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Methodologies Review

Harmonization Approach for Various Marine Litter and Plastic Pollution Monitoring and Modelling Methodologies

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UN environment programme

UN HABITAT FOR A BETTER URBAN FUTURE

DAVID NEWBY ASSOCIATES

GLOSSARY OF ACRONYMS AND

AQUASTAT	AQUASTAT is the FAO (UN Food and Agriculture Organisation) global information system on water resources and agricultural water management.
BRS	Basel, Stockholm, Rotterdam (Conventions)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DHI	DHI Group
EA	Environmental Action.
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GmBH)
GPML	Global Partnership on Marine Litter
HYCOM	HYbrid Coordinate Ocean Model
INC	Intergovernmental Negotiating Committee
ITC	International Trade Centre
IUCN	International Union for Conservation of Nature
MFA	Mass Flow Analysis
MSW	Municipal Solid Waste
NAP	National Action Plan
NGO	Non-governmental organisation
NIVA	Norwegian Institute for Water Research
OECD	Organisation for Economic Co-operation and Development
PPC	Plastic Pollution Calculator
POPs	Persistent Organic Polutants
PSI	Plastic Source Inventory
SDG	Sustainable Development Goals
SEEA	System of Environmental-Economic Accounting
SPOT	SPatio-temporal quantification of plastic pollution Origins and Transportation (model)
UN	United Nations
UN COMTRADE	United Nations Comtrade database.
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
UNEP-DHI	UNEP DHI Centre
UNFCCC	United Nations Framework Convention on Climate Change
UN Habitat	United Nations Human Settlements Programme
UNITAR	United Nations Institute for Training and Research
UoL	University of Leeds
WaCT	Wastewise Cities Tool

GLOSSARY OF ACRONYMS AND

WB	World Bank
WFD	Waste Flow Diagram
WHO	World Health Organisation

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GLOSSARY OF ACRONYMS AND

1. INTRODUCTION

This report has been prepared for UNEP and UN Habitat and reviews the Methodologies and Models presented and discussed at the Expert General Meeting (EGM) on Harmonization Approach for Various Marine Litter and Plastic Pollution Monitoring and Modelling Methodologies held at UN City in Copenhagen between the 22nd and 24th August 2022 and at the two preliminary Webinars held on the 2nd and 3rd August 2022 during which developers of key methodologies made short presentations on their plastic pollution monitoring and modelling methodologies.

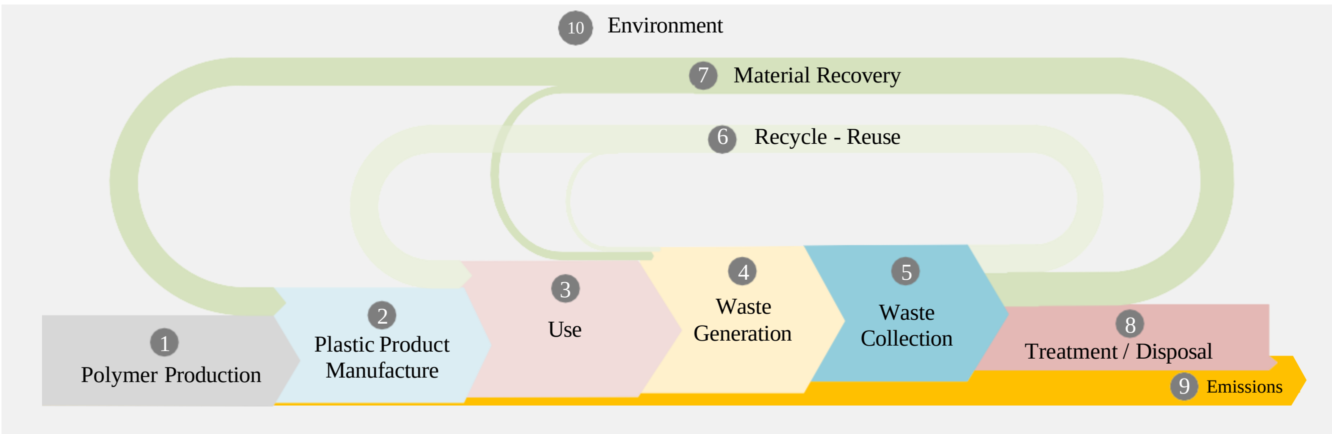
While this document is an initial review of the methodologies presented and discussed during the Webinars and the EGM, it concludes with some preliminary thoughts on potential for interlinkages between the methodologies and models. As some are as yet unpublished and some are "proprietary", some of these potential interlinkages identified are uncertain.

2. MODELLING METHODOLOGIES REVIEW

2.1 REVIEW FRAMEWORK

In undertaking this review we aim to consider the lifecycle of plastics from production to final fate in the environment examining the elements of that lifecycle that each methodology / model covers.

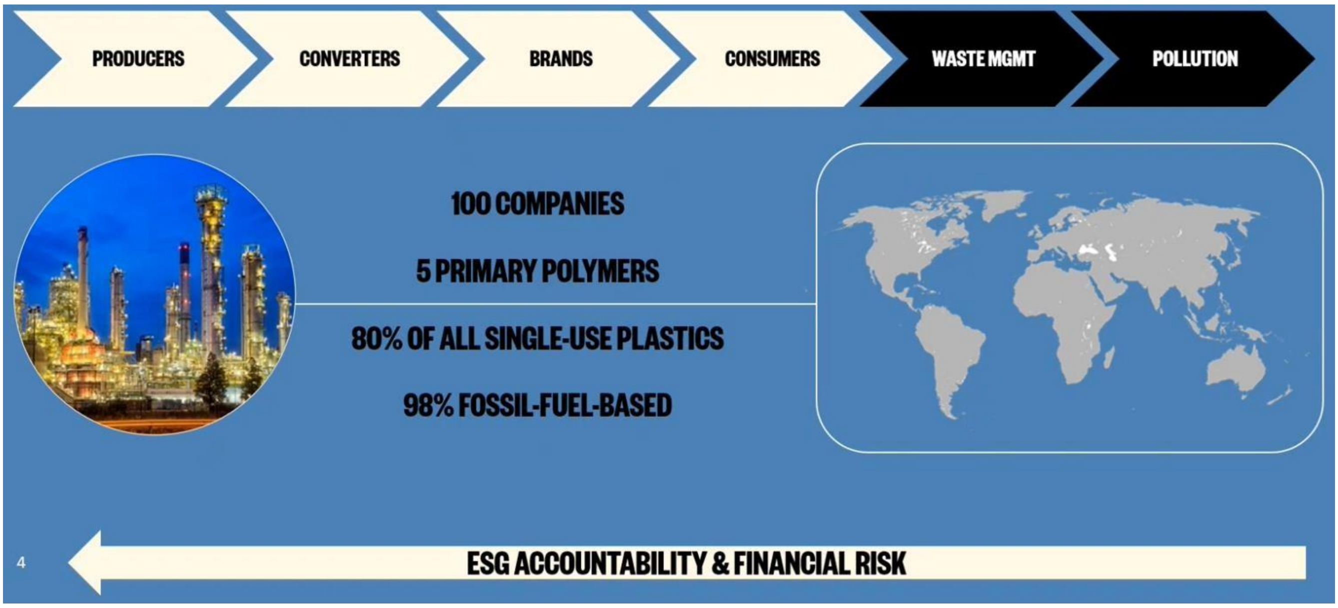
Simplified life-cycle model



2.2 METHODOLOGIES AND MODELS REVIEWED

2.2.1 Plastic Waste Makers Index

This model is a global material flow model, the methodology focusses on the large plastic producers, encouraging corporate transparency (approximately 300 companies across more than 100 countries) and focusses on 5 primary polymers which Minderoo believe account for 80% of all single use plastics, represent the majority of plastic in municipal solid waste (MSW), and are the primary source if marine plastic pollution. The methodology covers the early stages of the plastics life-cycle up to the point where plastic products become waste as illustrated below.



The methodology is applied in 6 steps:

	STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6
MATERIAL FLOW	Polymer production	Polymer trade	Polymer conversion	Trade in single-use plastics in bulk	Trade of single-use plastics in finished goods	Single-use plastics MSW*

The model aims to predict the annually generated quantity of single use plastic waste per capita (kg / person) by country.

The first results were published in May 2021, much of the source data is available annually or more frequently and the intention is to update the projections during 2022. At present the data projections cover just single use plastics but Minderoo are adding polystyrene material flows and plan to add textiles.

Minderoo indicate that the data at country-level can be made open-source, indicating it is not yet openly available.

2.2.1.1 *Data inputs*

The methodology utilises the following data sources:

	Data sources					
Modelling variable	**Wood Mackenzie**	**Export Genius**	**UN Comtade**	**American Chemistry Council**	**McKinset Global Institute**	**World International Trade Solution World Bank**
Polymer production	●					
Polymer trade		●	●			
Polymer conversion	●			●		
Bulk trade			●			
Finished goods trade					●	●
Population data						

2.2.1.2 *Data outputs*

The methodology estimates annual single use plastic waste generation (kg/capita) by country.

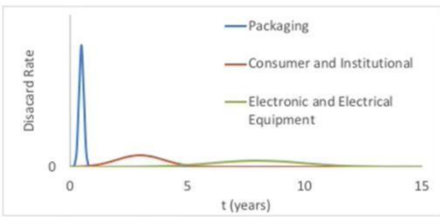
2.2.1.3 *Limitations*

This is a purely theoretical model based on production and trade statistics. The accuracy of results is very much dependent on the accuracy of the production and trade statistics used. The accuracy of results also dependent on the accuracy of population statistics. If comparing results with other methodologies it is critical to adjust for any differences in the population statistics used. The methodology focuses on single use plastics.

2.2.1.4 *Strengths*

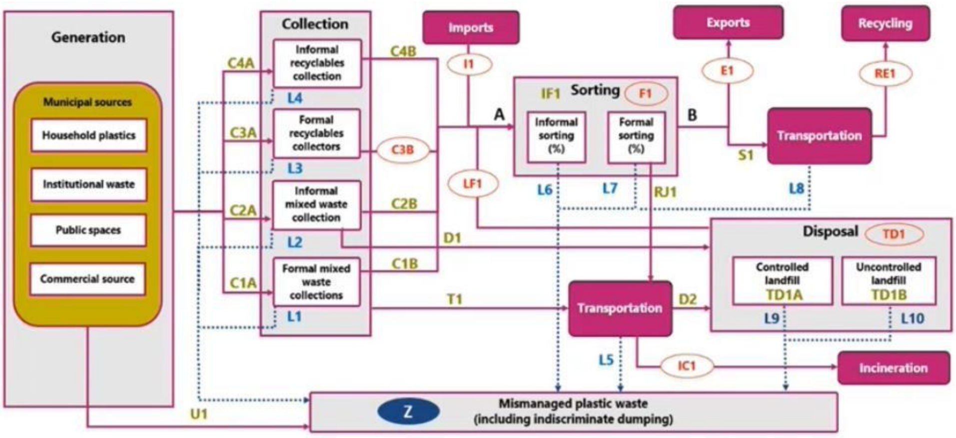
As the methodology focusses on production and trade, it avoids the limitation of those methodologies that work with solely with municipal solid waste data which may not include industrial, agricultural etc sources.

2.2.2 *BRS Plastic Waste Inventory*



The Basel Convention guidelines proposes a dual approach to development of Plastic Source Inventories. The first is a “top-down” approach based on estimation of plastic waste generation using the product lifetime approach developed by UNITAR.

The second approach focuses on on-the-ground waste generation and management using the Wastewise Cities Tool (WaCT) in combination with the GIZ Waste Flow Diagram (WFD). These are applied at “local” level, typically municipalities. The word “cities” in the name of the WaCT tool can be slightly misleading as the tool can be applied to geographical areas ranging from towns to groups of towns to mega-cities. The BRS methodology suggests using city “archetypes”, surveying a representative sample of these archetype cities and extrapolating to national level using population statistics.



2.2.2.1 *Data inputs*

The UNITAR methodology requires domestic production data and import and export statistics. WaCT and WFD require on-the-ground data collection (see Sections 2.2.16 and 2.2.12 respectively).

2.2.2.2 *Data outputs*

Data on national level plastic waste generation and management, in addition, if WaCT and WFD tools are used data is generated for the localities where they were applied supporting local intervention initiative development.

2.2.2.3 *Limitations*

The limitations are those of the individual tools used. The UNITAR methodology relies on the availability and accuracy of domestic production and trade data. That data then needs conversion to kg quantities. It is generally perceived the data accuracy will be at the lower end of the scale.

The combination of the WaCT and WFD tools can give a higher level of accuracy, but this is only for municipal solid waste and requires extrapolation to national level.

2.2.2.4 *Strengths*

The approach has been tested in more than 20 countries with the support of the Basel Convention Small Grant Programme, the Plastic Waste Partnership and the Basel Convention technical assistance programme.

In addition, the WaCT and WFD methodologies have also been widely applied.

Toolkits are freely downloadable complete with guidance documents; the guidance however has a low level of detail. The guidance for WaCT and WFD have a high level of detail (see Sections 2.2.16 and 2.2.12 respectively).

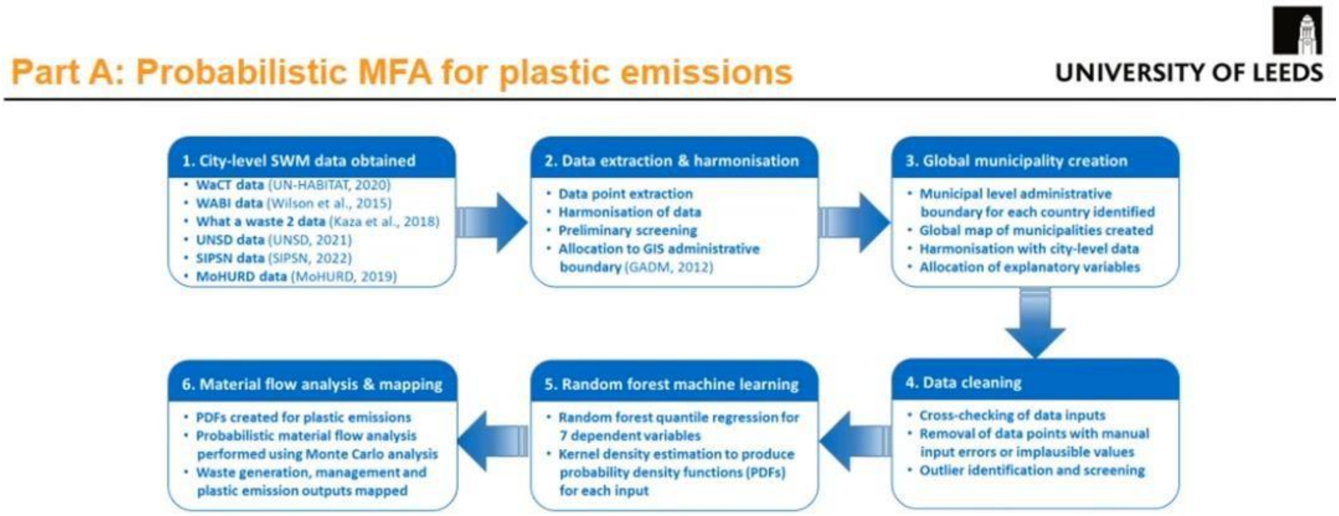
2.2.3 *"SPOT"*

"SPOT" is an acronym for the modelling methodology entitled "SPatio-temporal quantification of plastic pollution Origins and Transportation" which aims to link local data to global data. It combines a probabilistic mass-flow analysis using local (municipal) solid waste management data to calculate plastic emissions into the environment, with temporal geo-spatial modelling of the movement of those emissions.

It estimates emissions where municipalities do not have data using "random forest" machine learning. "Random forests" or "random decision forests" is an ensemble learning method for classification, regression and other tasks that operates by constructing a multitude of decision trees at training time[1].

[1] Wikipedia (https://en.wikipedia.org/wiki/Random_forest).

The methodology includes six steps for the probabilistic mass flow analysis:



Currently, Leeds University have used the SPOT model to calculate plastic emissions into the environment for 85,000 municipalities globally.

The SPOT methodology and model has not yet been published and therefore information on data inputs and outputs is limited.

2.2.3.1 *Data inputs*

Uses existing city level data, e.g. World Bank What a Waste 2.0, data collected using the Wastewise Cities Tool (WaCT), UNSD etc. supplemented by machine learning to fill data gaps.

Plastic waste distinguished by “rigid” and “non-rigid”.

The methodology utilises the following data sources[2]:

	Data sources					
Modelling variable	**World Bank " What a Waste**	**UN Habitat Wastewise Cities Tool**	**GIZ Waste Flow Diagram**			
Polymer production						
MSW Generation	●	●	●			
Polymer conversion						
Bulk trade						
Finished goods trade						
Population data	●	●	●			

[2] Incomplete as methodology not yet published

2.2.3.2 *Data outputs*

SPOT predicts plastic emissions from local through to global level. SPOT also models the movement of the plastics emitted from source of emission to river mouths.

2.2.3.3 *Limitations*

Reliant on good data from other sources / methodologies. Machine learning very dependent on quality of “training” data.

Resources required, ideally the model would be run using a super-computer otherwise the model takes considerable computer time to run. Part A (mass flow analysis and estimation of emissions) takes approximately 1 month without a super-computer, Part B temporal geo-spatial modelling of movements takes a further 2-3 months. Currently implemented only by University of Leeds (UoL). Code is likely to be publicly available on release of publication, but its usability may well be limited due to the necessary computing overhead.

UoL indicate it aims to continue providing quality assurance, it is not clear whether that is mandatory for use of the model.

UoL has committed to running the global version of the SPOT model every 6 months “incorporating new data and developments”, provided funding is available.

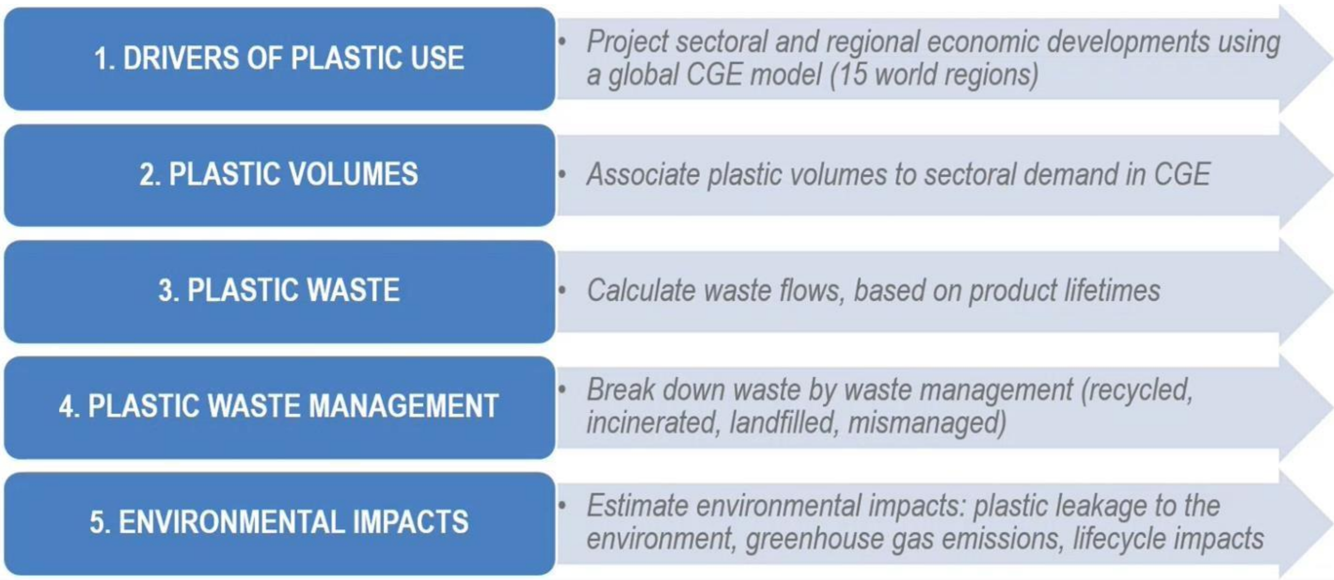
Results will be freely available via the Global Partnership on Marine Litter (GPML) digital platform.

2.2.3.4 *Strengths*

If the machine learning is effective, it can project for municipalities where data is missing and therefore focus attention on key locations for further data collection. It can predict national plastic emission source inventories.

2.2.4 *OECD Global Plastics Outlook (ENVI plus)*

This methodology takes a macroeconomic approach, starting with the drivers for plastic use using a recursive global CGE (computable general equilibrium) model covering 15 world regions. In total the model has 5 steps:



2.2.4.1 *Data inputs*

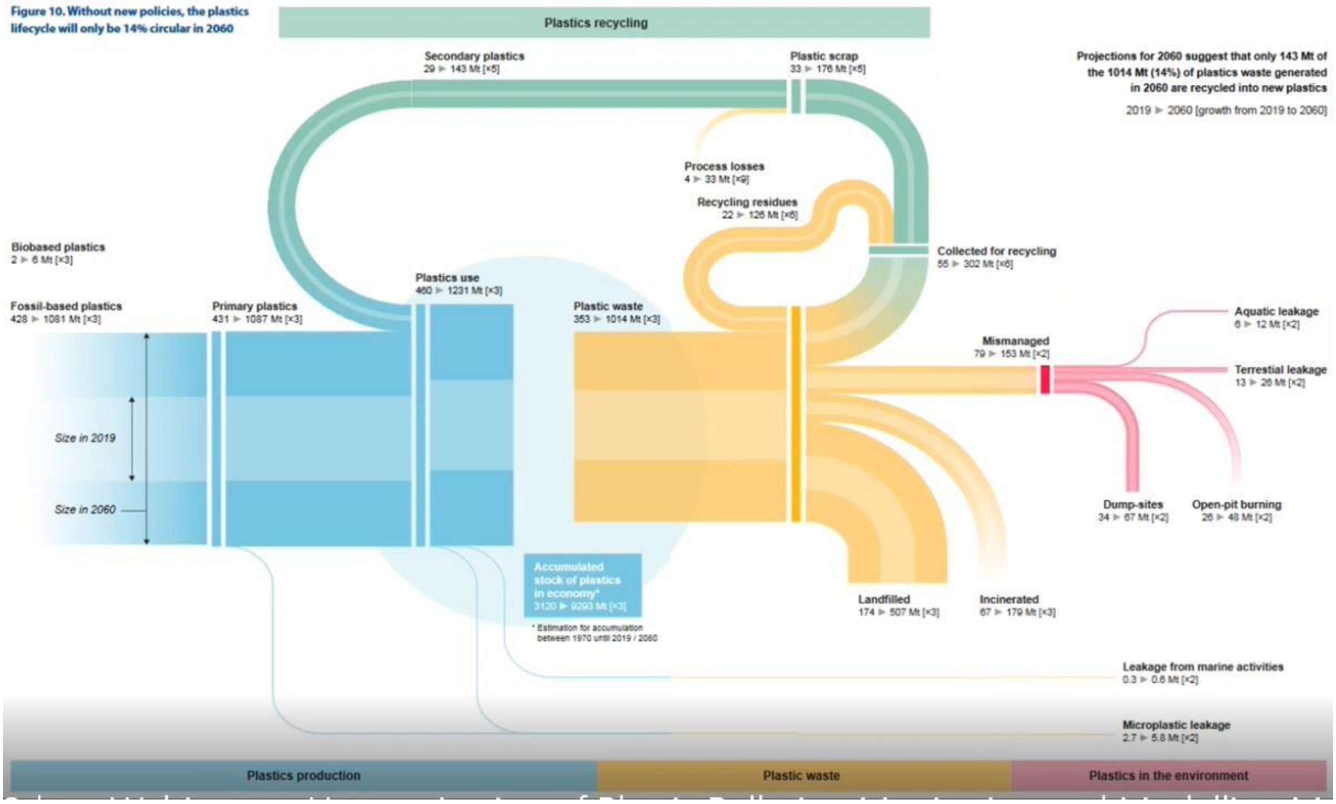
The overall methodology draws heavily on the OECD ENV-Linkages model, the successor to the “OECD GREEN” model. The ENV-Linkages model is built primarily on a database of national economies. The model covers production, consumption, and trade from a variety of sources including GTAP10 (Global Trade Analysis Project). This is supplemented by published secondary plastics data incorporating recycling loss rates from literature.

Data inputs on historical regional use by application and polymer again comes from published data, and use data for a “calibration year” (2015) also comes from published data.

Environmental impact data also comes from published data.

2.2.4.2 *Data outputs*

The methodology modelling generates a plastics lifecycle mass-flow, it adopts the “top-down” approach. For example:



2.2.4.3 *Limitations*

It shares the limitations of the ENV-Linkages model, compounded by the limitations of the literature search data subsequently used. It also adopts a global and regional approach, and does not cover national or local situations. It currently has no interoperability, but data generated can be used by other models.

2.2.4.4 *Strengths*

The methodology models the whole plastics life-cycle “cradle to grave”. The data generated is “open” and downloadable.

2.2.5 *UNEP IUCN Plastic Pollution Hotspotting*

The term “hotspot” herein is not used in the geospatial sense but means a component of the system that directly or indirectly contributes to plastic leakage and its associated impacts that can be acted upon to mitigate the leakage itself.

This methodology defaults to examining specific polymers categorised as PP, PET, PS, PVC, HDPE, LDPE, Polyester, Synthetic rubber and “Others”. It also covers may “applications” of polymers, ...

It is a complex methodology and takes a sectoral approach, defaulting to coverage of packaging, automotive and transportation, construction, electrical and electronics, medical, fishing, agriculture, textiles, tourism, and "others".

To date, it has been piloted in Africa and Asia (Thailand and Vietnam) and in two islands in Europe (Cyprus and Menorca).

2.2.5.1 Data inputs

WAW2, ICIS, UN Comtrade, UN world population prospects 2019, WB world development indicators 2012, UN Environment (2018) use share of polymer production.

2.2.5.2 Data outputs

The methodology estimates the quantities of waste generated by the target country by polymer type, and the quantities of plastic waste by polymer that are "properly disposed". It estimates the quantities of plastic wastes that are "mismanaged" (uncollected or improperly managed) by sector along with "leakage" and aims to identify hotspots for prioritisation of interventions.

2.2.5.3 Limitations

The methodology is very complex and is resource intensive to apply. While it is comprehensively supported by downloadable guides, training modules and tools, it is complex to apply.

2.2.5.4 Strengths

This methodology is open and supported by a comprehensive set of tools, guides and training materials.

2.2.6 PLASTEAX

PLASTEAX actually applies the UNEP IUCN methodology and model nationally for macro plastics. Data has been "collected, reconciled and released" for 45 countries.

2.2.6.1 Data inputs

Trade: CEPII BACI database, UN Comtrade database

Polmer production data: ICIS, national plastics producers associations, PLASTICS EUROPE.

Recycling: ICIS, reports and scientific papers.

Waste management: Eurostat, EEA, EU infringement decisions, reports, census data.

2.2.6.2 Data outputs

Country overview plastic mass flow analysis estimates (kt) by polymer type and by product types. PLASTEAX also generate MWIs (Managed Waste Indeces). Some generic data is available (via email request accessed on web page (https://www.plasteax.org/access-data-1). More detailed reports are available as a commercial service, an example can be downloaded (https://www.plasteax.org/_files/ugd/8cad30_fc91abe622b94b47b52e8658b6aab443.pdf).

2.2.6.3 *Limitations*

As per UNEP IUCN. The “tool” is not open access (although the UNEP IUCN toolkit is). Exactly how the PLASTEAX methodology improves on the UNEP IUCN “tool” is not clear. Users do not apply the “tool” or PLASTEAX methodology themselves, PLASTEAX apply it on behalf of “customers”.

2.2.6.4 Strengths

The strength of this is possibly that PLASTEAX apply the complex UNEP IUCN methodology / model and on behalf of clients, and therefore it might be applied in a consistent and comparable manner across countries.

2.2.7 Common Seas, Plastic Drawdown Tool

Methodology developed by Common Seas "in consultation with 24 governments", Common Seas claim the approach was endorsed by UN.

Common Seas users the plastic drawdown tool to "support partner countries" in three phases; a preparation phase, a technical phase, and a third phase which is to help partner countries create and implement a "National Roadmap". The methodology models the waste management system in a country and includes a feedback loop back into the technical phase for monitoring impact of roadmap implementation.

2.2.7.1 Data inputs

Input data comes from desktop research. A PD (Plastic Drawdown) Committee is established when applying the methodology in country, as a vehicle for consultation. Opinions sought via "expert elicitation". Field work may be undertaken to fill data gaps.

2.2.7.2 Data outputs

The methodology estimates Plastic waste generation (in kT), over a 10 years period. It aims to predict the increase in Plastic pollution over 10 years projecting changes in plastic waste generation based on a "business as usual" scenario (zero policy interventions) and estimates the impact of applying waste reduction policies over the 10 year period.

2.2.7.3 Limitations

For the methodology to be applied, the model needs current country-level waste management data, availability of that data can be extremely limited. The methodology mentions "field work" to fill data gaps.

2.2.7.4 Strengths

The methodology covers macro and micro plastics, and if good data is available may indicate potential for plastic waste reduction by application of policies.

2.2.8 EUROqCHARM

EUROqCHARM is an acronym for "**EURO**pean **Q**uality **C**ontrolled **H**armonisation **A**ssuring **R**eproducible **M**onitoring and Assessment of Plastic Pollution.

This is an EU funded project which started in November 2021 and scheduled to run until October 2023. It examines how to achieve harmonisation and standardisation of plastic pollution monitoring with aim of ensuring application of a standard methodological approach using state of the art procedures. EUROqCHARM has developed an innovative approach to support the identification of technical guidelines using the novel and combined approach of Reproducible Analytical Pipelines (RAPs), SWOT analysis, and Technology Readiness Levels (TRLs), and has disseminated outputs thus far to the expert working groups within monitoring and standardisation. This has specifically been used for the development of two standard methods for the determination of microplastics in water samples and solid matrices.

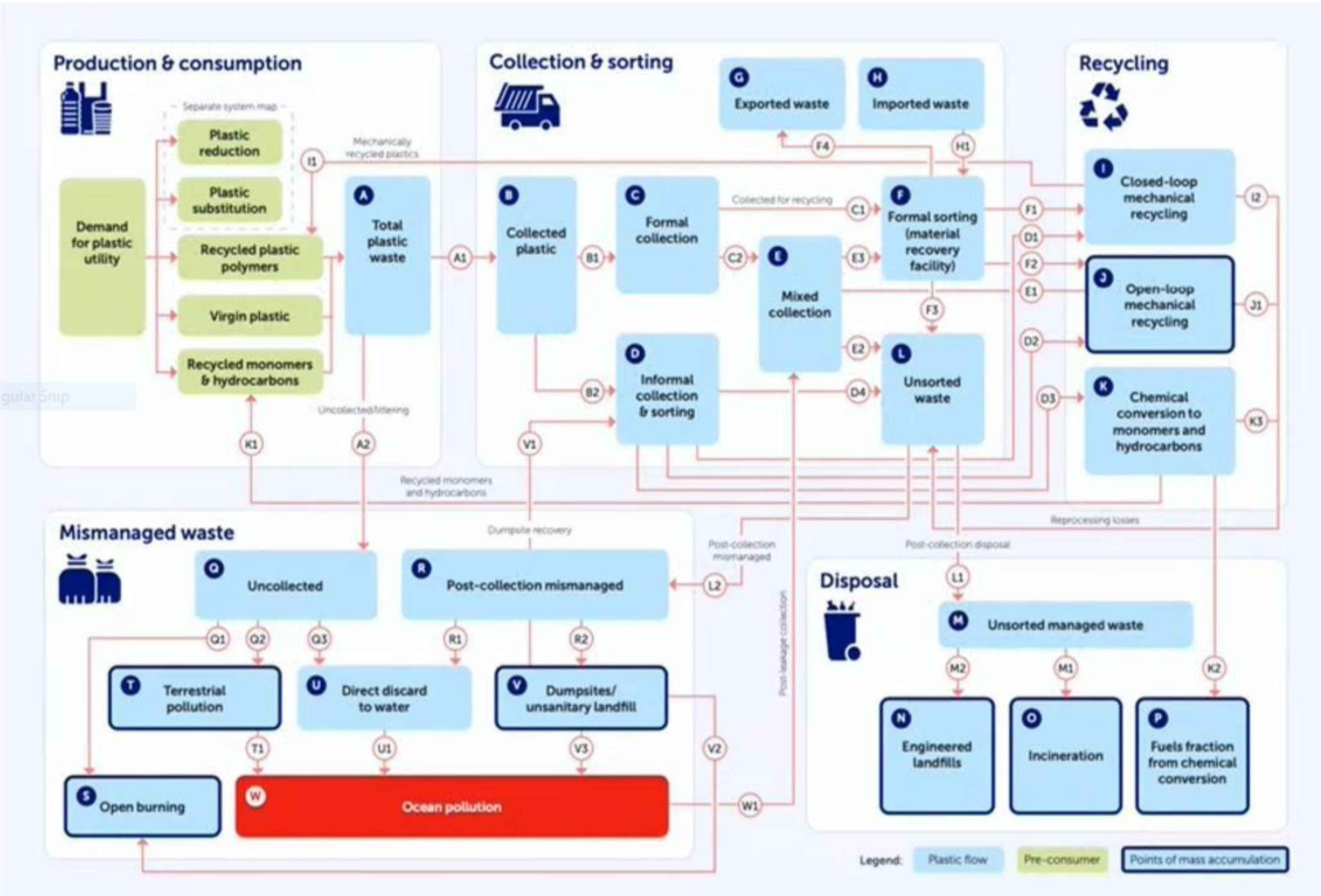
EUROqCHARM has a sampling and analytical methods focus, as such it is not a modelling system for supporting development of plastic emission source inventories, but has a role in monitoring plastics in the environment and therefore could ensure marine environment monitoring consistency improving validation tools for the various modelling methodologies.

2.2.9 Breaking the Plastic Wave Pathways Tool

This tool adopts the approach starting with macroeconomic modelling and examining the plastic value chain focussing on municipal solid waste management, social, economic and environmental data. The aim is to identify current and potential "plastic flows".

The "pathways tool" itself is an application. The tool will be "freely available", the timescale for availability is uncertain.

It claims to enable global, regional, national and city-level analysis. The application enables users to create a "plastic system map" and input "multiple plastic categories" (plastic types, polymer types, product types).



Claims interoperability and opportunity of linkages among models and tools. The model is very complex aiming to estimate demand reduction with economic analysis.

2.2.9.1 Data inputs

Based on a sample data sheet supplied, initial data input is similar to the GIZ Waste Flow Diagram (population and plastic waste generation quantity in kg/person/year) but expands on this to sub-categorise plastic into user-definable types. It takes this base data and models flows by those material types.

Data input includes costs of various management processes (US$ / ton) plus appears to use employment data for lifecycle.

2.2.9.2 Data outputs

Results to date from methodology application are "publicly available" online. An online data repository is intended.

2.2.9.3 *Limitations*

This looks to be a very powerful tool with a high level of flexibility allowing users considerable scope for customisation. This has an attendant limitation, as varying levels of "customisation" could impact comparability.

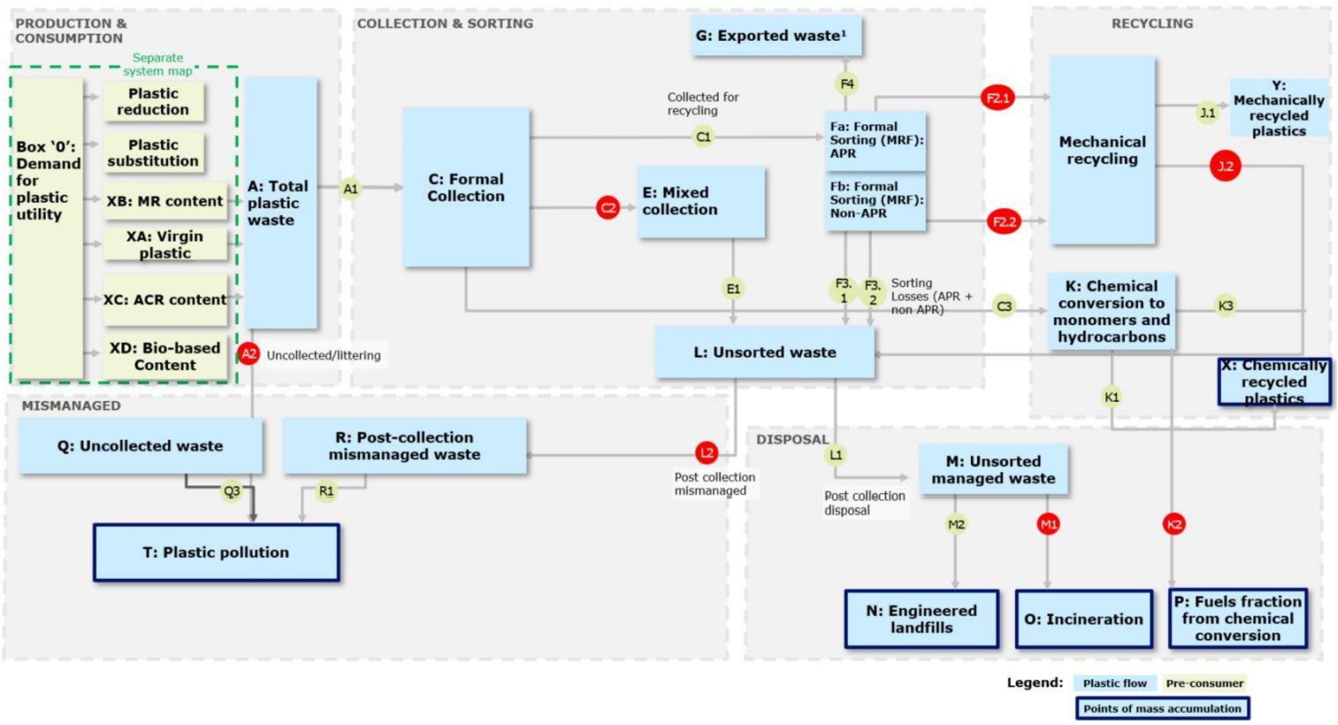
Like most models it requires good waste generation data to be available at national level.

2.2.9.4 *Strengths*

The methodology has potential to give complex baseline data and model scenarios both from a waste quantities perspective but also from an economic perspective.

2.2.10 *Plastic IQ*

Tool for companies to assess the impacts of policy changes on their plastic waste generation. Works with data in the background from SystemIQ projects. It is aimed at U.S. companies making and selling packaged goods to analyse the environmental footprint of their plastic packaging and assess the cost and environmental impacts of changes that could be made in their packaging portfolios. The methodology focuses on the development of an "adjusted" version of the plastic system map used in the pathways tool:



2.2.10.1 *Data inputs*

Plastic IQ works with partners, industries and recycling companies for example to gather the background data. For the system map flows, published data from a number of sources including US EPA, The Recycling Partnership, (TRP), Breaking the Plastic Wave (Pew), the Association of Plastic Recyclers, the American Chemistry Council. Sources are mainly American.

2.2.10.2 *Data outputs*

The methodology aims to identify the environmental footprint of a company's plastic packaging.

2.2.10.3 *Limitations*

The methodology has a corporate focus, corporates generally don't want to share data, SystemIQ "sells" the methodology as demonstrating a corporate environmental responsibility with potential cost savings. Another key limitation is that it focuses just on packaging. In addition, data sources for modelling are typically from USA limiting application globally.

2.2.10.4 *Strengths*

Scenario modelling capabilities for corporates for packaging waste reduction.

2.2.11 GPML Risk and Warning System for Macroplastic Litter in Rivers

Methodology applied by the UNEP-DHI Centre building on the DHI Global Hydrological Model, to model the movement of plastic waste emissions from their sources, via river systems to the marine environment.

2.2.11.1 *Data inputs*

Two modelling components - plastic waste generated in river catchments (e.g. Leeds University, UN Habitat) and modelling river transport of leaked plastics (uses DHIs global hydrological model). Utilises rainfall run-off model,

2.2.11.2 *Data outputs*

The model estimates plastics load in all major rivers, it is also capable of generating a time series of plastic loadings in rivers forecasting up to 9 months ahead.

2.2.11.3 *Limitations*

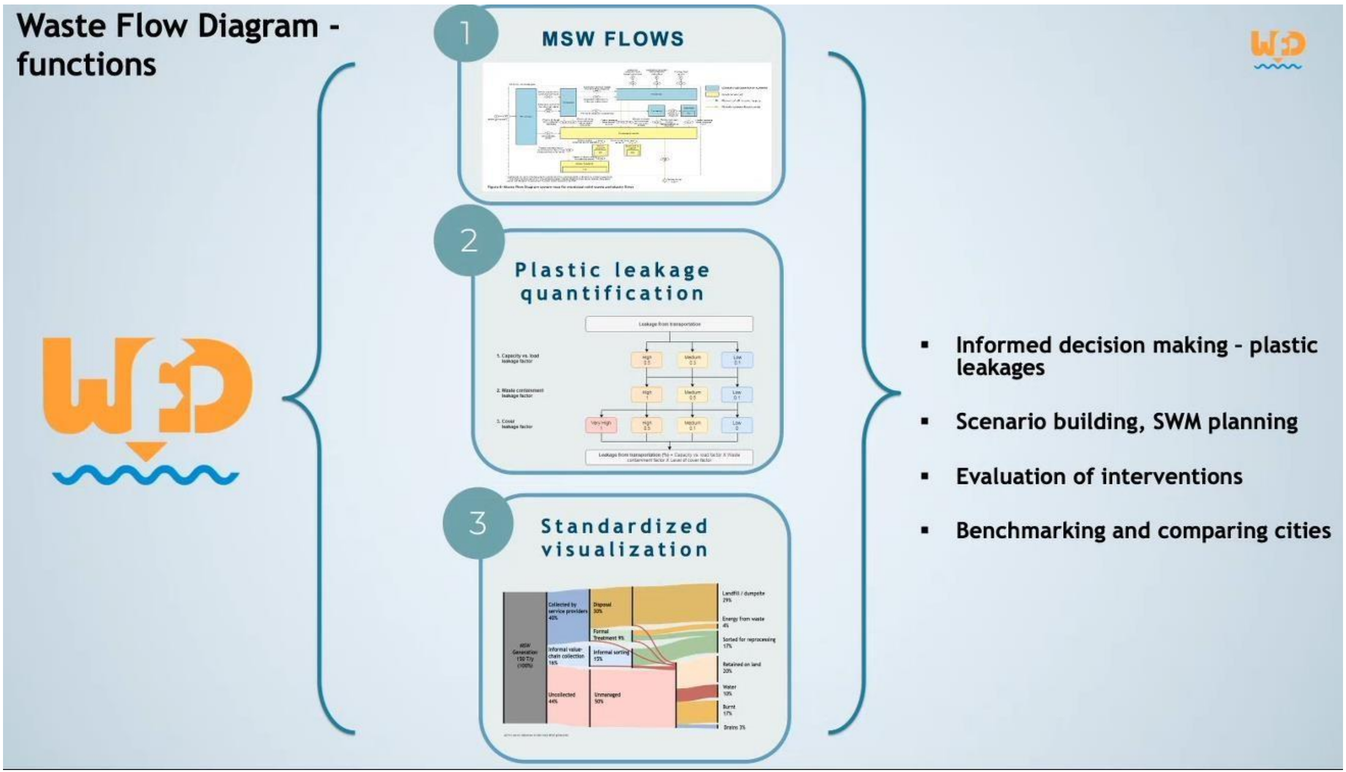
He methodology needs global data on the sources of plastic waste leaking in river catchment areas, updated regularly.

2.2.11.4 *Strengths*

Generates source data for marine transport modelling and can help focus interventions leading to a reduction in plastic marine litter.

2.2.12 Waste Flow Diagram (WFD)

The GIZ Waste Flow Diagram is a methodology to estimate plastic leakage (emissions) of the target city/study ares into the environment from municipal solid waste generation and management / mismanagement. It then models the likely fates of the leakage.



An excel tool has been developed, and is freely downloadable, for entering data collected using the Waste Flow Diagram methodology, an online portal is in the final stages of development scheduled for official launch in December 2022. Data can be uploaded to the data portal using a spreadsheet module developed for integration with the Excel WFD spreadsheet tool.

2.2.12.1 *Data inputs*

The methodology uses population data and waste generation factor in kg/person/day to calculate quantity of MSW generated and MSW waste composition data. Uses data on waste collection and management by waste fraction, and observational data on aspects of the collection and management system that affect leakage rates.

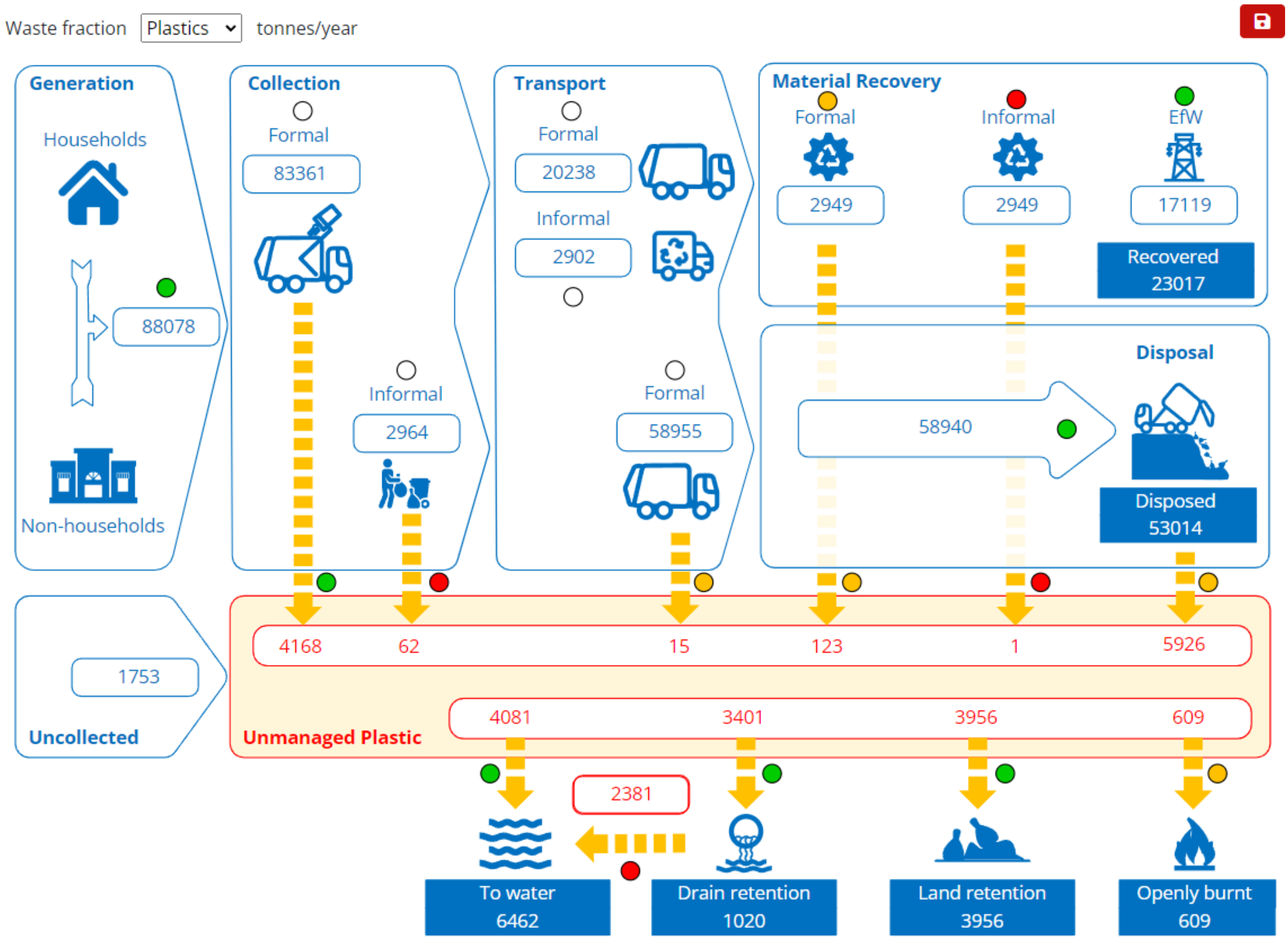
In the case of data input online, interoperability with the Wastewise Cities Tool data portal can enables the WFD data portal to query the WaCT data portal for input data for waste generation and management; an API “key” needs to be shared to enable this.

2.2.12.2 *Data outputs*

The model undertakes a Mass Flow Analysis (MFA) of MSW waste fractions (tons per year) and estimates quantities being leaked to the environment (openly burnt, retained on land, retained in drains, and to water systems).

Data is generated in the form of a “Waste Flow Diagram” infographic, results tables and Sankey diagram displays can also be generated.

Waste Flow Diagram Infographic



2.2.12.3 *Limitations*

The WFD focusses on the local level and only on municipal solid waste. In order to generate national data, as mentioned for the BRS methodology, extrapolation to national level needs application to an appropriate set of municipal solid waste management system “archetypes” within the target country.

The WFD model uses a set of leakage factors to assess the plastic leaked based on observations on the leakage “influencers” for each stage of the collection and management chain, and for determining the fates of leaked plastics. The quality of the output is dependent on the accuracy of these leakage factors.

2.2.12.4 *Strengths*

A key strength is that the methodology is based on actual on-the-ground data collection and observation.

The methodology has been widely applied and is supported by freely available tools, user guides, and extensive professional quality training materials. Interoperability with the Wastewise Cities Tool.

Use of the methodology for intervention planning and funding has been effectively demonstrated, and it is a proven engagement tool.

2.2.13 *Plastics Pollution Calculator (PPC)*

Developed by Leeds University with ISWA Marine Task Force. The methodology Takes a similar approach to

WFD but with a much mode granular approach, both in terms of influencers and plastic types.

The PPC is applied at "neighbourhood" level, aggregating to city or provincial level. The overall methodology can indicate potential impacts of interventions.

2.2.13.1 *Data inputs*

Primary data preferred for waste management practices, infrastructure and socioeconomic, secondary data for example plastic composition by land use, supplemented with literature data where primary data is not available. Tertiary data includes leakage factors and model assumptions.

2.2.13.2 *Data outputs*

As WFD gives estimates of leakage but with more granularity. As with WFD it supports development of local and national action plans, the increased granularity can facilitate development of more targeted actions.

2.2.13.3 *Limitations*

Higher cost of application than WFD although it may give improved cost-benefit depending on the user's needs. A wide range of assumptions must be made enabling a widening of scope compared with the basic municipal solid waste approach adopted by the WFD.

Data inputs cover 55 parameters so primary data collection can be quite onerous, but it is claimed that secondary default data can be supplied from the models "library".

As with SPOT, the model is as yet unpublished and not "publicly available", currently implemented only by Leeds University.

2.2.13.4 *Strengths*

The complexity over WFD potentially is a strength of the methodology. Can be applied with SPOT.

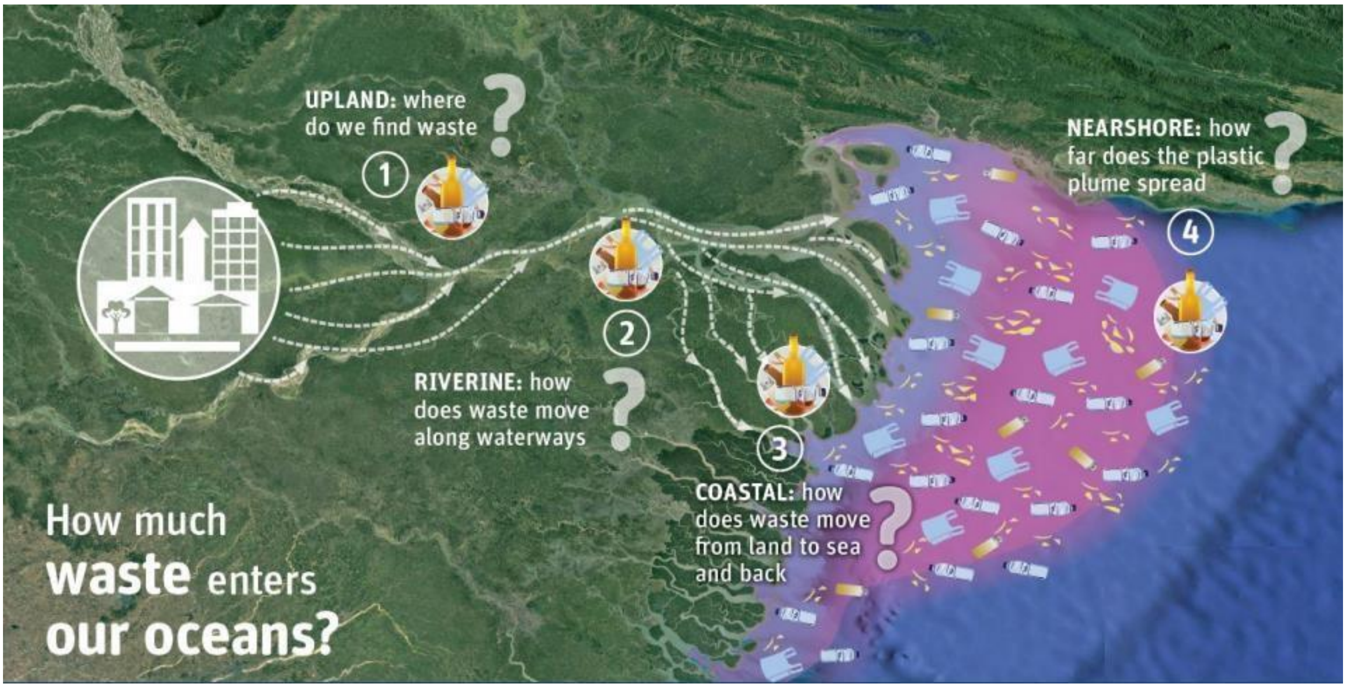
2.2.14 CSIRO Global Plastics Project

The CSIRO (Commonwealth Scientific and Industrial Research Organisation) methodology monitors plastics in the environment, sampling in inland and coastal sites, including rivers, streams, and near-shore environments. It aims to understand how plastics move through those environments.

One of CSIRO's objectives is to validate the estimates of pollution from land sources. Other objectives include hotspot identification, investigation of drivers and establishing baselines plus measurement of change.

2.2.14.1 *Data inputs*

On the ground monitoring of plastic in the environment, using a statistically robust sampling for inland, river, coastal and nearshore sites.



Aims to determine relationships between debris in the marine environment and sources of debris, identifying pathways.

2.2.14.2 *Data outputs*

CSIRO aims to develop a "comprehensive dataset" facilitating country level estimates leading to global estimates.

2.2.14.3 *Limitations*

The methodology uses intensive on-the-ground data collection, CSIRO are currently investigating drone monitoring and machine learning to supplement this. Selection of representative sampling locations to enable extrapolation is very difficult.

2.2.14.4 *Strengths*

Clearly capable of being used to verify the leakage estimates predicted by other methodologies, particularly WFD, PPC etc. although to do this effectively it would need to be applied in such a way as to measure change over a given period.

2.2.15 *Florida University Ocean Plastics Model*

This methodology applies a numerical ocean model developed by the Centre for Ocean-Atmospheric Prediction Studies (COAPS) of Florida State University.

2.2.15.1 Data inputs

Uses particle seeding data for direct inputs of mismanaged plastic waste from coastal regions and rivers, derived from literature sources.

2.2.15.2 Data outputs

The model predicts tons of plastic flowing between countries via oceans and seas, the results are published in pdf, csv and json formats on GPML digital platform and on the centre’s own website. The centre’s website also features is a description and summary of results (https://www.coaps.fsu.edu/our-expertise/global-model-for-marine-litter).

2.2.15.3 Limitations

Relies on old literature data. Would benefit from using newer modelled data, potentially from the UNEP-DHI Centre and/or SPOT models. The other limitation is the limited availability of data for validation of the model. Model can be shared but requires considerable expertise to run.

2.2.15.4 Strengths

The model quantifies the potential transport of plastics in the marine environment from country to country, it may have potential for mutual cross-validation with data obtained via beach litter monitoring.

2.2.16 Wastewise Cities Tool (WaCT)

The UN Habitat Wastewise Cities Tool was developed to collect primary data to measure the Sustainable Development Goal 11.6.1 indicator.

The methodology is applied in six data collection steps and a final modelling step.

The freely available spreadsheet tool is downloadable, along with the user guides, from UN Habitat’s web Wastewise Cities web page and from the Wastewise Cities Data Portal.

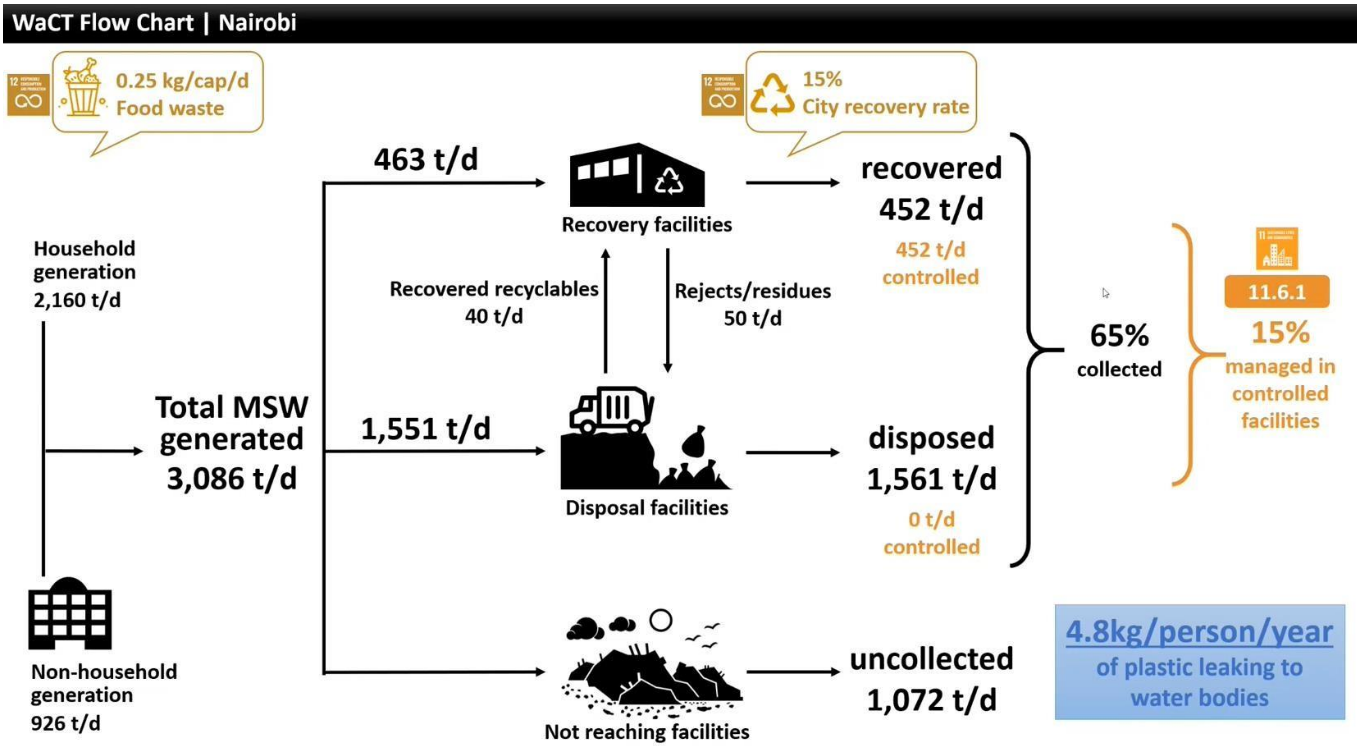
2.2.16.1 Data inputs

There is a published step by step methodology and toolkit for on the ground data collection. Waste generation data is collected for municipal solid waste generation and composition from households, quantities generated from non-household municipal solid waste sources. If there are insufficient resources for data collection from non-household sources a proxy can be used.

Data is collected on materials recovery system operators including quantities received by material type (for plastics the quantities are characterised by “plastics, dense” and “plastics, film”. Data is collected on waste disposal facilities including quantities and composition.

2.2.16.2 Data outputs

Output data is generated in the form of a municipal solid waste materials flow diagram and a data “factsheet”.



2.2.16.3 *Limitations*

The Wastewise Cities Tool is applied at "local" level and only covers municipal solid waste. Plastics for example from agricultural, fishing, and industrial sources are excluded. The methodology has been widely applied and experience has shown that data collection for non-household sources is difficult and resource intensive.

In order to extrapolate to national level, the methodology needs to be applied to a selection of "archetype" cities with different levels of waste management system development.

2.2.16.4 *Strengths*

WaCT is a robust well-defined methodology supported by user guides, spreadsheet tools and training videos. The methodology has been widely applied. It has a demonstrated ability to support intervention planning and financing.

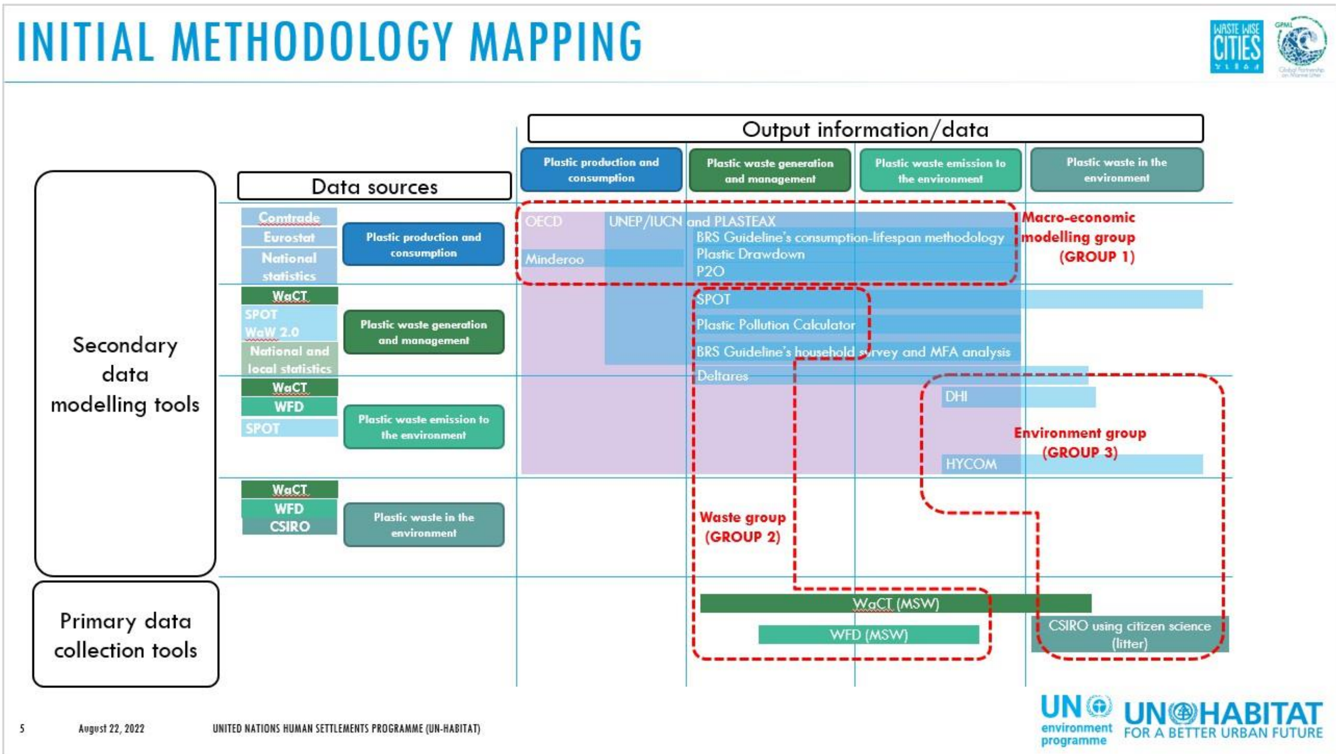
Data from WaCT can be utilised as primary data for other methodologies including Waste Flow Diagram (with which it has well defined linkages and is able to interoperate), PPC and SPOT. WaCT Data is publicly available via the Wastewise Cities Data Portal (if data providers agreement obtained).

While the city focus has been mentioned as a limitation, it is able, if applied to "archetype" cities, to estimate national inventories.

3. *METHODOLOGY MAPPING*

3.1 PRELIMINARY MAPPING PRESENTED AT THE EGM

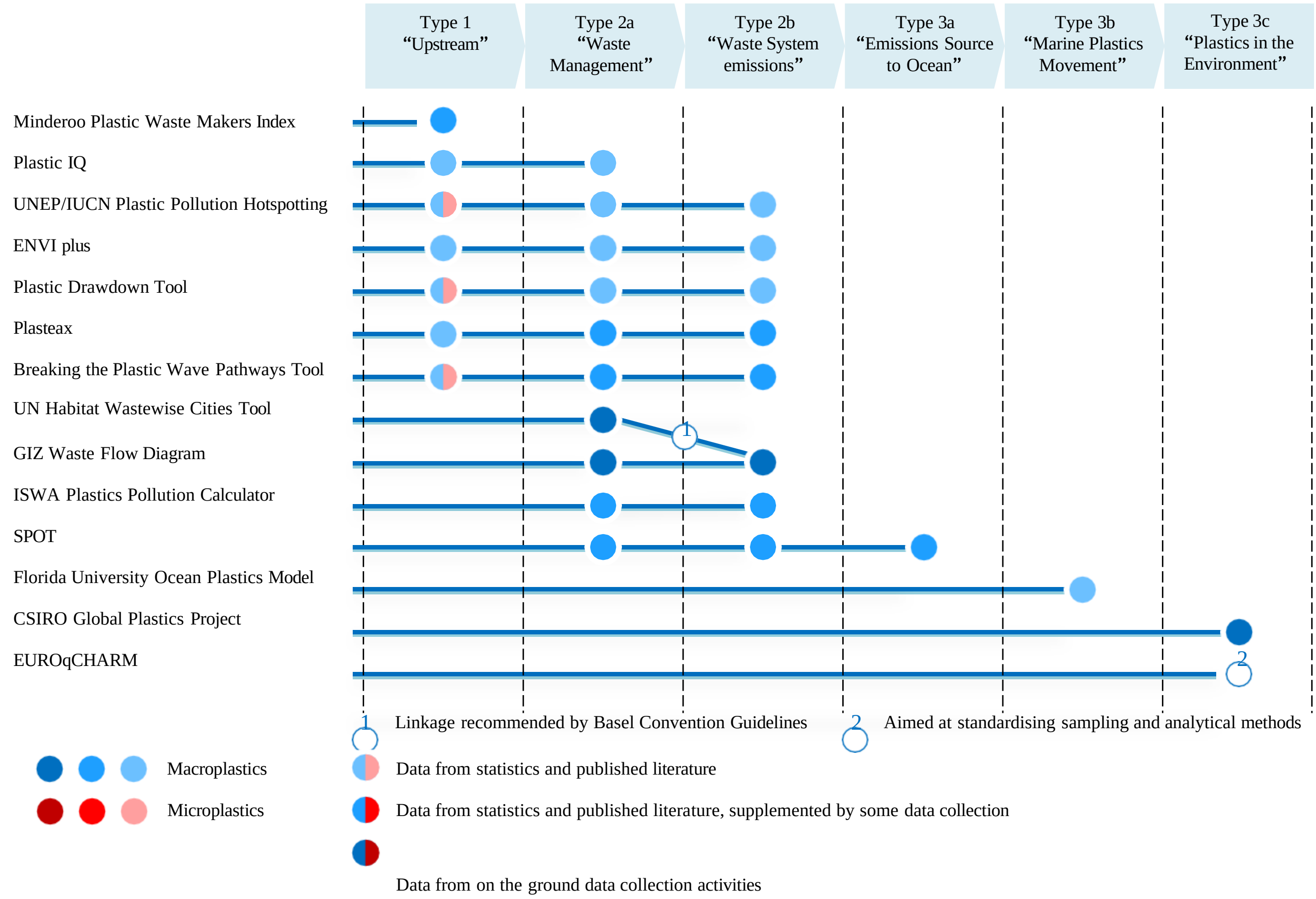
The following diagram shows the preliminary mapping of methodologies presented for discussion at the Copenhagen EGM on the 22nd August 2022.



3.2 MAPPING BY METHODOLOGY APPROACH

The methodologies reviewed fit into 3 broad approach categories, some include more than one approach:

1. "Upstream (top-down)" Approach. These methodologies start from production and consumption end of the plastic life-cycle. They aim to identify when plastic wastes will be generated and in what quantities.
2. "Waste System" Approach. These methodologies examine the system for managing plastic wastes from collection to final disposal, including material and energy recovery. These methodologies can be further sub-categorised as those that model the waste management system (2a) and those that aim to identify the sources of plastic emissions to the environment from the waste management system (2b).
3. "Environment" Approach. These methodologies examine the types and quantities of plastics in the environment, the methodologies can also be sub-categorised; those that model the flows of plastic emissions from source to ocean (3a), those that model the movement of plastics in the oceans/seas (3b), and, environmental sampling methodologies assessing the state of the environment (3c).



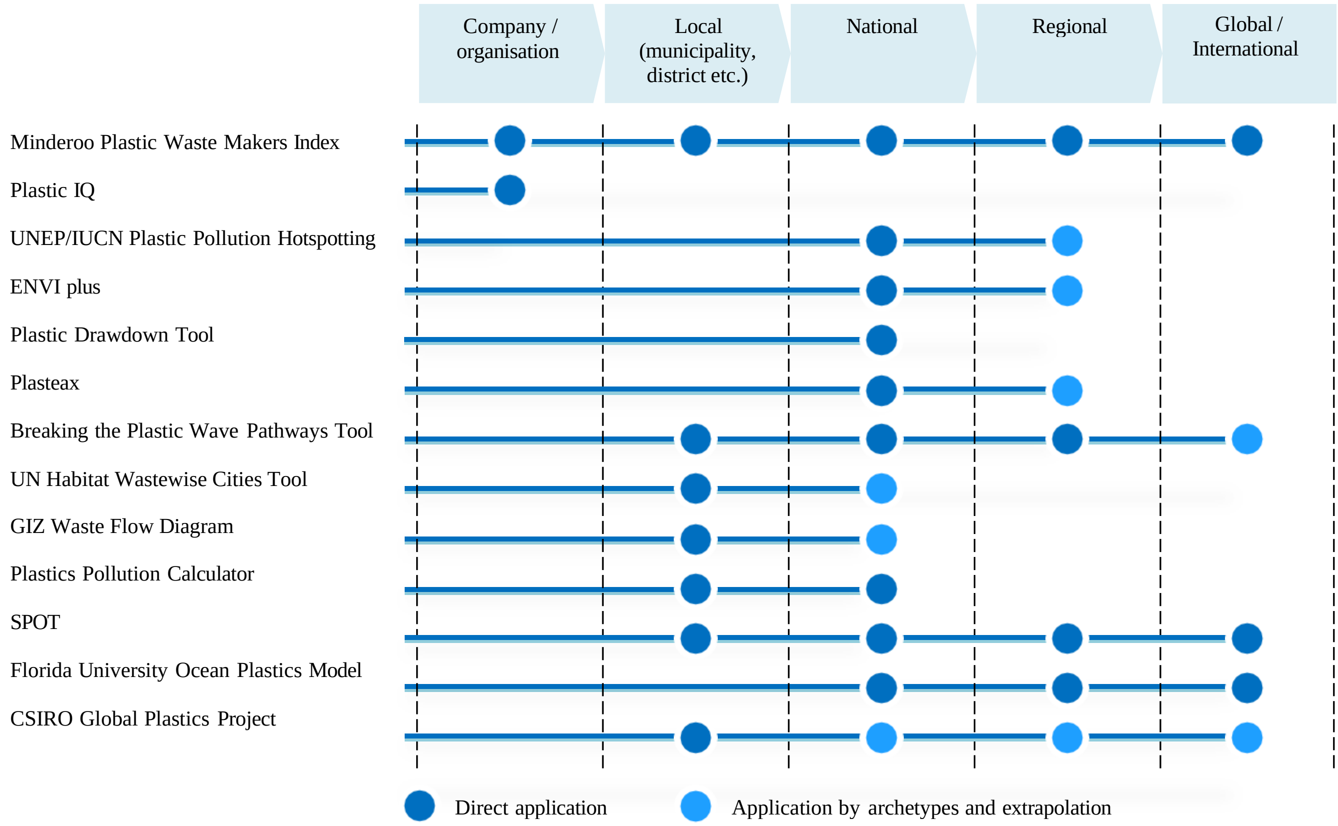
3.3 Methodology Mapping by Spatial Scope

The reviewed methodologies also differ in spatial scope, some have a local (municipality or district for example) others have a national scope, and some have regional scope while others have global / international scope. Some methodologies are also applicable to single companies or organisations.

The Minderoo Plastic Waste Makers Index methodology is full scope, it covers company / organisation level all the way up to global level, however it only takes an upstream approach focussing on polymer and plastic production and trade. It focusses on the large petrochemical companies and plastic manufacturers.

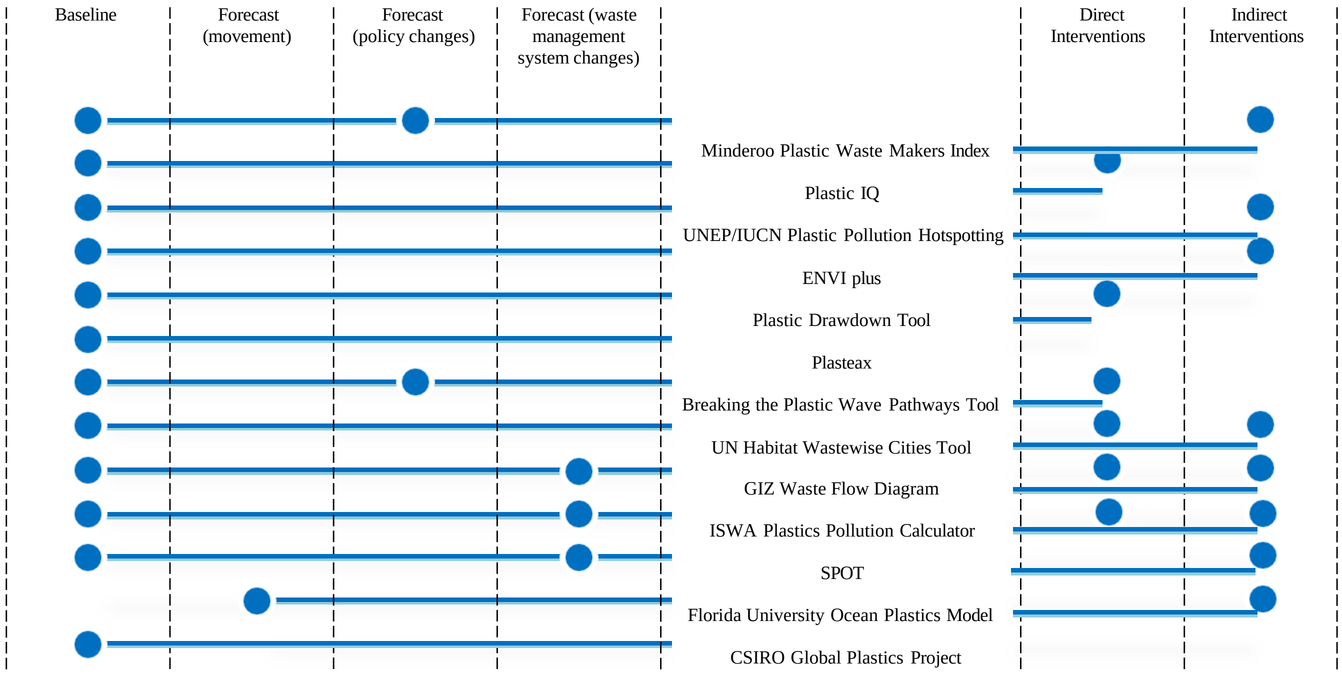
Plastic IQ has the most limited scope in that it is aimed purely at individual company / organisation plastic lifecycle.

The UN Habitat Wastewise Cities Tool and the GIZ Waste Flow Diagram also have limited scope in that they are tools for local data collection and modelling, although by multiple application across city waste management archetypes, they can apply to national level.



3.4 Methodology Mapping by Ability of Results To Inform Interventions

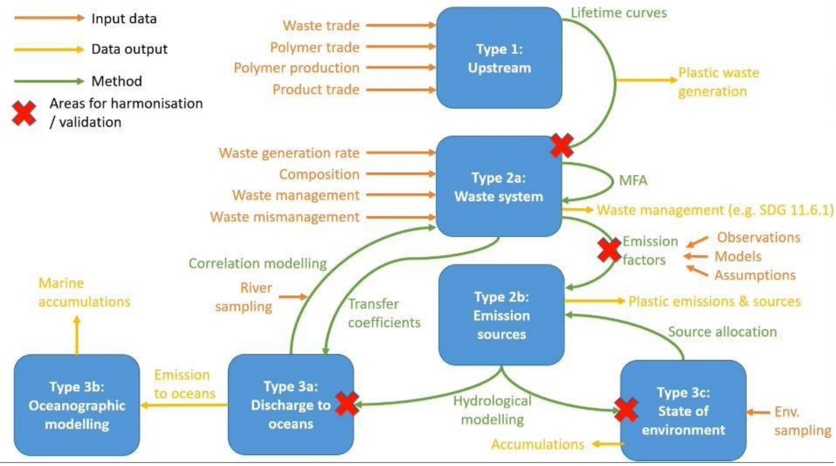
The methodologies generate baseline data, some methodologies also can forecast trends based in different scenarios. The Florida University model is a single-purpose tool which predicts movement of plastics in the marine environment.



4. POTENTIAL INTERLINKAGES BETWEEN METHODOLOGIES

4.1 Discussion at EGM

Costas Velis and Josh Cottom of Leeds University presented their thoughts on harmonisation and scope for cross-validation of methodologies.



The graphic attempts to map interlinkages between the three main categories of methodologies, showing data inputs, outputs and interlinkages between sections of the plastics lifecycle, and highlights some of the perceived issues for harmonisation with red crosses on the link arrows.

Between type 2a and 2b, different approaches have been taken to modelling the emission factors, with differences in approach, assumptions made, and factors used in the models. Between type 2 and type 3 ("monitoring" plastics in the environment) there is clearly potential for developing means of utilising output data from type 2 as input data to type 3, but it is necessary to determine which data elements, and how these should be utilised.

4.2 Existing Interlinkages

The interlinkage between the UN Habitat Wastewise Cities Tool and the GIZ Waste Flow Diagram has been widely exploited (Type 2a to Type 2b). The interlinkage is being elevated to the level of inter-operability between the WaCT Data Portal and the WFD Data Portal scheduled for launch in early December 2022. Enabling this interoperability required sharing of API "keys" issued and managed by UN Habitat. Currently, during the entry of waste generation and waste management data on the WFD Data Portal, the WFD Data Portal application is able (if a key has been obtained and configured) to query the WaCT Data Portal for latest data (if any) for the city in question.

With a shared key, other applications (online and appropriately enabled offline tools, such as Excel based tools) developed could also request data from the WaCT Data Portal.

Version 2.1 of the WaCT DCA (Data Collection Application) soon to be released features a WFD compatible MFA (mass flow analysis) enabling it to automatically generate the input data needed for the waste generation and waste management data inputs into WFD.

Other interlinkages are already being exploited manually, for example, WaCT and WFD data is being utilised by SPOT and PPC; and the Basel methodology published attempts to utilise the product lifetime approach developed by UNITAR in conjunction with WaCT and WFD.

4.3 Potential Unexploited Linkages

WaCT data is potentially useful to many of the methodologies covering Type 2a, that are using published literature, as supplementary data, with the limitation that it currently has a local (municipalities) focus and needs multiple application in a country across waste management system archetypes to be able to aggregate to national level. Currently, therefore, it can only be usefully interlinked to methodologies being applied at the same geospatial level. Currently there is no formal methodology adopted, and no tool, for this WaCT aggregation to national level, but if a formal methodology were to be developed, then this is a capability that could and should be added to the WaCT Data Portal.

Similarly, the WFD Data Portal has an API (Application Programming Interface) which can enable suitably programmed, online and off-line, tools to query WFD data. Again, this requires API "keys", issued and managed by GIZ, to facilitate API access. As with WaCT, the WFD has local geospatial scope and therefore has the same limitation, limiting its applicability to other methodologies covering Type 2b modelling looking for supplementary data for the same geospatial area.

The full SPOT methodology and model generates data which has potential to "seed" the Florida University Ocean Plastics Model.

The CSIRO methodology has some potential for validation of the outputs of WFD if representative sampling can be undertaken in the geospatial area covered.

The municipal solid waste only focus of WaCT has been mentioned as a limitation earlier in this document, interlinkage with other methodologies that cover non-municipal solid waste may assist in this regard. If the data collection on waste management does not manage to exclude non-municipal solid wastes, the collection efficiencies will be over-estimated unless non-municipal solid waste is accounted for in the model inputs (waste generation).

The above considerations are by no means exhaustive and need further development. Until the unpublished methodologies and models are finalised and published it is difficult to go into detailed interlinkage and interoperability opportunities with them. However, the APIs for WaCT and WFD offer very significant opportunities for data querying from other tools, whether those other tools are published or not.

4.4 Data Sharing

A critical factor with regard to interlinkages and, particularly, inter-operability using APIs, is privacy and the need for data sharing agreements. Issues of data ownership need to be understood and be resolved. To facilitate data sharing general principles for sharing need to be agreed. Many organisations have adopted open- data policies; but it is not at all clear how these policies are applied to data collected using these methodologies. Until these have been resolved for WaCT and WFD the interoperability features using their APIs cannot be properly leveraged.

It should be made clear to participants in programmes that utilise these methodologies what the respective open-data policies are, and which mechanisms for sharing are provided, which are optional, and which are mandatory; particularly when funded by public money.