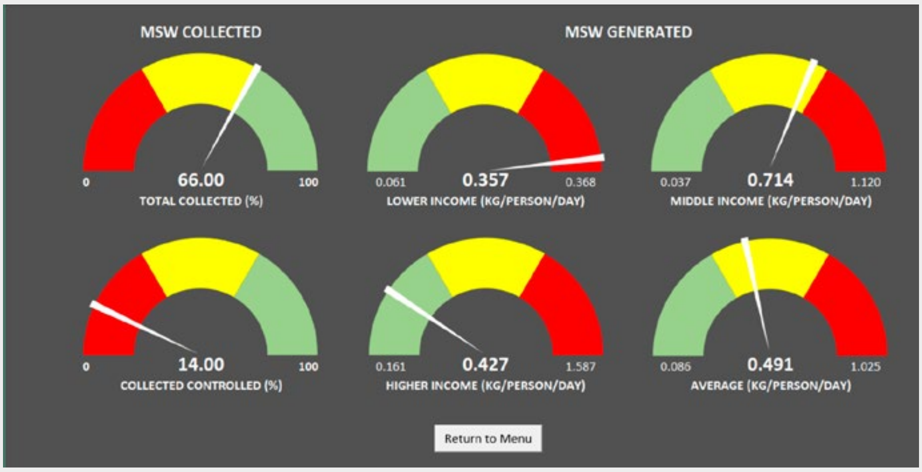
- Santo Domingo, Dominican Republic
- Dakar, Senegal
- Cape Coast, Ghana
- Lagos, Nigeria
- Bukavu, Congo
- Dar es Salaam, Tanzania
- Harare, Zimbabwe
- 4 cities in Kenya
- 3 cities in Ethiopia
- Victoria, Seychelle
- Sousse, Tunisia
- 2 cities in Pakistan
- Khulna, Bangladesh
- 2 cities in India
- 3 cities in Indonesia

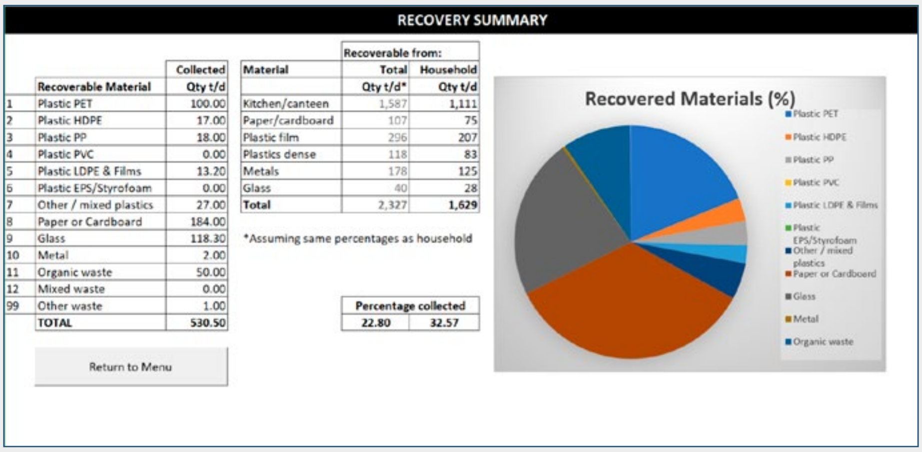
Useful links:

- Step by step guide:
  https://unhabitat.org/sites/default/files/2021-10/Waste%20wise%20cities%20tool%20-%20EN%2013.pdf
- User manual:
  https://unhabitat.org/sites/default/files/2021/04/wact-dca-manual_v1.40.pdf
- Free dataset:
  https://unh.rwm.global/Map
- Tool (request form):
  https://unh.rwm.global/getdca.php

Waste breakdown	
Municipal waste	Yes
Industrial waste	Yes
Packaging	No
Micro-plastics	No
Product specific	No
Polymer specific	No
Waste other than plastics	Yes
Waste fate	
Managed waste (excl. recycling)	Yes
Mismanaged waste (incl. uncollected)	Yes
Recycling	Yes
Leakage to ocean and waterways	No
Leakage to other compartments	No
Leakage impact on human health	No
Geographical coverage	
Global	No
National	No
Municipal/Sub-national	Yes
Assessment type	
Baseline	Yes
Forecast/Scenarios	No
Impact monitoring through direct and measurable interventions	No
Impact monitoring through indirect interventions	No
Technical requirements	
Data collection complexity	High
Waste management complexity	Low
Technical (software) expertise	Low

Figures – UN-Habitat WaCT




RECOVERY SUMMARY

	Recoverable Material	Collected Qty t/d
1	Plastic PET	100.00
2	Plastic HDPE	17.00
3	Plastic PP	18.00
4	Plastic PVC	0.00
5	Plastic LDPE & Films	13.20
6	Plastic EPS/Styrofoam	0.00
7	Other / mixed plastics	27.00
8	Paper or Cardboard	184.00
9	Glass	118.30
10	Metal	2.00
11	Organic waste	50.00
12	Mixed waste	0.00
99	Other waste	1.00
	TOTAL	530.50

Material	Recoverable from: Total Qty t/d*	Recoverable from: Household Qty t/d
Kitchen/canteen	1,587	1,111
Paper/cardboard	107	75
Plastic film	296	207
Plastics dense	118	83
Metals	178	125
Glass	40	28
Total	2,327	1,629

*Assuming same percentages as household

Percentage collected	
22.80	32.57

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Figures from Step-by-step Guide and the User Manual version 1.42

5.13 WWF Monitoring & Evaluation Framework

Context of application:

The framework is suitable for assessing the impact of direct and indirect measures at the city level (in the context of WWF's Plastic Smart Cities goal of reaching 30% plastic leakage reduction by 2030). It does not perform baseline evaluation, but baseline data is still needed to apply the methodology. As such, it is rather a complementary to a more technical baseline assessment tool, to add a layer of analysis on the impact of measures.

Author:

WWF, EA – Environmental Action

Year:

2022

Geographical coverage:

Municipal level

Assessment type:

Impact monitoring through direct and measurable interventions, Impact monitoring through indirect interventions

Target audience:

Local task forces, Government/Authorities, NGOs, Private sector, Professionals, Scientists

Target user:

Project managers, Technical people, Scientists

Online tool:

Yes, but timeline and access grants still need to be defined. It is already certain that data from WWF projects will remain private.

Input data:

The user is required to insert baseline data on plastic waste generation per capita, uncollected plastic waste, and plastic waste properly and improperly disposed (meaning in sanitary landfill/incineration and unsanitary landfills respectively).

The user can insert up to 10 projects, with a maximum of 20 direct and 20 indirect interventions in total.

Direct interventions are assessed based on:

- Reduced waste (kg/year)
- Collected waste (kg/year)
- Recycled waste (kg/year)
- Maturity level, or completeness, of the intervention

Indirect interventions are assessed based on:

- Number of people involved
- Reduction of waste generation per person (kg/year)
- Waste collected per person (kg/year)
- Waste recycled per person (kg/year)
- Maturity level, or completeness, of the intervention

Data collection complexity:

One week if data and baseline are already available, otherwise up to 2 months if all data still must be collected and baseline assessed.

Output data:

Results are delivered in an Excel dashboard, giving an assessment of the actual plastic leakage to the environment (equivalent to mismanaged waste in this context) and its actual reduction based on the implemented interventions. Moreover, it shows the potential leakage reduction, under the assumption that all project's interventions reach their pre-fixed goal. Assessments outputs are compared to baseline measurements and to the goal of reducing by 30% plastic leakage by 2030.

The tool gives a qualitative evaluation of the interventions in terms of reducing the overall plastic leakage of the city and helps to keep track of the progress over time.

Case studies:

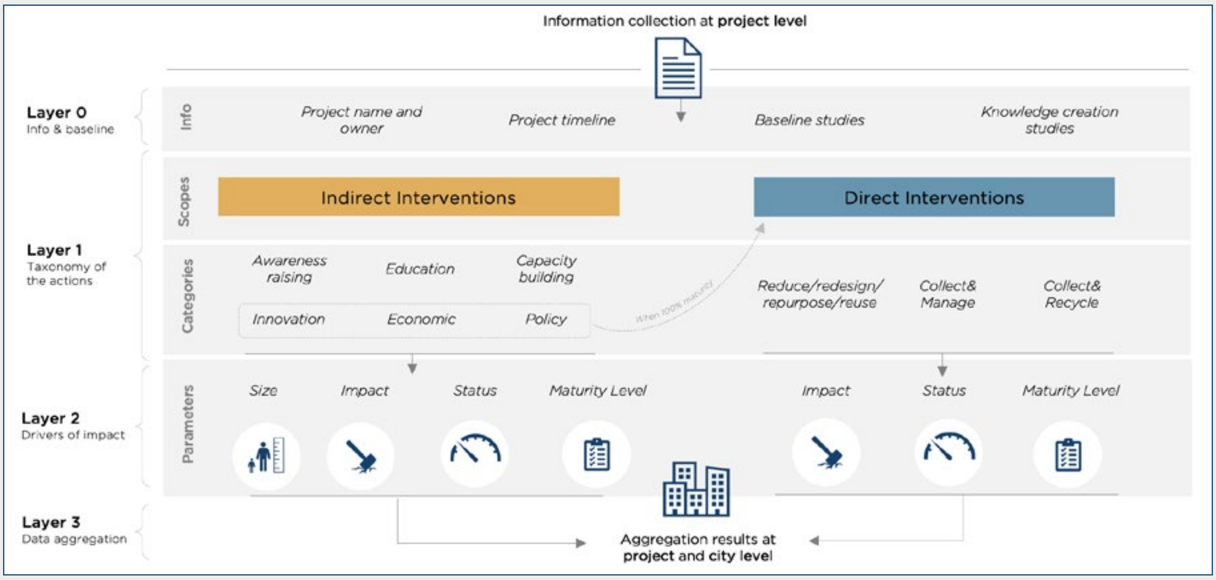
The methodology has been applied to a selection of five South-East Asian countries. Details and results are not publicly available, as they are property of the WWF.

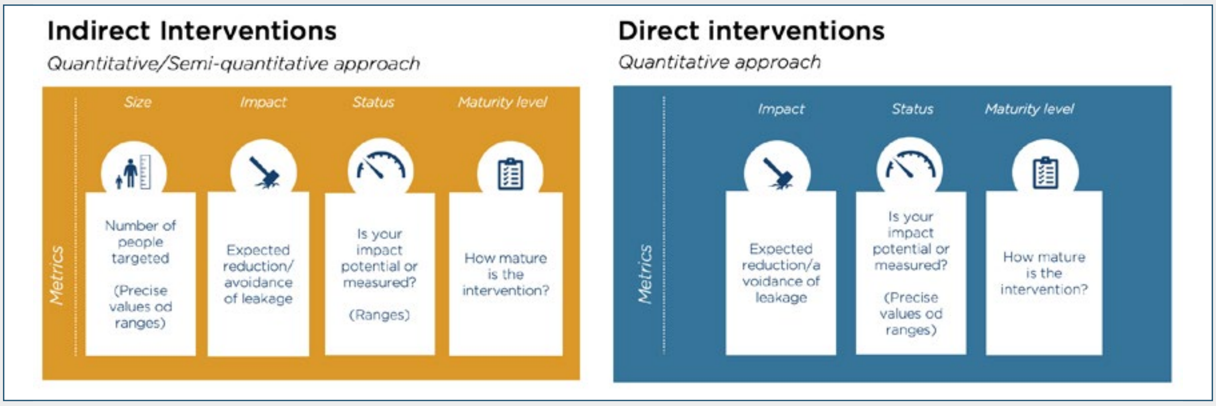
Useful links:

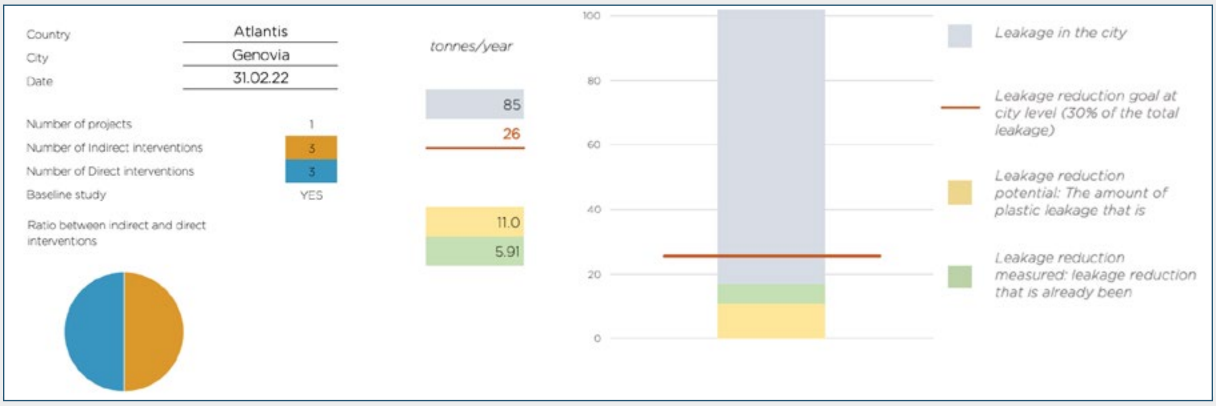
- Project context in which the methodology framework has been developed (Plastic Smart Cities Initiative): https://plasticsmartcities.org

Waste breakdown	
Municipal waste	Yes
Industrial waste	Yes
Packaging	Yes
Micro-plastics	No
Product specific	No
Polymer specific	No
Waste other than plastics	No
Waste fate	
Managed waste (excl. recycling)	Yes
Mismanaged waste (incl. uncollected)	Yes
Recycling	Yes
Leakage to ocean and waterways	No
Leakage to other compartments	No
Leakage impact on human health	No
Geographical coverage	
Global	No
National	No
Municipal/Sub-national	Yes
Assessment type	
Baseline	No
Forecast/Scenarios	No
Impact monitoring through direct and measurable interventions	Yes
Impact monitoring through indirect interventions	Yes
Technical requirements	
Data collection complexity	Medium
Waste management complexity	Low
Technical (software) expertise	Low

Figures – WWF M&E Monitoring







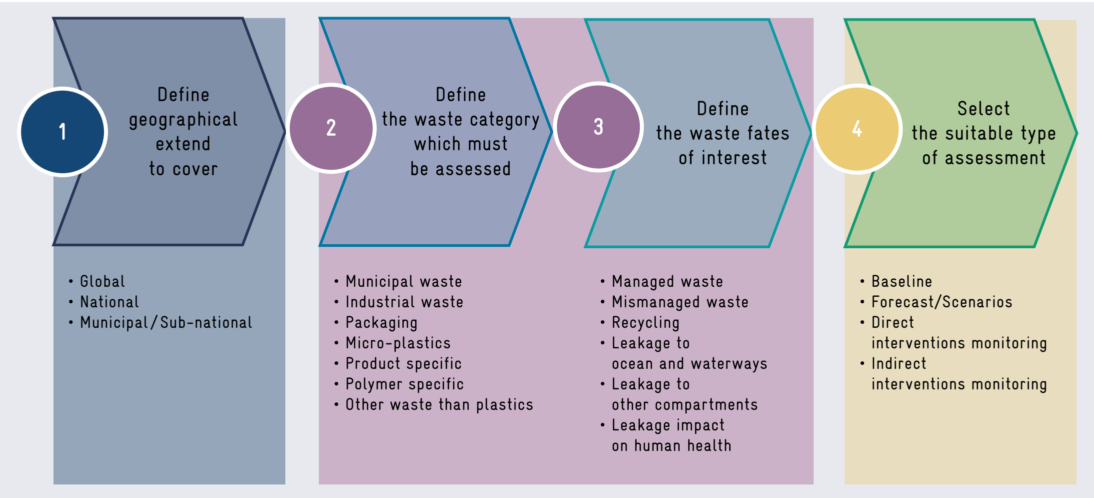
Conclusion

6

Table 2 summarizes the results of the benchmarking of plastic hotspotting methodologies conducted in this study. 13 methodologies and/or tools for assessing plastic flows and leakage within the waste management chain have been reviewed. Tools and methodologies allowing to perform assessment of a specific product at company level have not been included in the study.

As represented in Figure 8, the idea of the benchmarking framework is to provide guidance on the selection of a methodology for monitoring sub-national or national projects and programs. At first, it is advisable to define at which geographical scale the assessment of interest must be performed: whether it is at municipal or city level, or at national level. Most methodologies allow to perform an assessment of either national or sub-national level. The only exceptions are the Breaking the Plastic Wave and Pathways tool, which can perform analyses at a global scale.

Figure 9: Step-by-step methodology selection



The second step is to define which type of waste is of interest for the analysis. Issues such as whether the plastic from general municipal waste is granular enough need to be considered, or whether the assessment needs to focus specifically on the packaging sector, or be split in different product categories, or polymers. Polymer specific analysis can only be performed with PLASTEAX, the ISWA Calculator, Pathways, or the national Guidance (UNEP & IUCN). Whether or not to include industrial waste is also an aspect worth considering. Furthermore, only Breaking the Plastic Wave, the National Guidance (UNEP & IUCN), Plastic Drawdown, and Pathways allow for the inclusion of micro-plastics in the assessment.

The third step is to select the methodology that covers the largest possible number of waste fates desirable for the analysis. All the methodologies reported in this study include mismanaged waste and recycling. Most of them, except the UN-Habitat WaCT tool and the WWF M&E Framework, include estimates on the potential leakage to ocean and waterways, but none of them estimate the potential impact that plastic leakage can have on human health.

Finally, all the methodologies, except for WWF M&E Framework, allow to perform baseline assessment. As illustrated in the corresponding sections, Breaking the Plastic Wave, GPAP NAM tool, Plastic Drawdown, and Pathways include forecasting analysis and the possibility to predict the impact of direct measures, such as, e.g., policies or bans, over time. The WFD, ISWA PPC and Pathways include the possibility to fine-tune parameters to compare different scenarios and as such, to compare the results, if different actions were implemented. Only the WWF M&E Framework has been developed specifically to assess also indirect measures, through indicators such as the waste generation reduction and the number of people affected by the interventions, as explained in Section 4.5.

Since the methodologies and tools differ in the requirements in terms of data collection, waste management complexity, as well as technical knowledge, such as software and programming skills, three additional indicators were defined in this study. The three indicators are: Data collection complexity, Waste management complexity and Technical (software) expertise. Each of these indicators were assigned to a label (low, medium, high) to allow the user to make a comprehensive preliminary assessment of the effort required to apply a method. Definitions of the three labels are reported in Section 4.6.

It is worth mentioning that these methodologies can be seen as complementary to each other. For example, the SDG 11.6.1 methodology behind the UN-Habitat WaCT can be integrated to support the data collection process of the WFD. Country baseline data from PLASTEAX (available at polymer and product specific granularity) can serve as support for secondary data collection to other tools, such as the GPAP NAM or Pathways tools. The WWF M&E Framework requires a baseline assessment to be executed before being able to evaluate the impact of interventions. In this case, a municipal or a national level baseline tool can be used, depending on the geographical scope of the interventions that the user wants to assess.

Table 2: Comparison summary

		BC MFA	BC PoM	Breaking the Plastic Wave	GPAP NAM tool	ISWA Plastic Pollutor Calculator	Minderoo	UNEP&IUCN National Guidance	Pathways	PLASTEAX	Plastic Drawdown	Waste Flow Diagram	UN-Habitat Waste Wise Cities Tool	WWF M&E Framework
Geographical coverage	Global			✓			✓		✓					
	National	✓	✓	✓	✓		✓	✓	✓	✓	✓			
	Municipal / Sub-national	✓				✓			✓			✓	✓	✓
Waste breakdown	Municipal waste	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓
	Industrial waste		✓					✓	✓		✓		✓	✓
	Packaging		✓	✓	✓		✓	✓	✓	✓	✓			✓
	Micro-plastic			✓				✓	✓		✓			
	Product specific		✓	✓	✓	✓	✓	✓	✓	✓	✓			
	Polymer specific		✓				✓	✓	✓	✓				
	Waste other than plastics					✓			✓			✓	✓	
Waste fates	Managed waste (excl. recycling)	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
	Mismanaged waste (incl. uncollected)	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
	Recycling	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
	Leakage to ocean & waterways	✓		✓	✓	✓		✓	✓	✓	✓	✓		
	Leakage to other compartments	✓		✓	✓	✓			✓		✓	✓		
	Leakage impact on human health													
Assessment type	Baseline	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Forecast/Scenarios			✓	✓	✓			✓		✓	✓		
	Direct interventions			✓	✓				✓		✓			✓
	Indirect interventions													✓
Technical requirements	Data collection complexity	medium	medium	low	low	high	medium	low	low	low	medium	medium	high	medium
	Waste management knowledge	medium	low	medium	medium	high	low	low	medium	low	high	medium	low	low
	Technical (software) expertise	low	low	high	low	medium	low	medium	medium	high	low	low	low	low

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